Nordic Council of Ministers

# EU VERSUS NATIONAL CLIMATE POLICIES
## in the Nordics

Nordic Economic Policy Review 2023


BECK

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# Introduction: EU climate policy and Fit for 55

**Harry Flam and John Hassler**

In 2021, the EU decided to set more ambitious targets for the abatement of greenhouse gas emissions, including a 55% reduction in carbon emissions by 2030, compared to 1990 levels, and achieving climate neutrality – emitting and absorbing equal amounts of greenhouse gases – by 2050. To ensure that the new goals could be met, the EU Commission proposed a package of measures under the heading Fit for 55 to accelerate the abatement process. By the end of 2022, most of the proposed measures had been provisionally agreed in a trialogue between the European Parliament, the Council of the European Union and the European Commission. Final agreements are expected in 2023.

This issue of Nordic Economic Policy Review explores the implications of Fit for 55 for the Nordic countries. All of them have introduced more ambitious targets for abatement than the EU. However, the level of divergence has shrunk considerably, and EU requirements for greater uptake of carbon in forests and through land-use change are not necessarily satisfied under current national targets.

The new, more ambitious EU-wide climate policy gives rise to several questions: Are national targets and measures consistent with Fit for 55? If not, how should national policies be made consistent with EU policy? EU directives set targets for national climate policy, but member states are free to choose the means of achieving them. Are national measures to meet targets set by EU directives efficient? If not, how can they be made so? What are the costs and benefits of national climate policy aiming for more stringent targets than those under Fit for 55? We have put these questions to experts on the economics of climate policy in Denmark, Finland, Norway and Sweden. Before turning to their responses, it is useful to review the main elements of the Fit for 55 proposal package.

## Structure of EU climate policy

EU climate policy covers greenhouse gas emissions from all sectors of the economy, including land use and forestry. The policy consists of three parts:[1]

- **The EU Emission Trading System (EU ETS)**, which covers the energy sector, large industrial installations (about 15,000 of them) and aviation within the EU. EU ETS is a cap-and-trade system; every year a specified number of emissions allowances are allocated to the market, 43% without cost and 57% through auctioning. Each allowance affords the owner the right to emit one ton of greenhouse gases (measured as carbon equivalents). Allowances can be saved and traded. The system provides a ceiling on the total amount of emissions from the sectors covered. The amount is currently reduced by 2.2% of the average yearly number of emissions allowances allocated between 2008 to 2012. This corresponds to a yearly reduction of 43 million allowances per annum. In 2019, emissions of greenhouse gases from participants in the system amounted to 1,385 million tons. This was 38.5% of total emissions of 3,602 million tons in the EU (37.3% if international aviation is included in the calculation). In terms of $CO_2$, the coverage of EU ETS is close to 50% since most other greenhouse gases (methane and nitric oxide) are emitted from agriculture and waste management, which are not part of the EU ETS.

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1. For a more detailed account, see Vis et al. (2016).

- **The efforts sharing regulation (EU ESR)**, which covers the other sectors not included in the EU ETS: small industrial installations, agriculture, the operation of commercial and residential buildings, maritime and road transport, and waste management. A greenhouse gas reduction target is set for the EU as a whole and then for each member state ('efforts sharing'). The regulation implies a linear reduction of emissions for every year between 2021 and 2030. By 2030, emissions are required to be 40% lower than the 2005 level in Sweden and 39% lower in Denmark and Finland. Iceland and Norway have agreed to enforce the same reduction. The regulation allows a number of flexibility mechanisms to ensure cost-effectiveness. In particular, emissions allocations can be traded between member countries as well as Norway and Iceland. Within the EU ESR sector, buildings and road transport accounted for 37.8 and 20.1% of emissions under ESR in 2019. Agriculture accounts for a very small share of carbon emissions but a large share of other greenhouse gases, i.e., methane and nitric oxide. Measured by the carbon equivalent, agriculture was responsible for 10.6% of total emissions in the EU. Of these emissions, only 2.5% were in the form of $CO_2$.
- **Regulation of emissions from Land Use, Land-Use Change, and Forestry (LULUCF)**. Land use and forestry are both carbon emitters and absorbers. The land use and forestry sector in the EU, as a whole, absorbs more carbon than it releases into the atmosphere, meaning that it is a net carbon sink. The net uptake was 249.1 million tons of $CO_2e$ (carbon dioxide equivalents) in 2019. The net uptake varies considerably across countries. Among the Nordic countries, Sweden has a large net uptake, around 40 million tons per year (41.6 $MtCO_2e$ in 2021, which was almost as large as the total emissions of 47,9 $MtCO_2e$), while Denmark is a net emitter. The current EU regulation requires that the net uptake is positive in each country.

In addition, prior to Fit for 55, there were other goals, regulations and directives in specific areas. The average emission intensity of cars and vans measured in $CO_2$/km is capped for each manufacturer. Currently, the cap is 95 grams $CO_2$/km for cars and 147 grams for vans. Directives also existed to encourage the expansion of renewable energy, the increased energy efficiency of buildings and the taxation of energy products and electricity.

# EU ETS

Fit for 55 includes a comprehensive set of changes to emissions trading that should result in an overall emission reduction of 55% by 2030 compared to 1990.[2]

Within the EU ETS, the number of emission allowances allocated to the market each year will fall faster. The yearly reduction will increase from 43 to 84 million tons between 2024 and 2027, and to 86 million thereafter. If this reduction continues, no allowances will be allocated after 2040.

In addition, emissions from maritime transport will be included in the ETS, and the free allocation of emission allowances to intra-EU aviation and industries that are major carbon emitters will be gradually phased out as the carbon border adjustment mechanism (see below) is phased in. The EU participates in CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation), a global scheme for offsetting carbon emissions from international aviation. EU operators will offset emissions from their operations outside the union.

# Carbon border adjustment mechanism (CBAM)

The new carbon border adjustment mechanism seeks to prevent emission reductions in the EU being offset by increased emissions outside the Union either by the relocation of production from EU to non-EU countries or by increased imports of carbon-intensive products ('carbon leakage'). Exporters to the EU will have to buy CBAM certificates at a price equal to the price of ETS allowances in the same product category to ensure a level playing field between the EU and their non-EU competitors. Initially, CBAM applies to producers of iron and steel, aluminium, fertilisers, cement, hydrogen and electricity and includes some up- and downstream activities.

The creation of CBAM will facilitate the phasing out of the current free allowances system to major carbon emitters to prevent carbon leakage. Free allowances will be gradually phased out as the CBAM certificates are phased in.

2. For a more detailed account, see European Council and Council of the European Union. (n.d.).

## Non-ETS sectors

Fit for 55 sets more ambitious national targets for the sectors covered by the ESR – agriculture, the operation of buildings, small industrial installations, road transport and waste management. For 2030, the required reductions will be 50% relative to 2005 emissions for Denmark, Finland and Sweden.

A new, separate emissions trading system for road transport, the operation of buildings and the use of other fuels will also come into operation in 2026. The number of allowances allocated every year will fall linearly. If the agreed reduction factor is maintained, no new emission allowances will be allocated after 2044. In total, the new and the old system cover almost all carbon emissions (however, they only account for a small share of other greenhouse gas emissions such as methane and nitric oxide).

In addition to more ambitious national targets for road transport and its inclusion in a new emission trading system. Fit for 55 also sets more ambitious targets when it comes to carbon emissions from new cars and vans. From 2035 onwards, all new cars and vans must be emission-free in the EU.

## Land Use, Land-Use Change and Forestry (LULCF)

As part of Fit for 55, there is a provisional agreement to increase the net absorption from LULUCF from 249.1 to 310 $MtCO_2$ by 2030. Member states will be assigned national targets depending on the extent of their landmass and forests. These targets vary greatly across countries. For Sweden and Finland, the targets for 2030 are an uptake of 47.3 and 17.8 $MtCO_2e$, respectively, while Denmark is allowed to have a net release of 5.3 $MtCO_2e$.

## Fit for 55 and EU emissions

The Fit for 55 package puts a strict cap on almost all future EU carbon emissions. If the proposed rate at which the number of allowances allocated within EU ETS is maintained, no new allowances will be awarded after 2039. Until then, 16 billion new allowances, each corresponding to one ton of emissions, will enter the market. Similarly, in the new emission trading system for buildings and transport, approximately 11 billion emission allowances will be sold. Since the systems cover almost all carbon emissions, these will be capped at 27 billion tons. This corresponds to 60 tons per current EU citizen. To put this number in perspective, the Intergovernmental Panel on Climate Change (IPCC) carbon budget to ensure global warming stays below 1.5 degrees is 420 billion tons, corresponding to 52 tons per global citizen. The carbon budget for 2-degree warming is 1,150 billion tons, corresponding to 144 tons per citizen. Although emissions in the EU will be somewhat higher than 60 tons per citizen, since the new emission trading system will not be in place until 2026, it is clear that the Fit for 55 package represents an ambitious step forward.

## National vs EU climate policies

The Nordic countries' emission abatement targets are more ambitious than those currently set by the EU. Denmark's target for 2030 is 70% compared to 1990, Finland's target is climate neutrality by 2035 and net negative by 2040 (forests account for more than 75% of Finland's landmass), Norway's target is 55% by 2030, and Sweden's target for the non-ETS sector is 63% by 2030 relative to 1990 – and overall climate neutrality by 2045. With Fit for 55, the gap is closing considerably and, in some areas disappearing altogether. The deal includes some regulatory policies that differ from national tools. The Nordic countries also have sector targets that can appear redundant or at odds with EU policies. Here are some examples of how Nordic climate policies can or may be affected by Fit for 55.

The common view (shared by Rolf Golombek and Michael Hoel, see below) is that a more ambitious abatement in the ETS sector in one country allows room for higher emissions in another EU state since the number of allowances remains unchanged and therefore leaves the total emissions unaffected. In other words, a more ambitious national target gives rise to carbon leakage to the rest of the EU, even if this is not necessarily inconsistent with overall EU policy. Contrary to the more common view, Frederik Silbye and Peter Birch Sørensen argue in their paper that Denmark's more ambitious national policy for the ETS sector actually affects the EU cap on emissions and makes it more restrictive.

Matti Liski and Iivo Vehviläinen take the more ambitious Finnish climate policies in three sectors as a given and demonstrate how these could be made consistent with EU policies and remain cost-effective. In the road transport sector, they show that a national emission trading system can exist in parallel with an EU-wide system, making reaching more ambitious national targets possible while simultaneously achieving cost efficiency. In the building and construction sector, they argue that a more ambitious national target can be reached by creating an emissions trading system for the actual construction element, which is not covered by the new emissions trading system for the heating of buildings.

Norway has a substantial set of climate policies, including general as well as sector- and even city-specific measures (Oslo). Rolf Golombek and Michael Hoel argue that Norway does not need targets and policies for some sectors already covered by the EU ETS because of the reason mentioned above: The total amount of emissions in the EU is fixed, so these policies become ineffectual in reducing emissions under the cap. In the non-ETS sector, they argue that the Norwegian tax exemption for electric cars will become redundant when the EU creates an emissions trading system for the road transport sector and mandates that cars and vans must be emission-free by 2035.

David von Below, Björn Carlén, Svante Mandel and Vincent Otto use a detailed general equilibrium model of the Swedish economy to analyse the costs of self-imposed Swedish climate policies. These include a stricter emission target for the ESR sector, a special target for emissions from the transportation sector and restrictions on purchasing ESR allocations from other countries under the flexibility mechanism. The latter is particularly expensive and implies a cost in the order of 1% of national income. If ESR allocations are not used, different combinations of increased carbon taxes and forced biofuel blending in petrol and gas are analysed. To reach the national targets, Swedish carbon taxes need to be increased to between €700 and €1,700 per ton of $CO_2$, corresponding to approximately 7 to 17 times the current price.

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Nordic Economic Policy Review 2023

# National Climate Targets Under Ambitious EU Climate Policy

**Frederik Silbye and Peter Birch Sørensen**

## Abstract

We analyse the extent to which the climate effect of unilateral climate policy in Nordic frontrunner countries may be nullified by the mechanics of the European Emission Trading System (ETS) in light of the recent tightening of the system. We find that national initiatives to reduce emissions from the domestic ETS sector are likely to reduce total EU-wide emissions due to the endogeneity of the cap on ETS emission allowances. We also examine the cost-effective design of the unilateral climate policy of an EU frontrunner country, given the design of EU climate policy. Finally, we show that if the policy goal is to maximise national welfare, a uniform domestic carbon price across sectors is only optimal under special circumstances, and we highlight the importance of trade in emission rights and carbon leakage for optimal policy design.

**Keywords:** EU climate policy, Optimal unilateral climate policy, European Emissions Trading System

**JELcodes:** Q48, Q52, Q58.

# 1. Introduction

Despite the recent increase in the level of ambition of EU climate policy reflected in the commitment to reduce EU greenhouse gas emissions by 55% by 2030 relative to 1990, the Nordic members of the EU have adopted national targets for emission cuts that go even further. For example, the Danish Climate Act of 2020 obliges the government and Parliament to secure a 70% cut in total domestic emissions by 2030 and to aim at national climate neutrality no later than 2050. Finland aims at a 60% reduction of domestic emissions by 2030 and strives to achieve climate neutrality by 2035, in part through carbon sequestration in the large Finnish forests, and Sweden targets a 63% cut in emissions by 2030 and net zero emissions no later than 2045.

Small countries like those in the Nordic Region only account for a tiny fraction of global greenhouse gas emissions, so why should these countries set targets for emission cuts that go beyond their obligations towards the EU, despite their negligible direct impact on the global climate? This question has previously been thoroughly discussed in an article by Greaker et al. (2019) in this journal. One normative argument for an ambitious unilateral climate policy is inspired by the philosopher Immanuel Kant (1785/1993), who argued that moral actors should act in the same way as they would like others to act. Since it is generally agreed that worldwide, countries are not doing enough to stop global warming, and since all countries would presumably like to avoid catastrophic climate change, a Kantian approach would morally oblige each individual country to increase its effort at greenhouse gas abatement, even if others do not immediately follow suit.

A more common justification for an ambitious unilateral climate policy is that a frontrunner country may inspire other countries to pursue more ambitious policies by demonstrating that abatement costs are lower than previously expected or by developing new green technologies that help other countries reduce their abatement costs. To the extent that reciprocity mechanisms are at work in international negotiations on climate policy, frontrunner countries may also be able to exert stronger pressure for a tightening of emission reduction targets in other countries.[3]

In this paper, we take as a given that the Nordic EU member states wish to move faster towards climate neutrality than the rest of the EU. We then discuss two

3. Unfortunately, there is also a possibility that some countries will find it less urgent to cut their emissions if other countries are doing the job for them by adopting more ambitious targets for emission cuts. However, such a free-rider approach seems unlikely to emerge if the frontrunner countries are small and only have a tiny direct impact on the global climate.

major issues. First, to what extent will the direct climate effect of unilateral climate policy in a small Nordic country be nullified by the mechanics of the European Emission Trading System (ETS), given the new and tighter rules for the system recently agreed within the EU? Second, what is the cost-effective design of the unilateral climate policy of an EU frontrunner country, given the design of EU climate policy?

The first of these issues is analysed in Section 2 of the paper, and the second issue is addressed in Section 3. Section 4 contains our concluding remarks.

# 2. Is national climate policy in the ETS sector fruitless?

Nowhere is the potential conflict between European and national climate policy as evident as in the sector covered by the European Emissions Trading System (ETS), i.e. heavy industry, power plants and intra-EU aviation, which accounts for around 40% of total EU emissions. Here, the EU controls emissions by issuing new allowances. The ETS is a cap-and-trade-system, and in the textbook version of such a system, the cap is exogenous and fixed (Stavins, 2019). In the EU, a fixed total cap on ETS allowances would mean that any action taken by an individual member state to reduce emissions from the domestic ETS sector would release a corresponding amount of ETS allowances for use in other EU countries. Hence domestic emissions would simply 'leak' to other parts of the EU, and the leakage rate – defined as the increase in foreign emissions divided by the cut in domestic emissions – would be 100%, as the total EU emissions would remain the same.

In the following, we will question the premise of a fixed cap on total ETS emissions. Two arguments support the notion that the cap, to some extent, is endogenous and that it can be affected by the actions of individual member states. First, we explore the role of the Market Stability Reserve in the ETS, which has the power to cancel allowances. Second, we discuss the cap as the result of political negotiations and how the outcome of these negotiations can be influenced by national climate policies.

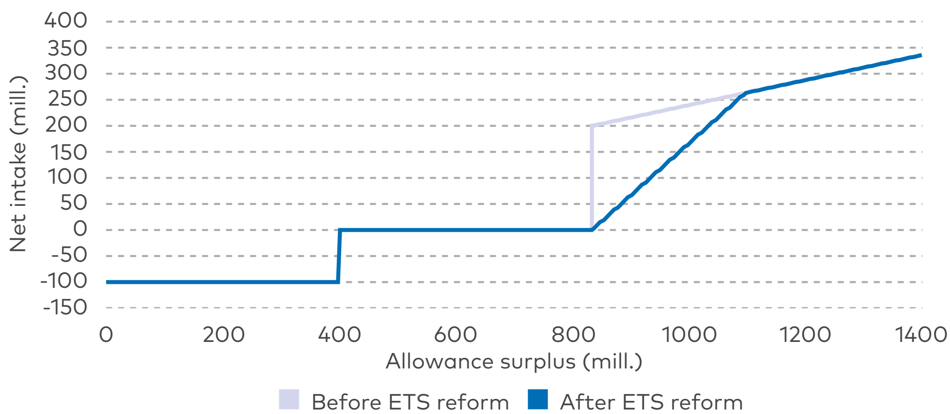
## 2.1 Reducing the ETS cap through the Market Stability Reserve

As noted, the textbook version of a cap-and-trade system has a fixed cap. However, ETS has moved beyond the simple world of the textbook by introducing the Market Stability Reserve (MSR). The reserve absorbs emission allowances when the allowance surplus in the market is large, and it releases allowances back to the market when the surplus is small. The critical element here is that the size of the MSR is limited. If the number of allowances in the MSR exceeds an upper limit, the exceeding allowances are permanently cancelled. Hence, it is no longer certain that the issue of an additional allowance will lead to the emission of an additional ton of $CO_2e$ at some future point in time. The consequence is that the ETS cap has become endogenous, and individual countries may attempt to reduce overall emissions in the system by adding to the allowance surplus. For instance, a national policy initiative that reduces emissions will release allowances that add to the surplus, and some of these allowances will enter the MSR. If the upper limit on the MSR is binding, the allowances are permanently cancelled. The bottom line is that individual nations may affect EU-level emissions, and this reduces carbon leakage below 100%. This effect is thoroughly described in the literature (Perino, 2018, Silbye & Sørensen, 2019, Beck & Kruse-Andersen, 2020).

Will the ETS reform agreed in December 2022 change the mechanics of the system? Following this reform, fewer new allowances will be issued, and this may lead to a lower market surplus and, hence, less endogeneity of supply. Two questions are relevant for policy makers: (i) What is the magnitude of the endogeneity through the MSR, and (ii) in which time period is the endogeneity active? Before addressing these two questions, gaining a better understanding of the mechanisms of the MSR will be instructive.

When the total allowance surplus in the ETS exceeds 833 million tonnes of $CO_2$, 24% of the surplus is placed in the reserve. However, if the surplus is between 833 and 1096 million, the intake is the difference between the surplus and the 833 million, and this effectively raises the marginal intake rate to 100%. This is an important new amendment to the intake rule, introduced to avoid threshold effects. The surplus is calculated by the end of each calendar year, and allowances are then placed in the MSR over a period of 12 months starting from 1 September the following year. When the surplus falls below 400 million, an amount of 100 million allowances is released to the market. Figure 1 illustrates the net intake rule.

**Figure 1.** Net intake rule of the Market Stability Reserve



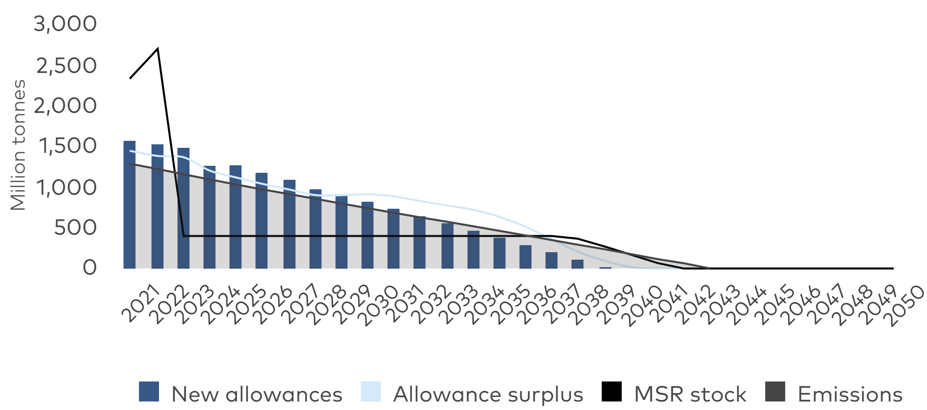

The recent ETS reform will also affect the maximum size of the MSR stock. Before the reform, the stock could not exceed the total volume of allowances auctioned during the previous year. However, the reform changes the upper bound of the MSR stock to a fixed limit of 400 million. As previously mentioned, allowances in excess of the MSR cap are cancelled.

To answer the two questions (i) and (ii) above, it is crucial to know if and when the allowance surplus is larger than 833 million and if and when the MSR stock hits its ceiling. In order for a national climate effort to have a long-term ETS leakage rate significantly below 100%, there must be several years where the surplus is large such that there is time for the released allowances to be soaked up by the MSR or at least one year with a surplus between 833 and 1096 million yielding a 100% intake rate. In these years, the MSR limit must also be binding, such that the marginal allowance in the reserve is cancelled.

We have used the forecasting model presented in this journal by Silbye and Sørensen (2019) to predict the evolution of the ETS implied by the reform of the system agreed in December 2022. The details of the model are documented in the Appendix to Silbye and Sørensen (2019, pp. 98–101). The model assumes that companies covered by the ETS minimise their total costs, including the costs of ETS allowances. In any given year, this leads to a downward-sloping demand curve for allowances. Over time, the demand curve shifts down due to increases in energy efficiency, the development of new green technologies and changes in the structure of the economy. If the expected supply of allowances exceeds the expected demand over the lifetime of the ETS, the allowance price falls to a level that eliminates the excess supply and ensures that the expected future price increase generates a rate of return on investment in allowances equal to the rate of return required by investors. The model is calibrated such that it reproduces the average allowance surplus and the average allowance price in 2021.

The model's prediction is depicted in Figure 2. We see that the allowance surplus exceeds 833 million until 2031. The size of the MSR is initially large, but it drops to 400 million in 2023 when the limit is enforced. This upper limit is binding until the end of the 2030s, and therefore all additions to the stock of allowances in the MSR from 2023 until the late 2030s will be cancelled.

**Figure 2.** Simulation of the ETS under the proposed Fit for 55 rules




Now consider a national climate effort that reduces emissions by one tonne of $CO_2$ in a specific year. This increases the allowance surplus and triggers an increased intake to the MSR. The exact intake depends on various factors, e.g. whether the marginal intake rate is 24% or 100%. Our model takes all the mechanics of the MSR into account, and the leakage rates for marginal emission reductions in various years are presented in Table 1.

**Table 1.** Carbon leakage rates through the ETS for marginal emission reductions

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 and beyond |
|---|---|---|---|---|---|---|---|---|---|---|
| Leakage rate | 0.05 | 0.08 | 0.12 | 0.23 | 0.53 | 0.19 | -0.56 | -0.78 | 0.00 | 1.00 |

Note: The leakage rate is defined as the difference between the initial emission reduction due to the national effort and the total reduction in the ETS over time, divided by the initial reduction. Hence, if there is no effect on total ETS emissions, the leakage rate is 1. If the total reduction equals the initial reduction, leakage is zero.

As long as the intake to MSR is active, a key finding in Table 1 is that leakage rates are very volatile and depend on the finer rules of the ETS. This complicates clear policy guidance. As a general rule, we can conclude that leakage rates will probably be low or medium-sized until the early 2030s. After that time, leakage will most likely be 100%.

The leakage rate may even become negative. The reason for this surprising result is the following: The allowance surplus around 2030 is between 833 and 1096 million, which implies a 100% MSR intake rate. As an example, consider an increase of the surplus by 120 allowances in year *t*. This will lead to 120 allowances being placed in the MSR starting from 1 September in year *t*+1, 10 each month. Therefore, the surplus is still 80·(120 - 4·10) higher by the end of year *t*+1, and this triggers an intake of 80 allowances to the MSR starting in year *t*+2. In that way, the total MSR intake exceeds the initial 120 additional allowances, leading to negative leakage rates. The reason for this lies in a combination of a 100% MSR intake rate and the delay between the calculation of the surplus and uptake to the MSR.

It should be noted that Table 1 considers one-year reductions. Most projects have a longer duration, e.g. a wind turbine park. When evaluating such a project, we need to consider an average leakage rate. For instance, a project that reduces emissions uniformly over 15 years from 2025 to 2039 has a leakage rate of 73%, according to our model of the ETS.

The results in Table 1 assume that emission reductions are not pre-announced. That is, the market cannot react beforehand to the upcoming reduction of the allowance demand. However, if the reduction is announced several years in advance, the allowance price will drop immediately, causing emissions to increase. This reduces the allowance surplus, which then dampens the cancellation effect in the MSR. As a consequence, pre-announcement tends to increase leakage rates, and rates may even surpass 100% for projects that will come into effect much further in the future but which have been credibly announced today (Gerlagh et al., 2021). If, for instance, a project is announced in 2025 with effect in 2035, the leakage rate is no longer 100%, as in Table 1. Instead, it increases to 142%. This shows that the timing issue also relates to the delay between announcement and effect.

To recap, three insights are worth emphasising. First, the MSR is basically a graveyard for allowances, at least on the margin. Additional allowances that enter the reserve will never be released again when the cap on the size of the MSR is binding. Second, the key date to focus on is when the intake to the MSR ceases. According to our simulations, 2031 is the last year where the allowance surplus exceeds the 833 million threshold. From 2032 and onwards, the ETS can be regarded as a textbook cap-and-trade system with 100% leakage. Third, leakage rates before 2032 are below 100%, but their magnitudes depend on the finer details of the ETS rules and are difficult to predict with high accuracy. Even negative leakage rates are possible.

## 2.2 Political endogeneity of the ETS cap

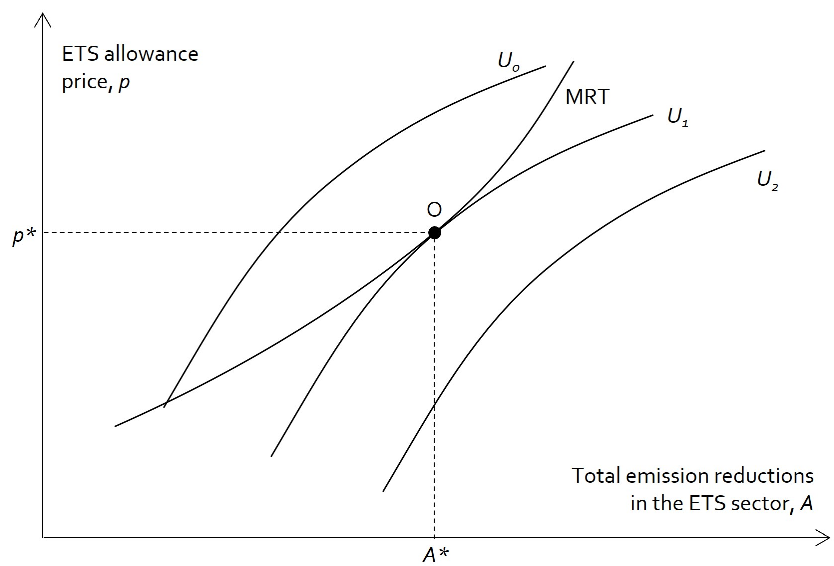
Often the rules and the cap of the ETS are taken as a given when analysing the effect of national climate policy. However, the ETS is not set in stone for the rest of its lifetime. In principle, the cap is currently fixed until 2030, but it has been tightened several times in the past, and its development beyond 2030 will depend on future political negotiations.

If this political endogeneity is taken into account, national policy may have an impact on the cap. The political negotiations can be seen as a trade-off between ambitious climate action and low abatement costs. If a national effort can shift the balance of this trade-off, the EU as a whole might be willing to accept a higher climate target and a tighter ETS cap. A member state that significantly reduces emissions enlarges the allowance surplus in the ETS, and this surplus is carried over to subsequent years. By adjusting the cap, the EU can effectively decide what to do with these extra allowances. When the allowance price falls, thereby reducing abatement efforts and the ensuing marginal abatement costs, the optimal choice will be to give higher priority to emission reductions, resulting in a lower cap.

This mechanism is illustrated in Figure 3, in which the *MRT* (marginal rate of transformation) curve indicates the ETS allowance price $p$ needed to ensure a given amount $A$ of total emission reductions in the ETS sector for the EU as a whole. The *MRT* curve is upward-sloping since it takes a higher allowance price to induce a larger volume of emission abatement. Moreover, the slope of the *MRT* curve is increasing, reflecting increasing marginal abatement costs: As the level of abatement increases and the cheaper abatement options are exhausted, it requires a larger increase in the allowance price to reduce emissions by one more tonne.

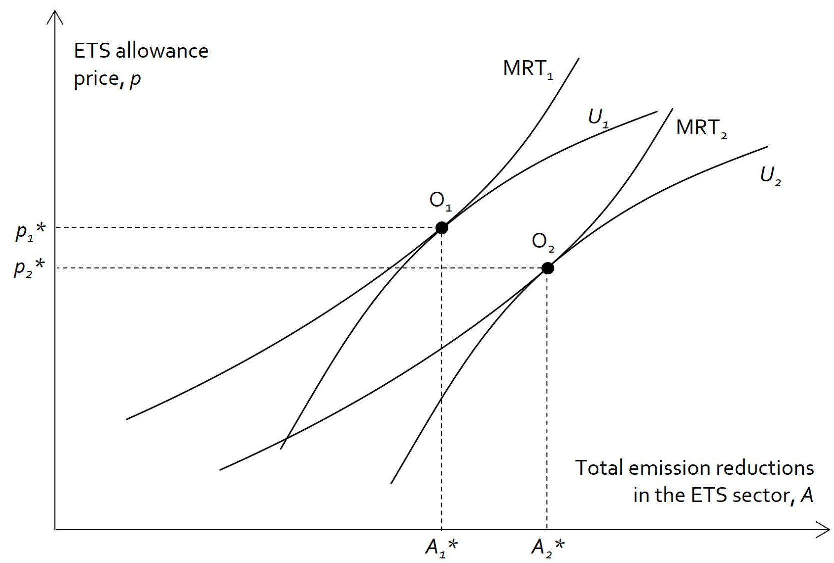
Figure 3 also includes three 'indifference curves' for EU policy makers, each labelled by a $U$. These indifference curves describe the preferences of policy makers, and each curve corresponds to a given level of policy maker 'utility' or policy maker popularity. *Ceteris paribus*, policy makers become more popular if they can ensure a larger volume of abatement, but they become less popular if the ETS allowance price goes up, since a higher allowance price translates into higher energy prices for households and companies. To maintain a given level of policy maker popularity, a higher allowance price must therefore be accompanied by a higher level of abatement. Hence, the indifference curves are upward-sloping, but the slope decreases as the allowance price goes up, since the marginal welfare loss for energy consumers increases as energy prices increase. An indifference curve located further to the right represents a higher level of utility, since policy makers prefer a higher level of abatement for any given level of the allowance price (and a lower allowance price for any given abatement level). To maximise their utility (popularity), EU policy makers will adjust the ETS allowance supply (and hence the allowance price) so as to realise the point *O* on the *MRT* curve where they cannot attain a higher utility, given that the combination of *A* and *p* must be located somewhere on the *MRT* curve. At this optimum point, the slope of the indifference curve equals the slope of the *MRT* curve.

**Figure 3.** Political endogeneity of the cap on emission allowance




Now suppose that an EU frontrunner country decides to introduce a national carbon tax on top of the ETS allowance price. As the carbon tax induces the country's emitters to increase their abatement efforts, the *MRT* curve will shift to the right, since any given allowance price will now be associated with a larger total level of abatement in the EU. As a consequence, the EU's political economy equilibrium will shift from point $O_1$ to point $O_2$ in Figure 4, where total abatement in the EU as a whole has increased despite the fall in the allowance price. In Figure 4, we see that the distance from point $A_1^*$ to point $A_2^*$ is shorter than the rightward horizontal shift of the *MRT* curve measuring the increase in abatement in the frontrunner country. Therefore, there will be some leakage of emissions from the frontrunner country to the rest of the EU, but the leakage rate will be less than 100%. Appendix A specifies a set of plausible technical conditions which will be sufficient to ensure this result.

**Figure 4.** Effect of an increase in abatement effort in a single EU member state on the political economy equilibrium of the ETS




The mechanism underlying the increase in total abatement is the following: The rise in carbon taxation in the frontrunner country increases abatement in that country, thereby releasing some ETS allowances which are offered for sale in the allowance market. If the total allowance supply were kept constant, the allowance price would then have to drop to a level that would generate a fall in abatement in the rest of the EU corresponding to the increase in abatement in the frontrunner country (100% leakage). However, since the allowance price has now fallen without generating an increase in total emissions, the trade-off between the desire for a low allowance price and the desire for a strong abatement effort becomes more favourable for EU policy makers. They prefer, therefore, to realise a part of the resulting utility gain in the form of a larger abatement effort and only part of the gain in the form of a lower allowance price. To achieve a fall in total emissions (i.e., an increase in total abatement), EU policy makers must thus decide to cut the total supply of emission allowances.

The graphical analysis above ignores the existence of the Market Stability Reserve. However, the effect of a reserve is easily understood. Its main effect is the automatic cancellation of allowances, but since the EU controls emissions, it can adjust the cap in the light of any MSR cancellations. This leads to two conclusions. First, the MSR does not alter our argument regarding the political endogeneity of the ETS cap, and even though the current ETS rules appear to imply a 100% leakage rate from unilateral national climate policy after 2031, the actual leakage rate is likely to become lower due to the political economy mechanisms described above. Second, the possibility of reducing the ETS cap through the MSR vanishes when we add political endogeneity. Or put differently, both types of endogeneity cannot exist to their full extent at the same time.

# 3. Cost-effective national climate policy in an EU frontrunner country

We now turn to the second major issue addressed in this paper: What is the optimal unilateral climate policy in an EU frontrunner country? We consider a country which has committed itself to a target for the reduction of total domestic emissions that goes beyond its EU obligations, as Denmark, Finland and Sweden have done, and we assume that this country imposes a carbon tax on all domestic emissions of $CO_2$e as the main policy instrument to meet its target. In the EU, the Effort Sharing Regulation (ESR) sets national targets for emission reductions from road transport, heating of buildings, agriculture, small industrial installations and waste management. There are also national targets for net greenhouse gas removals in the land use, land use change and forestry (LULUCF) sector, but since emission rights can be transferred between the ESR and LULUCF sectors (with some restrictions), we will treat these as one consolidated sector denoted the 'non-ETS sector'.

The 'carbon price' is the cost to companies and households of emitting an extra tonne of $CO_2$e. In the non-ETS sector, the carbon price is simply the domestic carbon tax rate. In the ETS sector, the carbon price is the sum of the domestic carbon tax rate and the price of ETS allowances if no credit for the allowance price is granted against the domestic carbon tax. The key policy question is whether or not the domestic carbon price should be the same across the ETS and the non-ETS sector, i.e., whether companies in the ETS sector should receive a 100% credit for the ETS allowance price against the (uniform) domestic carbon tax rate. The conventional answer to this question is "Yes", since it is believed that a uniform carbon price throughout the economy ensures that the target for domestic emission reduction is met in a cost-effective way. The reason for this is that cost-minimising companies and households will abate their emissions up to the point where their marginal abatement cost equals the carbon price, so through a uniform carbon price, all emitters will end up with the same marginal abatement cost, thereby ensuring that the total abatement cost in the economy as a whole is minimised.

However, in the following, we will show that a uniform domestic carbon price is generally *suboptimal* in an EU frontrunner country wishing to minimise the total national cost of meeting the target for domestic emission reduction. As will be revealed, the basic reason for this is that emission rights in the ETS sector and in the non-ETS sector can be traded between the domestic country and the rest of the EU, but not necessarily at the same price across the two sectors. Furthermore, the domestic government may worry about carbon leakage, and if the leakage rates differ between the ETS sector and the non-ETS sector – as they probably do, this gives further grounds for differentiating the total carbon price across the two sectors. We illustrate these points graphically below, inspired by the work of Kruse-Andersen and Sørensen (2022b)[4] and building on the formal analysis in Appendix B

## 3.1 The cost-effective national climate policy when emission rights for the non-ETS sector are not traded

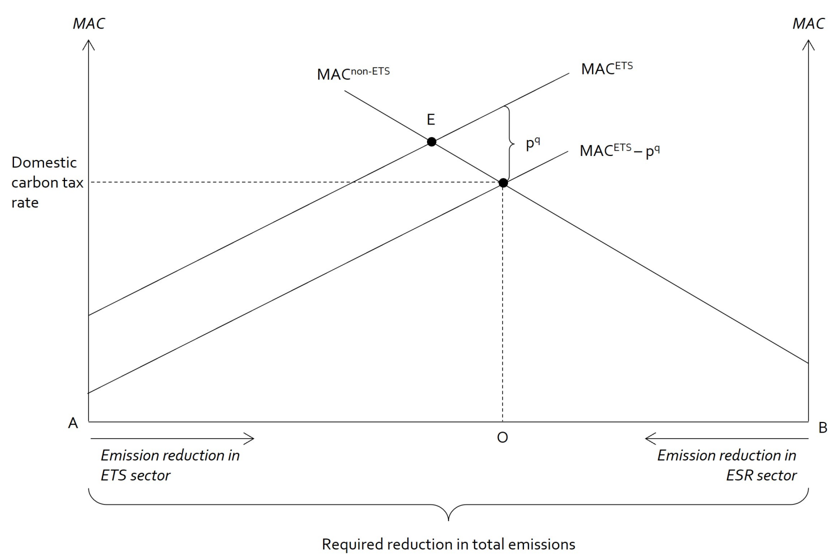
Although there is no private market for international trade in emission rights in the non-ETS sector, the EU does allow national governments to engage in bilateral trade in such emission rights (within certain limits). Thus, the government of an EU country may meet part of its obligation to cut emissions from the non-ETS sector by purchasing emission rights allocated to another EU government. For the moment, we will assume that the ambitious EU country does not plan to exploit the opportunity for trade in non-ETS emission rights and that its target for domestic emission reduction is sufficiently strict to ensure that the country's obligations under the EU Effort Sharing Regulation do not become a binding constraint on domestic climate policy. We also assume, for a start, that the country's government is not concerned about carbon leakage.

We can illustrate the country's cost-effective climate policy by means of Figure 5. The distance from *A* to *B* along the horizontal axis measures the government's target for the reduction of total domestic emissions from today until, say, 2030, measured in tonnes of $CO_2$e. The size of the cut in emissions from the domestic ETS sector is measured from left to right on the horizontal axis, while the reduction of emissions from the non-ETS sector is measured from right to left. The vertical axes measure the marginal costs of abating emissions from the two sectors, and the graphs denoted $MAC^{ETS}$ and $MAC^{Non\text{-}ETS}$ indicate the marginal abatement costs in the ETS and the non-ETS sector, respectively. Since cost-minimising companies and households will exploit the cheaper options for emission reduction before transitioning to the more expensive options, the marginal abatement costs are higher the larger the cut in emissions. For simplicity, we assume that the marginal abatement cost curves are linear. In practice, they are likely to be convex towards the origin, but this will not invalidate the qualitative conclusions from our analysis.

4. Kruse-Andersen and Sørensen (2022b) only account for trade in ETS allowances. Here, we extend their analysis by allowing for trade in emission rights for the non-ETS sector (in Figures 6 and 7).

According to conventional wisdom, a cost-effective national climate policy requires that the total carbon price be equalised across the ETS and the non-ETS sector. Cost-minimising agents will then reduce their emissions up to the point where their marginal abatement costs equal the common carbon price so that the economy's overall abatement costs are minimised. In Figure 5, this situation is attained at point *E* which would thus seem to represent the optimal allocation of emission cuts between the ETS and the non-ETS sector. However, this analysis neglects that for each tonne of emission reduction in the ETS sector, the companies in that sector save a cost equal to the price of an ETS emission allowance, denoted by $p^q$ in Figure 5. When a domestic ETS sector company needs one less emission allowance, it can sell the allowance in the ETS market for allowances, thereby earning an amount $p^q$. Since this amount is a transfer from the rest of the EU economy to the domestic economy, it represents a corresponding reduction in the total domestic marginal social cost of cutting emissions from the domestic ETS sector.

**Figure 5.** Cost-effective allocation of abatement effort when emission rights for the non-ETS sector are not traded




Hence the *net* marginal social abatement cost in the ETS sector is given by the graph denoted $MAC^{ETS}$-$p^q$ in Figure 5. From a national viewpoint, a cost-effective allocation of emission cuts between the two sectors is attained when the net marginal social abatement cost in the ETS sector equals the marginal abatement cost in the non-ETS sector. In Figure 5, this optimum is realised when the allocation of emission reductions corresponds to point *O* on the horizontal axis. To implement this allocation, the domestic carbon tax rate must be set at a level corresponding to the marginal abatement cost in the non-ETS sector at point *O*. At that point, the *gross* marginal abatement cost $MAC^{ETS}$ in the ETS sector *exceeds* the marginal abatement cost in the non-ETS sector by the amount $p^q$ corresponding to the ETS allowance price, but since an individual ETS company, as well as the domestic economy as a whole, saves the expenditure $p^q$ for each tonne of emission cuts in the ETS sector, the *net* marginal abatement cost in that sector equals the marginal abatement cost in the non-ETS sector at the optimum point *O*.

In summary, when there is no trade in emission rights for the non-ETS sector and the government is not worried about carbon leakage, a nationally optimal allocation of emission cuts requires that companies in the ETS sector be granted no credit at all for the ETS allowance price against their domestic carbon tax bill: Under the optimal climate policy, the total carbon price in the ETS sector exceeds the carbon price in the non-ETS sector (the uniform domestic carbon tax rate) by an amount equal to the ETS allowance price. This is "Model 1" for a domestic carbon tax scheme proposed by the Danish government's Expert Group on Green Tax Reform (2022).

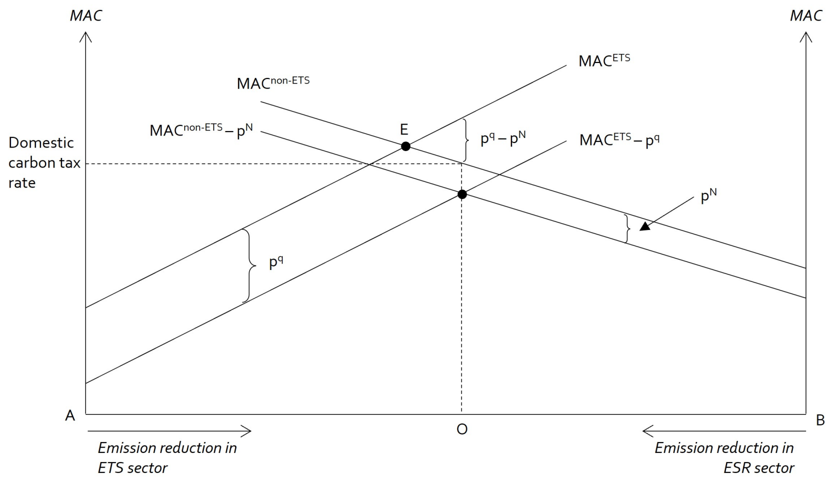
## 3.2 Allowing for trade in emission rights for the non-ETS sector

Matters become different if the domestic government adopts a more pragmatic version of the target for domestic emission reduction, allowing itself to purchase emission rights for the non-ETS sector from other EU governments if reducing domestic emissions to the extent required by the Effort Sharing Regulation proves overly expensive, and by selling non-ETS emission rights to other EU member states if the ESR is not a binding constraint on the planned domestic climate policy. This situation is depicted in Figure 6, which assumes that emission rights for the non-ETS sector can be purchased at the price $p^N$ per tonne of $CO_2$e. By an analogous reasoning to the one underlying Figure 5, the net marginal social abatement cost in the non-ETS sector is now given by the curve $MAC^{Non\text{-}ETS} - p^N$ in Figure 6, since the government (and domestic society) saves an expenditure equal to the price of foreign non-ETS emission rights for each tonne of domestic non-ETS emission reduction – money that would have had to be transferred to another EU government if the domestic emission reduction had not been undertaken.[5]

The optimal allocation of emission cuts between the ETS and the non-ETS sector is now given by the point of intersection of the two curves $MAC^{ETS} - p^q$ and $MAC^{Non\text{-}ETS} - p^N$ where the net marginal social abatement costs are equalised across sectors. To implement this allocation *O*, the domestic carbon tax rate must be set at the level indicated on the left vertical axis in Figure 6.

5. The net marginal social abatement cost in the non-ETS sector would still be given by the curve $MAC^{Non\text{-}ETS} - p^N$ in Figure 6 if the domestic government had a surplus of non-ETS emission rights it could sell abroad, since an extra tonne of domestic non-ETS emission reduction would then enable the government to sell one more unit of emission rights to a foreign government, thereby generating an extra transfer $p^N$ to the domestic economy.

**Figure 6.** Cost-effective allocation of abatement effort when emission rights for the non-ETS sector are traded



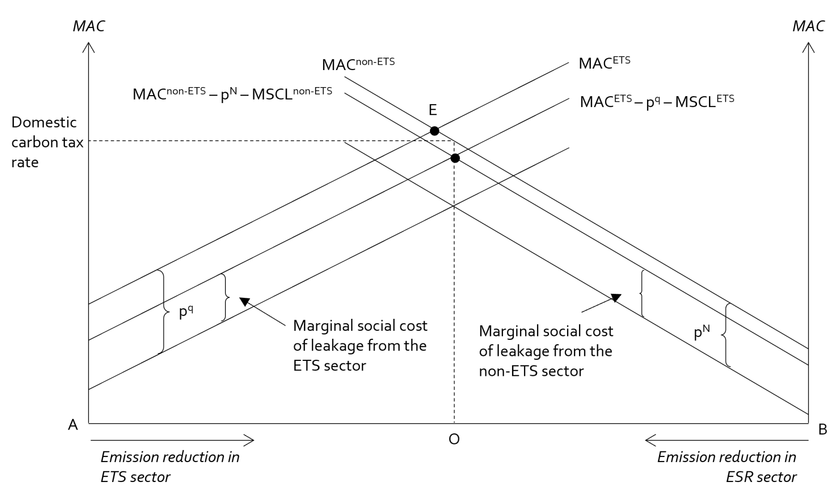

Note that since emission rights for the non-ETS sector are not traded privately but only among governments, cost-minimising non-ETS emitters will abate up to the point where their private marginal abatement cost $MAC^{Non\text{-}ETS}$ equals the domestic carbon tax rate. When the carbon tax rate is set at the level illustrated in Figure 6, emitters in the non-ETS sector are therefore induced to undertake the optimal amount of abatement *BO*. In this optimum, the gross marginal abatement costs in the two sectors ($MAC^{ETS}$and $MAC^{Non\text{-}ETS}$) are seen to differ by an amount equal to the difference between the ETS allowance price and the price of non-ETS emission rights. In Figure 6, we assume that the former price is higher than the latter. We see that now the total carbon price in the ETS sector should only exceed the domestic carbon tax rate by the amount $p^q$ - $p^N$. This means that domestic ETS companies should receive a partial credit for the ETS allowance price equal to the amount $p^N$ per tonne of $CO_2$e against their domestic carbon tax bill to ensure a total carbon price for ETS companies equal to the carbon tax rate + $p^q$ - $p^N$ consistent with the optimal allocation *O* in Figure 6.

If the price of non-ETS emission rights were to exceed the ETS allowance price, the optimal allocation of emission cuts would lie to the left of point *E* in Figure 6 rather than to the right of this point. In the interesting special case where the price of emission rights is the same across sectors ($p^q = p^N$), it is clear from Figure 6 that the optimal allocation would be at point *E*, consistent with the conventional recommendation that gross marginal abatement costs be equalised across sectors, since in this particular case the net marginal social abatement costs would also be equalised. In this case, ETS companies should receive a full credit for the allowance price against the domestic carbon tax. However, since the markets for ETS and non-ETS emission rights are not integrated in the EU, the prices of the two types of emission rights would only align by pure coincidence.

## 3.3 Optimal climate policy when carbon leakage is socially costly

We have so far assumed that the domestic government is not concerned about carbon leakage. However, suppose that when emissions from the domestic ETS sector fall by 1 tonne of $CO_2$e, emissions from foreign countries increase by a tonnes (on average) via carbon leakage operating through the mechanics of the ETS described in Section 2. Suppose further that the domestic government worries about leakage (because it is concerned about the impact of domestic policy on the global climate) and therefore assigns a social cost *c* to a tonne of $CO_2$e emitted abroad. The marginal social cost of the leakage from the ETS sector ($MSCL^{ETS}$) generated by a 1 tonne cut in emissions from the sector is then equal to a • c, where a is the leakage rate. This leakage cost is part of the total net marginal social cost of abatement in the ETS sector, which now becomes $MAC^{ETS} - p^q + MSCL^{ETS}$, as illustrated in Figure 7 where we assume that $MSCL^{ETS} < p^q$ (which is not, however, important for our qualitative reasoning). Similarly, if the leakage rate in the non-ETS sector is *b*, the marginal social cost of leakage from that sector is $MSCL^{Non\text{-}ETS} = b \cdot c$, and the total net marginal social cost of abatement in the non-ETS sector is $MAC^{Non\text{-}ETS} - p^N + MSCL^{Non\text{-}ETS}$, as shown in Figure 7 where we also assume, specifically, that $MSCL^{Non\text{-}ETS} < p^N$.

**Figure 7.** Cost-effective allocation of abatement effort when emission rights are traded and carbon leakage is socially costly



The cost-effective domestic allocation of emission cuts is given at point *O* in Figure 7, where the curves for the net marginal social cost of abatement in the two sectors intersect. This allocation minimises the total social cost of meeting the target for domestic emission reduction, accounting for the social costs of carbon leakage as well as for trade in emission rights in both sectors. As the figure is drawn, the optimal allocation lies to the right of point *E*, implying that society should accept a higher gross marginal abatement cost in the ETS sector than in the non-ETS sector. This means that ETS companies should still only receive a partial credit for the ETS allowance price against the domestic carbon tax. More precisely, the tax credit should be equal to $p^N + MSCL^{ETS} - MSCL^{Non\text{-}ETS}$ per tonne of $CO_2$e emitted from the ETS sector to implement the optimal allocation *O* in Figure 7.[6] In other words, the larger the rate of carbon leakage (and consequently the higher the marginal social cost of leakage) in the ETS sector relative to the leakage rate in the non-ETS sector, the larger the optimal tax credit for (part of) the ETS allowance price becomes, which is intuitive.

With a different combination of allowance prices and marginal social leakage costs, the optimal allocation could lie to the left of point *E*, in which case ETS companies should be granted a credit greater than 100% for the ETS allowance price or, alternatively, should receive a 100% credit for the allowance price and pay a lower rate of carbon tax than emitters in the non-ETS sector.

Note that the leakage rate a in the ETS sector also measures the *fall* in foreign emissions generated by a one-tonne *increase* in the excess domestic demand for ETS allowances, i.e., $a$ measures the fall in foreign emissions that would materialise if the domestic government decided to purchase one ETS emission allowance and withdraw it from the market. Hence, the amount $MSCL^{ETS} = a \cdot c$ also measures the marginal social benefit from the government's purchase of an ETS allowance. If this marginal benefit exceeds the allowance price $p^q$, the government could generate a domestic welfare gain by purchasing ETS allowances until its marginal willingness to pay for foreign emission cuts (i.e., $c$) falls to a level where $a \cdot c$ becomes equal to the allowance price. On the other hand, if $MSCL^{ETS} = a \cdot c$ is initially lower than the allowance price, the government should sell emission allowances in the ETS market (so long as it holds such allowances allocated to it by the EU) until $MSCL^{ETS}$ and the allowance price are driven into line. Theoretically, it could thus be argued that a

6. To see this, note that a cost-minimising ETS emitter will abate up to the point where $MAC^{ETC} = \tau + p^q - \kappa$, where $\tau$ is the domestic carbon tax rate, and $\kappa$ is the carbon tax credit. Moreover, cost-minimising non-ETS emitters will abate until $MAC^{Non\text{-}ETC} = \tau$. Hence $MAC^{ETC} = MAC^{Non\text{-}ETC} + p^q - \kappa$. Therefore, if the tax credit is $\kappa = p^N + MSCL^{ETS} - MSCL^{Non\text{-}ETS}$, it follows that $MAC^{ETC} - p^q + MSCL^{ETS} = MAC^{Non\text{-}ETC} - p^N + MSCL^{Non\text{-}ETS}$ which is exactly the condition for an optimal allocation of abatement effort across the two sectors, so a tax credit of this magnitude would lead to the optimal allocation.

rational government should intervene in the ETS allowance market to ensure that $MSCL^{ETS} = p^q$. If a similar arbitrage behaviour in the non-ETS sector were to ensure that $MSCL^{Non\text{-}ETS} = p^N$, the optimal allocation of emission reductions would be given by point *E* in Figure 7, again validating the conventional recommendation that gross marginal abatement costs be equalised across sectors. Once more, this would require a 100% credit for the ETS allowance price against the domestic carbon tax bill of ETS companies.

In practice, governments rarely behave in such a rational manner, and even if they tried to do so, the lack of an integrated and liquid market for emission rights in the non-ETS sector would probably prevent an equalisation of the marginal social cost of leakage and the emission allowance price in that sector.

Realistically, we would, therefore, expect the cost-effective allocation of emission reductions to deviate from point *E* in Figure 7. This, in turn, implies that the optimal domestic carbon tax credit for the ETS allowance price will deviate from 100%, i.e., that the optimal total carbon prices in the ETS sector and the non-ETS sector will differ from each other.

## 3.4 Optimal unilateral climate policy in an EU frontrunner country: Summary

The analysis in this section can be summarised as follows: The marginal social cost of abatement in an economic sector includes the technical marginal abatement cost plus the marginal social cost of carbon leakage from the sector minus the international price of emission rights in the sector. The criterion for an optimal unilateral climate policy is that the marginal social costs of abatement should be equalised across sectors. This means that a uniform carbon price across sectors is not necessarily the optimal setting. If the domestic government does not worry about carbon leakage, a uniform carbon price is cost-effective only if the international price of emission rights is the same in the ETS and the non-ETS sector. If the government is concerned about leakage, a uniform carbon price for all private emitters is only optimal if the rates of carbon leakage as well as the prices of emission rights are the same across the two sectors, which is unlikely to be the case.

A relatively high carbon leakage rate and a relatively low international price of emission rights in a given sector work in favour of having a relatively low total carbon price in that sector. *A priori* this theoretical insight does not tell us unambiguously whether the ETS sector should have a higher or a lower carbon price than the non-ETS sector. However, we found that if the government cannot or does not wish to trade emission rights for the non-ETS sector and is relatively unconcerned about carbon leakage, the total carbon price in the ETS sector should generally exceed the carbon tax rate levied on the non-ETS sector, i.e., some amount of domestic carbon tax should be imposed on the ETS sector on top of the ETS allowance price. The reason is that the allowance price makes it more expensive for society to emit $CO_2e$ from the ETS sector. In effect, the EU co-finances a part of the domestic cost of abating emissions from the ETS sector since the domestic economy saves the expense on an ETS allowance when emissions from that sector are cut by one tonne. *Ceteris paribus*, this makes it more attractive to reduce emissions from the ETS sector and consequently warrants a higher carbon price in the sector.

## 3.5 Caveats: The importance of the objective for climate policy

The policy recommendations above depend to a large extent on the specific target for domestic climate policy. This can be illustrated by comparing climate policy targets in Norway and Denmark. According to the Norwegian Climate Act, the total domestic $CO_2e$ emissions in Norway must be cut by 55% by 2030 compared to 1990, to live up to the country's commitment under the Paris Agreement. Norway co-operates with the EU on climate policy and participates in the ETS even though Norway is not a member of the EU. The Norwegian ETS sector's contribution to the fulfilment of Norway's obligations under the Kyoto Protocol, which preceded the Paris Agreement, was determined in negotiations with the EU. It was decided that Norway should be given a credit for emission reductions in the ETS sector corresponding to the reduction over time in the amount of ETS allowances allocated to the country under the ETS[7]. In other words, under the Kyoto Protocol in effect until 2020, the contribution of the Norwegian ETS sector to fulfilment of the country's target for total emission reductions did not depend on the actual emissions from the sector but rather on the politically determined quantity of ETS allowances allocated to Norway by the EU.

The contribution of the Norwegian ETS sector to the country's 2030 climate target has yet to be negotiated with the EU, but it is expected that it will be determined in much the same way as under the Kyoto Protocol. In such a situation where a cut in the *actual* emissions from the ETS sector does *not* contribute to the fulfilment of the country's national climate policy target, there is no case for imposing a domestic carbon tax in the ETS sector on top of the allowance price. Instead, the carbon tax should only apply to the non-ETS sector.

By contrast, according to the Danish Climate Act, which requires a 70% cut in total domestic emissions by 2030 relative to 1990, the ETS sector's contribution to

7. The amount of ETS allowances allocated to Norway was defined as the amount by which the total issue of ETS allowances was increased as a consequence of the country's participation in the ETS.

fulfilling this target is measured by the reduction of *actual* emissions from the sector, as assumed in our analysis above. Under such a specification of the policy target, the carbon price for the ETS sector should, in fact, include some amount of domestic carbon taxation when policy makers strive to secure domestic cost-effectiveness, as we have seen.

This conclusion assumes that the goal of domestic climate policy is to maximise *national* welfare rather than securing cost-effectiveness throughout the *EU as a whole*. This approach could be defended by the fact that a frontrunner country voluntarily incurs higher abatement costs than those required for fulfilment of its obligations towards the EU, and so it may legitimately seek to minimise the national cost of moving ahead of the EU. It can also be argued that a frontrunner country does not necessarily provide a viable example to other countries if the frontrunner mainly achieves its ambitious target for emissions reduction by forcing the production of $CO_2$e-intensive goods abroad rather than by reducing emissions per unit of domestic output. From this perspective, the frontrunner's carbon tax scheme should account for the risk of carbon leakage in line with the policy design illustrated in Figure 7.

On the other hand, one could adopt the "Kantian" approach that a frontrunner country seeking to lead by example should pursue a climate policy similar to one it would like adopted by the whole of the EU. Presumably, this would be a policy securing a cost-effective abatement of *total EU emissions*, i.e., a climate policy ensuring an equalisation of the total carbon price between the ETS and the non-ETS sector. Such an approach to national climate policy in an EU frontrunner country should not discriminate between the two sectors.

The choice between these two approaches is obviously a normative issue to be decided, in the end, by policy makers.

# 4. Concluding remarks

In the introduction, we mentioned some reasons why the Nordic countries might want to act as frontrunners in EU climate policy. We then challenged the conventional wisdom on the design of unilateral climate policy on two fronts.

According to the conventional view, unilateral action to reduce emissions from the ETS sector in a single EU country makes little sense, since the rate of carbon leakage to other EU countries will be 100%, at least in the long term, where the total cap on emissions is likely to be binding. However, in both the short and medium term, a unilateral cut in emissions from a country's ETS sector will, in fact, permanently reduce the concentration of $CO_2$e in the atmosphere due to the intricate mechanics of the Market Stability Reserve (MSR) in the ETS, although the precise overall effect on total emissions is difficult to predict. More fundamentally, we argued that the total amount of emission allowances issued over the long term is likely to be endogenous, as EU policy makers trade off their desire to control the quantity of emissions against their desire to avoid excessive fluctuations in the allowance price. Under such a policy setting, a unilateral member state policy that reduces emissions from the ETS sector, thereby creating a greater allowance surplus, will sooner or later induce a cut in the total allowance supply. The introduction and recent reforms of the MSR suggest that such political dynamics are, in fact, at play in the EU, implying that unilateral climate policy aimed at the ETS sector does have a permanent climate impact.

Another conventional view is that a cost-effective way of meeting a target for reduction of domestic greenhouse gas emissions is to implement a uniform carbon price across all sectors of the economy. Under such a policy, companies in the ETS sector would be granted a 100% credit for expenses on ETS allowances set against their domestic carbon tax bill. We saw that such a policy could be defended under a "Kantian" policy approach, but if the aim of domestic climate policy is to maximise national welfare, we found that a uniform carbon price is only cost-effective under rather special circumstances which are unlikely to prevail. Instead, we showed that the carbon price should be differentiated between the ETS and the non-ETS sector according to differences in the international prices of emission rights and differences in carbon leakage rates (when carbon leakage is a concern for the government).

In practice, designing the optimal unilateral carbon tax scheme for an EU frontrunner country will be difficult due to uncertainties surrounding the future price of emission rights and carbon leakage rates in the different sectors. This could present an argument for restricting the use of reduced carbon prices to a few subsectors where the risk of leakage is likely to be high.

Finally, we should note that rather than addressing carbon leakage via tax credits and/or reduced carbon tax rates for (sub)sectors exposed to leakage, the government could, in principle, grant an output subsidy to such sectors, combined with a consumption tax on similar imported goods, differentiated according to their carbon content.[8] In this paper, we have ignored such national policy instruments as they may be incompatible with EU law and difficult to administer.

8. For a formal analysis of the various instruments to counter carbon leakage, see Kruse-Andersen and Sørensen (2022a).

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# Appendix A: A simple political economy model of ETS allowance supply

In this appendix, we set up the political economy model for the determination of the supply of ETS emissions allowances which underlies Figures 3 and 4. We assume that the preferences of EU policy makers are given by a 'utility function' of the following form,

$$U = U(A, p), \text{ (A.1)}$$

$$U_A \equiv \frac{\partial U}{\partial A} > 0,\ U_{AA} \equiv \frac{\partial^2 U}{(\partial A)^2} < 0,\ U_p \equiv \frac{\partial U}{\partial p} < 0,$$
$$U_{pp} \equiv \frac{\partial^2 U}{(\partial p)^2} < 0,\ U_{Ap} = U_{pA} \equiv \frac{\partial^2 U}{\partial A \partial p} = \frac{\partial^2 U}{\partial p \partial A} \leq 0,$$

where $A$ is the total volume of abatement of $CO_2$ emissions from the EU ETS sector, and $p$ is the price of ETS emission allowances. The assumption $U_A > 0$ reflects that, ceteris paribus, EU policy makers are more popular the larger the cut in ETS emissions they manage to secure, but since $U_{AA} < 0$, the marginal popularity gain from emission reduction decreases with the level of abatement. The assumptions $U_p < 0$ and $U_{pp} < 0$ mean that, ceteris paribus, EU policy makers lose popularity when the ETS allowance price goes up and that the marginal loss of popularity increases with the allowance price level. These assumptions reflect that a higher allowance price translates into higher energy prices which are unpopular with voters and industry. The final technical assumption $U_{Ap} = U_{pA} \leq 0$ is sufficient (but not necessary) to ensure that the indifference curves in Figures 3 and 4 are indeed concave, as intuition suggests. The utility function (A.1) should be thought of as a weighted average of the preferences of individual EU member states, where the weights depend on the distribution of voting rights and bargaining power.

The total abatement in the ETS sector is the sum of abatement undertaken by a frontrunner EU member state, $g(p + \tau)$, where $\tau$ is the frontrunner country's domestic carbon tax rate which adds to the total domestic carbon price $p + \tau$, and the abatement implemented in the rest of the EU, $f(p)$. A higher carbon price induces greater abatement efforts, but at a decreasing rate since marginal abatement costs increase with the level of abatement. Hence,

$$A = \overbrace{g(p+\tau)}^{\text{Abatement in front runner country}} + \overbrace{f(p)}^{\text{Abatement in the rest of the EU}},$$
$$g' > 0,\ g'' < 0,\ f' > 0,\ f'' < 0. \text{ (A.2)}$$

In the absence of the ETS and national climate policies, the total emissions from the ETS sector would equal the business-as-usual level $E_0$ which we treat as exogenous, but under the ETS and the national climate policy in the frontrunner country, actual emissions become $E_0$ - $g(p + \tau)$ – $f(p)$. The total supply of ETS emission allowances is $\bar{S}$, so the equilibrium allowance price must satisfy the market equilibrium condition

$$E_0 - g(p+\tau) - f(p) = \bar{S}. \text{ (A.3)}$$

Equation (A.3) may be solved for the equilibrium allowance price to give a price function of the form

$$p = p(\bar{S}, \tau), \quad p_{\bar{S}} \equiv \frac{\partial p}{\partial \bar{S}} = \frac{-1}{f' + g'} < 0, \quad p_\tau \equiv \frac{\partial p}{\partial \tau} =$$
$$\frac{-g'}{f' + g'} < 0. \text{ (A.4)}$$

Inserting (A.2) and (A.4) in (A.1), we get

$$U = U(f(p(\bar{S},\tau)) + g(p(\bar{S},\tau)+\tau), p(\bar{S},\tau)). \text{ (A.5)}$$

Rational EU policy makers will choose the supply of ETS emission allowances so as to maximise the utility function (A.5). The first-order condition for maximisation is

$$\frac{\partial U}{\partial \bar{S}} = 0 \Longrightarrow U_A \cdot (f' \cdot p_{\bar{S}} + g' \cdot p_{\bar{S}}) + U_p \cdot p_{\bar{S}} = 0 \Longleftrightarrow$$
$$-\frac{U_A}{U_p} = \frac{1}{f' + g'}. \text{ (A.6)}$$

Equation (A.6) is the formal characterisation of the optimum point *O* in Figure 3 where the slope of the indifference curve $U_1$ (the left-hand side of (A.6)) equals the slope of the *MRT* curve (the right-hand side of (A.6)). The optimum condition (A.6) can be written in the form

$$[f'(p(\overline{S},\tau)) + g'(p(\overline{S},\tau)+\tau)]U_A(f(p(\overline{S},\tau)) \;\; +g(p(\overline{S},\tau)+\tau), p(\overline{S},\tau))$$

$$+U_p(f(p(\overline{S},\tau)) + g(p(\overline{S},\tau)+\tau), p(\overline{S},\tau)) = 0. \quad \text{(A.7)}$$

Equation (A.7) defines the total ETS allowance supply $\overline{S}$ as an implicit function of the frontrunner country's carbon tax rate $\tau$. If $\frac{d\overline{S}}{d\tau} < 0$, the introduction of a national carbon tax in the frontrunner country will induce a fall in the allowance supply, thereby reducing total EU emissions. By implicit differentiation of (A.7) and use of the results in (A.4), we find after some manipulations that

$$\frac{\partial \overline{S}}{\partial \tau} = -\left\{ \frac{g'[U_{pp} + (f' + g')U_{Ap} + U_A f' (\frac{f''}{f'} - \frac{g''}{g'})]}{U_{pp} + U_A(f'' + g'') + U_{AA}(f' + g')^2 + 2(f' + g')U_{Ap})} \right\} \quad \text{(A.8)}$$

As a benchmark, suppose the frontrunner country and the rest of the EU have access to the same abatement technologies so that the slopes of their marginal abatement cost curves are identical. For example, this will be the case if

$$f(p) = ap^{\alpha}, \quad g(p+\tau) = b(p+\tau)^{\alpha}, \quad 0 < \alpha < 1, \quad \text{(A.9)}$$

where $a$ and $b$ are positive scalars. If the frontrunner country starts out from an initial carbon tax rate of zero, it follows from (A.9) that

$$\frac{f''}{f'} - \frac{g''}{g'} = \frac{a\alpha(\alpha-1)p^{\alpha-2}}{a\alpha p^{\alpha-1}} - \frac{b\alpha(\alpha-1)p^{\alpha-2}}{b\alpha p^{\alpha-1}} = \frac{\alpha-1}{p} - \frac{\alpha-1}{p} = 0. \quad \text{(A.10)}$$

Given the properties of the utility function specified in (A.1), we see from (A.8) that the result in (A.10) is a *sufficient* (but not a necessary) condition to ensure that $\frac{d\overline{S}}{d\tau} < 0.$ Hence, it seems safe to conclude that, under plausible conditions, the introduction of a national carbon tax on top of the ETS allowance price in an EU frontrunner country will indeed reduce total EU emissions by inducing a cut in the total allowance supply, as illustrated in Figure 4.

# Appendix B: The cost-effective national climate policy in an EU frontrunner country

This appendix describes the formal analysis underlying Figures 5 through 7 in section 3. We use the following notation where all variables refer to the domestic economy:

$TC$ = total social cost

$TAC^{ETS}$ = total abatement cost in the ETS sector

$TAC^{non-ETS}$ = total abatement cost in the non-ETS sector

$A^{ETS}$ emission reduction in the ETS sector

$A^{non-ETS}$ = emission reduction in the non-ETS sector

$\overline{A}$ = total required domestic emission reduction (exogenous)

$E_0^{ETS}$ = business-as-usual emissions from the ETS sector (exogenous)

$E_0^{non-ETS}$ = business-as-usual emissions from the non-ETS sector (exogenous)

$\overline{E}^{ETS}$ = ETS emission allowances allocated to the country (exogenous)

$\overline{E}^{non-ETS}$ = emissions from the country's non-ETS sector allowed by EU regulation (exogenous)

$a^{ETS}$ = rate of carbon leakage from the ETS sector (exogenous)

$a^{non-ETS}$ = rate of carbon leakage from the non-ETS sector (exogenous)

$c$ = domestic willingness to pay for a 1 tonne cut in foreign emissions (unit social cost of leakage, exogenous)

We assume that the social planner wishes to minimise the total national social costs associated with the use of fossil fuel and other inputs generating greenhouse gas emissions. These costs include abatement costs that depend on the levels of abatement, expenses on the purchase of emission rights (since these expenses represent a transfer to the rest of the EU), and the costs of carbon leakage that depend on leakage rates and on the government's willingness to pay for a reduction in foreign emissions ($c$). Hence, we have

$$TC = \overbrace{TAC^{ETS}(A^{ETS}) + TAC^{non-ETS}(A^{non-ETS})}^{\text{Total abatement cost}}$$

$$+ \quad \overbrace{p^{q} \cdot (E_0^{ETS} - A^{ETS} - \overline{E}^{ETS})}^{\text{Cost of net purchase of ETS allowances}}$$

$$+ \quad \underbrace{p^{N} \cdot (E_0^{non-ETS} - A^{non-ETS} - \overline{E}^{non-ETS})}_{\text{Cost of net purchase of non-ETS emission rights}} \quad +$$

$$\underbrace{c \cdot (\, a^{ETS} \cdot A^{ETS} + a^{non-ETS} \cdot A^{non-ETS})}_{\text{Cost of carbon leakage}} \quad \text{(B.1)}$$

where we assume that marginal abatements costs ($MAC$) are positive and increasing in the level of abatement in both sectors:

$$MAC^{ETS} \equiv \frac{dTAC^{ETS}}{dA^{ETS}} > 0, \qquad \frac{d^2 TAC^{ETS}}{(dA^{ETS})^2} > 0,$$

$$MAC^{Non-ETS} \equiv \frac{dTAC^{Non-ETS}}{dA^{Non-ETS}} > 0, \qquad \frac{d^2 TAC^{Non-ETS}}{(dA^{Non-ETS})^2} > 0. \quad \text{(B.2)}$$

The social planner chooses the abatement levels $A^{ETS}$ and $A^{Non\text{-}ETS}$ in the two sectors of the economy so as to minimise the total social cost given by (B.1) subject to the constraint that total abatement is sufficient to meet the target $\bar{A}$ for reduction of the total emissions from domestic territory, that is,

$$A^{ETS} + A^{Non-ETS} = \overline{A} \quad \text{(B.3)}$$

Solving (B.3) for $A^{Non\text{-}ETS}$ and inserting the result in (B.1), we can write the total social cost as a function of $A^{ETS}$ only. Doing this, taking the first derivative of the social cost function, and using the definitions of marginal abatement costs stated in (B.2), we obtain the following first-order condition for the optimal abatement effort in the ETS sector:

$$\frac{dTC}{dA^{ETS}} = 0 \Longrightarrow$$

$$\overbrace{MAC^{ETS} - p^{q} + MSCL^{ETS}}^{\text{Net marginal social cost of abatement in ETS sector}} = \overbrace{MAC^{Non-ETS} - p^{N} + MSCL^{non-ETS}}^{\text{Net marginal social cost of abatement in non}-\text{ETS sector}}, \quad \text{(B.4)}$$

where $MSCL^{ETS} \equiv c \cdot a^{ETS}$ and $MSCL^{non\text{-}ETS} \equiv c \cdot a^{non\text{-}ETS}$ are the marginal social costs of leakage in the two sectors. According to (B.4), the cost-effective allocation of abatement effort between the ETS and the non-ETS sector ensures that the net marginal social costs of abatement are equalised across sectors. If the social planner is indifferent to leakage and does not wish to exploit the opportunity for trade in non-ETS emission rights, we have $c = p^N = 0$. The optimum determined by (B.4) then corresponds to point $O$ on the horizontal axis of Figure 5. When the social planner does exploit the opportunity for trade in non-ETS emission rights but does not care about leakage, we merely have $c = 0$, in which case condition (B.4) gives the optimum point $O$ on the horizontal axis of Figure 6. In the scenario where the social planner is concerned about leakage and is willing to engage in trade in emission rights in both sectors, (B.4) identifies the optimum point $O$ on the horizontal axis of Figure 7.

# Comment on F. Silbye & P. Birch Sørensen: National Climate Targets Under Ambitious EU Climate Policy

**Lars Gårn Hansen**

My thanks to authors Frederik Silbye and Peter Birch Sørensen for their very considered response to my comments. Any remaining errors and opinions are, of course, mine alone.

## 1. Introduction

This paper poses the question: what constitutes an optimal climate policy for an EU member state with climate ambitions after the recent 'fit for 55' policy reform? The authors focus on how an ambitious country's climate policy interacts with the EU climate emission quota market (Emission Trading System: ETS) and what adjustments to its climate policy this interaction might entail. The paper offers three main contributions:

- Using an ETS simulation model, the authors find quota sector leakage rates will be 'around zero' in the period to 2032 but 'close to 100%' after that, assuming ETS rules and emission quota supply do not change.

- They argue that the ETS quota supply is unlikely to remain unchanged and, more importantly, that the political process around future ETS supply changes is systematically affected by the ambitious country's prior unilateral 'extra' emission reductions, in a way that reduces leakage from these extra reductions, for example, so that leakage after 2032 is likely to be below 100%.
- Assuming that the ambitious country is not only focussed on its own climate emissions but also on the scale of global emissions, they find that the optimal policy is to set the total payment for emitting $CO_2$ in the quota sector to:

$$\text{WTP + ETS quota price – leakage cost}$$

where "WTP" is the political willingness to pay for national climate emission reductions. The ETS quota price should not be deducted from the national carbon tax because the payment is to an external entity, the revenue from which (at the margin) does not accrue to the ambitious country. Finally, the carbon tax should be reduced proportionately to leakage to the extent that the country is also concerned about global reductions in emissions.

I enjoyed reading the paper. It is well written and argued and addresses an important policy issue facing the Nordic countries. I find the ETS leakage simulations to be a (very) useful contribution since this informs the discussion about ambitious EU member states' climate policies. In the following, I will focus my review on the two latter contributions, where I have some reservations, before offering some concluding remarks on how an ambitious EU member state's climate policy should be designed.

# 2. Leakage effects of endogenous ETS quota supply

The authors argue that the political process for making future ETS quota supply decisions is likely to reduce leakage caused by a unilateral decision to abate within the quota sector by an ambitious EU member state. Their basic argument (illustrated in Figure 4 of their paper and developed mathematically in Appendix A) is that the EU's cost of emission reductions is lowered relative to the initial state when the ambitious country unilaterally undertakes extra abatement measures. Thus, when emission quota supply is reconsidered at some point in the future, it would be less costly to reduce quota supply than it would otherwise have been (all other things being equal). This causes the EU-level balancing of climate reductions against abatement costs (reflecting an underlying bargaining process between member states) to shift toward even more reductions, assuming that the EU-level trade-off evaluation between costs and emissions reductions remains the same. This is an appealing argument perhaps in part due to its simplicity. It may, however, be too simple.

While unilateral emissions reductions in the ambitious country unequivocally reduce EU abatement costs, it is not clear that this will leave the EU-level trade-off between emissions and abatement costs unaffected. In the following, I offer an example where this trade-off is affected in such a way that quota supply is increased, not reduced.

I assume that the EU-level trade-off between emission reductions and costs is the result of a Nash bargaining process between an ambitious and an unambitious block of member states, illustrated in Figure 1. Initially, both blocks have the same abatement cost curves, labelled *A- and UA-MAC* in Figure 1. Emissions are measured from the right, and the point where the *A- and UA-MAC* curves cross the horizontal axis (labelled $O_1$) indicates the level of emissions when the price of $CO_2$-emissions is zero (no regulation). As the price of emissions (indicated on the vertical scale) increases, each block's emissions are reduced, as indicated by its *MAC* curve. Adding the two emission curves horizontally gives the EU emissions curve labelled *EU MAC*. Emission reductions for the EU and for each block are correspondingly measured from the left, starting at points *O* and $O_1$, respectively. Horizontally adding each block's emission reductions measured in this way, as indicated by the blocks' *MAC* curves, gives the EU emissions reduction indicated by the *EU MAC* curve.

The ambitious and unambitious blocks have a willingness to pay for their own reductions, labelled *A-WTP* and *UA-WTP*, respectively (willingness to pay for reductions in the other block is assumed to be zero). Initially, the only difference between the blocks is that the ambitious block has a higher level of WTP, as indicated by the two WTP lines in Figure 1.

I assume that the Nash bargaining equilibrium that results from the negotiation process is the quota supply (labelled 'bargaining equilibrium ETS supply' in Figure 1), where each block has the same bargaining-power-adjusted welfare loss compared to its preferred quota supply. I also assume that the bargaining process rules outside payments through quota grandfathering so that quotas are grandfathered to each block in a proportion that ensures no revenue/quotas are transferred between blocks in the resulting equilibrium. Given this, each block's preferred quota supply is the one that results in a quota price that implements its own preferred level of reductions, indicated by the blue and green dots, respectively, in Figure 1. The blue and green triangles are the welfare loss for each block resulting from the bargaining solution ETS supply indicated by the red dot in Figure 1. Thus, Figure 1 illustrates a bargaining solution in which the ambitious block has greater bargaining power and, in turn, the bargaining equilibrium leaves them with a smaller welfare loss than the unambitious block.

After the implementation of this bargaining solution, the ambitious block decides to unilaterally implement policies that ensure its own preferred abatement level, which is illustrated in Figure 2. This could be by imposing a local carbon tax equal to its equilibrium WTP (WTP at the blue dot indicated in Figure 2) minus the quota price (labelled *A-block tax* in Figure 2), for example. If the quota price is lower than equilibrium WTP, the abatement incentive equals the equilibrium WTP. If it is greater, the abatement incentive equals the quota price. After implementation of this policy, the *A-block MAC* curve shifts to the indicated vertical line under the equilibrium WTP since these abatements have already been undertaken. The result is that quota prices under this level no longer affect the abatement efforts of the ambitious block. This results in a corresponding shift in the *EU MAC* (total EU quota demand) curve and so causes a fall in the quota price, as indicated by the downward shift of the red dot in Figure 2 (consistent with the authors' assumption).

**Figure 1**

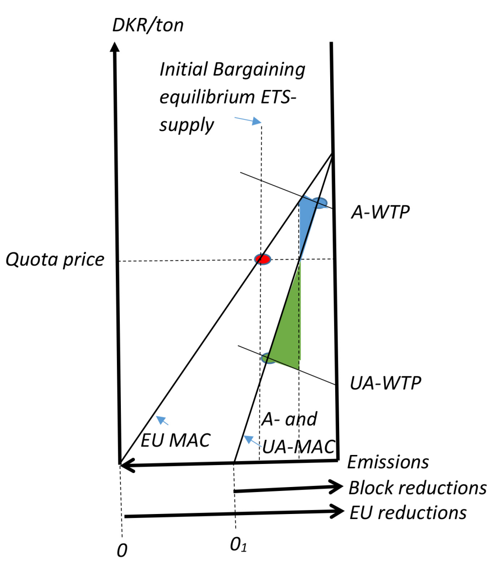
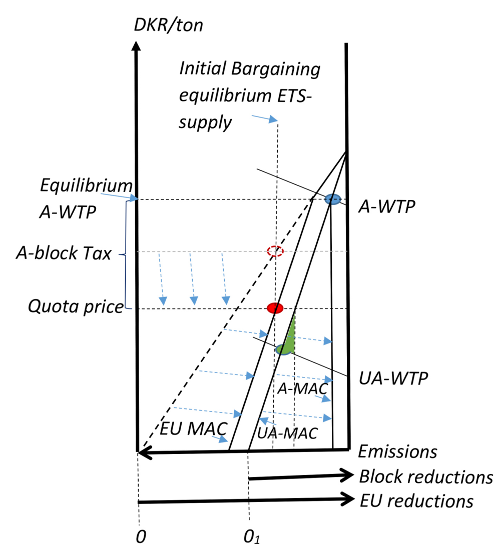



**Figure 2**




Now suppose there is a renegotiation of quota supply (after the unilateral abatement of the ambitious block has been fully implemented) following the same bargaining process as the initial negotiation and with no side payments. The resulting quota supply will again be the one that equalises the blocks' bargaining-power-adjusted welfare loss relative to their preferred supply. Looking at Figure 2, we see that the preferred abatement levels are the same as before. Let us consider the current quota supply as a candidate for the new 'bargaining-equilibrium ETS supply'. The welfare loss of the unambitious block is now lower than under the last negotiation (as indicated by the smaller green triangle in Figure 2) because of the lower equilibrium quota price, and correspondingly lower abatement level for this block. However, there is still a strictly positive welfare loss. The ambitious block's welfare loss is, on the other hand, reduced to zero because it now has policies in place that reduce its own emissions to their preferred level. In fact, the ambitious block now has no preference as to which ETS quota supply is chosen as long as it does not induce a quota price greater than their equilibrium WTP. Thus, the resulting negotiation will increase quota supply relative to the current supply level until the unambitious block's remaining welfare loss is also eliminated. Essentially, the ambitious block is no longer interested in the common ETS policy since it is no longer driving its emissions. Instead, the common policy is decided by the unambitious block, which is the only remaining agent with a stake in the outcome of the negotiation. Thus, the EU-level trade-off between abatement and costs is negatively affected, causing quota supply and leakage to increase.

Although this is just one example, it seems plausible that the positive effects on quota supply of unilateral climate policy can be shown for a (wide) set of negotiation scenarios. Of course, other assumptions regarding bargaining power, WTP for emission in the other block, side payments, etc., might well lead to a negative effect on endogenous supply, as the authors suggest. That the negotiation process could lead to a reduction in supply and leakage, as put forward by the authors, is therefor in no way ruled out by the example I give here. However, it does suggest that even the sign of the effect of a unilateral climate policy on endogenous ETS supply (and thus leakage) cannot be determined theoretically: Empirical evidence is needed before drawing any conclusions about the sign of this effect. Given that our understanding of political negotiation processes is limited, I would hesitate to factor in such an 'endogenous supply' effect.

## 3. Incentives in the quota sector

The paper's third contribution is to structure the policy design problem of an ambitious member state that values national as well as global emission reductions and only has carbon taxation as an instrument. Assuming that this is the case, the paper structures the design problem concisely and illuminates two important points. The first is that payment for ETS quotas is a real cost borne by the emitting country, essentially because its revenues from quota sales are unaffected by the marginal quota purchase of its polluters. Thus, the marginal cost of abatement should be reduced by the emission quota price when a cost-minimising policy is designed. The second point, illustrated by Figure 6 in the paper, is that the core of the ambitious country's policy decision problem lies in allocating reductions between polluting sectors and that the optimal distortion of this allocation away from the standard uniform-incentive baseline depends on differences in quota prices and differences in leakage rates between sectors. The authors acknowledge that differences in leakage rates could be more efficiently addressed through production subsidies (and corresponding consumption taxes) but assume that this instrument is not available.

Under the assumed frontrunner policy goals, the paper concisely frames the policy decision problem faced by an ambitious EU country, as noted above. However, as the authors also acknowledge, the Kantian moral imperative 'to act in the way one would like others to act' and the more common practical motive of 'inspiring other countries by setting an example to follow with low costs' could imply other frontrunner policy goals. Specifically, if it is important for the frontrunner country to exemplify policy that other countries can follow, it becomes correspondingly important that its policy design is scalable and that its costs reflect those that potential emulators would face. If, for example, the EU as a whole, were to consider copying a Nordic frontrunner's climate policy, then policy-design features such as being optimized to reduce leakage through the EU ETS and to capture gains from quota sales to other EU members would not be relevant, while any resulting cost savings would be misleading. This is because there would be no ETS leakage nor any possibility of reducing costs by selling quotas at EU level. This would also be the case if the frontrunner wants to inspire non-EU countries, which account for almost 90% of all greenhouse gas emissions.

To demonstrate the consistency issue, imagine a situation where the EU decides to become just as ambitious as the frontrunner country and to achieve this in an efficient manner (presumably what the frontrunner is hoping for). If the frontrunner has implemented a uniform carbon tax with full deduction for the quota price, then this will happen seamlessly as its extra carbon tax in the quota sector falls to zero and its carbon tax in the non-quota sector becomes just sufficient to meet EU reduction demands. On the other hand, if the frontrunner has implemented an ETS-optimised policy in the way proposed by the authors, then the frontrunner's abatement incentives will be distorted between the quota and non-quota sectors compared to the EU incentives. Letting this distortion continue would seem to clash with the Kantian moral imperative, though it would undoubtedly be economically advantageous for the frontrunner. Eliminating it would, on the other hand, beg the question of why the distortion was introduced in the first place. Thus, as the authors point out, the fundamental question of why precisely a country aspires to be a frontrunner is a critical prerequisite for a discussion of how its policy should be designed.

# 4. How should an ambitious EU country's climate policy be designed?

The authors present the relevant policy decision problem for an ambitious EU-member country assuming that national and global reductions (and not scalability) are the key policy goals. Focussing on the situation after 2032, this decision problem depends critically on leakage through the EU quota system, which will also encompass the transport, buildings and construction sectors following the latest reform. The authors' first contribution shows that leakage will be close to 100% if the endogenous quota supply effect is ignored. This suggests a rather narrow frontrunner strategy primarily focused on agricultural emission reductions. If we assume a (substantial) leakage reducing endogenous quota supply effect, this narrow focus could be moderated, and the authors' recommendations go in that direction. However, as they also point out, optimising frontrunner climate policy design in line with their proposals is difficult because of substantial uncertainties about leakage rates in general and endogenous ETS supply effects in particular. For this reason, the approach risks opening the door to permanent tax reductions/-exemptions rooted in concerns such as the special interests of certain companies, etc., under the guise of securing global $CO_2$-reductions/reducing leakage. Doing this might be tempting if securing such special interests is considered less legitimate by the general public compared to securing global $CO_2$-reductions/reducing leakage.

Another way to argue for a more balanced frontrunner policy design is to require scalability. This would imply ignoring gains from quota sales, ETS leakage, and, I would argue, ignoring leakage in general since, the country is a frontrunner for a world where most other countries also undertake climate policy, and as a result, leakage is minimal. If this is the starting point, then arguing for tax reductions/exemptions becomes more of an uphill battle, and there is a strong case for making these measures temporary. However, the authors highlight an important point, stressing that such an approach comes with a welfare cost in the form of underutilisation of the gains from ETS quota sales to other EU-member countries and potentially underutilised opportunities for global emission reductions (to the extent that there is a WTP for these in the ambitious country).

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# National and EU climate policies in conflict: Lessons from three sectors in Finland

**Matti Liski and Iivo Vehviläinen**

## Abstract

This article reviews and responds to policy frameworks across three sectors with the intention of efficiently reconciling national and EU climate-policy targets. The rationale behind national policies stems both from national policy ambitions and sector-specific commitments, but these may prove incompatible with broader EU policies such as the EU emissions trading system (EU ETS). Consequently, disparities between national and EU policies must, in turn, be adjusted accordingly, sector by sector. We show that reconciling differing policies does not necessarily rule out market-based instruments but that the efficient implementation of national targets can, in fact, build on and expand them.

**Keywords:** Emissions trading; transport; buildings and construction; electricity

# 1. Introduction

This article is informed by policy structures in three sectors: transport, buildings and construction, and electricity. From 2019–2022, the authors worked with the relevant ministries and advised on decision-making proposals related to carbon-neutrality targets. We have focused on market-based policy proposals and their impact on the implemented legislation and finally offer some suggestions as to how national policies can be efficiently integrated into EU policies.

Our key takeaway is that carefully defined national market-based mechanisms can, and sometimes even should, overlap with EU market mechanisms. These could take the form of a system based on either taxation or tradable emission rights or, as we outline in some of our proposals, a combination of the two.

The rationale behind national policies stems both from national policy ambitions and sector-specific commitments, but these may prove incompatible with broader EU policies such as the EU emissions trading system (EU ETS). National and EU policies must then be reconciled, sector by sector. We demonstrate that this alignment does not rule out market-based instruments but can build on them through the efficient implementation of national targets.

The transport sector forms the basis for our first case study, in which national emissions targets cannot be reached by relying solely on EU regulation. Incorporating the transport sector into the EU emissions trading system may prove efficient in terms of achieving the EU goals, but the plan contains no provision for national goals that may not be met when the EU has reached its target. In such a situation, member states could still resort to market-based solutions to achieve their national goals. We have developed a policy proposal in AEI (2019)[9] to address this issue, and our proposal has been adopted by the Finnish government as a backstop solution: if it transpires that alternative measures prove insufficient for reaching the national goals, a national trading system will be implemented (Kervinen & Teittinen, 2021). In this paper, we outline the market design for reaching the national goals set in Finland and show how these could be linked to the EU emissions market if such a linking mechanism is required. We argue that the strict quantity target for domestic emissions justifies a market-based mechanism built on tradable rights, although in principle a system of taxes could deliver similar benefits. In fact, we propose that a combination of these two instruments would allow policy makers to control emissions targets and the incurred cost of reaching them.

9. The report was prepared by Aalto University's economics working group, consisting of Matti Liski, Oskari Nokso-Koivisto, Eero Nurmi and Iivo Vehviläinen.

The buildings and construction sector provides our second case study, illustrating a very different interdependence between national and EU regulations. Based on our AEI (2021) report[10], we argue that the EU market mechanism already covers a major part of the embodied carbon emissions from buildings, and therefore a potential national programme should focus on emissions from the construction-time use of materials not already covered by EU policies. We outline a strategy for national emission trading and argue that it could deliver allocative efficiency improvements while implementing the national targets for this sector. We pay particular attention to preventing leakage of emissions from the national to the supranational system that, in principle, could jeopardise the additionality of the national emissions reductions. This case study illustrates how national ambitions for additionality can be achieved in a cost-efficient manner. Again, practical implementation challenges lead us to propose a system based on rights, although a conceptually equivalent price-based system could be envisaged.

Our final case study is the electricity sector, in which the starting point for policies has been EU-wide emissions trading, involving a common price for emissions from power generation. This policy, combined with the 'energy only' market for wholesale electricity, is a concept that has guided decarbonisation investments and planning in Finland as part of the Nordic and European markets for electricity. We have witnessed a European trend that has, in part, reversed the idea of the common price for energy and emissions: through the adoption of additional policy tools, member states have implemented national targets for renewables and other carbon-free technologies. Essentially, the capacity portfolios are based on and follow national ambitions and needs. We discuss how this development manifests itself in Finland and in the Nordic Region, and we extrapolate future a development in which there are separate markets for capacity and wholesale electricity. In the greater scheme of things, EU emissions trading may become an aggregate backstop instrument for aggregate emissions reductions that will no longer be binding should national ambitions and results supersede the set (EU) targets.

The policy conclusions for the electricity sector concur with those of the other two sectors: The emergence of national goals and their implementation does not spell an end to the use of markets for attaining those goals. National capacity portfolios can be efficiently realised by using market-based capacity mechanisms. The EU-level energy-only market and emissions trading are still important elements for allocative efficiency.

We focus specifically on market mechanisms to emphasise their usefulness in

10. The report was prepared by Aalto University's economics working group, consisting of Matti Liski, Oskari Nokso-Koivisto, and Iivo Vehviläinen.

implementing national policies as part of a larger policy design. However, almost by definition, distributional goals and policies for their implementation occur at a national level. We supplement our transport sector case study by illustrating the distributional burden of carbon prices across income groups in Finland by using detailed micro data on vehicles, kilometres driven and individuals' socioeconomic variables. We also describe some rebate schemes introduced to alleviate the cost burden on low-income groups. This description builds on our report to the Ministry of Transport and Communications (AEI, 2020).[11]

In our concluding remarks, we focus on efficiency and competitiveness. The policy designs suggested in this article are intended to improve allocative, and sometimes distributional, efficiency, which can help the economy grow and improve 'competitiveness' in a broader sense. We conclude by pointing out the need for fundamental regulatory reform of the basic energy infrastructure (the electricity networks, which can best be described as one of society's most important infrastructures). This role will become even more prominent as society becomes increasingly electrified and transitions to a carbon-neutral future. What is the most efficient way to organise monopoly regulation for the energy transition and relevant sectors? As will be revealed, the answer to this question calls for a fundamental reform of the current policies.

# 2. Transport

## 2.1 Background

The EU requires Finland to reduce its greenhouse gas emissions by 50% in the designated burden-sharing sector by 2030, compared to the 1990 level. The burden-sharing sector includes emissions from transport, agriculture, heating, and waste management, among other areas. According to the Finnish government's programme, the medium-term climate plan and the national climate and energy strategy will be updated to achieve these emission reductions. The measures are evaluated from the point of view of efficacy and cost-efficiency, taking regional differences and employment effects into account.

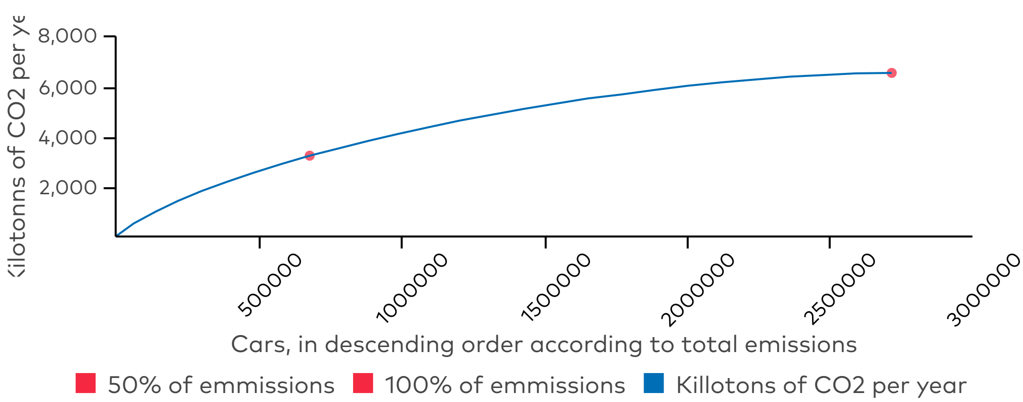
This burden-sharing target is binding. Traffic is responsible for 40% of the burden-sharing sectors' emissions and 20% of Finland's greenhouse emissions. The government programme commits to halving traffic emissions by 2030 and concludes that the greatest potential for reducing greenhouse gases lies in the

11. The report was prepared by Aalto University's economics working group, consisting of Arttu Ahonen, Matti Liski, Oskari Nokso-Koivisto, Eero Nurmi and Iivo Vehviläinen.

emissions from road traffic. The government's stated goal is consistent with the mid-term climate policy plan published in 2017. With the implementation of the 2030 goal, Finland intends to be carbon neutral by 2035. This will lead to heavy pressure to reduce traffic emissions.

Emissions from traffic can be understood as the combined effect of three factors. Total emissions depend on the number of kilometres driven, the energy efficiency of the means of transport, and the carbon content of the fuel used per energy unit. Traffic emissions can be reduced by influencing one or all these factors. Emissions caused by vehicles are not evenly distributed. In 2016, for which we have comprehensive vehicle microdata, over 6,000 kilotons of $CO_2$ emissions were accumulated from almost three million vehicles in private use, half of which was produced by the group of approximately 750,000 most polluting vehicles (see Figure 1).[12] In other words, approximately a quarter of privately used cars produced half of all emissions.

**Figure 1.** Cumulative emissions of the private car stock in 2016




The total emissions produced by the fleet can be divided into sections according to the age groups of the cars. Figure 2 shows how emissions in each age group depend on the number of cars, their use, and their technology. Average emissions increase with age as a function of these factors, reaching their peak just before the tenth year of the cars' lifetime. Although the emissions per kilometre of older cars (over 20 years old) are higher than those of new ones, their average annual emissions are lower because they are driven less.

Based on Figures 1–2, the mid-term target cannot be reached by incentivising carbon-neutral choices in the new car market, and in addition, the government is

12. AVERO data from the Government research unit includes vehicles subject to vehicle tax used privately in Finland in 2016 and the people who used them. For about 75% of the vehicles, the 2016 mileage has been obtained directly from readings during inspections, while for 9%, data from the previous or following years has been used. For the remaining 16%, the kilometres driven have been estimated using statistical reasoning. The emissions by vehicle are calculated by using the model-specific emission rates.

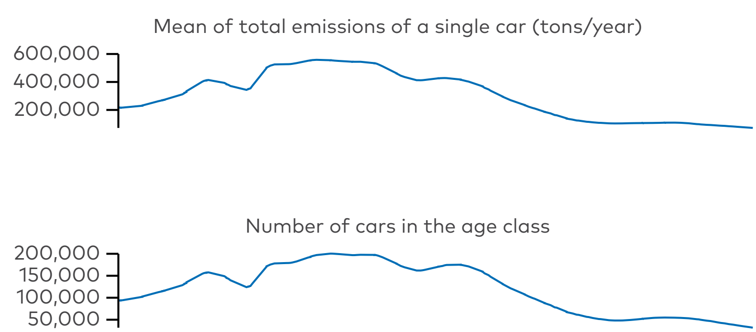
forced to severely reduce emissions from the old car fleet.

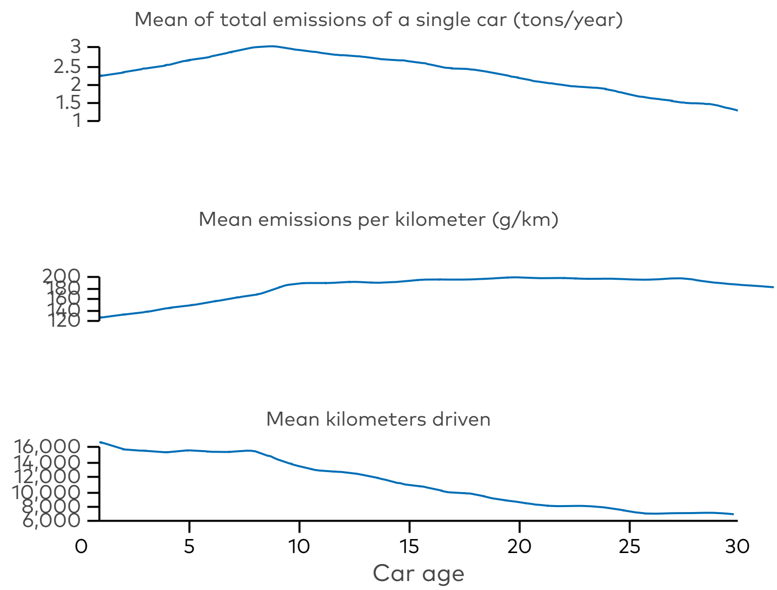
In the AEI report of 2019 (AEI, 2019), we evaluated different regulatory measures that can be implemented at national level to achieve broad emission reduction goals within the transport sector. In addition to a more general description of the instruments available, the report presented a model by which emission reductions could be achieved in a cost-effective and predictable manner. This model would ensure the achievement of emission reduction in accordance with the agreed commitments while guaranteeing consumers and companies the widest range of opportunities to adapt to the changes effected by these emission targets.

The main features of the proposal include:

1. A licensing scheme for fuel sales in Finland to reduce all road traffic emissions by 50% by 2030. The scheme would set quotas for the carbon content of fuels.
2. This quota system has several important advantages compared to non-market instruments for reducing emissions. It is a cost-effective way to achieve emission reduction goals. In addition, the system makes it certain that the goal will be reached, as the quotas can be set at the desired level. The quota system would enable consumers and companies to adapt flexibly to emission reductions and can be practically implemented through regular auctions. It can also be modified to account for any economic uncertainty caused by fuel price fluctuations through the application of both a price floor and a ceiling.

**Figure 2.** Emissions analysis of the private car stock






## 2.2 Justification for the Proposal

**National targets:** The emission reduction targets for the transport sector represent Finland's national target. The emission reduction methods employed must be initiated at a national (not EU) level if the governmental control in achieving these goals is the desired outcome. The proposed solution is, therefore, a specific tailormade solution for the Finnish conditions.

**Technology frontier:** Finland is unable to directly influence which transport sector technology will become globally dominant. New vehicle technology is determined exogenously. For example, in the Finnish context, subsidies for the purchase of electric cars cannot be justified by domestic technological developments in the country. Should a specific technology become internationally dominant, it may become necessary to enhance local networks, for example, by investing in distribution networks or by subsidies to promote the spread of the technology (see, e.g., Springel, 2021). If, on the other hand, there are ongoing uncertainties surrounding a given technology, one may end up supporting the 'wrong breakthrough' technology. The national quota system ensures flexibility in making cost-efficient choices on the technology frontier, or, more precisely, these choices will be delegated to the market.

**Public funding:** The limited nature of public funding must be considered when planning emission-reduction measures. Financial subsidies are likely to prove an expensive way of achieving the emission reduction goal and provide no certainty of reaching it. In contrast, the quota system generates revenues for the public budget that can be used to reach the general public sector spending objectives, including dealing with distributional objectives that may be affected by the zero-emission targets in the transport sector.

Multiple adjustment channels: Consumers and companies have different ways of tackling change in the regulatory environment. Measures adapting to traffic-reducing emissions policy could include some of the following:

- Changing place of residence (e.g., location in relation to the workplace)
- Changing place of work
- Changing mode of transport (e.g., private car, train, bicycle, etc.)
- Changing vehicle to a less energy-consuming model
- Combining trips and increasing vehicle utilisation levels (e.g., ridesharing)
- Reducing driving
- Organisation of work (e.g., remote work, video conferencing)
- Adapting leisure activities
- Changing energy carrier (e.g., petrol/diesel, biogas, electricity)

Technology standards, subsidies for certain technologies and scrappage programmes only target the last adjustment channel listed above[13]. While it may seem obvious to economists, it is useful to recap: The market instrument does not take a position on which means of adaptation are used to reduce emissions. It thus enables the most favourable way for each economic actor to adapt. This is an important detail because only the consumer and companies themselves know the most effective way to reduce emissions from their point of view.

**Comparison to tax instruments:** The price signal can be achieved in two ways; through a carbon tax, which defines a certain price level for carbon content, and through a fuel quota system, which would define the total limit for emissions[14]. Both are market-based approaches and can deliver the efficiency gains outlined above. However, the difference between the two lies in their implementation: Setting tax at a level that leads to the achievement of the emission reduction goal is a significant challenge. Predicting an appropriate tax level is difficult: One that is neither too low (where the emission reduction goals would not be met) nor too high (where the goals would be met but the cost to the economy would be unnecessarily high).

13. Cash for Clunkers programmes can lead to costly emissions reductions. See, e.g., Hoekstra et al., 2017
14. In 2016 carbon tax was ca. 16.25 eurocents/litre.

We argue that the need to reach the quantity target justifies using the quota system as a basis for our proposal. However, it is possible to combine elements in the permit system that would take the uncertainty of future permit prices into account. This could be achieved by creating a price collar within the system, in which the price of permits could vary. This would prevent the permit price and the associated costs of emission reductions for society from becoming unreasonably high. In practice, this would combine quantity regulation with price regulation. In essence, the government would announce a price floor, at which retailers can sell quotas back to the government, and a price ceiling, at which the government will sell additional quotas. This price collar could, however, create some uncertainty about how the system will reach the government's goals for emissions reductions.

## 2.3 Details of the proposal

Finland's goal is to significantly reduce traffic emissions in a timely manner. To facilitate this, the policy should be aimed directly at emissions. The price should, therefore, directly target the source of the emissions, i.e., the carbon content of fuel.

When aiming for emission reductions, it is not worth setting a price on elements such as driving performance, traffic, or the technology used to travel. These choices are best left to private actors, as they are probably the most aware of the most effective way to reduce fossil fuel use in any given situation. This ensures the cost effectiveness outlined above. In addition, what can be considered the most effective method may change over time, depending on how different technologies evolve.

The strength of the quota system lies in predictability in terms of emissions, as the number of emission permits traded within the quota system can be set to any desired level. One mechanism for creating a quota system that fulfils the emission reduction goal would be the introduction of a system of fuel-sales licenses, under which the distributor buys a license from the state for each litre of fuel sold, tied to the carbon content of the fuel. The permit system should target distributors to ensure the price signal reaches all end users.

The permit system would be relatively easy to implement under current Finnish conditions: other industries covered by emissions trading already face similar regulatory environments. The permit system would undoubtedly reach the goal if the number of permits was to decrease over time and the number available was tied specifically to that goal. There is plenty of international experience available regarding the issuing and selling of permits through regular auctions, for example, EU emission trading. When planning auction arrangements, it is essential to ensure sufficient competition, for example, by organising auctions at regular intervals to ensure the continuous availability of permits so that the market share owned by a single operator does not grow too large.

The key benefit of the permit system is cost efficiency. It puts a price on the input causing the problem, which in this case is the carbon content of fossil fuel. The idea is that the emission reduction goal converts to price signals faced by consumers and producers, which in turn guides their behaviour in each situation. A particularly positive aspect of the mechanism is that while it guides and encourages each company and consumer to adopt their own best solution, it also directs the reduction of consumption to those actors who can achieve it at the lowest cost.

The permit system makes it possible to achieve the reduction goal flexibly so that the financial burden is evenly distributed over different years. This can be achieved by issuing permits generously in the early years of the programme and allowing the market to decide how many permits will be used now and how many will be saved for the future.

For the sales license system to work effectively, no changes to the current vehicle or fuel taxation or the mandatory distribution of biofuels would be required. If the rest of the regulation were kept in place in its current form, the quota system would act as a backstop and ensure that the goals can be achieved. The price of a fuel-sales permit would equal the difference between the price determined by the quota level of the sales-permit system and the price implied by current regulations.

The two scenarios described below illustrate this point. In *Scenario 1*, the price of the quota system falls below the price implied by the current regulation, so the price of permits becomes zero. Conversely, this would also mean that traffic emissions would decrease by more than the 50% target by 2030.

In *Scenario 2,* the price of the quota system is higher than the price of emissions according to the current regulation. The price of the sales license is then the difference between the two. In this scenario, the emission-reduction goals would not be met without the introduction of the quota system.

**Figure 3.** Scenario 1: Quota prices below current $CO_2$ price

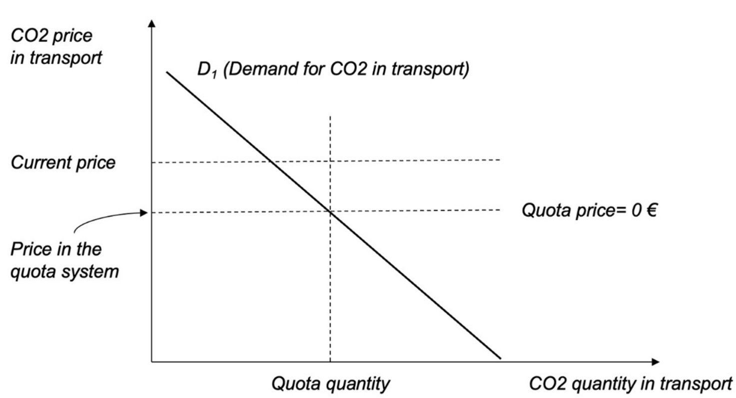
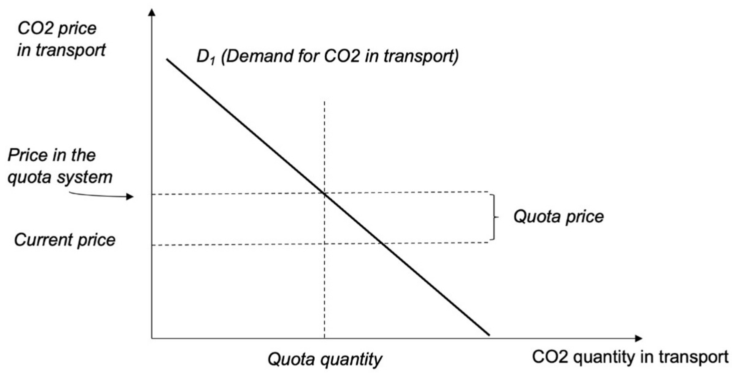


**Figure 4.** Scenario 2: Quota price exceeds current $CO_2$ price




## 2.4 Conflict of National vs EU-level policies: Lessons from the transport sector

National road transport emissions trading is a feasible alternative regardless of EU trade in them.

The justification is simple: The goals of the transport sector are binding, and Finland does not have the option to use the EU emissions-trading system to reach national goals. Trading in the EU means that the Finnish transport sector can increase emissions without restrictions through the import of emission permits, and there is no automatic mechanism built into the system to ensure that the national goals are reached. Relying solely on an EU programme would lead to a situation where, in addition to EU emissions trading, the transport sector would have to be controlled through varied and undoubtedly economically expensive means (e.g., scrapping payments, purchase subsidies, outright bans, etc.).

National emissions trading ensures the emissions reduction goal will be reached in a predictable and cost-effective way. It is administratively inexpensive because it displaces other control measures while generating income for the state. Finally, it can be directly linked to the EU emissions trading regime should a different or expanded EU mandate be introduced at a later date.

To elaborate on this last point, we will explain how a national target could be maintained while remaining fully linked to EU-level emissions trading. It must be borne in mind, however, that the starting point for planning should be the national emissions target, not so much the linking to the EU emissions trading system: The target sends a clear message about the number of permits in circulation in Finland during the target period (e.g., by 2030 in which the emissions should be 50% lower). This means a commitment to an implementation method such that the effect of the EU's emissions trading on the number of permits in Finland is neutralised. How could this neutralisation be achieved in practice?

If a national system is set up in Finland and there is no EU equivalent, then the number of permits to be used in Finland would be obvious. If, however, an EU system is created for transport, the number of permits in Finland will still correspond to the country's target if a two-price system is created for emission permits as follows. Permits put into circulation in Finland will be openly available at the market price. However, imported transport emission rights will require an import permit issued by the emissions trading authority monitoring Finland's emissions target. A market price for the import permits will be formed, which is higher the greater the gap between the country's realised emissions and its targets. The price of import permits will drop to zero if Finland reaches its goal directly as part of the EU's emissions trading system.

As we can see, implementing a national system within the framework of the EU system is possible. In this case, the EU system would indicate a market-level price signal. To protect the economy from price spikes, a ceiling price could be set for import permits. The number of permits available would therefore enable and be tied to achievement of the annual target.

# 3. Buildings and Construction

The policy proposals related to emissions from the buildings and construction sector paint a very different picture than that of transport: The impact of existing EU-level emissions regulations should be identified, isolated, and carefully utilised when designing domestic market-based regulations for this sector.

## 3.1 Background

Emissions from the real-estate sector can be divided into three time-based elements: the construction phase, the use of the building, and its demolition. When developing regulations, it is also important to ascertain what kind of regulations are already in place for each emission source, where these occur and how to measure them.

Construction phase emissions can be roughly divided into those from building materials and the energy used in construction (e.g., electricity and fuels).

Building materials are subject to separate EU-level emissions regulations. It is worth noting that uncertainty exists in relation to building materials' emissions and the calculation methods used. For example, regarding the life-cycle emissions of wood vs concrete, different conclusions can be reached depending on how the wood is used (cf. the carbon sink debate).

Energy use during construction, including both electricity and fossil fuels, is subject to existing emission regulations that are independent of policies for the construction sector. The same is true of embodied emissions during a building's use: Most of these, primarily relating to electricity and heating, are covered by other existing emission-control policies.

Energy production is almost exclusively covered by the EU emissions trading system. Emissions trading creates a price signal that is transmitted to the prices of end products such as housing. In addition, national initiatives have already been put in place to ban the use of coal in energy production, and preparations are underway to end the use of peat. These measures are also reflected in the energy prices paid by consumers.

The demolition phase is primarily linked to the recycling of building materials, the quality of that recycling or the extent of their disposal. Waste legislation is the key regulatory instrument that addresses the external effects of the demolition phase.

## 3.2 Life-cycle regulation

Finland is currently preparing a renewal of the buildings and construction regulation; we have placed the regulation in preparation under the heading "life-cycle regulation", in which the expected lifetime emissions of each building covered by the regulation must be below the limit value in use at the time of construction. Life-cycle emissions include emissions from the manufacture of building materials, emissions from construction, some embodied emissions during use, and emissions incurred at the end of the building's life-cycle.

Emissions that result from the construction phase would be determined by the life-cycle estimates of the building materials involved and the emissions from energy use. Emissions during the in-use phase would be calculated using a formula that combines engineering estimates of the building's energy use with administratively decided projections of the length of the building's life cycle and predicted energy production emissions.

The current proposal for regulation is problematic from the point of view of efficiently reducing emissions because the proposal is based on:

1. Administratively decided assumptions regarding the length of the regulated building's life-cycle assessment period.
2. Administratively decided assumptions about future emissions in energy production.
3. Evaluation of the technical functionality of heating and insulation technologies.

If the administratively set emission factor for future energy use is too high, more materials might be used in the construction phase to reduce energy consumption than would be efficient. This could take the form of the use of excessive insulation leading to inefficient high emissions from the production of raw materials, for example. On the other hand, if the administrative emission factor is too low, it could make the building a greater source of emissions than the target level. Similar considerations hold true for the life-cycle decisions and the engineering estimates.

Reducing life-cycle emissions is cheaper in some locations than in others. Under the current plan, all locations are compelled to remain below the same threshold. In terms of emissions, however, the same results could be achieved at a lower cost if emissions were reduced in an environment where it is cheaper to reduce life-cycle emissions than in a location where it is demonstrably more expensive.

From the point of view of construction, there is remarkably little or no empirical evidence on the costs of reducing emissions. Although developers have the most detailed information about of the costs, obtaining this information through surveys is difficult due to the conflicts of interest inherent in sharing this data.

### 3.3 Alternative proposal: a market-based mechanism

We have proposed in AEI (2021) a national emission-rights system for building materials:

- The builder should acquire a number of emission rights corresponding to the carbon emissions of the building materials from a public auction or secondary market before the building is taken into use.
- Acquired rights and documentation of verified construction material emissions should be presented to the local authority at the time of the final inspection of the building. Submission of rights and documentation of emissions from construction materials would be a prerequisite for final approval and commissioning of the building.

The system that we have proposed would create a backstop for emission cuts that can be implemented in conjunction with current or upcoming regulations. This implementation would be based on the same database as the alternative or existing regulation.

This means that emissions cuts would be targeted more effectively than in the current regulatory proposals, which do not take into consideration builders' knowledge and experience regarding the most efficient ways to reduce emissions. Choices available include materials, building designs, the amount of total construction, energy efficiency, and the use of new technologies. Although the system achieves emission reductions, it also leaves these decisions in the hands of private operators. The system's price also signals direct consumption reduction to those actors who can achieve this at the lowest cost.

National emissions regulation can increase emissions in another sector or outside the country's borders. This leakage can be prevented by acquiring or cancelling emission permits from emission markets where an overlap occurs.

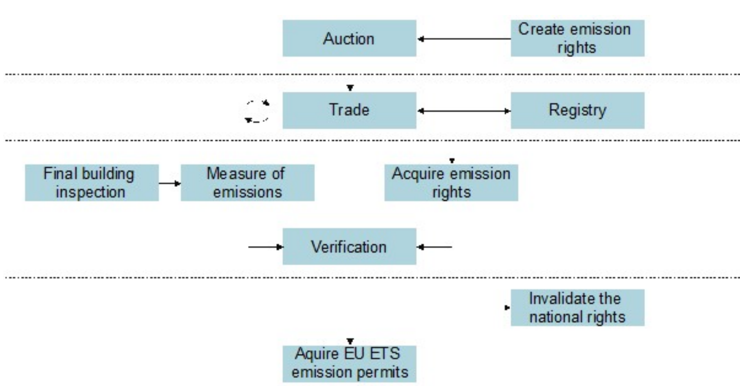
## 3.4 Details of the proposal

The design of the market mechanism is based on the following goals: (i) reducing the $CO_2$ emissions from construction, building use and demolition as efficiently as possible (lowest cost/emission unit); (ii) preventing the leakage of emissions to other sectors or areas. The market mechanism imposes a price on emissions from materials, although this could also be achieved by imposing a corresponding tax on emissions. As for the transport sector, if the policy objective is stated in terms of quantity reductions, a system of tradable permits will certainly achieve the quantity target.

The regulation of emissions should target materials because, during the time the building is in use, emissions from electricity and heat production are already under specific regulations. For this reason, including these in construction sector regulation is unnecessary. Likewise, energy-related emissions in the construction phase will fall under energy-sector regulation. In the case of demolition, it is important that, for example, the external effects of construction waste are priced correctly, and that possible market deficiencies in the demolition waste market can be corrected.

Given these parameters, national regulation of emissions from building materials would constitute a reasonable target for policy intervention. Figure 5 outlines the proposal, the steps of which are detailed below.

**Figure 5.** Proposed National emission-rigth system for building materials




**Creation of emission rights:** The state creates a number of emission rights that corresponds to the emission targets set for building materials.

**Auction and trading of emission rights:** The state sells the emission rights it creates in regular auctions held, for example, once a month. These can be traded.

**Measuring of emissions:** The manner and stage at which generated emissions are measured lies at the heart of any emission regulation. A natural emissions control checkpoint could be part of the building permit process, for example, as part of the final inspection. At this stage, the developer must be able to demonstrate the emissions embedded in the building materials. Emissions can be measured using the same mechanism as the planned life-cycle regulation.

**Acquisition and verification of emission rights:** The developer acquires the number of emission rights corresponding to the greenhouse gas emissions of the building's construction materials from the market and presents the emissions tally from the building materials and the corresponding emission permits to the national authority, which invalidates the emission permits.

**Acquisition and cancellation of EU ETS emission permits:** Since manufacturing of some building materials, for example cement, are subject to EU wide market-based emissions regulation, it is important to ensure that the reduction of emissions according to the national mechanism does not increase emissions in another sector or outside the country's borders. This can be prevented by acquiring and cancelling permits from EU ETS where an overlap occurs.

### 3.5 Conflict of National vs EU policies: Lessons from buildings and construction

The above proposal demonstrates how the effects of EU-level policies should be isolated when designing domestic policies to avoid creating overlapping regulations. Nevertheless, national policy ambitions can motivate a market-based intervention that effectively puts a price on national aspirations and fulfils them in a cost-effective way. Next, we will elaborate on the link between EU emissions trading, national objectives, and the proposed mechanism[15].

The diagram below Figure 6 illustrates the operation of the linked market mechanism. The graph shows the volume of emissions and the price of them for consumers and companies. In the diagram, consider first a situation in which no price has been set for the externality of emissions, and in this case the number of emissions from construction would be $Q$.

A reduction in emissions can be achieved through different mechanisms: (i) builders replace high-emitting materials and products with lower-emitting ones, (ii)

15. See Böhringer and Fischer (2020) for an analysis of various instruments to prevent leakage within a trading system.

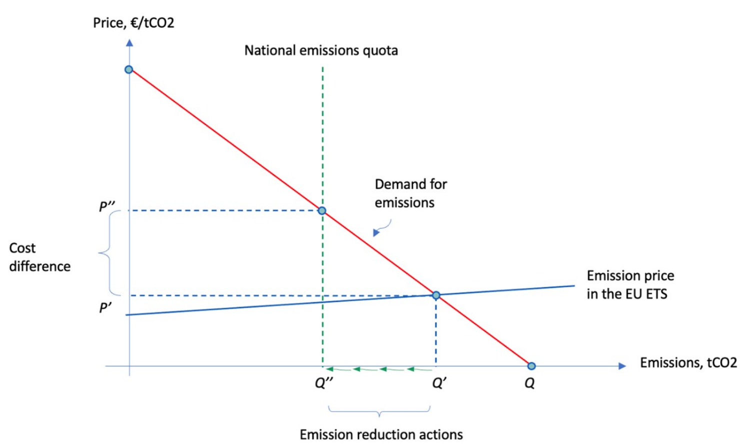
buildings are designed so that the use of high-emitting materials is reduced, (iii) construction becomes more expensive so that the amount of construction is reduced, and (iv) new technologies are developed that reduce emissions.

A significant part of the emissions caused by the manufacture of building materials already falls under the EU emissions-trading system. This has raised the price of emissions so that construction emissions are now lower than they would be without the intervention of emissions trading. At this juncture, the volume of emissions has, therefore, already decreased to the level *Q'*, which is lower than the volume without any regulation (*Q*).

The national quota system raises the costs of construction emissions above the EU emissions trading level. It can be assumed that the emission quota *Q"* shown in the graph corresponds to the price level *P"* of domestic construction emission permits, which is higher than the price level of the EU emission trading.

At the same time, the price level informs the regulator directly of the additional costs of regulation, i.e., the cost difference between the price of national regulation and the EU emissions trading in the graph. This can be especially useful in a situation where a national level of ambition higher than the rest of the EU is maintained in a single sector.

**Figure 6.** Illustration of the market mechanism in the context of national objectives and EU emission trading




# 4 Electricity market

## 4.1 Background

The electricity sector is the main contributor to emissions and has historically been the principal target for EU climate action. As a result, it comes as no surprise that the design of the EU emissions trading programme (EU ETS) has had a considerable impact on the electricity sector. A single common price for emissions and the 'energy-only market' have been the guiding principle for electricity market integration in the EU.

Interestingly, the current European electricity market design has its roots in the Nordic market model of the 1990's. The design principles underpinning the Nordic model included keeping the rules as simple and transparent as possible while trusting the market to make dispatch and investment decisions in the power system that would best serve society. By the early 2000's, the EU had agreed highly ambitious policies for fully integrated internal energy markets. Since then, several regulatory steps have been taken to encourage member states to adopt similar rules and regulations regarding market organisation, and how electric system operations are managed. Today, there is an EU-wide price-coupling procedure that seeks to implement a system-level equilibrium by collecting the bids to buy and sell electricity from all European bidding zones.[16]

The fully integrated energy market, including the integrated emissions market, is a landmark undertaking that is closely aligned with economists' typical recommendations. Anticipation of this development was clearly evident, for example, in the reports supporting nuclear-power investments in Finland: an expectation that the higher central European electricity price level combined with higher emissions prices would prevail in the Nordic countries was seen to justify market-driven investments in low marginal cost and carbon-free technologies.

While progress towards an integrated market is ongoing, it has been partly slowed or reversed by supplementary policies directly related to a combination of increased climate concerns and the urgency of the Russian-imposed energy crisis. These policies tend to reduce the role of the market in guiding the longer-term development of the power system. The four priorities in the European Green Deal are: (i) energy efficiency; (ii) use of renewable resources; (iii) affordable energy supply, and (iv) integration and digitalisation of the markets.

It could be argued that electricity markets are not developing in a direction where market-based investments determine the technologies and associated capacities because various other policies determine the technologies that society wants. If investment needs are set by the policy objectives, it is natural to use markets to

16. The EU price-coupling procedure is documented in https://www.nemo-committee.eu/

procure these investments efficiently, e.g., through various capacity mechanisms (see e.g., Grubb & Newbery, 2018; Joskow, 2019; Wolak, 2021). If this is the case, then the role of the energy and emissions markets would be primarily to deal with the temporal efficiency of allocations, not the long-term direction of the market.

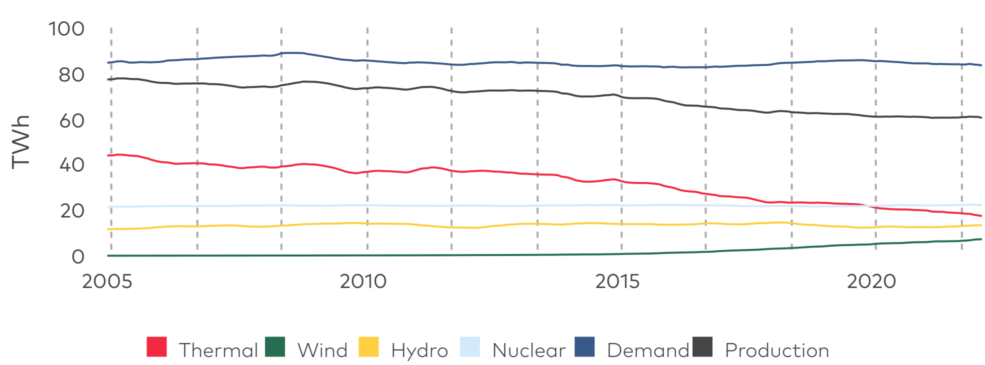
We discuss how this development can be observed in Finland in the following section.

## 4.2 Finnish climate and energy policies

Finland has chosen a different path towards decarbonisation than its Nordic peers. Although the share of wind power is now increasing rapidly, at the beginning of the millennium, the emphasis was placed on nuclear power. In 2002, the decision was taken to build a fifth national reactor, Olkiluoto 3, followed in 2010 by decisions to build the sixth and seventh reactors. The belief was that increased market integration with Europe combined with stricter European climate policies would deliver long-term gains, from the carbon-free and stable baseload to the industry collectively building these plants. At the time, there was also less immediate pressure to invest in renewables.

Figure 7 documents the volume trends for the Finnish electricity market as rolling three-year averages of annual totals. The anticipated growth in demand has not materialised, rather, demand has been relatively consistent over time. Nuclear expansion has been slow due to delays and cancellations; under the original plans, nuclear output would have doubled by 2020. The total production of electricity in Finland has declined because of the dwindling thermal output; after 2015, the growth in wind power has equalled the decline in thermal. From a climate perspective, this is what we would want to see: a marked reduction in the use of polluting coal-, peat-, and gas-fired technologies.

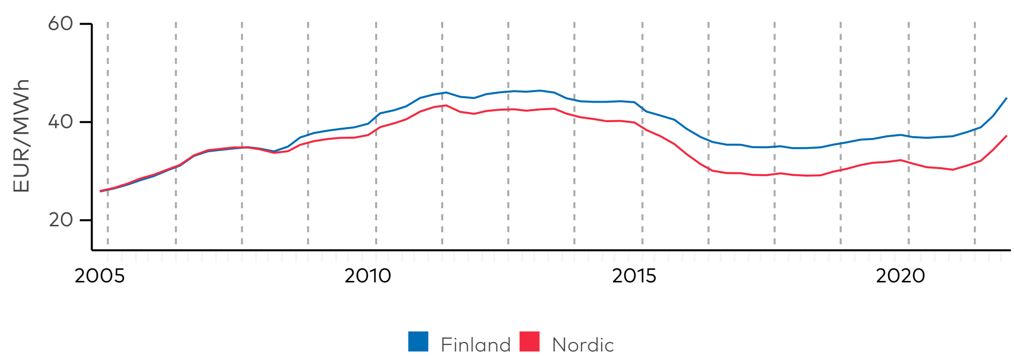
**Figure 7.** Finnish electricity market volume




Note: The data presented is constructed from three-year averages of annual totals

To understand the decline of thermal units in Finland, it is instructive to look at the prices in Figure 8, which shows the three-year averages. In the past decade, the price level in Finland has continuously been higher than the average in the Nordic Region (the system price), but both took a downward turn after 2015. During those periods, Finland benefited from the integrated market through trade. Availability of cheaper imports, mostly from other Nordic countries where large-scale wind expansions were implemented at a much earlier stage, reduced domestic demand for thermal power, leaving many plants standing largely idle. In addition, the waiting time for the continuously delayed Olkiluoto 3 unit has added to the uncertainty of replacement investments for the other ageing plants. A ban on the use of coal in energy by 2029 has been introduced.

**Figure 8.** Finnish and Nordic electricity prices




Note: Data presented is constructed from three-year averages of annual totals

## 3.1 Conflict of National vs EU-level policies: Lessons from the electricity sector

The official energy policy in Finland has been consistent with the European project: market integration has been supported by government representatives, and the energy-only market model has become the predominant driver of investment decisions[17]. However, in an integrated market, the persistent price differences documented in Figure 8 would not be expected. As noted, these differences are partly due to idiosyncratic reasons peculiar to Finland (e.g., the delay and cancellation of large supply units) but also partly by national subsidies elsewhere. These subsidies have, to a certain degree, been a response to earlier EU targets, those set in the 20-20-20 package where member states agreed binding targets to increase their share of renewable energy sources.

Bearing in mind that the price difference in Figure 8 cannot solely be attributed to

17. The renewable subsidy programmes began in earnest in 2011, and though overly generous at the time, the market impact was not felt until the end of the decade.

subsidies, it nevertheless illustrates the costs associated with the national ambitions: The price difference indicates an allocative inefficiency that should not arise in an integrated market. Similar inefficiency can be found in the transport and construction sectors if local ambitions override market outcomes; in these markets, the domestic price of emissions exceeds the EU price to support deeper domestic cuts of emissions than those otherwise reached because of the EU price.

The national electricity price may deviate from the price prevailing in the wider market area, depending on the type of locally implemented policy. For example, a higher-than EU price for emissions contributes to an increase in the cost of domestic electricity. By contrast, national ambitions related to certain types of supply-side technologies can motivate subsidies, which can lead to a fall in the local price.

The electricity market case is different from the transport and construction sectors in that it is difficult to design instruments that neutralise the impacts of national policies on other countries. For the emissions quota system, it is possible to ensure that the reduction of emissions due to the national mechanism does not increase emissions in another sector or outside the country's borders. In contrast, by their nature, national subsidy schemes awarded to energy technologies ignore the spillover to neighbouring countries.

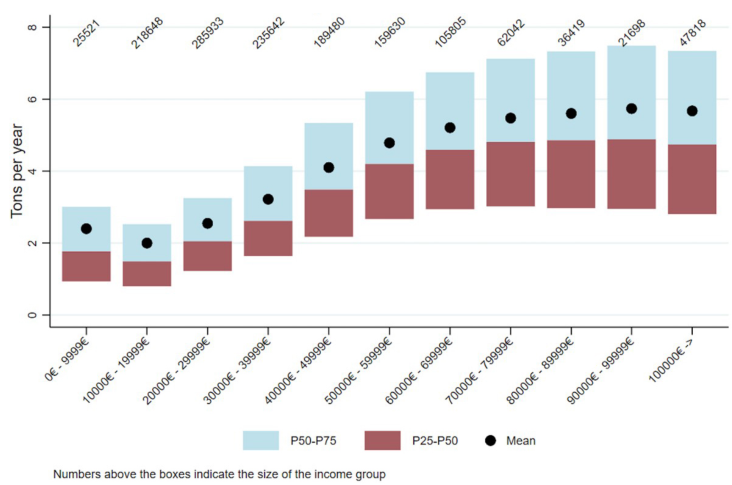
Our policy recommendation in this situation builds on the observation that the use of markets minimises the efficiency losses from national policy aspirations. For example, where local security-of-supply or carbon-emissions targets call for certain capacity portfolios that are not delivered by the current energy-only market, the portfolios can be efficiently built up by using market-based capacity mechanisms such as procurement auctions. The EU energy-only market and emissions trading are still important for allocative efficiency.

# 5. Carbon pricing and redistribution: illustration from transport

Redistributive policies affecting individuals are national, almost by definition. There is an emerging literature on how individuals could be compensated when climate policies lead to a potentially uneven distribution of cost burdens. However, limited data exists on the actual quantitative magnitudes of the cost burdens, although there is ample evidence from surveys where the policies and related costs are hypothetical (Grainger & Kolstad, 2010; Cronin et al., 2019). In this section, we shed light on the actual cost burdens arising from the existing carbon taxes on fuels in the transport sector. To this end, we examine the burdens on households using detailed microdata on vehicles and individuals in Finland. Here, the Nordic administrative data sets demonstrate their usefulness in evaluating the impacts of policies on emissions and in designing tools for mitigating these distributional impacts.

**Figure 9.** Household's $CO_2$-emissions from driving by income

Only car-owning households



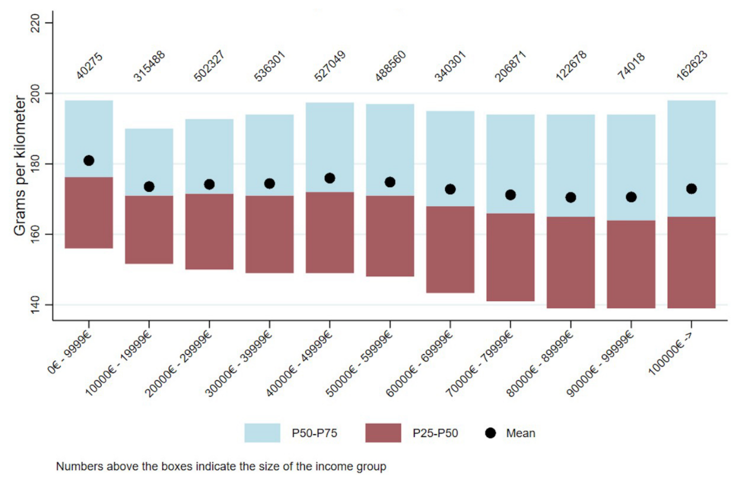

The quantitative analysis is based on our report to the Ministry of Transport and Communications (AEI 2020), in which we used data from 2016 detailing kilometres driven by each individual vehicle[18]. There are approximately 2.6 million cars in private use, of which the 25% worst emitters are responsible for 50% of total emissions.

The typical value (median) of emissions is around two tons of $CO_2$ per year, up to an annual income of €30,000 per household, but rises sharply above this annual threshold. Above an annual income of €70,000, the typical value of emissions is closer to five $CO_2$ tonnes per year. This is presented in Figure 9.

18. AVERO data includes vehicles subject to vehicle tax used privately in Finland in 2016 and the people who used them. For about 75% of the vehicles, the 2016 mileage has been obtained directly from readings during inspections, while for 9%, data from the previous or following years has been used. For the remaining 16%, the kilometres driven have been estimated using statistical reasoning. Statistics Finland's FOLK personal information data contains individual-level demographic structure and employment data for all persons living in Finland. Data from 2016 have been used in the illustrations.

**Figure 10.** Vehicle's $CO_2$ emissions per kilometer by household income of the owner

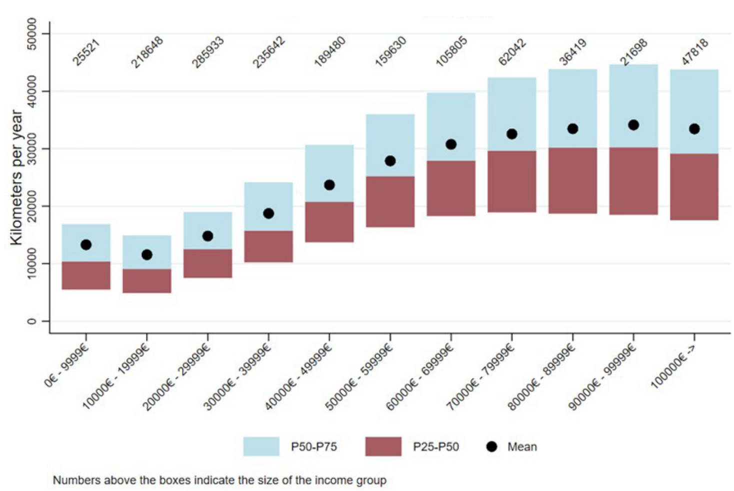
Only car-owning households




Emissions are affected by the intensity of use and the technology of the car. It emerges that typical car emissions (160-180 $CO_2$g/km) do not vary much with income, although the range of high- and low-emission cars increases at the highest income levels (see Figure 10). Thus, the increase in emissions correlated to income is directly explained by the intensity of use: up to an annual income of €30,000, the typical number of kilometres per household is less than 15,000, but with an income of €80,000 that figure typically rises to 30,000 kilometres per year. This pattern is shown in Figure 11.

**Figure 11.** Household's kilometers driven by income

Only car-owning households



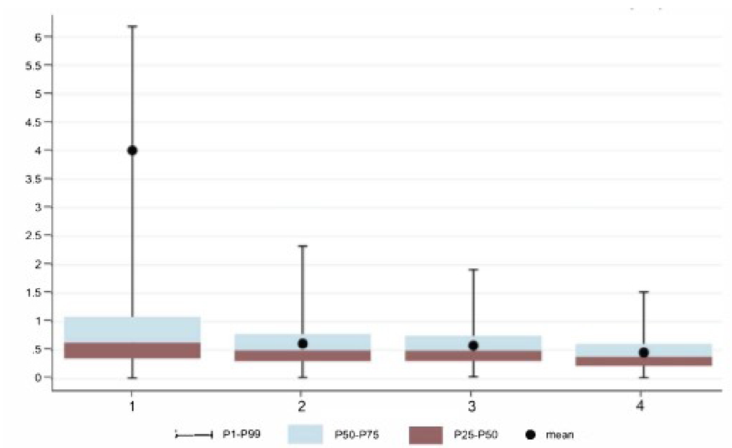
We will now present a hypothesis based on the stylised facts from Figs. 9–11. A national emissions trading, as described in the section Conflict of National vs EU-level policies: Transport sector, may not necessarily lead to adverse distributional impacts: The new emission-free technologies are most likely to be adopted first by individuals with relatively high incomes who also account for the highest current emissions. When the aggregate emissions goal is given, the adaptation of new vehicle technologies leads to downward pressure on the price of emissions which then automatically lowers the cost burden on low-income individuals. We could therefore predict that, in this market, a system of emissions trading could even out the cost burdens favourably in the long term. An emissions tax does not have this built-in property for levelling out private cost burdens unless the tax is flexibly adjusted downwards in response to aggregate emissions.

Let us turn to the actual emission costs from the carbon tax, in place since 2016, which stood at €16.25 cents/litre. Based on the kilometres driven, we can calculate the carbon tax paid per household. The tax burden can be described in relative terms by relating it to the household's disposable net income. We divide the car-driving households into four groups based on income (see Figure 12). The internal distribution of each group is described by a boxplot, where the lower edge of the box is the upper limit of the lowest quarter of the distribution, the middle line is the median, and the upper limit is the lower limit of the upper quarter. Half of the distribution, therefore, sits inside the box. There are whiskers on each side of the box, which fit the entire distribution except for the top and bottom percentiles. In addition, there is a black dot for each box representing the mean value of the distribution.

In the bottom quartile, the average tax share of income is precisely 4%, which is much higher than the group median. This is partly explained by the fact that in the lowest income category, there are cases with very low reported incomes, in which case the carbon tax they pay can be multiple times compared to their income. In the top group, both the mean and the median are close to 0.5%. The lowest group also has the largest dispersion, as 1% of households pay more than 6% of their income in tax, while in the highest income group, this top group is already reached with an income share of 1.5%. The boxes containing half of the households reduce as income increases, which further shows a decrease in dispersion as income increases.

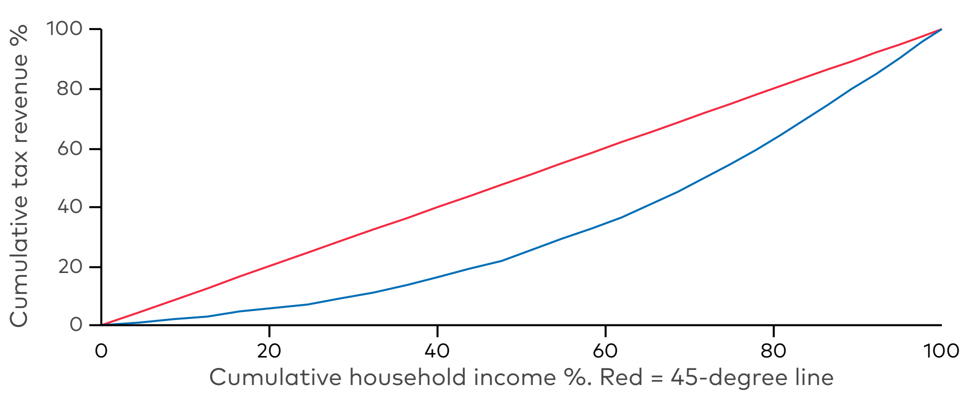
The carbon tax on fuel is regressive: low-income earners pay a higher percentage of their income in tax than high-income earners. However, the regression is quite mild, except for the very lowest-income housing units. From their point of view, it is important to bear in mind that the graph only covers one year's income, which may include a significant number of housing units that in that year happened to earn less than usual due to unpaid leave, for example but did not dramatically reduce the number of kilometres driven.[19]

**Figure 12.** Income groups




People on low incomes pay more carbon tax to drive, but in absolute terms, high-income people clearly pay more in total: the calculated total tax revenue from private driving, based on the 2016 data and tax level, is about €0.5 billion, of which the lower-income households account for 25%. Figure 13 shows how the tax amount is collected from households (vertical axis), whose incomes are summed up in order of magnitudes on the horizontal axis. For example, in the middle of the vertical axis, 50% of the tax has been accumulated, but 75% of the total households have been reached. The wealthiest 25%, therefore, pays the remainder, i.e., 50% of the total tax revenue collected.

**Figure 13.** Carbon tax revenues and household income distribution




19. In addition to the carbon tax, the consumer price of fuel consists of the energy content tax (which is higher than the carbon tax), the security of supply fee, and the tax-free price and the value added tax that comes on top of the previous ones. Adding these expenses to the picture would raise, but not change the differences between the levels.

Tax rebates can be used both to determine how much households ultimately pay for emission cuts and how redistribution could be implemented. The simplest refund is a flat rebate of the entire tax. This is not efficient because tax revenues should preferably be saved for alternative uses in the public sector, but the calculation is a useful point of comparison for other rebate models. A full equal refund rewards low-income households, i.e., their cost increase at the petrol pump will be lower than the tax refund: motorists at a higher income level finance this higher gain through their increased tax payments. However, the regressive nature of the tax can be removed with a much smaller, more precisely targeted return; for example, 15% of the total tax collection would be sufficient for this purpose if the refund is allocated only to the lowest income groups. We elaborate on these rebate methods in our report AEI 2020.

# 6 Concluding remarks

The policy designs introduced in this article are guided, on the one hand, by a desire to respect national commitments for emissions reductions and, on the other, by an intention to improve both allocative and distributional outcomes that will boost the economy and improve 'competitiveness' in its broadest sense. We conclude by noting the connection to, and the importance of, electricity across all sectors. The use of electricity will significantly increase in the future through the electrification of traffic and heating, and increases in the production of various electricity-based fuels and hydrogen.

Current trends point to a rapid large-scale expansion in renewable electricity generation. More recently, during this transition, the Russian attack on Ukraine and the resulting international energy repercussions have intensified the role of national interests, and it is unlikely that the member states will leave it to the single European energy market to guide their energy infrastructure investments. More plausible is a continued procuring of the investments needed for the national renewable transition, e.g., through long-term contracting. In that scenario, the role of the energy and emissions market would be to maintain the efficiency of short-term allocations.

Finally, the success of electrification depends critically on how electricity networks act as a technology-neutral platform that enables sustainable development, helps in fully utilising renewable energy, facilitates the development of efficient electricity systems, and provides critical infrastructure. The distribution networks are local monopolies, but current regulations do not sufficiently reflect the full set of services that society expects from them. Regulatory goals should be derived from the entire vertical structure, starting with the generation of electricity, and ending with transmission via the network to the end user.

An appropriate approach to regulation should start by asking if the network to be regulated is in a steady state or in a state of transition. The broad goals for security of supply and climate and energy policy mean that there will be a need for investment and possible unforeseen changes in the services expected from the grid company. If this is the case, the approach to regulation should be different compared to a stable operating environment (Armstrong & Sappington, 2007). Price regulation is best suited to situations where the operating environment is stable and the quality requirements for operations are well-defined. In practice, price regulation sets the rules for how price changes are made based on general inflation and industry-efficiency metrics. Price regulation results in a very strong incentive to cut costs because the monopoly company receives all the possible cost savings, ultimately to its own benefit.

Unlike direct price regulation, cost-based regulation is based on observable costs. This model includes the common rate-of-return regulation, which means that a pre-agreed return is paid for the capital tied up in the operation in addition to the operational costs. In principle, the regulatory model can compensate these costs as transfers, but in the case of electricity transmission, the established practice is to collect the costs directly from the end user of the network: the costs approved by the regulatory authority determine how much the company is allowed to charge the end user in the form of network usage fees (i.e., tariffs).

Cost-based regulation is suitable for situations in which a company is expected to implement a project with an outcome that is difficult to predict. Therefore, there are clear grounds for cost-based regulation in the transmission of electricity in the green transition: regulated operations are under significant pressure to change. The new quality goals set for operations, as well as broader goals for security of supply and climate and energy policy, may possibly result in unforeseen changes in the services that the grid company normally supplies. Cost-based regulation offers a solid basis for regulation in a changing operating environment, but only as a basis: a more comprehensive model would enhance its features to emphasise the interests of the network's end users.

The regulatory model in Finland incorporates key features of the cost-based model, but the following fundamental problem remains[20]: Operational turnover, and thus the price paid by the customer, is ultimately determined by the company because, in the end, it decides which investments are necessary. For this reason, the model should be applied (i.e., corrected) so that turnover is regulated directly. Of course, the cost-based model often strives to achieve this but, in practice, the turnover is not fixed in advance. Regulation of turnover would allow for a comprehensive review of the company's goals, including a broad interpretation of the quality of

20. The most recent change in the law has emphasised the role of development plans, but without prior approval of investments and inclusion in the income framework, the change does not correct the basic problem targeted by the direct regulation of turnover.

operations. The goals of the regulation revolve around efficiency in the entire vertical structure, from production to end user. This vertical structure has different goals in different network areas and consequently different turnovers derived from those goals (see similar reasoning in Ofgem (2013)).

Research suggests that adjusting the model would make economic sense so that, in addition to cost-based regulation, turnover could also be regulated directly as part of the approval process for operational planning. In practice, this would mean, for example, increasing the role, transparency, and obligations of national development plans. Careful public documentation of the process will also create the conditions for subsequent monitoring, which is of vital importance for all parties involved.

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# Comment on M. Liski & I.Vehviläinen: National and EU climate policies in conflict: Lessons from three sectors in Finland

**Markku Ollikainen**

## Background

The European Union's climate policy framework covers three sectors: (i) The emissions trading sector comprises the energy and processing industry. As a single market, EU ETS is a cost-efficient instrument ensuring that marginal abatement costs equal the emission allowance price across emitters. (ii) The effort-sharing sector (ESR) covers the remaining fossil emissions – generated in transport, agriculture, waste management, heating of houses, small energy use and F gases. In this sector, the mandatory reduction targets are set separately for each member state, resulting in marginal cost differences between countries and ETS. (iii) Finally, the land-use, land-use change, and forestry (LULUCF) sector regulates the net carbon sink (the removals of carbon), which is roughly a product of forest sink and soil emissions from agriculture and land-use change, that also sets separate targets for each member state, contributing to the achievement of the EU's overall LULUCF net sink.

The difference in the marginal abatement costs between the ETS and ESR sectors and, consequently, between member states' marginal costs poses a challenge for those countries with a high reduction requirement in the ESR sectors. Finland and Sweden provide an instructive example of this problem. Both are among the ten richest countries measured by GDP and have been assigned a 50% emissions reduction requirement by 2030. In Finland, the estimated marginal abatement cost of achieving this goal is €120–150 /t CO2e, that is, much higher than the allowance price in the EU ETS (Honkatukia et al., 2021). The recent EU plans for the new EU mechanisms, such as ETS for heating and transport, are based on the EU average. This means that, in practice, member states with high ESR reduction targets may have difficulty achieving them. Therefore, the most advanced member states need to establish overlapping regulations, which some stakeholders often perceive as unnecessary and incomprehensible. Furthermore, business opportunities associated with the green transition are also leading to differences in national energy and industrial policies.

These tensions lie at the heart of Liski and Vehviläinen's paper. They examine how emissions trading schemes can be applied as a nationally cost-efficient instrument that copes with the overlap between national and EU regulations. They also examine how trading can tackle distributional issues. In addition, they discuss how the development of electricity markets has become increasingly policy-driven and functions as a cost-efficient means of achieving the policy targets instead of promoting emerging technologies via market mechanism.

## Emissions trading for transport

The starting point for the discussion on transport centres on the fact that Finland has set a 50% reduction target for transport. Initially emerging as an estimate for the cost-efficient contribution of transport to achieving the Finnish ESR target (when the target was a 39% reduction of emissions), it has since become outdated, as the current Finnish ESR reduction target is 50% (the authors do not note this change in their paper). Liski and Vehviläinen suggest a national emissions trading for transport. This is not a new suggestion, as experience from other transport trading schemes around the globe is readily available and shows that such a mechanism works well (Ahlvik et al., 2022). The suggested mechanism entails a licensing system for distributors, setting an upper limit on CO2 emissions. I believe that the suggested scheme represents an excellent solution. It ensures cost-efficiency and certainty in achieving any climate target. It can easily be linked to the EU-wide emissions trading for transport and heating. Further, they show that trading not only provides funds to correct the distributional impacts but also levels these out through economic behaviour. Although the authors do not specifically discuss it, my understanding is that emissions trading also improves producers' incentives to supply alternative fuels above and beyond mandatory blending requirements as demand for alternative fuels increases. Another interesting aspect not discussed in the paper relates to the difference between light and heavy-duty vehicles. The price elasticity of heavy transport is extremely low and, therefore, trading greatly affects industry's costs. Recently, there has been much discussion of compensatory mechanisms for logistic firms. This is not analysed in the paper, even though revenue generated would facilitate it.

One drawback to the paper is the lack of numerical analysis. The Finnish Climate Change Panel has examined trading using estimates for short- and long-term price elasticities in the Finnish transport sector (Ahlvik et al., 2022). The target was to produce an additional reduction of emissions of 0.6 Mt above the existing instruments by 2030 to ensure that Finland achieves its reduction target for the ESR sector. This requirement results in a need for a greater than 50% reduction in transport emissions. We account for the uncertainty on price elasticities and report results in terms of medians and 50% and 90% confidence intervals. The median carbon price in the year 2030 would be €205 /CO2t resulting in a €0.34 /l medium increase in that year. Linking the scheme to the EU ETS would mean companies buying both EU and national allowances so that the effective CO2 price is the sum of national and EU prices. Naturally, in this case, state revenue would be lower than under the purely national scheme. Our numerical calculations show that the suggested mechanism works well, lending credence to Liski and Vehviläinen's suggestion.

## Emissions trading for building and construction

In contrast to transport, the suggestion of employing emissions trading in the building and construction sector is novel and perhaps one of the more unusual I have heard concerning emissions trading. The essence of the proposal lies in tailoring emissions trading to building materials' emissions and, more precisely, emissions embodied in or created when producing these materials. Under this mechanism, the builder would acquire a given number of emissions rights at public auction or on secondary markets, corresponding to the embedded carbon emissions from building materials and, on completion, submit allowances matching emissions from these.

In Finland, building materials cover 25–30%, buildings 5%, energy use of houses 60%, and demolition 1–2% of emissions from construction. Emissions from energy use are already covered by carbon policies, and demolition should be subject to recycling policies. Thus, the suggested emissions trading on building materials would cover 25–30% of emissions from buildings. Steel, concrete (cement), wood, and bricks constitute the primary building materials. Emissions from steel and cement production belong to the EU ETS, and wood is subject to LULUCF regulation. The authors emphasise that under this system, Finland should cancel emission allowances from EU ETS if this policy leads to an additional reduction of emissions, but no suggestions are offered in relation to the LULUCF sector, which is equally subordinate to climate policy.

The suggested mechanism is interesting but by no means easy to implement. The authors rightly point out the data challenges involved and the existing regulation overlap. I would like to add the need to focus on the system boundaries of the suggested trading scheme. Suppose construction companies minimise materials' emissions costs. This may not prove optimal for the use of energy and for the overall carbon footprint of construction. What if these choices lead to lower rates of insulation, higher use of energy and emissions and greater costs to the consumer, for example? Would this distort the climate efficiency of the overall system? I believe this is a more serious problem than the possible overlapping impact on the EU ETS. Moreover, for the planned regulation and the suggested mechanism, it is crucial to note that there is a considerable step from architecture and planning to practical implementation – where are the crucial decisions actually made, in the planning or in the construction phase? To demonstrate the benefits of the suggested trading scheme at a systemic level, and to examine in detail the information requirements, behavioural impact analyses and numerical assessment of the outcomes would be required. This exercise would be an invaluable way of demonstrating how promising this suggestion is.

## Electricity system

In an ideal well-functioning scenario, electricity markets would promote emerging and evolving production technologies. The authors note that individual countries' targets currently have a major impact on the direction electricity markets take. For example, Sweden and Finland have different targets for nuclear power: the former is closing plants, and the latter is increasing capacity. As a result, the way the electricity markets serve these targets also differs (nationally). The upshot is electricity price variations within a country (Sweden) or between countries (Finland vs Sweden and Norway). In contrast, the EU promotes single electricity markets, which should gradually lead to unified electricity prices. The authors conclude that integrated electricity markets are at a crossroads, where governments gravitate towards manipulating new investment decisions. It would have been interesting to see the authors' assessment of this current situation and the measures required to maintain and strengthen an integrated electricity market. Contrary to the previous section, should the EU impose common policy principles to prevent national subsidies, increased competition and divergence of electricity production within member states? The answer to this question remains open.

## Conclusions

The tension between EU policy and mandatory requirements for member states and national aspirations is clear and will continue to be in the future. The authors propose some interesting and well-defined solutions to overcome this discrepancy and ensure that advanced climate-ambitious countries can continue to promote national obligations and ambitions in a way that is coherent with EU policies and targets. In an exemplary fashion, the paper demonstrates the power of economic analysis in climate policy. It also shows how instrumental economics can be in analyses of just transition by assessing the impacts of climate policy in the transport sector on income distribution.

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Nordic Economic Policy Review 2023

# Climate policy and climate goals in Norway

**Rolf Golombek and Michael Hoel**

## Abstract

This paper examines the Norwegian policy to reduce emissions in the short term and the strategies proposed to promote technology switching and facilitate Norway's transition to a climate-neutral society by 2050. Relying on European tradable emissions permits and domestic emission taxation is not regarded as sufficient to meet the ambitious long-term target of becoming a low-carbon society by 2050.

The key policy recommendations from our analysis are: First of all, Norway should carefully reconsider the goals and policies in place aimed at sectors already covered by the EU ETS. Second, although subsidising electric vehicles has been a good policy in the past, the time may have come to gradually phase out these supports. Finally, establishing new 'green' industries in Norway should be based on sound economic principles.

**Keywords:** climate neutrality, EU ETS, green industries, CCS, hydrogen.

# 1. Introduction

Two features of the Norwegian economy set it apart from almost all other countries:

- a large offshore petroleum sector
- an electricity sector almost completely composed of renewables.

These two factors mean that the distribution of greenhouse gas emissions differs significantly from other countries, as shown in Table 1.

**Table 1** Norwegian greenhouse gas emissions. 2021

| Sector | ETS or non-ETS | Emissions (Mt $CO_2$ eq.) | Percent of total emissions | Percentage change in emissions, 1990-2021 |
|---|---|---|---|---|
| Petroleum extraction | ETS | 12.1 | 24.7 | 48.4 |
| Manufacturing and mining | Mostly ETS | 11.7 | 23.9 | -40.8 |
| Road traffic | Non-ETS | 8.7 | 17.8 | 17.1 |
| Other transportation | Mostly non ETS | 7.5 | 15.3 | 40.8 |
| Agriculture | Non-ETS | 4.6 | 9.4 | -4.7 |
| Energy supply* | Non-ETS | 1.7 | 3.5 | 405.6 |
| Heating of buildings | Non-ETS | 0.5 | 1.0 | -80.5 |
| Other | Mostly non ETS | 2.1 | 4.3 | -25.3 |
| **Total** | | **48.9** | **100** | **-4.7** |

*GHG emissions primarily from fossil-based heat production, and to a small extent also waste-based and bio-based electricity production.
Note: ETS stands for the Emission Trading System implemented in Europe
Source: Statistics Norway (2023a).

This table differs dramatically from similar one's for almost every other country in three respects:

- Norway has a big offshore petroleum sector with large emissions originating from the gas turbines on the platforms, which are used to generate electricity for extraction activities.

- There are virtually no emissions associated with electricity generation; Norway's electricity supply is based on 91% hydro and 8% wind power (in 2021); see Statistics Norway (2023b).
- Hardly any emissions are generated by the heating of Norwegian buildings, which is primarily done by electricity.

Offshore extraction of oil and natural gas, which is henceforth referred to as petroleum extraction, has been a key element in the Norwegian economy since the early 1970s and has played a major role in making Norway one of the richest countries in Europe, measured in per capita GDP. The industry's share of GDP was 21% in 2021, and preliminary national account figures suggest an even higher share (36%) in 2022 due to the extremely high prices for natural gas. (In the summer of 2022, daily gross income from sales of natural gas peaked at €1bn.)

In addition to its pivotal importance, the petroleum extraction sector is also a large purchaser of inputs from other sectors of the Norwegian economy. These inputs are partly for offshore investments but also for various types of intermediate inputs. Supplying and supporting offshore extraction involves both manufacturing and service industries. The impact and significance of offshore petroleum extraction for the rest of the Norwegian economy have been discussed in several articles in recent decades, see, e.g. Eika (1996), Cappelen et al. (2013) and Bjørnald and Thorsrud (2016).

Measured by area, Norway is the sixth biggest country in Europe, and the distance from South to North makes it one of the longest, too. There is a strong political preference for ensuring that a substantial portion of the population can live in rural/semi-rural districts. Transport – by vehicle, ship, train and plane – is, therefore, a key activity from a business and social point of view. While transport plays a key role in preserving thriving districts, road, sea, and air transport also emit substantial amounts of $CO_2$ (see Table 1).

Greenhouse gas emissions from agriculture consist mostly of methane and nitrous oxide from livestock and the use of fertilizers. While these emissions are important, we do not discuss them in this paper as the policies to reduce them differ greatly from those designed for other sectors.

Most countries have significant emissions from electricity generation and heating buildings. In many cases, cutting these emissions is less costly than cutting emissions from other sources. As noted above, this is not the case in Norway. Therefore, in order to reduce non-agricultural emissions, Norway must reduce emissions from the first four sources listed in Table 1.

This paper will discuss Norwegian climate policy in light of current and proposed strategies to radically reduce emissions in the four sectors and achieve a low-carbon society by 2050; the latter is defined as cutting emissions by at least 95% relative to 1990. We examine the Norwegian policy for cutting emissions in the short term from an economic perspective and some of the suggested initiatives aimed at achieving radical reductions in these sectors in the long term. As will become clear from the following, the guiding principle is to obtain a low-carbon society by promoting technology switching, in particular through carbon capture and storage, the electrification of petroleum extraction and the introduction of zero-emissions transport technologies.

Although Norway is part of the EU ETS—Table 1 shows that both the emission-intensive manufacturing sectors and extraction of petroleum are covered by this arrangement—relying solely on European tradable emissions permits and domestic emission taxation are regarded as insufficient measures if the ambitious long-term target of becoming a low-carbon society is to be achieved by 2050.

## 2. Theory

It is widely recognised among economists that a common price on carbon emissions, through either a carbon tax or a price for tradeable emission permits, is the most important policy instrument available to cut emissions. Standard economic reasoning also implies that in the absence of other market failures, an appropriately set carbon price is the only instrument necessary to achieve an efficient climate policy. In practice, however, most countries use a variety of other policy instruments in addition to an appropriate price for carbon emissions. These include explicit or implicit subsidies to carbon energy alternatives coupled with various forms of direct regulation.

There may be several reasons for using additional instruments, some good and some not so good. Among the good reasons are the following three:

- Distributional considerations may imply that the price of carbon is set too low.
- Governments are unable to commit to a future carbon price.
- Other externalities and market failures.

In practice, distributional concerns are important in all policy settings. Even if the government intends to fully recycle carbon tax revenues, the individual voter might focus purely on the visible tax increase and have little faith that carbon tax revenue will be used in a way that compensates him or her. Moreover, some people will be more adversely affected by a carbon tax than others. This will be the case for those consuming more than the average share of fossil fuels due to their current preferences or earlier investments (e.g., they may have acquired a large house and/or have a long commute). On the production side, some industries will bear a disproportionately high share of the total carbon tax cost. Consumers who use large amounts of fossil fuels, as well as workers and owners in high-emission sectors, may lobby against a carbon tax.

By contrast, sectors that generate renewable energy or inputs into this production will benefit from subsidies for renewables and may lobby for them. Another factor worth bearing in mind is that the costs of various types of subsidies and direct regulations are likely to be less visible to the typical voter.

These arguments suggest that it might be easier to obtain political support for a renewable's subsidy than for a carbon tax. As a consequence, the price of carbon may end up being set too low to achieve the emission goal(s) set by the government. Other policy instruments then have to be used as well.

For future carbon emissions to be strongly reduced, large investments in renewable energy and other low-carbon technologies are needed. Clearly, the profitability of such investments will depend strongly on the future price of carbon emissions. If the current government were able to commit to a carbon price far into the future, this would not be a problem. However, such a commitment is not feasible in practice, which suggests that decisions relating to investments in renewable energy and other low-carbon technologies must be based on market agents' expectations about future carbon prices.

If the current price of carbon is controversial (partly because of the distributional concerns mentioned above), market agents' expectations about future prices may be biased downwards compared to what current policy makers intend. If this is the case, the incentives to invest in low-carbon energy and technology will be too low, even if the current price of carbon is set at an appropriate level. This argument suggests that other policy instruments also need to be used to generate sufficient investment in low-carbon energy and technology.

Some support for the latter policy conclusion is found in the literature. Gaure et al. (2022) show that if there is a chance that the current carbon tax is set lower than the (true) social cost of carbon, then the current government should offer R&D subsidies to climate-friendly electricity technologies. However, subsidies should only be offered if these technologies compete with fossil-fuel-based technologies for new investments in production capacities. Ulph and Ulph (2013) also analyse a two-period model with a current and a future government setting climate change policies. In their study, the two governments assign different weights to environmental damages relative to net consumer benefit. The current government cannot commit the future government and thus may use an R&D subsidy to stimulate investment in abatement technology. According to the Ulph and Ulph study, even if market expectations of future carbon prices remain unbiased, the uncertainty about these future prices may weaken the incentives for investing in low-carbon energy and technology.

There may be other externalities and market failures in addition to climate change. Perhaps some of the most obvious are various market imperfections associated with the development of new technology. These are, of course, still relevant, independent of the climate issue. However, with economies rapidly transitioning from the use of fossil fuels, the introduction of new technologies is likely to be more important than ever. Hence, appropriate policies addressing externalities and other market failures related to these, for example, the patent system, will play an increasing role.

In addition to the market imperfections mentioned above, various types of co-ordination issues may also arise in (rapidly) transitioning economies. Here is an obvious example: No one will buy an electric car if they expect there will be no charging stations, and no one will invest in charging stations if they expect there will be no electric cars. It is not obvious that an unregulated marked will manage such types of coordination in an optimal manner, see e.g. Greaker and Midttømme (2016). Hence, there are reasons for policies, in addition to imposing a price on carbon, to address coordination issues.

To sum up: A price on carbon emissions at an appropriate level (relative to the emissions goal) should be a key element of any efficient climate policy. There are also positive grounds for various other forms of policies. However, this does not mean that the more policy instruments, the better. Each additional instrument should have a proper rationale. In Section 3, we discuss some of the Norwegian policies in light of these considerations.

# 3. Norwegian climate goals

The most important policy goal for Norway is its commitment to the Paris agreement: Norway's nationally determined contribution (NDC) is to reduce the country's emissions by 50–55% by 2030 compared with 1990, see Table 2.

Norway also has a threefold agreement with the EU. First, it is part of the EU ETS; this covers approximately half of the Norwegian emissions (see Table 1 for details). Second, domestic emissions in the non-ETS sectors should be reduced annually towards 2030. At present, the agreement with the EU requires Norway to gradually reduce emissions so that the non-ETS emissions in 2030 are 40% below their 2005 levels. There is some flexibility in this agreement: Norway can use the EU's Effort Sharing Regulation (ESR) to cut its emissions by less than the commitment as long as it buys additional emission reductions from other EU countries.

However, the EU has tightened its emissions requirements for 2030 as part of the European Green Deal to become climate neutral by 2050. To reach this long-term target, the EU has committed to cutting total emissions by at least 55% by 2030, partly by strengthening the EU ETS and by introducing emission trading arrangements for road transport and buildings. In light of the more ambitious EU emissions targets for 2030, Norway's agreement with the EU will probably be revised. In particular, the target for cuts in Norwegian non-ETS emissions may be raised significantly.

**Table 2** Norwegian climate goals and ambitions

| Overall goal or ambition | Details |
|---|---|
| Paris agreement | Reduce Norway's emissions by 50–55% by 2030, compared with 1990. Formally part of the EU/EEA-wide goal. |
| Agreement with EU | Participate in EU ETS;<br>Specific commitment for non-ETS emissions;<br>Specific commitment for LULUCF. |
| Norwegian Climate Change Act | Norwegian emissions required to be 50–55% lower by 2030 and 90–95% lower by 2050, both compared with 1990.<br>The Act explicitly allows for co-operation with the EU. |
| "Hurdalsplattformen":<br>Goal/ambition for Norway's *total* emissions | Reduce *total* emissions (non-ETS plus ETS) by 55% by 2030 (compared with 1990). |
| Various sectoral goals/ambitions | Examples:<br>All new cars should be emission-free by 2025;<br>Reduce offshore emissions (from extraction of oil and natural gas) by 50% from 2005 to 2030;<br>Oslo and several other municipalities have specific goals/ambitions. |

The third element of the agreement with the EU concerns Land Use, Land Use Change, and Forestry (LULUCF). Like policies on emissions from agriculture, LULUCF policies are noticeably different from others discussed in this article and so are not included here.

In addition to Norway's international commitments, Norway has a Climate Change Act. This law requires Norwegian emissions to be 50–55% lower by 2030 and 90–95% lower by 2050, both compared with 1990. The Act explicitly allows for co-operation with the EU. Hence, these goals are not directly linked to emissions from Norwegian territory since flexible mechanisms like the EU ETS or EU ESR can be used.

The above goals have been set by the Parliament, with broad cross-party support.

Moreover, they relate both to the Paris agreement and Norway's agreement with the EU and involve binding international commitments. It seems likely that these goals will, therefore, have a significant influence on future policies.

Norway also has various other climate-related goals. Since these are not international commitments, they might better be described as ambitions rather than goals.

First, the previous government presented the goal that all new private cars should be emissions-free by 2025. In 2022, 79% of all purchased new cars were electric (OFV, 2023). Second, in 2021 the Government laid out additional goals/ambitions in its policy platform "Hurdalsplattformen": Norway's *total* emissions (both non-ETS and ETS) should fall by 55% by 2030. This sounds highly ambitious: As Table 1 shows, total emissions decreased by 4.7% from 1990 to 2021 (whereas there have been radical changes in the composition of emissions across sources). In order for emissions to be 45% of the 1990 level by 2030, they must fall by almost 8% annually from 2021 to 2030.

The same policy platform also announced that various sector-specific emissions targets will be introduced. The Parliament has already set a goal for the offshore petroleum sector (which is part of the ETS): emissions should be reduced by 50% between 2005 and 2030.

In addition to goals set by central government, some cities and municipalities have defined their own climate goals. Oslo, for example, aims to cut emissions by 95% from 2009 levels by 2030. An obvious question is how seriously these aspirations should be taken: Oslo's actual emissions only fell by 26% during the eleven-year period 2009–2020, i.e., by an annual reduction of 2.7%, partly because of the nationwide ban on oil-fired heating systems. To reach the 2030 goal, emissions in Oslo would have to fall by an annual rate of 24% from 2020 to 2030.

# 4. Norwegian Climate Policies

Approximately 50% of Norwegian emissions are covered by the EU ETS, including the petroleum extraction sector and most of the emissions from manufacturing. With few exceptions, all non-ETS emissions are subject to the general carbon tax, which is NOK 952 (about €91) per ton of $CO_2$ as of 2023. Because the ETS price in December 2022 varied between €84–94 (Trading Economics, 2023), the price of carbon emissions for ETS sectors and the general tax for non-ETS sectors are roughly of the same magnitude. Note that the current Parliament has approved the previous government's plan to gradually raise the non-ETS price to NOK 2,000 (about €200) in 2030 (plus an adjustment for general inflation from 2020 to 2030).

On top of the ETS quota price, there is a Norwegian carbon tax on petroleum extraction (NOK 761) and domestic aviation (NOK 649). As a result, these two sectors have a much higher total carbon price than the rest of the Norwegian economy.

An important element of Norwegian climate policy has been subsidies for electric cars. Since 1955, Norway has imposed a relatively high tax on new car purchases. For regular cars, the total purchase tax (including VAT) is about 50%, while the standard VAT for other goods and services is 25%. Electric cars are completely exempt from VAT. Electric cars are also eligible for other benefits, such as reduced charges on toll roads, permission to drive on bus lanes, and reduced, or even no, parking fee in public areas.

Approximately 25% of Norway's total emissions come from extraction of petroleum. These emissions originate from the gas turbines on platforms, which are used to generate electricity for the extraction process. As mentioned previously, Norway aims to reduce these offshore emissions by 50% by 2030. The only way to achieve this (without reducing total oil and gas extraction) is to replace the electricity from the offshore gas turbines with (emission-free) electricity. Some electrification of this type is (marginally) profitable for the petroleum companies given the high price they must pay for their carbon emissions. However, to achieve the goal of a 50% cut in emissions, the government would have to impose electrification on the industry.

# 5. Goals and policies in light of EU policies

The EU ETS covers about 45% of EU's emissions. The basic idea behind quota systems of this type is that total emissions are regulated by the cap, and that the quota market gives a common price of emissions so that a cost-effective allocation of emissions is achieved within the cap. Any additional policy instruments directed towards emissions from sectors within the quota system gives a reallocation of emissions away from the most efficient allocation, and should hence be avoided. In light of this, the Norwegian $CO_2$ tax on offshore petroleum production and on domestic aviation is hard to justify. Likewise, it is difficult to find any good reason for the emission goals and electrification requirement for the offshore petroleum sector.

Under current EU policies, it makes sense for Norway to have a uniform domestic carbon tax on non-ETS emissions. Additional goals and policies related to specific parts of the non-ETS emissions are not so easy to justify. Consider, in particular, the subsidies related to electric cars: The cost of these is obviously difficult to calculate, partly because it is difficult to calculate the decline in carbon emissions due to the transition to electric cars. The national budget for 2020 (Ministry of Finance, 2019) has made some cost calculations, and all of these suggest that the cost-per-ton of $CO_2$ avoided exceeds €500. This is a very high cost both compared with the EU ETS quota price and the general carbon tax applied in non-ETS sectors. Even restricting oneself to the non-ETS sectors, this suggests that efficiency gains can be achieved by increasing the general $CO_2$ tax and reducing some of the benefits to electric cars.

On the other hand, altering the composition of the national car fleet will take considerable time, even under ideal conditions with a 'correct' price on carbon. Moreover, this transition may face other obstacles not captured by simple economic analyses. Examples can include the co-ordination problem associated with charging stations mentioned previously and other uncertainties and incomplete information facing buyers of new cars.

The Norwegian policies encouraging electric cars must also be viewed in the light of the EU's mandatory emission reduction targets for new cars. Like most EU regulations, the rules are quite complex. The short version of this regulation is that for *all new cars* sold in the EU/EEA, average emissions of $CO_2$ per km cannot exceed an upper limit. This regulation applies to the aggregate sale of new cars, including electric ones, so that if one seller exceeds the limit, it can purchase additional allowances from another seller that is below the limit. This system resembles a renewable portfolio standard; see, for example, Greaker et al. (2014).[21] To illustrate this, assume that the limit is 100g $CO_2$ per km and that all fossil-fuel-based cars emit 150g $CO_2$ per km. In order to reach the average limit of 100g $CO_2$ per km, one-third of all cars sold must, therefore, be zero-emissions vehicles (in practice, electric vehicles).

The current limit is 95g $CO_2$ per km for passenger cars. As long as this limit is binding, any additional policy promoting electric cars will have no effect on the emissions from the total fleet of new cars: The policy will simply make it easier for car manufacturers to satisfy the regulated average emissions per km. In other words, subsidising new electric cars will, in fact, be a subsidy for the whole fleet of new cars since the composition of new (emission-free) cars will be determined by the regulation. This relates to a general property of renewable portfolio standards, pointed out by, e.g. Greaker et al. (2014): A subsidy for renewable energy when a renewable portfolio standard is binding is a subsidy to *all* energy. As a direct

21. An example of a renewable portfolio standard is a requirement that a specific share of all electric energy should be renewable.

consequence, the use of dirty energy will also go up. Subsidising the purchase of electric cars may increase the total number of new cars but will also increase the number of cars running on fossil fuels. Although this effect may be weak, it illustrates that the effects of subsidizing electric cars are by no means obvious.

An important element of the EU's future climate policy is the introduction of a new quota system covering emissions from road transport and buildings. As with the current ETS, quotas will be tradable across countries, the total number of quotas will be regulated by a cap, and the cap will be adjusted through a market stability reserve (MSR).

For practical reasons, the upstream actors will be required to buy quotas, and it is expected that the EU-wide quota price will be passed on to the downstream actors. If the domestic carbon price faced by the downstream actors in road transport and buildings exceeds the equilibrium quota price, then that country does not need to take part in the new quota system. This may well prove to be the case for Norway, as the general carbon tax can easily exceed the quota price; the latter is expected to be below €45/t$CO_2$. If so, it is difficult to see why Norway should be part of the new quota system. If, however, Norway does decide to join, then the Norwegian policies of encouraging electric cars will be even more difficult to justify. Nevertheless, additional instruments may be justified by the reasons mentioned above.

# 6. The transition to a low-carbon society

## 6.1 Introduction

In Section 3, we outlined the Norwegian climate targets, in particular, the commitment to cut emissions by 90–95% by 2050 relative to 1990. Henceforth, this target will be referred to as the transition to a low-carbon economy. The current government has announced a policy platform that provides some guidelines on how to reach these goals, see Office of the Prime Minister (2021). The most important measures include:

- Imposing industry-specific and sector-specific climate targets; these should be developed in co-operation with the industries. Currently, one industry-specific target has been announced (petroleum extraction), see Section 3
- Electrifying petroleum extraction, see Section 3
- Developing a value chain for carbon capture and storage (CCS)

- Developing a value chain for hydrogen and reaching targets for (blue and green) hydrogen production
- Investing heavily in offshore wind power
- Developing a sustainable battery industry
- Continued participation in the EU ETS framework
- All sales of new passenger cars and light commercial vehicles should be emission-free by 2025.

Before we examine some of the policy measures listed above, see Sections 7–11, we provide a short discussion of how active the state may be in ensuring a green transition.

## 6.2 The role of the state

Transition towards a low-carbon economy requires the phasing out of emissions and dirty technologies in some sectors and their replacement by climate-friendly technologies and green economic activities. Because the latter technologies and activities will have a long lifetime, it is vital to avoid serious mistakes. Therefore, a key question is whether the government should design a general policy package that provides industry-neutral incentives to invest in climate-friendly activities or actively invest in specific industries, i.e., pick a set of future climate-friendly industries and technologies expected to become successful and invest in these.

In standard economic theory, the economy is referred to as imperfect if there are various market failures, such as positive or negative externalities, natural monopoly, and other cases of imperfect competition. Typically, it is assumed that each market failure is corrected by separate targeted policies and that economic actors therefore internalise social costs and benefits. The role of the state is largely to correct these well-defined market failures and to ensure that property rights are respected. We refer to this as the *neoclassical* state.

An alternative view is that radical social change, like the green transition, requires a *proactive* state. The role of the state is in this case to facilitate the transition by co-ordinating various policy measures across sectors; across private actors with diverging interests; and across government bodies, each being responsible for a distinct policy field such as technology development or industry and employment, see Mazzucato (2021). According to Mazzucato (2021), 'missions' should be designed to organise and assist major social changes, like the green transition, and they should ideally have the following properties:

i. Be bold and address societal values.

ii. Specify concrete targets: you should know when you get there!

iii. Involve research and innovation to ensure technological readiness over a limited time frame.

iv. Be cross-sectoral, cross-actor, and cross-disciplinary.

v. Cover multiple competing technological solutions supplemented by rules to stop funding of R&D in technologies that do not show sufficient improvement.

It is beyond the scope of the current paper to discuss and compare these two alternative approaches. Clearly, the neoclassical state approach relies heavily on the creative nature of individuals, whereas the proactive state relies heavily on well-informed and benevolent politicians and bureaucrats. Needless to say, both are open to criticism. The policy platform of the current government (see above) is a mix of the neoclassical and the proactive state, but as a rule of thumb, priority is given to non-neutral incentives, i.e., a proactive state is called for. As a consequence, there are several sector-specific policies which we will examine in detail in the next sections.

# 7. Sector-specific policies: I Petroleum extraction

## 7.1 Introduction

Norway is a major supplier of oil and natural gas; in 2021, the country was the 11$^{th}$ largest global supplier of crude oil, see Wiki (2023a), and the 7$^{th}$ largest global supplier of natural gas, see Wiki (2023b). Most of the Norwegian natural gas is exported to the European market. While Russia has for decades been the largest supplier of natural gas to Europe, this ranking changed in 2022 because of radical reductions in Russian gas exports following the invasion of Ukraine. As a result, Norway became the largest natural gas exporter to Europe in 2022.

In Norway, emissions from the extraction of petroleum increased by around 50% in the 1990s, but later emissions have been relatively stable, with a small decrease in recent years. As seen in Table 1, emissions from the extraction of petroleum amounted to 25% of total Norwegian emissions in 2021.

### 7.2 Strategy: future offshore activities

Current emissions from the extraction of petroleum are not exactly in line with a transition to a low-carbon economy. Therefore, the government has announced that these emissions must fall by 50% by 2030 and reach net zero by 2050, primarily through electrification using emission-free electricity, e.g., offshore wind power, see Office of the Prime Minister (2021). According to this policy platform, the aggregate level of offshore activity should be stable over time, but new types of activities like (i) a value chain for CCS; (ii) a value chain for hydrogen; (iii) offshore wind power; and (iv) other offshore non-petroleum activities will be phased in. This strategy reflects that demand for petroleum may fall significantly over the next 30 years: According to WEO (2021), global demand for oil in the "sustainable development" scenario will be 50% lower in 2050 than in 2020 (p. 315), whereas demand for natural gas in Europe will be 80% lower in 2050 than in 2020 (under the same scenario). With lower petroleum-related activities, new offshore activities will have to be phased in to meet the target of retaining the current level of offshore activity.

# 8. Sector-specific policies: II CCS

### 8.1 Introduction

While prominent international organisations like the IEA and the IPCC have argued that Carbon Capture and Storage (CCS) is pivotal in ensuring a cost-efficient solution to the climate change problem, there is, to date, no market for carbon storage.

The Norwegian involvement in CCS dates back to 1996 when $CO_2$ emitted from the extraction of natural gas was captured and stored in order to increase pressure in the gas reservoirs. In 2007 the government launched the so-called "moon-landing project": to build a gas power plant fully integrated with facilities to capture $CO_2$. This project was intended as a game changer for the European gas industry: with environmentally friendly gas power, Norway could sell more natural gas, which in turn would generate more income without causing a rise in total emissions of $CO_2$.

The project was not the overwhelming success expected and was cancelled seven years later. In addition, because of a low ETS price (albeit only until the end of 2021), there has been little interest in CCS in the European electricity industry. Also, with radical cost decreases and various support mechanisms for renewable electricity (onshore wind power and solar PV), investment in solar and wind has proven more attractive than establishing fossil-fuel-based power plants with integrated carbon capture facilities.

## 8.2 Strategy: How to establish a CCS value chain?

There is, as of yet, no commercial market for CCS. This may partly reflect a standard co-ordination problem: anybody considering constructing a carbon storage site may not be willing to invest before being confident that there are enough clients with captured carbon who will demand storage services. Likewise, anybody considering investing in carbon capture facilities may not be willing to invest before being confident that reliable transport and storage facilities for the captured carbon will be available.

Typically, there are three possible outcomes in a coordination game: (i) no investment; (ii) moderate investment; and (iii) heavy investment, see, e.g., Farrell and Saloner (1986) and Greaker and Midttømme (2016). Golombek et al. (2022) study the coordination game of establishing a CCS value chain. Their study focuses on plants (with $CO_2$ emissions) considering investment in capture facilities and terminals considering investment in facilities to transport the captured $CO_2$ to a storage site. The government has a role in ensuring that substantial investments are undertaken, in addition to correcting for market imperfections, such as abuse of the market power of terminals, which are local monopolists.

A key insight from Golombek et al. (2022) is that integration of terminals and storage facilities is socially beneficial; it gives these actors the correct incentives to invest. However, as long as plants considering to invest in capture facilities tend to invest too little, and there are additional market imperfections, there still is an important role for policy: through a suitable package of instruments, the government can ensure that the first-best social outcome can be reached.

## 8.3 The Longship project

In 2020, the Norwegian government approved the Langskip project (Longship, named after Viking sea-going vessels) which is a government commitment to develop a value chain for CCS, see Norwegian Ministry of Petroleum and Energy (2020a); investment in carbon transport and storage will be funded primarily by the government and not private equity. Interestingly, in line with the conclusions of Golombek et al. (2022), in Longship, terminal and storage facilities are integrated into one single actor. Initially, the project is intended for Norwegian industries that lack cheap options for cutting emissions, e.g., cement or hydrogen production based on Norwegian natural gas.

Longship has two principal components. The first, which is referred to as the Northern Lights project, relates to a terminal on the Western coast of Norway and a pipeline from the terminal to an offshore storage site. In the first phase of the Northern Lights project, the annual $CO_2$ terminal capacity and the annual injection capacity to the storage is 1.5 Mt $CO_2$ (in 2021, total GHG emissions in Norway amounted to 49 Mt $CO_2$ equivalents, see Table 1). If phase one, which is mainly state-funded, proves successful, i.e., full utilization of the storage capacity is reached, a second phase will be initiated. In this phase, the capacities can be expanded to 5 Mt of $CO_2$. However, no government funding will be made available. Again, if successful, the capacities can be expanded further: Equinor (formerly Statoil) has detailed scenarios for 20 Mt and even up to 100 Mt of carbon storage on the Norwegian Continental Shelf. It is envisaged that the majority of clients will be foreign manufacturing firms that have invested in carbon capture facilities (Equinor, 2019). According to Andersen (2022), seven countries have already negotiated access to the Northern Lights' storage facilities in 2022.

The second component of Longship is government-funded investment in carbon capture facilities at a cement plant in Norway (Mongstad) and a commitment to fund carbon capture facilities at a factory transforming non-recyclable waste to energy in Oslo. The captured $CO_2$ will be transported by ship to the terminal in the west of Norway.

## 8.4 The future of CCS in Norway

There are ten existing or planned carbon capture and utilisation projects in Norway; see Engh (2021). However, none of these covers emission-intensive carbon industries such as alumina, ferroalloys or iron and steel. In these industries, only a proportion of total emissions can be captured with the current production technology, see Prosess21 (2020). According to this report, if plants in these industries want to invest in carbon capture facilities, most of them would have to change their technology. The potential of CCS in Norwegian manufacturing is around 1.7 $MtCO_2$ in 2030, see Norwegian Environment Agency (2022).

As there currently is no commercial market for captured carbon, Longship has the potential to become a game changer for CCS in Europe. However, there are challenges with respect to both demand and supply of storage services. First, even though there will be a carbon storage unit off the Norwegian coast, plants may still be reluctant to invest in capture facilities: for years, the ETS price was below €20/$tCO_2$, and thus investment would not be profitable. However, since November 2021, the ETS price has roughly fluctuated around €80/tCO2, which may be close to making carbon capture investment profitable. Also, the extent to which governments in Europe will provide incentives, regulations and legal requirements that stimulate investment in carbon capture facilities depends on public and political acceptance of storage of $CO_2$.

On the supply side, Norway may see increased competition, as Scotland, the Netherlands and Denmark also plan to develop carbon storage sites. All of these sites have high fixed costs and need to attract customers to be profitable. Competition may emerge between storage suppliers, although different geographical locations may hamper competition to some degree. On the other hand, the location effect may not be so strong because captured $CO_2$ is primarily transported by ship, not in pipelines, to a terminal or directly to the storage site. As ships are a flexible transport solution, more competitors in the field may lower the market price for storage services overall. On the other hand, more competitors may raise total R&D costs and some of the knowledge generated may spill over to the competitors, thereby lowering future costs of investment in storage facilities.

# 9. Sector-specific policies: III Hydrogen

## 9.1 Introduction

In addition to removing carbon from industrial processes, such as cement production, a carbon storage site may be a crucial element in establishing a Norwegian value chain for hydrogen based on natural gas. In the literature, production of hydrogen based on natural gas is referred to as "blue" hydrogen if the $CO_2$ has been removed and is stored. In contrast, hydrogen production based on natural gas (or coal) without carbon removal is referred to as "grey". A third category is "green" hydrogen. Here, renewable electricity is used to produce hydrogen through the electrolysis of water. For the hydrogen consumer, the colour, i.e., the environmental footprint of each "type" of hydrogen, may possibly be of little interest, as it has no impact on the quality of the end product.

Currently, hydrogen is a marginal energy carrier in Europe. Its share of the European energy mix is less than 2%. Hydrogen is mainly used by refineries and by the chemical industry to produce ammonia. Yet, hydrogen has great potential, both in the EU, see European Commission (2020a) and in Norway, see Norwegian Ministry of Petroleum and Energy (2020b). In the manufacturing industries, it can be used to produce methanol and metals, for example, alumina and steel. In transport, it can be used for heavy-duty road vehicles, to power maritime transport, and perhaps even for aviation in the long term. In the building sector, hydrogen can replace natural gas for heating and cooking. In the electricity sector, hydrogen can be used to store energy.

## 9.2 The first challenge of hydrogen

Hydrogen faces two main challenges. First, it is expensive. Even grey hydrogen, which is the cheapest type, is expensive, partly because of high energy loss factors, see IRENA (2020). According to European Commission (2020b), the cost of blue hydrogen is about one-third higher than the cost of grey hydrogen prior to paying for carbon emissions. For green hydrogen, the corresponding number is, according to European Commission (2020b), at least two, maybe even higher than three.

Note that these cost ratios are based on the price of natural gas just prior to 2020. The price of natural gas in Europe has fluctuated extremely since 2019. It reached a minimum price level in the summer of 2020, then started to increase slowly, and has skyrocketed since summer 2021: The price in August 2022, six months after the Russian invasion of Ukraine, was more than four times higher than 12 months previously. However, the price of electricity in Europe has also increased significantly since the summer of 2021, reflecting the high price of natural gas.

To be more specific, according to DNV GL (2019), if the price of *natural gas* is €22/MWh, then the cost of blue hydrogen is €1.5/kg $H_2$. In September 2022, the average price of natural gas was, however, much higher (around €200/MWh), which implies a cost of blue hydrogen at approximately €7/kg $H_2$. In comparison with green hydrogen: it costs approximately €5/kg $H_2$ if the price of *electricity* is €67/MWh; see DNV GL (2019). Again, in September 2022, the price of electricity was significantly higher than €67/MWh but varied across countries and sectors. If the price of electricity is €120/MWh, then the cost of green hydrogen is €7/kg $H_2$, i.e., equal to the cost estimate of blue hydrogen in September 2022.

At least in Norway, and probably in most European countries, the price of electricity in September 2022 was higher than €120/MWh for plants paying the market price, i.e., units not having a long-run, fixed-price contract. This suggests that blue hydrogen was cheaper than green hydrogen in September 2022.

The all-time high price of natural gas in the summer of 2022 will undoubtedly represent a temporary phenomenon. According to WEO (2021), in a scenario with net zero global carbon emissions by 2050, the price of natural gas in the European Union in 2050 will be slightly lower than in 2020 (p. 101), whereas in another scenario where "all climate commitments made by governments around the world [...] will be met in full and on time" the price of natural gas in Europe in 2050 will be around 50% higher than in 2020. These predictions suggest that blue hydrogen may yet be competitive in the long run.

## 9.3 The second challenge of hydrogen

The second challenge facing hydrogen is that there is no significant commercial market for it in Europe. To encourage a radical increase in the take-up of hydrogen, a transport infrastructure is needed, for example, by utilising parts of the existing gas transmission and distribution grids and/or by developing a hydrogen transmission network. This points to the double co-ordination problem faced by a potential blue hydrogen producer: Before investing in facilities, the potential producer must believe that there will be a storage site for the captured carbon and that there will be demand for their product. The latter requires investment in facilities designed for the transport and use of hydrogen. For a Norwegian blue hydrogen producer, the first co-ordination problem was removed when the Norwegian government launched the Northern Lights project.

## 9.4 Strategy: business models for hydrogen

In general, the development of a value chain for hydrogen requires suitable business models that address risk-sharing between key actors. The government, or the EU, could offer risk-sharing schemes to ensure socially correct investment incentives for private stakeholders, i.e., provide incentives that sustain socially warranted investment in the various links of a value chain. Longship provides an example of risk sharing; the government shoulders most of the risk as the value chain is developed, whereas private companies assume all of the risk in investment in transport and storage facilities if the (initial) value chain is expanded.

Without any involvement from the government, an investor in a capture facility saves an amount equal to the captured $CO_2$ times an uncertain future $CO_2$ price. If the government wants to reduce the uncertainty for private stakeholders, a possible business model could include the government guaranteeing a minimum price for all captured carbon: If the future price of carbon turns out to be lower than the minimum price, the investor obtains a transfer from the government equal to the difference between the minimum price and the future price (for each unit of captured carbon). As a result, the investor has actually saved an amount of money equal to the minimum price multiplied by the amount of captured carbon. If the future carbon price exceeds the minimum price, no transfer is received from the government.

# 10. Sector-specific policies: IV Offshore wind power

## 10.1 Introduction

Norwegian electricity supply has always been characterized by a large market share of hydropower; production consists mainly of reservoir hydro stations, but there are also pumped-storage hydro and run-of-river hydro plants.

A few onshore gas-fired power stations have been set up in the past, but one has already been dismantled, and the others are not currently online. However, over the last 20 years, there has been a steady stream of investment in onshore wind power; this technology accounted for 8% of total Norwegian electricity supply in 2021. In addition, the government recently approved offshore wind power developments in designated areas. Over time, offshore wind power supply may—in order to electrify the offshore petroleum sector—replace the small offshore gas-power plants that currently serve the extraction industry. Offshore wind power will also meet conventional electricity demand, both domestically and abroad.

## 10.2 Will investment in offshore wind power in Norway be profitable?

To assess whether Norway should develop offshore wind parks, we draw on Gaure and Golombek (2022a), which studies the future composition of a fully decarbonised European electricity generation sector. To this end, they minimise the total costs of investment and production of electricity plus costs of investing in storage capacity (batteries) subject to the assumption that the only available electricity generating technologies are onshore wind power, offshore wind power and solar. As they are interested in the long-term characteristics of a completely carbon-free electricity system, they impose the condition that all capacity be built from scratch.

Using spatial, hourly data for 23 European countries over ten years (2006-15), Gaure and Golombek (2022a) find that the cost-efficient capacity share of offshore wind power is approximately 20%. Due to Norway's advantageous offshore wind conditions, it is optimal that 20% of desired European offshore capacity is installed in Norway, i.e., 4% of total capacity.

## 10.3 Strategy: Does Norway enjoy a comparative advantage in offshore wind power?

In Gaure and Golombek (2022a), it is assumed that the cost of investment does not differ from country to country. However, because of competences gained from offshore petroleum extraction as well as the efficient supply chains serving that industry, Norway may have a competitive advantage in deep-water offshore wind power production, see Greaker et al., (2019). This strengthens the case for developing an offshore wind power industry in Norway. In particular, by becoming an early mover, Norwegian supply chains could, through learning by doing in the home market, become sufficiently competitive also to serve the same industry abroad.

On the other hand, the current cost of offshore wind power production is relatively high and far above the cost level that would make investment profitable if the price of electricity continues in the range observed between 2010 and 2020 (i.e., significantly less than 100 €/MWh). R&D and increased industrial know-how are likely to create a significant cost reduction over time; this may suggest that Norway should not be over eager to invest today but wait and learn from developments in other countries. But how long should Norway wait? If future long-term electricity prices in Europe remain relatively close to those seen in the spring/summer of 2022, i.e., after the Russian invasion of Ukraine and the radical drop in Russian gas supply to Europe, investment in offshore wind power will surely be profitable. However, due to radical structural changes in the electricity markets, future electricity prices remain uncertain; WEO (2021) provides no predictions.

# 11. Sector-specific policies: V Batteries

## 11.1 Introduction

Demand for batteries for electric appliances such as smartphones and PCs has risen radically in recent decades and may continue to do so. Furthermore, with more electrification in order to cut emissions of greenhouse gases, demand for batteries used in the electricity sector will increase.

## 11.2 Intermittent power and batteries

The EU aims to decarbonise electricity supply by 2050, see European Commission (2018). This will require a higher share of intermittent power, primarily from solar and wind power. Electricity supply from these technologies depends on installed capacity and the weather (in particular, solar irradiance and wind speed). In order to ensure that total electricity generation always equals the load—the system will physically break down if this is not the case—some type of flexibility is required.

One possible source of flexibility is electric batteries: in periods where total supply exceeds the load, the difference can be charged into batteries. Similarly, in periods where the load exceeds supply, electricity can be discharged from the battery. As such, a key question is: how much energy storage capacity is needed for a decarbonised European electricity market?

Gaure and Golombek (2022a) calculate the cost-efficient investment in electricity-generating technologies and batteries (to store energy) for 23 European countries, see above. They find that the optimal size of the battery corresponds to 16 average hours of consumption of electricity (5.6 TWh). However, if the technology also includes bio-CCS power (in addition to solar and wind), the optimal battery size amounts to less than one average hour of consumption.

In the Gaure and Golombek (2022a) study, gross production is far above consumption. In fact, 42% of gross production has to be curtailed, i.e., the production facilities are temporarily disconnected from the grid. Alternatively, this amount of electricity is used in other sectors or exported. Economists see curtailment as part of an optimal solution. For others, including politicians, however, it is often regarded as a waste of resources and not socially acceptable.

To illustrate the implications of not allowing for curtailment, Gaure and Golombek (2022b) use their model to study an electricity system where the *total* intermittent production in the planning period (2006-15) equals total consumption in the same period, i.e. there is no curtailment. As in Gaure and Golombek (2022a), the electricity system is based on onshore power, offshore power, solar PV, electric batteries and bio-CCS. The battery strategy is as follows: in hours when intermittent production exceeds load, the battery is charged, whereas it is discharged in hours when load exceeds intermittent production. The bio-power technology is used only if intermittent supply is lower than load and the battery is flat, i.e., bio-power is 'plan B'.

Minimising the energy battery capacity and using the same data set as in Gaure and Golombek (2022a), Gaure and Golombek (2022b) find that the optimal battery size corresponds to 15 days of average consumption (123 TWh), which is 22 times higher than in Gaure and Golombek (2022a).

To sum up, if curtailment is socially acceptable in a decarbonised European electricity market, the need for storage capacity becomes rather limited. If, however, curtailment is not allowed, the need for storage becomes much higher. If the entire demand for energy storage is serviced by batteries (not by other technologies, like reservoir hydro and hydrogen), how great is the demand for batteries in the two cases studied above?

In both Gaure and Golombek (2022a) and Gaure and Golombek (2022b), it is assumed that the lifespan of batteries is ten years, that a battery can be recharged

1,000 times, and that the price of batteries (in 2030) will be €150/kWh, see Bogdanov et al. (2019). If curtailment is socially acceptable, see Gaure and Golombek (2022a), then under these assumptions, annual gross income from battery production equals €84bn. This corresponds to the value of vehicles purchased by German households in 2020; see OECD (2022).

By contrast, if curtailment is not socially acceptable, see Gaure and Golombek (2022b), annual gross income of battery production equals €1,845bn, which is roughly 10% higher than total final consumption of households in Germany in 2020, see OECD (2022). This number (€1,845bn) is so high that the EU clearly has an incentive to find an alternative solution for the electricity generation sector.

### 11.3 Does Norway have a comparative advantage in battery production?

Batteries are heterogeneous products that may differ in size, loss factors and other technical characteristics. Still, batteries from one producer can easily be replaced by batteries from another. Hence, battery price, adjusted for technical elements like loss rates, is the key factor in capturing market shares. There is hardly any brand preference for batteries with respect to design nor any network externalities that might lock in customers. This suggests that there is probably not any first-mover advantage to be gained from producing batteries.

Countries with a competitive advantage in battery production, because of, for example, technical competence in related fields, should develop a battery industry. However, we are not aware of the existence of this type of competence in Norway. Establishing a competitive advantage in the short term is not simple: if the government sustains a low price for electricity to a private battery producer, e.g. via subsidies, this does not represent a comparative advantage from a national perspective, although the private battery producer may indeed make substantial profits.

## 12. Policy recommendations and concluding remarks

We conclude our discussion of Norwegian climate policies by listing the policy implications of our analysis.

- Norway should carefully re-evaluate its goals and policies for sectors already covered by the EU ETS: Such goals and policies tend to undermine the whole idea behind the ETS, namely setting a cap on total emissions covered by the ETS and let the market find the most cost-effective way to achieve the target.
- In particular, it seems difficult to justify the explicit goal for emissions from the offshore petroleum sector, which is covered by the ETS. This goal will only be possible to achieve with electrification that is unprofitable even with the high carbon price facing this sector.
- Although generous subsidies for electric vehicles may previously have been a good policy, perhaps the time has come to phase them out. The introduction of a new EU-wide quota system for transportation, and the strengthening of the EU mandatory emission reduction targets for new cars, are additional reasons for phasing out Norwegian subsidies to electric vehicles.
- Scaling up new "green" industries in Norway should be based on sound economic principles. In particular, it is important to avoid subsidising electricity provision to these new industries unless such subsidies can be fully justified.
- Similarly, battery production in Norway should only be considered if it can be proven that it will be profitable without state subsidies.
- The Longship project, which is mainly funded by the Norwegian government, is crucial to establishing a value chain for carbon capture and storage in Norway and may provide the foundation for a European carbon storage industry. However, the introduction of additional and expanded storage facilities in Norway should be funded solely by private equity.

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# Comment on R. Golombek & M. Hoel: Climate policy and climate goals in Norway

**Taran Fæhn**

This comment refers to an initial draft of the article published for the peer review conference in November, 2022.

## 1. Introduction

This review responds to the paper by Rolf Golombek and Michael Hoel with the title "Climate policy and climate goals in Norway" presented at the Nordic Economic Policy Review Conference in Oslo on 26 October 2022. It sums up the main points of my discussion of the paper at the conference. As the intention behind involving discussants and reviewers is to encourage improvements of the original manuscripts, the final published article in this journal will expectedly have been revised. This review nevertheless offers some perspectives on Norway's climate policies that may have broader relevance and interest.

Golombek and Hoel's paper examines the Norwegian government's short-term policies to reduce emissions as well as its long-term strategies to cut emissions radically. The authors restrict their discussion to three key sectors that currently account for significant shares of Norwegian greenhouse gas emissions: manufacturing industries (24%), petroleum extraction (25%) and transport (33%). The paper starts by providing an overview of the complex Norwegian climate policy goals, instruments and strategies in the context of the country's energy and emissions situation. They highlight the following policy implications: (i) Norway should carefully reconsider its goals and policies in sectors already covered by the

EU emission trading system (ETS), (ii) carbon pricing in the non-ETS sectors should be uniform across all emission sources and (iii) establishing and expanding new "green" industries in Norway should be based on sound economic principles.

Although it is easy to concur with these conclusions on a more general level, it is not always exactly clear on what grounds they are reached. What, for instance, are sound economic principles? Indeed, ahead of their conclusions, the authors provide an economic theory section. Unfortunately, it is not sufficiently illuminating due to its generic form. The normative arguments would have been more useful if, instead, they were related directly to the discussions of the Norwegian policy instruments and strategies in the subsequent sections.

I have three suggestions that I think might tease out a closer connection between conclusions and arguments. The first concerns the status of different climate policy goals, the second and third seek to add nuance to Golombek and Hoel's presentation of some implemented and potential policy instruments for achieving the short-term 2030 targets and the long-term 2050 targets, respectively.

## 2. The different status of climate policy goals

By making a clear distinction between Norway's climate *commitments*, on the one hand, and the additional *ambitions* set by the government on the other, it would be easier to draw policy implications from the normative conclusions in the paper. My reasoning is that commitments must be regarded as binding, while self-imposed ambitions can more easily be adjusted in response to normative findings. Norway's commitments are established by law in the Norwegian Climate Change Act and in international agreements. The Act quantifies the maximum greenhouse gas emissions permissible by 2030 and 2050, respectively. The 2030 target was also pledged in the Paris Agreement. Moreover, an agreement with the EU (and Iceland) splits the 2030 commitments into one for emission sources covered by the EU ETS and one for sources outside the Emission Trading System (ETS). These are currently under renegotiation to accord with the overall EU targets and the updated Norwegian Paris Agreement pledge.

Golombek and Hoel treat the net-zero ambition in 2050 as a commitment. It is not: The obligation in the Act is to become a low-emission society, quantified as a 90–95% cut from the 1990 level. The cost of moving from a 90% to a 100% cut is probably very high.

Golombek and Hoel advise that some sector-specific goals should be reconsidered, including the *transformation* goal that aims to cut all Norwegian ETS-covered emissions within its own borders and not purchase emission allowances under the EU ETS. These are, however, only ambitions and can be revisited at a later date. Another ambition that could be reconsidered, but that Golombek and Hoel do not mention, is the *climate-neutrality* goal for 2030. It would be interesting to see a discussion of how it relates to the long-term low-emission commitment, let alone the net-zero ambition for 2050.

Golombek and Hoel choose to omit a discussion of the third, and probably most difficult, commitment in the EU agreement: on the net emissions from the land use, land use change and forestry (LULUCF) sector. The EU as a whole has decided to increase the overall LULUCF goal for 2030 from a previous net zero target to a net *uptake* of 310 million tonnes of $CO_2$-equivalents. The resulting commitments for each member state, as well as their access to flexibility mechanisms, are still not clear. However, this bolstering of the goal, along with several technical adjustments, has undoubtedly increased Norway's LULUCF challenges considerably. It will require significant reductions in land use emissions and represents a potential area of conflict with several other climate-motivated needs for energy infrastructures and installations, bioenergy production and agricultural measures.

# 3. Available policy instruments towards 2030

The agreement with the EU allows for several flexibility mechanisms intended to increase the cost-effectiveness of climate policies. There is, however, one severe restriction: Norway is obliged to refrain from using credit markets outside the EU. This also applies to arrangements within the UNFCCC framework, like those under the auspices of Article 6 in the Paris Agreement as well as the Clean Development Mechanism. Golombek and Hoel misinterpret the acquisition of carbon offsets from countries/agents outside Europe being used to fulfil international commitments.

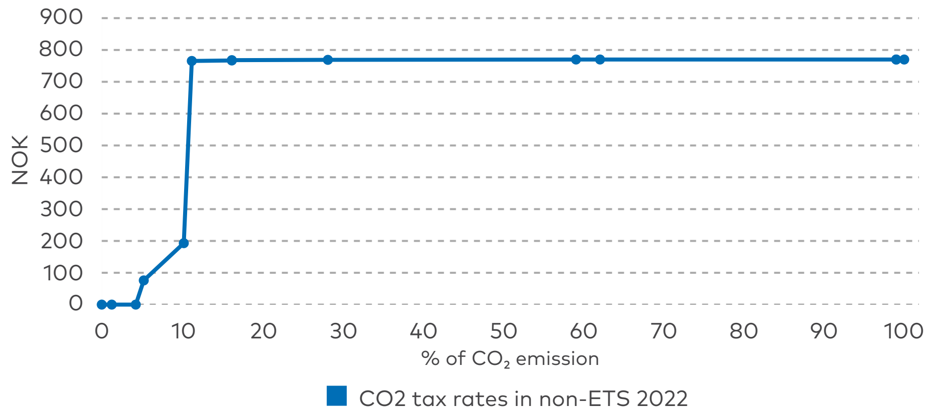
On the other hand, the EU agreement provides several new instruments. Golombek and Hoel judge a couple of the EU *fit-for-55* by 2030 initiatives as promising: The Carbon Border Adjustment Mechanism (CBAM) and the new, separate ETS for buildings and transportation are examples. Recently, details of these reforms have been agreed.

In the period 2026–2034, CBAM will gradually replace current measures against carbon leakage, the free allocation of ETS allowances and the national aid compensating for allowance costs passed on in electricity prices. This package is welcomed by Golombek and Hoel. The literature states that an ideal carbon border adjustment system would normally outperform the current system (Hoel, 1996; Fischer & Fox, 2012; Böhringer et al., 2017). However, it is important to note that the EU CBAM is not quite as recommendable in its current form. There are two main reasons: It only applies to the import side and only to direct emissions. On the export side, to the extent that the EU ETS-covered firms compete against non-regulated suppliers on other world markets, they still face the relative disadvantage of paying the ETS price. Regarding indirect emissions, no arrangement has yet been agreed for to replace the current aid designed to compensate for indirect electricity price impacts of the EU ETS. Consequently, it may make more sense for Norwegian companies to argue against the CBAM reform than Golombek and Hoel acknowledge.

As a means of reducing efficiency losses currently originating from the large variation of marginal abatement costs across borders, Golombek and Hoel's expectations for the new buildings and transportation ETS seem unreasonably high. In fact, its design is not intended to work in the same way as the current ETS under which Norway can, for instance, conveniently choose to substitute costly domestic abatement by purchasing relatively affordable allowances. Buildings and transportation are still subject to the non-ETS commitment that will be the binding target. Thus, buying allowances under the new ETS will not reduce the obligation to mitigate greenhouse gas emissions from non-ETS sources on Norwegian territory. Rather, the price established in the new ETS will work as a minimum, EU-wide tax on these emissions. This price is expected to be relatively low and has little impact on the already highly taxed fossil fuel prices in Norway.

This brings me to another claim by Golombek and Hoel that warrants discussion. They are concerned about the significant carbon price variation across the non-ETS sectors, implying an inefficient allocation of emissions. They explain this variation by "sectors being exempted from taxation and sectors being exposed to additional taxation." As a matter of fact, recent state budgets have made considerable progress toward levelling up carbon tax rates across non-ETS sectors, as seen in Figure 1.

**Figure 1** $CO_2$ tax rates in Norwegian non-ETS sectors, 2022




Roughly 90% of the $CO_2$-emissions had the general full rate of NOK 766 /t in 2022. Moreover, several non-$CO_2$ greenhouse gas sources also face this tax rate. It is nevertheless true that other taxes apply to some of the emission sources, but these are motivated by considerations other than mitigating climate change. In particular, market intervention against the local environmental impacts of transport activities can explain the highest effective tax rates imposed on households reported by Golombek and Hoel. In general, since externalities associated with economic activities differ, it is far from obvious that sizable efficiency gains can be achieved by making the total effective rates uniform.

## 4. What are sound policy strategies towards 2050?

Golombek and Hoel's extensive discussion of Norway's long-term prospects for radical reductions in emissions reveals many interesting details relating to emerging green markets and technologies. The authors offer impressive insight and convincingly substantiate some of the future comparative advantages of the Norwegian economy.

The main conclusion from this section is that new green industries' expansion in Norway towards 2050 should be based on sound economic principles. Partly due to the structure of the paper, it is not always easy to distinguish between description and advice: nor is it clear what constitutes sound economic principles, nor grasp whether, in this context, *Norway* refers to the central government. It is also unclear whether an intervening state should go beyond carbon pricing. The theory section introduces the following reasons for using a more ample toolbox than carbon pricing alone: Distributional considerations, commitment problems, knowledge spillovers and co-ordination problems. A key question is posed: Should policies generate industry-neutral incentives or actively promote specific investments and industries, i.e., pick winners? However, neither the answer nor the arguments provided are clearly laid out.

A closer reading brings the following arguments to the surface: CCS and hydrogen production are examples of technological fields suffering from co-ordination challenges that can legitimise state involvement beyond just carbon pricing. The justification for subsidising electricity as a source in new green industries, including offshore wind power and batteries for storage, is less obvious in their view.

Golombek and Hoel's reflections on long-term climate policies address electrification, power generation and hydrogen production. These foci are natural given their expertise and the direction set by government through formulating its transformation ambition in terms of domestic abatement of the emissions covered by the EU ETS.

I would like to have seen a discussion of two other areas of technological development that are expected to play crucial roles in the net-zero transformation of the Norwegian, European and global economies: The circular economy and carbon dioxide removal. Establishing a circular industry will call for co-operation and co-ordination across and beyond existing value chains, innovation of products, processes and organisations and a local focus. Economic thinking is essential, and Norwegian public and private initiatives are, so far, lagging behind. Carbon dioxide removal measures span from well-known LULUCF-associated low-tech practices to intensely science-based, immature, large-scale technologies. It will inevitably form part of net-zero strategies, as gross emissions will not be eliminated by 2050.

# 5. Concluding remarks

My recommendation to distinguish commitments from ambitions is partly rooted in the advantages I see for a small, open country of entering into international agreements. Norway's coalition with the EU renders it among the most ambitious and serious climate policy agents in the world. There are also several valid reasons for cost savings to be expected. Beyond reducing carbon leakage when joining forces, binding agreements and other legal arrangements like the Climate Change Act decrease the commitment problem described by Golombek and Hoel.

On the downside, many targets, regulations and instruments implemented by the EU do not always naturally fit Norwegian particularities and priorities. This can generate political tension and additional economic costs. However, as Golombek and Hoel point out, many national initiatives have their own disadvantages, too.

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# Comment on R. Golombek & M. Hoel: Climate policy and climate goals in Norway

**Linda Nøstbakken**

This comment refers to an initial draft of the article published for the peer review conference in November, 2022.

## 1. Introduction

Norway co-operates closely with the EU on climate policies, and in November 2022, following the EU lead, Norway bolstered its nationally determined contribution target under the Paris Agreement to reduce greenhouse gas emissions by at least 55% compared to 1990 levels by 2030 (previously, the target was to reduce emissions by at least 50% and towards 55%). In addition, Norway aims to reduce emissions by 90–95% by 2050. Norwegian greenhouse gas emissions have been relatively stable since 1990. In 2021, they were 4.7% below 1990 levels, although this figure does not include the effects of forestry and agriculture. This underscores the level of climate target ambitions that Norway has set itself and its continued reliance on EU co-operation to reach them.

Golombek and Hoel's article gives an overview of Norway's climate goals and the current and proposed policies to reach them. The paper starts by reviewing some key findings from the literature on carbon emissions reduction; the authors argue that carbon pricing should be the main policy instrument, and they briefly discuss why and under which circumstances policymakers could consider additional measures. This section also touches on some political economy issues related to climate policy. The following section provides an overview of Norway's climate targets and policies, placing emphasis on the period to 2030, and shows the close link between Norway's and the EU's climate policies. In the fourth section of the paper, Golombek and Hoel discuss the current government's plans and ambitions to transform the Norwegian economy into a low-emissions future, as outlined in the government's coalition agreement (the Hurdal platform). More specifically, this section presents and discusses plans for the oil and gas sector, carbon capture and storage (CCS), hydrogen and batteries.

Golombek and Hoel's paper gives readers a solid overview of Norway's current climate goals and policies, its collaboration with the EU and its overall plans and ambitions to transform the energy industry and move towards a low-emissions future. In the following, I will provide some comments on the paper and some of the topics it discusses.

## 2. Goals and policies towards 2030

The section of the paper entitled *Norwegian climate goals and climate policy* provides a concise overview of Norway's climate goals for 2030 and 2050 and of the key policies necessary to reach the 2030 targets. The authors deftly describe the use of carbon pricing to regulate emissions both in sectors that are part of the EU emissions trading system (EU ETS) and in non-ETS sectors. However, I would like to have seen an introduction to the third main pillar of the EU climate policy; the Land Use, Land-Use Change and Forestry (LULUCF) regulation, which commits Norway and other European countries to emissions reductions and carbon removal in the land use and forestry sectors. A presentation of the LULUCF regulation and how this element of European policy affects Norway would benefit this part of the paper.

In line with standard economic thinking, the authors argue against imposing national carbon taxes on sectors that are part of the EU ETS. To understand their reasoning, consider the case of the offshore petroleum sector in Norway, which is currently subject to a national carbon tax in addition to the EU ETS. This extra taxation forces the industry to abate more, at a higher (marginal) abatement cost than if they were solely subject to the EU ETS. However, the overall impact on total European emissions is negligible. Additional emission cuts in the Norwegian petroleum sector leave more EU ETS credits for others in the carbon permit market. If we disregard the possibility that these additional emission cuts trigger the market stability reserve mechanism (permit removal), the emission cuts in Norway's offshore petroleum sector will be offset by higher emissions from other companies and sectors in the EU ETS. Consequently, a national carbon tax, in addition to the EU ETS, will not only increase the abatement cost of the affected sector but also the total European abatement cost while having little or no impact on the aggregate emissions level.

Despite this and given the Norwegian government's stated aim of promoting the creation of value chains for CCS and hydrogen offshore, I wonder whether this could be an argument in favour of a special carbon tax on offshore oil and gas activities. Even though the effect on total emissions is limited in the short term, longer-term effects could prove positive if the higher carbon price in this sector encourages the industry to develop and implement new and improved CCS technologies. As I will return to below, some solid arguments can be made for opposing policies that try to pick winners and stimulate development in specific industries rather than providing industry-neutral incentives. However, as Golombek and Hoel discuss in the latter part of their paper there is also an argument that Norway has some advantages in the development of technologies such as large-scale CCS. Hence, the literature on second-best policies might be relevant here (see e.g. Goulder et al., 1999; Fischer et al., 2021).

An aspect that Golombek and Hoel pay little attention to is whether Norway's climate goals and ambitions are realistic. As mentioned above, Norway has thus far (as of 2021) reduced its greenhouse gas emissions by about 5% compared to 1990 levels, which is very far from the 55% reduction target for 2030. To reduce emissions in non-ETS sectors, the government has announced that it will gradually raise carbon taxes to about NOK 2,000 by 2030 in constant 2020 prices. It would be interesting if the authors could say something about whether this price path will be sufficient in itself to meet the targets or to what extent Norway will rely on the flexibility mechanism of the EU Effort Sharing Regulation (ESR), for example by buying emissions reductions from other countries that are part of the EU ESR.

## 3. Long-term goals and policies

In the fourth section of their paper, Golombek and Hoel present ambitious policy measures related to Norway's transition to a low-carbon economy, as outlined in the current government's coalition agreement. More specifically, they consider the part of this agreement that describes measures to actively stimulate a transition away from oil and gas and toward other offshore and energy-related activities. In addition to petroleum extraction, Golombek and Hoel discuss CCS, the production of blue and green hydrogen, battery production and offshore wind power.

In June 2022, the Norwegian government launched a roadmap that provides more detail on how they plan to promote green industries[22]. This identifies seven areas that the government will prioritise as part of the green industrial initiative. In addition to value chains for offshore wind, batteries, hydrogen, and CCS (areas discussed by Golombek and Hoel), the roadmap outlines the government's plans for a clean and energy-efficient process industry, a green maritime industry, and forestry/timber and other bioeconomy sectors. Thus, it would be possible for Golombek and Hoel to broaden the scope of their paper beyond the energy sectors by also covering these initiatives and other areas that perhaps should have been higher on the government's agenda.

In terms of policy evaluation, Golombek and Hoel raise the dilemma of whether to use industry-neutral incentives to promote climate-friendly activities or make active investments in specific industries. They recommend letting "sound economic principles" guide policy measures encouraging new green industries. It is hard to disagree, but it would have been helpful if the authors could have been slightly more specific on what this actually implies, both in more general terms and in the specific cases they discuss in this part of their paper.

While green technology investments will probably be inadequate without direct policy intervention (Greaker & Popp, 2022), many economists are sceptical of governments' attempts to pick winners in the green transition. History provides numerous examples of such failures, while the prospect of subsidies or direct public investments in projects and technologies increases the potential for rent-seeking behaviour (see e.g. Baldwin & Robert-Nicoud, 2007). However, others argue that governments trying to single out winners is a necessary policy facet to combat climate change. Meckling et al. (2022) state that in a climate change context, this approach is warranted and offer some advice on how to choose suitable projects, including recommendations for limiting rent-seeking behaviour. They present three main arguments for the importance of picking winners through public investments: (i) it is unlikely that governments on their own will implement sufficient carbon pricing to drive technological change at the required pace, (ii) some technologies have significant future emissions reduction potential, but high capital investments are needed today to drive down the cost curve, and (iii) picking winners can encourage governments to shift the balance of power from polluters to the beneficiaries of decarbonisation. Meckling et al. (2022) argue that many

22. Roadmap - The green industrial initiative, June 2022, available from: https://www.regjeringen.no/en/dokumenter/roadmap-the-green-industrial-initiative/id2920286/

governments are already (directly or indirectly) trying to pick winners, and hence, it is important that they do this effectively. They recommend that in the early stages of an evolving new technology, policymakers should pick companies or consortia that are involved in bringing them to market, and then, as the technologies mature, the shift should be towards supporting their wider deployment. They also argue that policymakers should prioritise technologies with the greatest potential for emissions reductions and that investment decisions should be rules and goals based. I believe that more specific advice on how to pick winners while minimising rent-seeking behaviour would strengthen the active industry measures discussion and provide a clearer basis for the policy recommendations offered by Golombek and Hoel.

This section of Golombek and Hoel's paper also includes a detailed discussion of calculations from previous research papers, assessing the potential scale of the (future) European battery market. While this is undoubtedly interesting, I think it receives more attention (and space) than deserved, given the paper's overall subject matter. I believe that in assessing the government's initiative to set up a battery value chain, the question of whether Norway has any inherent advantages in battery production compared to other potential producers is more important than the exact size of the market. Key factors for battery production include labour, competence and considerable amounts of available electricity. I would have preferred a discussion that focussed on some of these issues. For example: How can Norway best utilise its electricity resources, given the demands of new green projects and the ongoing electrification of society.

Finally, I am curious as to how the Norwegian government's long-term plans correlate with those of the European Union and how international co-operation can reach common climate goals in an efficient way.

# 4. Concluding remarks

Golombek and Hoel's paper shows that there are many climate-related aspirations, goals and policies in Norway and that the level of ambition is high. Climate policies in Norway are typically expected to deliver on far more than just climate goals, for example, by stimulating new green industries, increasing exports, creating new jobs, and boosting economic activity in rural areas. However, resources are scarce (both human and energy resources), even for an energy-rich country like Norway. It is vital to define a set of well-founded priorities and invest and implement policies based on these. Golombek and Hoel discuss some important issues related to this, with particular emphasis on the energy sector.

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# Climate policy in Sweden in the light of Fit for 55

**David von Below, Björn Carlén, Svante Mandell and Vincent Otto**

## Abstract

Sweden has long supported a more ambitious domestic climate policy than that required by the EU, providing strong incentives for some abatement options (e.g., switching to biofuels or electricity in transport) while other activities have faced a relatively low carbon pricing regime. The Fit for 55 package reduces this ambitions gap. This leads to the question: should Sweden continue to go it alone or harmonise its domestic policy with that of the EU? We use a computable general equilibrium model to assess the cost savings accruing to Sweden from introducing a more uniform domestic climate policy and trading emission-quota units with other member states. The results indicate that such a policy shift would be welfare-enhancing. The analysis does not capture any losses to Sweden by being less of a forerunner (e.g., smaller demonstration effects). An EU-wide cost-benefit analysis of the policy reform would also consider the trade gains accruing to the countries that sell emission-quota units to Sweden.

**Keywords:** Cost-effective climate policy, international emissions trading, general equilibrium analysis.

**JEL codes:** C68, Q54, Q58.

# 1. Introduction

The EU has adopted a climate law ('European Climate Law'; Regulation (EU) 2021/1119, 2021 ) stating that the Union must become climate neutral by 2050 and that its net greenhouse-gas emissions by 2030 should be at least 55% less than those in 1990. To reach these new targets, the European Union's (EU) climate policy is being revised. This process started when the EU commission released its proposal, Fit for 55, in June 2021.

This paper addresses Sweden's climate policy in the light of the proposed revisions in Fit for 55. Sweden has long conducted a national climate policy that, by some margin, has been more stringent than that required by the EU. The reasoning behind this approach has been that Sweden should act as a forerunner, providing an example for others to follow. However, based on the proposals put forward in the Fit for 55, the EU is rapidly catching up. For instance, according to the programme, Sweden is obliged to reduce its so-called ESR[23] emissions in 2030 by 50% relative to 2005, either by domestic actions or by buying emission-quota units from other member states – the Swedish national target corresponds to a domestic reduction of at least 52%. In other respects, in particular, the net uptake of carbon dioxide ($CO_2$) in forests and land, the proposed EU targets for Sweden are more stringent than Sweden's national policy aims.

There may be good reasons for Sweden to act as a forerunner. However, there are also costs involved. Given the decreasing margin between Swedish national climate policy and that required by the EU, it might be appropriate to re-evaluate the forerunner strategy. In this paper, we focus on the cost side of the chosen approach. Whether Sweden should only adhere to EU requirements, retain its current forerunner strategy, or opt for even more stringent national targets is for politicians to decide. However, as part of this decision, a thorough discussion of the costs associated with different choices may prove instructive.

The analysis presented below starts with a discussion in which we identify the additional costs that Swedish climate policy imposes on Swedish households. Thereafter we use a computable general equilibrium model of the Swedish economy EMEC[24] to assess the magnitude of these additional costs. The model captures economic activity in Sweden while keeping track of greenhouse-gas emissions. All major climate-policy instruments currently in use in Sweden are explicitly modelled.

23. ESR is short for Effort Sharing Regulation, which distributes tradable emission quotas among member states. Currently the ESR sector includes non-energy-intensive industries, buildings, road transports, agriculture and small heat and power producers.
24. Environmental Medium-term Economic model.

We use the model to compare the outcome in 2030 under the national climate targets and the policy instruments currently applied to reach them to a situation where Sweden reaches the same reduction of its net emissions in other ways, either by means of different policy instruments or by means of international emissions trading. The difference can be measured in terms of GDP, fuel prices and several other measures that may be of interest.

The paper is organised as follows. The next section provides a brief introduction to the EU's climate policy framework and the proposals in Fit for 55. It also contains a discussion of the flexibilities that the EU's climate policy provides. Section 3 details current Swedish climate policy and a formal discussion regarding cost effectiveness. Section 4 introduces EMEC. Section 5 presents a series of model results to illustrate the different policy scenarios' outcomes. Section 6 concludes.

# 2. EU climate policy

The European Climate Law (adopted in April 2021) states that the EU must become climate neutral by 2050. The law also includes an interim target for 2030 stating that the Union's net greenhouse-gas emissions must be reduced by at least 55% compared to 1990 levels. The EU Commission has put forward a series of legislative proposals aimed at reaching these goals. The Commission's proposal, known as the Fit for 55 package, revises all relevant policy instruments and suggests some new ones. The package strengthens the ambitions of the EU emission trading system (EU ETS), the effort sharing regulation (ESR) and the Land Use, Land-Use Change and Forestry sector (LULUCF).[25] [26] In the following, we account for the most important revisions.

## 2.1 EU Emission Trading System (ETS)

The most important proposal in Fit for 55 regarding the EU ETS is the reduction of the number of permits allocated to the market. This is achieved by increasing the linear reduction factor (LRF) from its current value of 2.2% to 4.2% of the allocation in 2010. The LRF may be recalibrated in the future, but if it remains at 4.2%, the future allocation of permits, and thus emissions, will be reduced by a total of 14 billion tonnes $CO_2$e. No further permits will be allocated to the market after 2040,

25. The EU ETS is a cap-and-trade system that currently covers energy-intensive industries, large heat and power producers and aviation within the EEA area. The ESR is an agreement that distributes tradable emissions quotas to the member states for their emissions outside EU ETS, i.e., mainly transports, individual heating and non-energy intensive industries. LULUCF is an agreement regulating the member states' storage of carbon in land and forests.
26. The ETS and ESR targets cover emissions of carbon dioxide from fossil fuels, methane, and nitrous oxide. In line with IPCC's bookkeeping convention, carbon-dioxide emissions from combustion of biofuels are not counted in the sector where the combustion takes place. Instead, these emissions are booked as reduced carbon storage in the country where the biomass was harvested.

as opposed to 2057, in the current design.

Fit for 55 outlines several other changes concerning the EU ETS, including:

- The market stability reserve is revised in a way likely to increase the number of permits being cancelled (rather than fed back to the market).
- Emissions from (parts of) the maritime sector will be included in the EU ETS.
- A carbon border adjustment mechanism will be introduced to tackle the risk of carbon leakage.

One proposal incorporated into the EU ETS legislation, which in practice affects emissions in the ESR sector, is a new emissions trading scheme that will cover emissions from the heating of buildings and road transport. This ETS BRT (Buildings and Road Transport) dimension is discussed below.

## 2.2 Effort Sharing Regulation (ESR)

Fit for 55 proposes that all member states, except Malta, be allocated more stringent emission quotas for their ESR sectors by 2030. For example, Sweden's current ESR quota amounts to a 40% reduction relative to the Swedish emissions level in 2005. In Fit for 55, this quota is lowered to 50% of the 2005 emissions level.

Generally, it is up to each member state to implement national policies such that they keep their emissions below a level corresponding to their ESR quota *plus* any net imports of quota units. However, there are also some EU-wide proposals in Fit for 55 aimed at the ESR sector. One example is the more stringent carbon emission standards for new cars and vans. These will provide an upper limit on average emissions for each car manufacturer and will decrease over time. By 2035, no end-of-pipe emissions will be permitted, effectively prohibiting the sale of new combustion-engine vehicles.

A second example is the separate emissions trading scheme, ETS BRT, mentioned above. This will provide a uniform price on emissions from individual heating and road transport throughout the block. However, as these emissions are still included in the ESR targets, member states are also likely to use other policy measures aimed at these emissions as well. Thus, the 'total' price of these emissions will probably differ between member states, which may affect the cost effectiveness of the policy.[27]

## 2.3 Land Use, Land-Use Change and Forestry (LULUCF)

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27. Differences in the (explicit and implicit) pricing of carbon between member states and their implications for the cost effectiveness of ETS BRT is discussed at greater length in, e.g., Ovaere & Proost (2022).

The LULUCF sector has, from a climate perspective, faced less stringent policies than the EU ETS and the ESR. One reason may be that up until recently, the EU expressed climate targets in terms of limits on emissions. The climate law, adopted in 2021, however, sets the target in terms of net emissions, i.e., emissions minus uptake. As a result, the LULUCF sector now plays an important role in fulfilling the climate target.

Consequently, Fit for 55 proposes stringent targets for the LULUCF sector. The union's net uptake should amount to 310 Mt $CO_2$e by 2030. This can be compared to the estimated business-as-usual uptake of 225 Mt. This target will be distributed between member states as binding annual national net-uptake obligations for the period of 2026 to 2030. The proposal states that Sweden must increase its net uptake in 2030 by 4 Mt $CO_2$e relative to the reference period of 2016 to 2018. According to the Swedish Environmental Protection Agency (2020), the average Swedish net uptake during this period was 43.3 Mt $CO_2$e.

## 2.4 Flexibilities

Each of the three sectors, EU ETS, ESR, and LULUCF, have individual targets. The proposed allocation may deviate from the cost-effective allocation. However, there is room for some flexibility between sectors over time as well as between member states. Such flexibility usually reduces costs and, therefore, enhances welfare.

To illustrate, consider two agents, *A* and *B*, with individual emission quotas such that the last unit of emissions reduction is more costly for agent *A*. If we introduce flexibility, in the sense of allowing the agents to trade emission-quota units with each other, agent *A* (facing high marginal abatement costs) would like to pay agent *B* (with lower marginal abatement cost) to increase abatement. Agent *B* thereby emits less, while *A* can emit correspondingly more. As long as the two agents face different marginal abatement costs, a price exists whereby both agents benefit from such trade. This price is lower than *A*'s marginal abatement cost, i.e., *A* would rather pay than face the cost of having to emit one additional unit less, and higher than *B*'s marginal cost, i.e., the payment from *A* will exceed the cost *B* incurs from reducing its emissions by one additional unit. Trade will continue up to the point where the two agents face identical marginal abatement costs.

The resulting outcome is such that total emissions are the same as before, i.e., equal to the sum of the two individual emission quotas, but the total cost, i.e., the sum of the two agents' total costs, is minimised. As trade is voluntary, neither agent will be worse off than before. This illustrates a general point: allowing different parts of the system to trade with each other may decrease total costs without endangering the integrity of the climate policy overall.

Perhaps the most prominent example of how this kind of flexibility works is the EU ETS itself. An emission trading system ensures that emissions are kept at a given level. However, it does not specify where emission reductions occur. This is left to the market to decide. If the system works, it will result in a cost-effective outcome in the same way as illustrated above. Thus, flexibility regarding where emission reductions will be made decreases total abatement costs without influencing total emissions.

The EU ETS is also a good example of flexibility over time: permits in the EU ETS may be banked for future use. Borrowing from future allocations is not permitted, however.

The ESR allocates individual emission quotas to each member state for their respective ESR sectors. However, member states can trade ESR-quota units. States with low abatement costs may undershoot their quotas and sell the resulting surplus of ESR-quota units to others with higher abatement costs. Thus, the ESR contains an element of emissions trading, making it similar to the EU ETS. For the moment, actual trade seems to be relatively limited. However, as targets become tighter and more costly abatement is needed, more trade in ESR-quota units may well occur.

The LULUCF regulation displays, in this respect, many similarities with the ESR. Here, the individual member states are allocated individual uptake obligations. As in the ESR, it is possible for member states to trade net-uptake certificates such that if one state overshoots its obligation, it may sell certificates to other member states that otherwise would not reach their individual obligations.

There is also a link between the ESR sector and the LULUCF sector in that ESR-quota units may be used to cover a deficit in the LULUCF sector. That is, a member state facing difficulty in reaching its LULUCF obligation may at the same time overachieve in its ESR sector and can use the resulting surplus of quota units to reach its LULUCF obligation or purchase quota units from other member states for the same purpose.

There are thus several routes through which the different sectors and different member states' targets can interact with each other. The purpose of these flexibilities is to provide the possibility of decreasing the total costs without influencing the overarching targets in the EU's climate law.

# 3. Sweden's climate policy

As outlined above, the EU has developed a comprehensive and ambitious climate policy resting on what essentially are three separate cap-and-trade systems – EU ETS, ESR and LULUCF. In the EU ETS, the trading decisions have been delegated to the emitting entities. Their interest in continuing profits is likely to guide them towards the cost-effective allocation of emission abatements. The ESR and the LULUCF regulations place obligations on the member states' governments and, to enhance the cost effectiveness of the policies, allow them to trade ESR-quota units and LULUCF credits, respectively, between themselves. However, Sweden has announced a domestic climate policy that restricts its use of such emissions trading. In the following, we provide a brief description of this climate policy and identify what additional costs it implies for Swedish households.

## 3.1 Swedish climate policy targets and instruments

Sweden has set a long-term target and two interim targets for its greenhouse-gas emissions reduction (Swedish Government, 2017). The long-term target states that the total emissions from Swedish ETS entities *and* the Swedish ESR sector must be at least 85% lower by 2045 than in 1990 and that any remaining emissions must be compensated for by supplementary measures.[28] The interim targets apply only to the ESR sector. According to these, the Swedish ESR emissions must be 63% lower by 2030 compared to those in 1990 (of which up to 8 percentage points may be achieved by supplementary measures) and 75% by 2040 (here, up to 2 percentage points may be achieved by supplementary measures). Sweden has no national target for the storage of carbon in its LULUCF sector.

Comparing the Swedish and EU's long-term targets, two things are worth noting. Firstly, Sweden hopes to reach net-zero five years before the EU. Secondly, Sweden's net-zero definition is different from that of the EU. The EU's target implies that the combined ETS and ESR emissions by 2050 will be below or equal to the total net uptake of carbon dioxide in land and forests across the block. The Swedish target implies that any remaining ETS and ESR emissions in 2045 (a maximum of 15% of the 1990 level) must be compensated for by supplementary measures. If we apply the EU's definition, Sweden is likely to become climate neutral long before 2045. In 2021 the net uptake in the Swedish LULUCF sector corresponded to 87% of the Swedish ETS and ESR emissions combined[29]. However, given that Sweden has no nationally set carbon dioxide net uptake target

28. Examples of supplementary measures include financing emission abatements in other countries or increasing the net uptake of carbon dioxide in Swedish forests. Carbon capture and storage is also included.
29. In 2021, Sweden's net uptake in its LULUCF sector amounted to 41.6 Mt $CO_2e$ (Swedish Environmental Protection Agency, 2023a) while its ETS and ESR emissions came to 47.7 Mt $CO_2e$ (Swedish Environmental Protection Agency, 2023b).

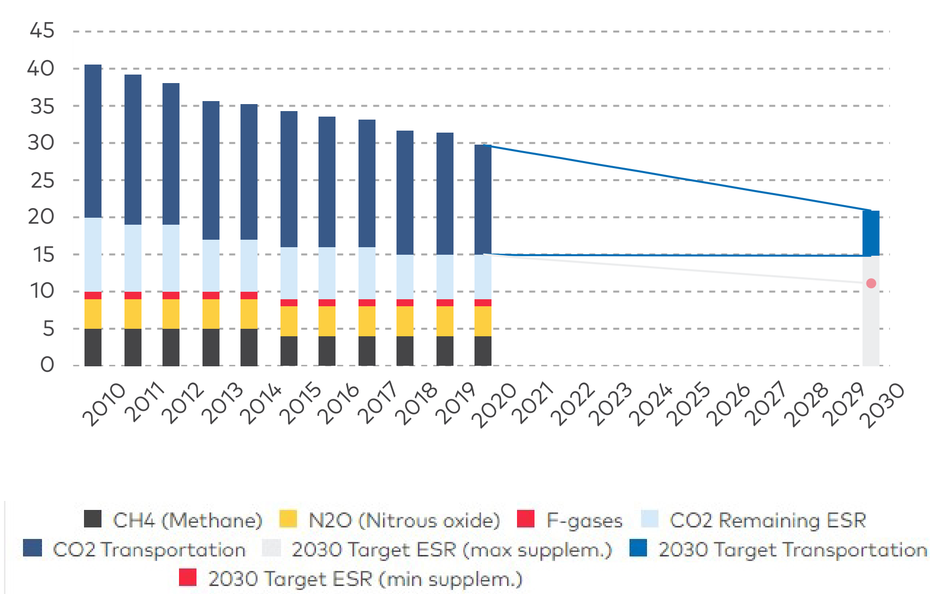
in its LULUCF sector, the Swedish long-term target may also be met in ways deemed not climate neutral, according to the EU's definition of the term.

In addition, Sweden has stated a specific emissions target for domestic transport (excluding aviation), namely that these emissions by 2030 must be at least 70% lower than 2010 levels. No supplementary measures can be employed to achieve this target.

The Swedish interim target for 2030 goes beyond the country's ESR obligation. Stated in terms of the 2005 emission levels, the target translates into a reduction of 61%. If the option to use supplementary measures is used to its full extent, emissions must be reduced by 52%. The current ESR gives Sweden an emission quota for 2030 that is 40% lower than the emission level in 2005 and provides an opportunity to trade emission-quota units with other member states (Regulation (EU) 2018/842, 2018). As noted above, the Fit for 55 proposes an emission quota for Sweden for 2030 that is 50% lower than the emissions in 2005 (Regulation (EU) 2021/1119, 2021).

The emissions target for transport implies that a large portion (if not all) of the Swedish abatement efforts must be in the transport sector, as illustrated by Figure 1. According to the figure, the emissions from domestic transport must be reduced by around 60% in less than ten years, while the residual ESR sector may not need to abate its emissions at all.

**Figure 1** Swedish ESR emission levels and targets [Mt $CO_2$e]




Note: The red dot represents the maximum emissions level for the ESR sector outside transport if the 2030 ESR target is to be met without supplementary measures and given that the transport emissions target is fulfilled.
Sources: Swedish EPA (2022) and own calculations.

The workhorses of Swedish climate policy are carbon-differentiated energy taxation and biofuel standards for petrol and diesel. The Swedish biofuel standards require that the fuel distributors reduce the life-cycle emissions associated with their sales of petrol and diesel by blending in biofuels. How much biofuels the fuel companies must blend in depends on the emission performance of the biofuel used. More precisely, the share of biofuel (in energy terms) that is just enough to fulfil the requirement for fuel *i* (*i* = diesel, petrol) is given by

$$\beta_i = \frac{a_{fi}}{a_{fi} - a_{bi}} R_i$$

where $a_{fi}$ and $a_{bi}$ denote the life-cycle emissions per unit of fossil and biogenic energy mixed in fuel *i*, respectively, and $R_i$ is the politically determined reduction factor for fuel *i*.[30] The reduction factors for 2022 require a biofuel share in petrol and diesel of around 10 and 30%, respectively. The Swedish Energy Agency (2022) assesses that the system in 2030 will require biofuel shares of around 30% and 70%, respectively. These shares lie substantially above the EU's requirement, put forward in RED II (Directive (EU)2018/2001,2018), of 14% biofuel use in transport by 2030. Due to the current situation in the international fuel markets, the Swedish system with biofuel standards has temporarily been frozen at 2022 levels (Swedish Government, 2022). The recently elected government has also announced that as of 2024, the Swedish biofuel standard will be reduced to the minimum level allowed by the EU. Since this has not yet been formally decided, this policy shift is not included in the reference scenario in the subsequent analysis in Section 5.

Table 1 states the energy and carbon-dioxide tax rates on some major fossil fuels when used in the Swedish ESR sector. In general, pure biofuels are exempt from taxation. However, these tax rates also apply to the biofuel components used to fulfil the biofuel standards. The Swedish tax rates on petrol and diesel lie substantially above the EU's minimum levels, which roughly correspond to SEK 3,950 per $m^3$ and SEK 3,630 per $m^3$, respectively (approximately €359 per $m^3$ for petrol and €330 per $m^3$ for diesel).[31]

30. The expression is derived from the regulation stating that the life-cycle emissions associated with the sales of fuel *i* shall be a fraction $R_i$ lower than had the whole sales volume been fossil based, i.e., $a_{fi} x TWhfossil + a_{bi} x TWhbiogenic \leq (1 - R_i) a_{fi} (TWhfossil + TWhbiogenic)$. According to the original decision the reduction factors for petrol and diesel, stated in energy percentages, were supposed to evolve as follows.

| | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|
| Petrol | 7.8 | 10.1 | 12.5 | 15.5 | 19 | 22 | 24 | 26 | 28 |
| Diesel | 30.5 | 35 | 40 | 45 | 50 | 54 | 58 | 62 | 66 |

Source: Swedish Government (2020).

31. Using an exchange rate of SEK 11 to 1 EUR, as of 21 February 2023

**Table 1** Swedish energy and carbon-dioxide tax rates on fossil fuels in 2023, SEK per litre.

| Fossil Fuel | Carbon dioxide tax | Energy tax | Total |
|---|---|---|---|
| Petrol | 2.87 | 3.44 | 6.31 |
| Diesel | 2.49 | 1.58 | 4.07 |
| Heating oil | 3.79 | 0.28 | 4.07 |
| Natural gas | 2.84 | 1.11 | 3.95 |

Source: Swedish Ministry of Finance (2022).

This combination of energy and carbon taxation and biofuel standards has substantially reduced the use of fossil fuels in transport and increased the relative price of petrol and diesel. It should be noted that these instruments do not target emissions of methane or nitrous oxide.

In addition to these cornerstones of its climate policy, Sweden has developed a broad palette of policy instruments with the purpose of controlling its ESR emissions. The Swedish Climate Policy Council, through Panorama (n.d.), lists around 30 policy instruments or measures targeting the ESR sector or the whole economy. These include a subsidy programme for climate investments (including charging posts), a reduction of the taxable benefit for 'green cars' and additional climate considerations in public procurement. Until recently, Sweden had a bonus-malus system for new passenger vehicles. The bonus element of the system was abolished in November 2022. This change is reflected in the scenario analyses in Section 5. Roadmaps towards fossil-free competitiveness have also been designed for many industry sectors, often combined with promises of state-funded support of various kinds.

Many of these additional instruments or measures supplement the incentives already provided by more general policy instruments. For example, additional climate considerations in public procurement require adjustments over and above those that the EU ETS price, energy and carbon taxation and biofuel standards have already made profitable. Similarly, the Swedish bonus-malus system for new cars was layered on top of the EU's emission standards for new light-duty vehicles.

Sweden does not have a general policy to increase the net uptake of $CO_2$ in its LULUCF sector. The exception is a rather limited support scheme for restoring wetlands.

## 3.2 The costs of Sweden's extra steps

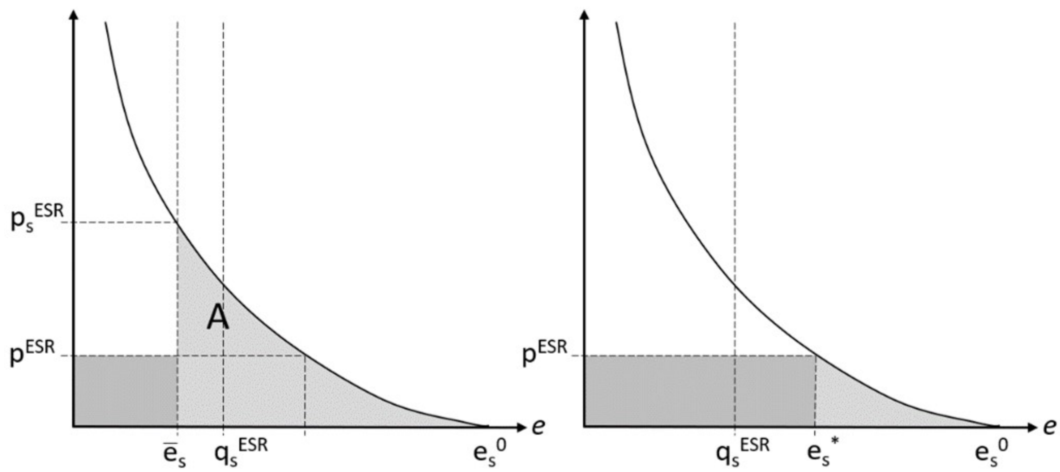
The Swedish climate policy sets a target for its ESR emissions that lies below its allotted emission quota and, to a large extent, precludes the government from engaging in emissions trading with other member states. Below, we identify the additional costs this imposes on Swedish households. To keep the presentation succinct, several simplifying assumptions are made. For instance, we assume an efficiency-oriented government, we ignore income effects and other general-equilibrium effects, and potential distributional restrictions. We also assume that there is only one externality to control.

### 3.2.1 The cost of an emission target below the allotted emission quota

Consider the lefthand panel in Figure 2 below. It illustrates the outcome for a country that pursues a climate policy akin to that adopted by Sweden. The country aims at a domestic emission target $(\overline{e}_S)$ below the country's emission quota ($q_S^{ESR}$) and abstains from trading emission-quota units at the price $P^{ESR}$. The marginal abatement cost (*MAC*) curve illustrates the value of the consumption that the country's households must give up when further reducing its emissions. To reduce its emission from $e_S^0$ (its business-as-usual level) to $\overline{e}_S$, the country must introduce the domestic price $P_S^{ESR}$ on emissions. Total abatement costs correspond to the light-grey area in the figure. The country's cost of fulfilling its ESR obligation in this way equals total abatement costs *plus* the value of the quota units used to cover remaining emissions (the darker area) *minus* the value of the unused quota units. The value of the latter term is given by $v(q_S^{ESR} - \overline{e}_S)$, where the value parameter $v$ depends on how these quota units are used. They may be annulled, sold, saved under the ESR, or transferred to the LULUCF sector.

The right panel depicts the outcome under an alternative policy. Here, the country decides to attain its ESR obligation to a large extent by means of emissions trading. Given the quota-units price $P^{ESR}$, the country finds it optimal to abate up to $e_S^*$ (the level where its *MAC* equals the quota-unit price) and to buy $e_S^* - q_S^{ESR}$ quota units from other member states. The country's compliance costs under this policy correspond to the light-grey area *plus* the value of the quota units used to cover its emissions, $p_{ESR}e_S^*$ (the dark-grey area).

**Figure 2** The additional cost of an emissions target below the allotted ESR quota

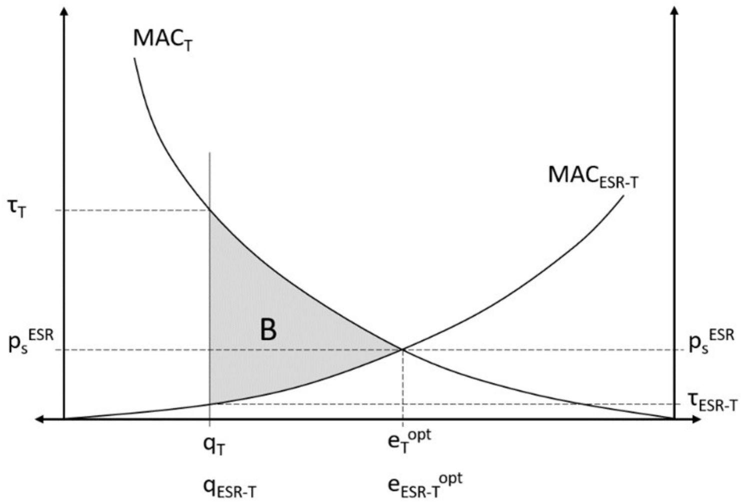



The difference in compliance costs between the two policy strategies equals the avoided costs of domestic abatements (area *A*) *minus* the value of the freed-up quota units $(v(q_S^{ESR} - \overline{e}_S))$. This is the additional cost of a policy that abstains from international emissions trading and aims at a domestic emissions target below the quota allotted by the ESR. It should be noted that this assessment presumes that the country controls its emissions in a cost-effective manner so that abatements are conducted in the order that the *MAC* curve ranks the options. As previously mentioned, Sweden has a separate emissions target for domestic transport, whereby this requirement is not met.

### 3.2.2 The cost of sub-sector targets

Figure 3 illustrates how sub-sector targets increase the cost of attaining a given national emissions target. In the figure, the emissions of the transport sector (*T*) are counted from left to right and the emissions of the residual ESR sector (*ESR-T*) from right to left. The two subsectors *T* and *ESR-T* may together emit $\overline{e}_S$ (the length of the x-axis). Let $q_T$ denote the sector target for transport and $q_{ESRT-T}$ the target for the *ESR-T* sector. The allocation $q_T, q_{ESR-T}$ requires that emissions from transport are priced at $\tau_T$ while it is sufficient with the price $\tau_{ESR-T}$ in the *ESR-T* sector. As the figure is drawn, it is possible to reduce the cost of reaching the emission target $\overline{e}_S$ by letting the transport sector emit more and requiring the *ESR-T* sector to abate more. The cost-minimising allocation of abatement efforts is given by ( $e_T^{opt}, e_{ESR-T}^{opt}$ ) at which emissions are priced at $P_S^{ESR}$. Compared to the policy with sub-sector targets, the cost savings correspond to area *B*.

**Figure 3** The additional cost of sub-sector targets




Again, this is an adequate assessment only if the policies within each sector are cost effective. If the policy leads to non-uniform incentives to abate, the control costs will be higher than the figure indicates.

### 3.2.3 Additional costs due to non-uniform policies

Here, we illustrate how the Swedish climate policy palette creates strong incentives for certain abatement options and low incentives for others, hence reducing emissions in non-cost-effective ways.

The unit cost of reducing carbon-dioxide emissions of fossil origin by means of biofuel standards for diesel and petrol, respectively, can be expressed as

$$\frac{\Delta C_R}{\Delta e_R} = \frac{p_b - p_f}{u_f}$$

where $p_i$ denotes pump prices and $u_f$ states the amount of $CO_2$ emissions from burning a litre of fossil fuel.[32] Consider an example for diesel. Assume that $p_f = SEK10$ per litre, that $p_b = 3p_f$ and that $u_f = 2.6$ kg $CO_2$. Then, the cost of reducing the $CO_2$ emissions of fossil origin in the transport sector by blending in biofuel in diesel amounts to SEK 7.7 per kg avoided.

By increasing pump prices, the biofuel standards also have an indirect impact on emissions. The energy and carbon-dioxide taxation increases the diesel price (excl.

32. The biofuel standard increases production costs with $\Delta C_R = (1-\beta)p_f + \beta p_b - p_f = \beta(p_b - p_f)$ and reduces the end-of-pipe emissions of fossil origin with $\Delta e_R = u_f - (1-\beta)u_f = \beta u_f$, where $\beta$ denotes the blending share (in volume terms) that are consistent with $\beta$ above.

VAT) with SEK 4.1 per litre (see Table 1). In addition, given a blending share (in volume terms) equal to 0.3, the biofuel standard increases the price of diesel by approximately SEK 6 per litre. The total price increment of this policy combination equals SEK 10 per litre of diesel. Thus, the marginal incentive to reduce emissions by abstaining from buying diesel amounts to SEK 5.5 per kg of fossil $CO_2$.[33] The results of this example correspond to earlier assessments.

The Swedish Transport Administration (2020a) appreciates the costs of reducing emissions from road traffic by means of electrification or energy efficiency measures to SEK 2–4 per kg $CO_2$, by blending in biofuels to SEK 1.3–2.6 per kg[34] and through measures reducing traffic to SEK 5.2 per kg. The Swedish National Audit Office (2020) estimates the costs of the bonus allocated to low-emitting cars at SEK 6 per kg $CO_2$. It should be noted that as a substantial portion of the electricity-fuelled cars sold in Sweden is exported to Norway after a couple of years, the cost increases to SEK 16–19 per kg.

Few instruments target emissions from the ESR sector outside transport. Biofuel mandates and energy and carbon taxation also apply to the use of fossil fuels outside the transport sector. However, the substantial emissions of methane and nitrous oxide are only targeted by small subsidy programmes, which explains the appearance of Figure 1.

The discussion above indicates that the instruments in place for controlling the domestic ESR emissions are leading to an allocation that is potentially far from the cost-effective one.

### 3.3 The lack of a Swedish LULUCF policy may prove costly

As mentioned above, the Fit for 55 proposal allocates net-uptake obligations for member states for the period 2026–2030. The finer details are still to be negotiated. However, it seems that Sweden is to be allotted an obligation to accomplish a net uptake in 2030 that is 4 Mt $CO_2$ higher than the average net uptake during a reference period 2016–2018, which according to the Swedish Environmental Protection Agency (2020) was 43.3 Mt $CO_2$e. Sweden can achieve this obligation by (i) increasing its storage of carbon in forests and land, (ii) buying LULUCF credits from other countries and/or (iii) using ESR-quota units. All these measures have associated costs.

33. SEK 10 per litre divided by (1 - 0.3)2.6 kg $CO_2$ per litre equals SEK 5.5 per kg.
34. The Swedish Transport Administration assumes a smaller price difference between fossil and biogenic diesel as well as a lower price on fossil diesel than in the calculation above.

The net uptake may be increased by reducing the outtake of biomass, employing longer rotation periods, restoring wetlands, reforesting, increasing forest growth by fertilisation and moving the carbon stored in trees to other storage pools (e.g., by constructing durable wooden structures). As mentioned above, Sweden lacks a general policy aimed at controlling carbon storage in its LULUCF sector. Studies therefore indicate that the Swedish net uptake may be increased, at least initially, at rather low costs (NIER, 2021). For instance, Gong and Guo (2017) find that a carbon price/subsidy of SEK 0.17 per kg emission/uptake would increase the storage of carbon in Swedish forests by around 14 million tonnes $CO_2$.

At what prices Sweden might buy LULUCF credits from other member states remains unclear. However, the EU Commission (2021) assumes prices at around SEK 0.05 – 0.10 per kg $CO_2$ uptake in their calculations.

If Sweden does not avail of the options above, then it may have to use ESR-quota units to cover a LULUCF deficit. It can obtain quota units for this purpose in three ways: (i) import of ESR-quota units from other member states at the price $P^{ESR}$, (ii) annulling fewer ESR-quota units than planned at the unit cost *v*, and (iii) further reducing its domestic ESR emissions at a unit cost $\tau_T$ or $\tau_{ESR-T}$ (in terms of Figure 3). As pointed out previously, with unsuitable instruments, the cost may well be higher.

It should be noted that the EU Commission's impact assessment of the Fit for 55 calculates a price on ESR-quota units of approximately SEK1.5 per kg carbon dioxide in 2030 (EU Commission, 2020).[35] If large high-cost countries abstain from trading, the price could be much lower.

Although annulling fewer ESR-quota units would not implyany financial cost for Sweden, this option would probably carry a political cost, as it would increase the EU's aggregate emissions.

To further reduce domestic ESR emissions with the sole purpose of fulfilling the LULUCF obligation appears to be the most costly option, given the cost assessment referred to above.

In all scenarios, the LULUCF regulation implies that there will be a cost associated with using biomass in ways that release carbon dioxide into the atmosphere. Not developing a domestic policy that, to some extent, increases the uptake in the Swedish LULUCF sector may prove sub-optimal in the long term.

35. This price lies over and above the 'prices' implicitly included in the countries' reference scenarios.

### 3.4 The aggregated additional climate policy cost

The additional costs of the Swedish climate policy, relative to a policy that fulfils Sweden's EU obligations at the lowest possible cost, consist of the sum of:

- the cost of reducing the EU's aggregate emissions by more than what is implied by the EU ETS, ESR and LULUCF.
- the cost of achieving this by additional abatements in Sweden.
- the cost of designing a policy that does not reduce Swedish domestic emissions in a cost-effective way.

In addition, the upcoming LULUCF regulation will introduce a cost for countries using biomass in ways that release carbon dioxide into the atmosphere.

Assessments of the cost savings and other economic consequences of Sweden shifting towards a climate policy that fulfils its EU obligations at the lowest cost possible requires a general equilibrium approach. Such a policy shift would likely produce large changes in domestic energy prices and timber products, giving rise to greater general-equilibrium effects.

# 4. EMEC – a general equilibrium model

Environmental Medium-Term Economic Model (EMEC) is a computable general equilibrium (CGE) model for the Swedish economy. It explicitly captures links between economic activity, energy use and greenhouse-gas emissions and has been tailored to answer research questions about the economic effects of various climate policies. EMEC is formulated as a mixed-complementarity problem using the Mathematical Programming System for General Equilibrium Analysis (Rutherford, 1999). A full description of EMEC is provided in NIER (2023). Here, we restrict ourselves to a description of the basic features of the model and focus on the main climate-policy instruments in place in Sweden, including the EU ETS, domestic energy and carbon taxes and biofuel standards ("Reduktionsplikten").

Several economic agents interact by demanding and supplying commodities on markets. We specify representative households for six types differentiated by income and residential area. Households enjoy final consumption products and leisure time, own their hours available for work and leisure, have a marginal propensity to save and invest in capital and own the resulting stock of capital.

We specify representative firms across 35 sectors, producing 43 different products in all, where a product can be a good or a delivered service. Production requires capital, labour in the form of working hours and intermediate inputs from other industries, where the inputs can move freely between sectors.

The model includes a government collecting taxes, paying subsidies, consuming final consumption goods and services and paying net transfers back to the households. The government also holds the balance of payment for imports and exports in foreign exchange, and we let the price of foreign exchange adjust endogenously.

The economy is specified as open and small relative to other countries, meaning that world market prices are taken as given. However, domestically produced products are generally assumed to be imperfect substitutes for imported products, allowing for domestic product prices to differ from the world market prices. This is modelled using the formulation in Armington (1969). The markets for labour and capital are assumed to be domestic only.

Agents behave rationally but have imperfect foresight over time.

## 4.1 Households

Households maximise utility (henceforth referred to as welfare) subject to their budget constraint. Welfare is specified as nested-CES[36] functions of leisure hours and bundles of final consumption products, and we measure welfare changes as equivalent variation, i.e., calculating the income change that would give the same welfare change as the policy change. By allowing households to derive welfare from leisure hours, we introduce a trade-off between leisure and consumption and make their supplies of working hours endogenous. Enjoying more leisure hours increases welfare but also decreases labour income, and thus welfare is derived from consumption.

Final consumption products are bundled into multiple consumption bundles. Within the consumption bundle of housing-related products, we distinguish between electricity, district heating and various heating fuels.

As the Swedish transport sector has an individual climate target for 2030 and is subject to substantial policy measures, considerable model development has been conducted regarding this particular sector. Within the consumption bundle of transport products, we distinguish between sea, air, rail, and road transports. Within road transports, we further distinguish between purchased and own road transports. When it comes to own road transports, we further distinguish between own road transports with new and two vintages of used light-duty vehicles. We specify vehicle stocks with the help of capital dynamics equations and with

36. CES stands for constant elasticity of substitution.

household ownership of these stocks. In addition, the model includes a technology-rich representation of vehicles by distinguishing between multiple types of light-duty vehicles and fuel blends. Specifically, we distinguish between light-duty vehicles with (i) diesel engines running on a diesel blend, (ii) petrol engines running on an E10 blend, (iii) petrol engines running on an E85 blend, (iv) petrol engines running on an E10 blend and electricity (plug-in hybrid electric vehicles) and (v) electric motors. We let the choice of vehicle type for use in own road transports be governed by a CES function over vehicle types and be based on the total user cost of the vehicle and fuels in the current period. We assume a relatively high substitution elasticity for the choice of new vehicle types and a relatively low substitution elasticity for the choice of used vehicle types in own road transports. EMEC is thus able to analyse, e.g., the effects of bonus-malus on emissions through how it affects the vehicle stocks. Similarly, the model can capture how changes in biofuel standards (see below) affect fuel prices and how this, in turn, affects the choices of new vehicle purchases and, therefore, the speed at which electric vehicles are introduced. In this way, the model captures the recent rapid increase of electric vehicles as a share of new cars. We do not specify any scrapping subsidies or exports of used vehicles.

Further, we assume an income elasticity of demand for transport products of less than one to reflect the fact that some household transport demands are non-discretionary (e.g., commuter journeys) and that household transport demands, therefore, increase less than proportional to increases in household income.

Note that environmental quality does not enter the welfare function, implying independence of the demand functions for goods with respect to environmental quality.

## 4.2 Firms in production sectors

Producers maximise profits subject to their production functions, specified as nested-CES functions of capital, working hours, energy, transports and other intermediate inputs.

Within the nest of energy inputs, we distinguish between electricity, district heating and fuels, and we further distinguish between various solid and liquid fuel types (e.g., coal, oil, and gas).

Intermediate use of transport products is specified similarly to the specification of household consumption of transport products. We specify the same choice of light-duty vehicles and fuel blends. In addition, we distinguish road transports between passenger and cargo road transports, further distinguish between purchased and own cargo road transports, and between own cargo road transports with new and two vintages of used heavy-duty vehicles (HDVs). HDVs with diesel engines can run on both the regular diesel blend and a pure biodiesel blend (HVO100). However, we do not specify HDVs with electric engines. We again specify stocks of all vehicles with the help of capital dynamics equations. Since capital is embodied in the vehicles, the households own these vehicle stocks as well.

Constant returns to scale in production and the perfect-competition assumption imply zero profits.

## 4.3 Greenhouse-gas emissions and prices

Firms' production processes, intermediate use of fuel products by firms, and final consumption of fuel products by households give rise to emissions of greenhouse gases and may all be subject to policy and emission prices. Firms subject to the EU ETS need emission permits to emit greenhouse gases. In addition, they may need to pay a domestic carbon tax if the firm, production sector and emission source are subject to the tax. Households may need to pay a domestic carbon tax if the emission source is subject to the tax.

When faced with an emission price, households and firms choose to keep on emitting and pay the emission price, or reduce their emissions and avoid paying the price, or a combination of both, whichever is the cheapest. When choosing to reduce emissions, households have the abatement options of substituting other final consumption products for the polluting one (e.g. choosing less carbon-intensive fuels for own road transports or heating), of substituting low carbon-intensive consumption bundles for high carbon-intensive consumption bundles (e.g. consuming less of the road transport bundle and more of the rail transport bundle), of enjoying more leisure hours instead of consumption bundles, or a combination of multiple abatement options. Similarly, firms have the abatement options of substituting other intermediate inputs for the polluting intermediate input (e.g. choosing less carbon-intensive fuels in own road transports or other parts of their production process), of substituting capital and labour for intermediate inputs (e.g. choosing more fuel-efficient engines in own road transports or other parts of their production process), or by cutting back the production level or a combination of multiple abatement options.

Revenues generated by the auctioning of EU ETS permits flow out of the country (to the EU Commission). The Swedish government does receive a share of total auctioning revenues (from the EU Commission), but this share is exogenous in the model. Domestic carbon tax revenue accrues to the government.

## 4.4 Biofuel standards ("Reduktionsplikten")

Transport fuel blends are specified as functions of a fuel product and fuel standards. Such a function is specified for each combination of a fuel blend (e.g., E10) and matching fuel products (e.g., petrol and ethanol). Multiple fuel products can thus be sold as the same fuel blend. A set of fuel standards, however, ensures that fuel blends meet minimum and maximum volume requirements on the use of biofuel and fossil-fuel products. For example, we require the E10 blend to have a minimum ethanol volume content of 10% and a minimum petrol volume content of 90% initially.

In the model, the fuel standards are implemented with the help of tradable allowances. This is a way of assuming that fuel distributors can distribute the required emission reductions across fuels in the most economically efficient way. Fuel distributors need to submit certain shares of the biofuel allowance (e.g., 10%) and the fossil-fuel allowance (e.g., 90%) for each litre of the fuel blend. At the same time, fuel blends made from the biofuel product (e.g., ethanol) earn one biofuel allowance per litre sold, whereas fuel blends made from the fossil-fuel product (e.g., petrol) earn one fossil-fuel allowance per litre sold. In case the initial biofuel content is too low, demand for the biofuel allowance will exceed its supply, and the allowance price will increase until it is profitable enough to supply the minimum required amount of the biofuel. The same price setting applies to fossil-fuel permits. We interpret the allowance prices as shadow prices of required cross subsidisation between the fuel products since permits have not been introduced in the real world. These prices change the relative prices of the fuel blends.

In real life, the fuel standard for diesel and petrol, respectively, may trade with each other (i.e., an underachievement in the fuel standard for petrol may be compensated by overachieving for diesel and vice versa). Such trade between fuel standards is not implemented in the current model.

## 4.5 Equilibrium and growth

Households and firms solve their respective optimisation problems. Markets for production factors and final goods are assumed to be perfectly competitive. When all markets clear and household income balances hold, the set of output, price and income levels constitute an equilibrium. The equilibrium is static in that the optimisation problems are based on current-period variables only.

We solve for the static equilibrium in the years 2019 through 2050, allowing us to perform a comparative-static analysis of policies in these years. In between these years, we impose several exogenous changes to the model to let the economy grow, as measured in terms of GDP. For example, factor supplies, energy efficiencies and policies can all change. We cannot account for business-cycle behaviour but instead calculate the new equilibria under the assumption that all agents have sufficient time to adjust their behaviour (e.g., choice of the number of hours worked) to the changes imposed.

### 4.6 Calibration

The model is calibrated to the Swedish economy in 2019. We use the system of National and Environmental Accounts (Statistics Sweden, 2022) as our main data source for economic activity, energy use and emissions of greenhouse gases. World-market prices for fossil fuels (crude oil, coal and natural gas) and EU ETS emission-permit prices are exogenous to the model and are set according to the EU Commission's recommended parameter values (EU Commission, 2022). Import prices of biofuels (ethanol and biodiesel) are assumed to rise in line with the crude oil price. The base-year calibration reflects a production cost for ethanol that is 1.5 times the cost of petrol per litre, while for biodiesel, the corresponding figure is 2.5 times relative to fossil diesel. Additional model details on transport fuels and vehicles in the base year are calibrated based on several data sources, including the Swedish Energy Agency (2020; 2021) and Transport Analysis (2020). The relative price of electric vehicles has been calibrated with a downward trend over time to reflect exogenous productivity growth and economies of scale, as well as an implicit cross-subsidy from EU regulation on the emission intensity of new vehicles. The model replicates the strong growth in the sales of new electric passenger vehicles in the period 2019 through 2022.

## 5. Model results

In this section, we assess the additional costs the announced Swedish climate policy imposes on Swedish households relative to a policy that achieves the same greenhouse-gas emission reduction in a more cost-effective manner. We do so by comparing a reference scenario with four policy scenarios. All policy scenarios reach the same greenhouse-gas emissions reduction. In three of them, the entire emission reduction occurs in Sweden. In the fourth, a part of the reduction occurs in other EU member states through trade in ESR-quota units.

The reference scenario is a business-as-usual scenario calibrated to the demographic and macroeconomic development described in NIER (2022) and in which we assume that Sweden's main trading partners undergo a similar demographic and macroeconomic development. We include only climate and other policies currently in place (up to and including December 2022).

Current policies include the EU ETS, energy and carbon taxes, and biofuel standards ("Reduktionsplikten") as the primary policy instruments within the Swedish ESR sector. Note that several industry exceptions exist for energy and carbon taxes. Moreover, a carbon tax is also levied on the biofuel products in the E10 and diesel blends covered by the biofuel standards. This means that as long as biofuels are more costly to produce than their fossil counterparts, there are no incentives to raise the biofuel shares in the fuel blends above what is required by the biofuel standards. The E85 and HVO100 blends are assumed to retain the exemptions from carbon and energy taxes that they currently enjoy. In addition, current policies also include an aviation tax, subsidies to certain types of climate innovation[37] and 'bonus-malus' for new vehicle purchases.[38] In the reference scenario, the greenhouse-gas emissions from the Swedish ESR sector fall to a level 51% below the 1990 level by 2030, leaving a gap of 12 percentage points to reach the national target level of 63% below the 1990 level, by 2030. Relative to the 2005 emission level, this represents a reduction of about 48%. In other words, an emissions level close to the Swedish ESR-emission quota suggested in the Fit for 55.

The national target, a 63% reduction relative to 1990, corresponds to a further reduction of about 5 Mt compared to the 50% reduction proposed in Fit for 55. In the four policy scenarios, we specify greenhouse-gas emission reductions equivalent to those implied by this national target, but we do so in different ways (see Table 2).

The first scenario labelled *A1*, is identical to the reference scenario, but we lift the current set of positive carbon tax rates –with an equal amount– to the levels needed to reach the overall emissions reduction target within the Swedish ESR sector by 2030. That is, we keep the current design of the carbon tax and leave both the carbon tax on the biofuel products in the fuel blends and the industry exceptions in place.

The modelled set of carbon tax levels thus remains differentiated between emission sources and industries.[39]

The second scenario, labelled *A2*, deviates from scenario *A1* to reflect current policy proposals. Scenario *A2* contains lower biofuel standards for petrol and diesel fuel blends to 15%, which represents our estimate of an EU minimum level in 2030.

In the third scenario, labelled *B*, we move towards a more uniform carbon taxation. More precisely, we do so by (i) removing the aviation tax, (ii) removing the climate and industry leap subsidies, and (iii) removing the carbon tax from the biofuel components in fuel blends and removing the industry exceptions (other than sea transport) from the tax. As the tax is only levied on the fossil component, it will now influence blend-in levels. However, as the assumption about the EU minimum biofuel standard still applies, the blend-in will never fall below 15%. We again increase the carbon tax to the level needed to reach the emissions reduction targets

37. The 'Klimatklivet' and 'Industriklivet' support schemes.
38. The lump-sum subsidy (the bonus) is reduced to zero from 2023 onwards, while the vehicle tax component (the malus) of the policy is assumed to remain in place.
39. Note that we do not use any instruments aimed at reducing the emissions of methane and nitrous oxide in the Swedish ESR sector. The reason for this is two-fold. Firstly, such policy instruments would, in the real world, be associated with high transactions costs. Secondly, if implemented unilaterally such a policy would probably jeopardise the Swedish farmers' competitiveness.

within the Swedish ESR sector by 2030. It should be noted that the resulting carbon tax is not fully uniform within the Swedish ESR sector due to carbon emissions from sea transports continuing to be exempt from the domestic carbon tax in this scenario and other greenhouse gases being similarly left untaxed.[40]

The fourth scenario, labelled *C*, is identical to scenario *B*, but with the difference that we now increase the carbon tax exogenously, let the model compute the domestic carbon emission reduction and purchase ESR-quota units from other EU Member States (MS) to make up the difference to the national emission reduction target level of 63% below the 1990 level by 2030. In line with uniform pricing, we set the carbon tax and the quota-unit price at the same level. The quota-unit price is highly uncertain, and we assume a price of SEK 2,000 per tonne $CO_2e$ by 2030. We test the sensitivity of the model results for the ESR-quota price and the LULUCF-certificate price in section 5.6 below.

**Table 2** Summary of scenarios

| Reference | *A1* | *A2* | *B* | *C* |
|---|---|---|---|---|
| **Current policy** | Current policy<br><br>+ Keep current design of carbon tax | Current policy<br><br>+ Lower biofuel standards<br>+ Keep current design of carbon tax | Current policy<br><br>+ Lower biofuel standards<br>+ No tax on bio component<br>+ No aviation tax<br>+ No climate and industry leap subsidies<br>+ More uniform design of carbon tax | Current policy<br><br>+ Lower biofuel standards<br>+ No tax on bio component<br>+ No aviation tax<br>+ No climate and industry leap subsidies<br>+ More uniform design of carbon tax |
| **Target not reached** | + Increase set of carbon tax levels to reach target | + Increase set of carbon tax levels to reach target | + Increase carbon tax level to reach target | + Increase carbon tax level to equal ESR-quota unit price<br>+ Purchase ESR-quota units to reach target |

In the four policy scenarios, we keep the saving rates, balance of payments and final consumption by the government fixed at their respective levels, computed in the reference scenario.

40. Note also that the carbon tax within the Swedish ESR sector still differs from the EU ETS price as well as the shadow price of net emissions in the LULUCF sector.

The model is not explicitly designed to account for the LULUCF sector. None of the four policy scenarios includes any active measures to increase carbon uptake in Swedish forests. However, the harvesting of forests varies across policy scenarios, mainly due to the variation in carbon tax rates. We control for this effect in the following way. We let the model calculate the amount of carbon stored in either growing forests or in durable timber products. We do this by assuming that the forests grow exogenously, in the same way, across policy scenarios. Using data on carbon uptake in the LULUCF sector from the Swedish Environmental Protection Agency, we calculate net carbon uptake as forest growth (before harvesting) minus total forest harvest plus the share of the harvest that is used in the timber products industry. This measure shows the largest uptake in scenario *A2*, followed by *A1, B* and *C*. We then require purchases of LULUCF credits from other member states in scenarios *B* and *C* to cover the difference with respect to the uptake in scenario *A1*. In scenario *A2*, the calculated over-achievement in the LULUCF sector allows for the sale of LULUCF credits to other member states. We assume the same price per LULUCF credit as for ESR-quota units, i.e., SEK 2,000 per tonne. The sale or purchase of LULUCF credits does not affect the model results in any material way.

Table 3 summarises the effects of the modelled policies on greenhouse-gas emission levels within the Swedish ESR sector as well as on carbon emission prices and household welfare levels as our main measures of policy cost. Besides studying the costs of the policies in Sections 5.1 through 5.3, we compare the effects on the macroeconomy and transport fuel prices in Sections 5.4 and 5.5 and conduct a sensitivity analysis in Section 5.6.

**Table 3** Effects of modelled policies on greenhouse-gas emission levels and $CO_2$ prices within the Swedish ESR sector and welfare by 2030

| Scenarios | **Greenhouse-gas emission level** (% change from 1990 levels) | **$CO_2$ emission price** (SEK/tonne $CO_2$) | **Welfare** (% change from reference case) |
|---|---|---|---|
| **Reference** | -51 | 0 – 1,497 | - |
| *A1*: Current design of carbon tax | -63 | 0 – 8,300 | -0.61 |
| *A2*: Current design of carbon tax + lower biofuel standard | -63 | 0 – 18,906 | -0.57 |
| *B*: Toward a uniform carbon tax | -63 | 7,476 | -0.35 |
| *C:* Toward a uniform carbon tax + trade in ESR quotas | -63 | 2,000 | 0.49 |
| - of which domestic | -36 | 2,000 | |
| - of which abroad | -27 | 2,000 | |

Notes: 'trade' in the scenario name refers to trade in ESR-quota units between EU MS. Carbon prices are in 2019 terms. Welfare is specified as the aggregate welfare of the six household types, and we measure welfare changes as equivalent variation.

## 5.1 Scenarios A: Current design of carbon tax and no trade in ESR-quota units with other EU Member States

In scenarios *A1* and *A2*, the current positive carbon tax rates are shifted upwards with an equal amount to keep the emissions at the target level (reduce the emission by an additional 9% relative to the reference scenario). In scenario *A1* in which we keep the biofuel standards at the same levels as in the reference scenario, we find that the maximum tax rate in the set of modelled carbon tax levels increases to SEK 8,300 per/tonne $CO_2$. This tax level is more than five times higher than the maximum level in the reference scenario and reflects the fact that the Swedish aggregate marginal abatement-cost function is quite steep. In scenario *A2*, in which we lower the biofuel standards for petrol and diesel fuel blends to the EU minimum level, we find that the maximum carbon tax level increases to almost SEK 19,000 per/tonne $CO_2$. Lowering the standards leads to higher carbon emissions from the use of the fuel blends and requires higher carbon tax levels to keep the emissions at the target level. Given that the carbon tax is also levied on the biofuel component in the fuel blends under the current carbon tax structure, the tax does not provide direct incentives to increase the amount of biofuels in the fuel blends. As a result, the current set of carbon taxes must be set at much higher levels to provide incentives for other abatement options with higher marginal costs to firms and households.

When measured in welfare terms, we find that the additional emission reduction also comes at a cost in both scenarios *A1* and *A2*. The higher carbon tax levels directly increase the cost of production and consumption for many products, depending on their carbon intensity. Yet we also find that a part of these cost increases is offset by cost decreases from lower prices of capital, labour and imported products. Of these three prices, we find that the price of capital falls relatively more due to more carbon-intensive product production also tending to be relatively more capital intensive. Note here that our assumption of free mobility of production factors between production sectors helps the firms in (especially non-carbon intensive) production sectors gain from these price decreases. In addition, households respond to the lower wage by working fewer hours and can offset a part of their welfare loss derived from reduced consumption with a welfare gain derived from more leisure hours.

Moving from scenario *A1* to *A2*, we find that the welfare losses are of similar size and that the welfare loss is slightly smaller in scenario *A2* than in *A1*. When decomposing the welfare losses, we find that the lower biofuel standards in scenario *A2* worsen the welfare losses of the current non-uniform structure of the carbon tax. Yet, we also find that the lower standards and higher carbon tax levels lead to a higher adoption rate and stock levels of electric vehicles and hence more of the assumed exogenous productivity improvements that come with these. It should also be noted that in scenario *A2* a larger share of the regulation rent of the domestic emission target is captured as tax revenues (as opposed to being dissipated in higher production costs for fuels). Since tax revenues are transferred back to the households, this reduces the welfare loss of moving from *A1* to *A2*.

## 5.2 Scenario B: Toward a uniform carbon tax and no trade in ESR-quota units

In scenario *B*, we find that the uniform tax rate needed to keep the Swedish ESR emissions at the target level in 2030 amounts to almost SEK 7,500 per/tonne $CO_2$. This tax level is again more than five times higher than the maximum tax level in the reference scenario but is lower than the maximum tax level in scenario *A1* and much lower than in scenario *A2*. Given that we now levy the carbon tax more uniformly on more carbon emissions within the Swedish ESR sector and that we now remove the tax from the biofuel components in fuel blends, abatement options with lower marginal abatement costs are incentivised and a lower carbon tax level is sufficient to keep the emissions at the target level in scenario *B* as opposed to scenarios *A1* and *A2*.

We find that the additional emission reduction comes with a modest welfare loss in this scenario relative to the reference scenario and that the welfare loss is now smaller compared to that in scenarios *A1* and *A2*. In addition to the welfare effects found in scenario *A*, we now also find a welfare gain due to the removal of the distortion costs of the aviation tax, climate and industry leap subsidies and the non-uniform carbon tax structure. That is, cheaper carbon emission abatement options are incentivised elsewhere in the economy and much of the negative income effects attributed to the distortions are reduced or removed in this scenario, compared to the previous scenarios. These cost savings correspond roughly to area *B* in Figure 3.

### 5.3 Scenario C: Toward a uniform carbon tax and trade in ESR-quota units

In scenario *C*, we find that the assumed carbon tax and ESR-quota unit price of SEK 2,000 per/tonne $CO_2$ leads to a greenhouse-gas emission reduction of 36% at home and 27% abroad, compared to the greenhouse-gas emission level within the Swedish ESR sector of 1990, by 2030.

We find that the additional emission reduction now comes with a welfare gain in this scenario relative to the reference scenario and scenarios *A1, A2* and *B*. In addition to the welfare effects found in scenarios *A1, A2* and *B*, we now also find a welfare gain from removing part of the distortion costs of the domestic carbon tax. That is, cheaper greenhouse-gas emission abatement options are incentivised elsewhere in the EU and part of the negative income effect attributed to the domestic carbon tax is here reduced compared to the previous scenarios.

### 5.4 Macro-economic effects

Table 4 shows that the four policy scenarios have different macroeconomic effects as well as different welfare implications.

A contraction of GDP occurs in scenario *A1*, relative to the reference scenario. As the increasing levels of the set of carbon taxes make production and product prices more expensive, we find that gross production levels decrease. Production levels of goods fall relatively more than those of services, as the production of goods is more carbon intensive than the production of services. Agriculture and forestry are hit particularly hard, followed by transport services and mining and manufacturing. Further, export levels fall slightly more than import levels as import prices become cheaper relative to export prices. Levels of private household consumption decrease in line with higher prices for consumer products and lower household income. Similarly, investments in fixed capital decrease in line with lower household income.

A greater contraction of GDP can be observed in scenario *A2*, relative to the reference scenario and scenario *A1*, which is also reflected in gross production levels of goods and services as well as exports and imports. Production in agriculture and forestry again experiences the largest effect, with a fall of over 10% relative to the reference scenario.[41] Investments in fixed capital fall slightly further relative to scenario *A1* and the reference scenario, while household consumption experiences a similar decrease as in scenario *A1*, relative to the reference scenario.

A lesser contraction of GDP can be seen in scenario *B* relative to the previous scenarios. We find that the macro-economic effects are qualitatively similar to those in scenarios *A1* and *A2* but smaller in magnitude, in line with the smaller welfare loss in scenario *B*. Gross production in mining and manufacturing benefits the least of all the production sectors, as the move to a more uniform carbon tax in scenario *B* sees its current tax exemption removed.

In scenario *C*, we see an expansion of GDP relative to the previous scenarios. We find that levels of household consumption and investments in fixed capital increase. In addition, the negative income effect of the carbon tax is reduced, with household income and savings increasing more as a result. Similarly, gross production levels of most goods and services now increase relative to the previous scenarios and the reference scenario. The exception is again mining and manufacturing, where gross production is now lower than in scenarios *A1* and *B*. A sharp fall in the production of biofuels in line with the lower levels for the biofuel standards and carbon tax drives this result in scenario *C*.

41. These model runs indicate a higher sensitivity of the production in agriculture to the domestic price on carbon than found in some other studies, e.g., Beck et al., (2021). The discrepancy may be explained by differences in how the input factor land is modelled. In the "GreenREFORM" model used in Beck et al., the land area for agricultural production is fixed, whereby a higher carbon price implies lower land rents. In EMEC, on the other hand, land in not explicitly modelled as an input factor. Instead, it is embedded in the factor capital, the price of which does not vary that much in the scenarios. Instead, a higher domestic carbon price lowers the profits in the agricultural sector whereby it shrinks.

**Table 4** Effects of modelled policies on selected macro-economic variables by 2030 (% changes compared to the reference scenario)

| | Scenario (% changes compared to reference scenario) | | | |
|---|---|---|---|---|
| | *A1* | *A2* | *B* | *C* |
| GDP | -0.7 | -0.9 | -0.4 | 0.5 |
| Gross production | -0.9 | -1.3 | -0.5 | -0.3 |
| - Agriculture and forestry | -6.9 | -10.4 | -3.7 | 1.1 |
| - Mining and manufacturing | -1.4 | -2.5 | -1.2 | -1.8 |
| - Utilities and construction | -0.6 | -0.8 | -0.1 | 0.1 |
| - Transport services | -2.6 | -3.1 | -1.2 | 0.5 |
| - Non-transport services | -0.4 | -0.5 | -0.2 | 0.0 |
| - Public-sector output | 0.0 | 0.0 | 0.0 | 0.0 |
| Exports | -1.2 | -2.1 | -0.7 | -0.7 |
| Imports | -1.2 | -1.9 | -0.6 | -1.1 |
| Household consumption | -0.6 | -0.6 | -0.3 | 0.5 |
| Investments in fixed capital | -0.8 | -0.9 | -0.4 | 0.5 |
| Price of fixed capital | -1.6 | -3.0 | -0.7 | 0.4 |
| Price of labour | -1.4 | -2.0 | -0.7 | 0.1 |

Notes: Scenario *A1* refers to the current design of the carbon tax and no trade in ESR-quota units with other EU Member States, scenario *A2* is identical to *A1* but with low biofuel standards for petrol and diesel, scenario *B* refers to a more uniform carbon tax and no trade in ESR-quota units with other EU Member States and scenario *C* refers to a more uniform carbon tax and trade in ESR-quota units with other EU Member States. Levels of GDP, gross production, exports, imports, private consumption, and investments in fixed capital are in fixed price terms. Price of capital and labour are in real and 2019 terms.

## 5.5 Effects on selected transport fuel-blend prices

Table 5 shows the effects of the modelled policy changes on selected transport fuel-blend prices in the four policy scenarios relative to the reference scenario. The prices of the regular petrol and diesel fuel blends change largely in line with the carbon tax level and vary substantially between the policy scenarios. Compared to the reference scenario, we find that these prices are higher in scenarios *A1* and *A2*, that the price increases are less in scenario *B* and even negative in scenario *C*.[42] The E85 fuel blend, which consists primarily of ethanol, shows smaller price variations across all scenarios. Finally, we find that the prices of HVO100 and electricity mainly follow economic activity and GDP and only exhibit small variations between scenarios. The relatively stable prices of the HVO100 blend and electricity across scenarios means that these fuels gain market shares when the regular petrol and diesel blend experience high price increases, especially in scenarios *A1* and *A2*. This occurs through substitution away from the regular diesel blend and towards the HVO100 blend in HDVs and through faster growth in the share of electric vehicles in new vehicle purchases.

**Table 5** Effects of modelled policies on selected transport fuel blend prices by 2030 (% changes compared to the reference scenario)

| | Scenario (% changes compared to the reference scenario) | | | |
|---|---|---|---|---|
| **Price of transport fuel blends at the pump** | *A1* | *A2* | *B* | *C* |
| **- E10 petrol blend** | 95.5 | 178.7 | 40.6 | -17.8 |
| **- Diesel blend** | 100.2 | 169.4 | 26.7 | -29.0 |
| **- E85** | 18.9 | 48.4 | 12.1 | -4.2 |
| **- HVO100** | -0.4 | -0.6 | 0.0 | 0.1 |
| **- Electricity** | -1.0 | -1.9 | -0.6 | 0.1 |

Notes: Scenario *A1* refers to the current design of the carbon tax and no trade in ESR-quota units with other EU Member States, scenario *A2* is identical to *A1* but with low biofuel standards for petrol and diesel, scenario *B* refers to a more uniform carbon tax and no trade in ESR-quota units with other EU Member States and scenario *C* refers to a more uniform carbon tax and trade in ESR-quota units with other EU Member States. Prices of transport fuels are inclusive of all taxes faced by purchasers and are in real and 2019 terms. Prices for the E10 and diesel blends are SEK 28.6 and 29.7 per litre, respectively, in the reference scenario in 2030.

## 5.6 Sensitivity analysis

Table 6 reports the sensitivity of our results to key parameter values. We use central parameter values in all sensitivity scenarios except for the parameter subject to analysis. Given the importance of energy use, associated carbon emissions and abatement costs for our findings, we choose the parameters for the substitution elasticities between value added and energy inputs in production, autonomous energy efficiency improvements and the ESR-quota unit price. Further, considering the significance of the prices of fixed capital and imported products in offsetting much of the cost increases associated with the additional carbon emission reduction, we also choose the parameters for the depreciation rate of fixed capital

42. In absolute terms, the petrol and diesel prices in 2030 in scenario A1 hover around SEK 56 per litre and SEK 57 per litre, respectively. These price levels are of the same magnitude of those found in other studies of this policy scenario, see for instance Swedish Transport Administration (2020b).

and the (Armington) substitution elasticities between imported and domestic products. We report effects as percentage changes relative to the reference scenario.

The general result from Table 6 is that our findings are robust to the range of parameter values considered. A more uniform carbon tax and allowing for trade in ESR-quota units with other EU Member States in scenario *C* still provides the best welfare implications for households, followed by a more uniform carbon tax only, in scenario *B*, and then followed by the current set of carbon taxes presented in scenarios *A1* and *A2*.

Turning to the specific parameters subject to analysis, assuming a higher depreciation rate for fixed capital leads to slightly lower welfare losses in all policy scenarios relative to the reference scenario. A higher depreciation rate for fixed capital decreases the capital stock and increases the price of capital relative to the regular scenarios, all else being equal. Given that capital and energy are net complements in many production sectors, we find that the higher price of capital leads to lower emission levels already in the reference scenario, in turn leaving smaller emission gaps to close in the policy scenarios. As a consequence, we also find that the required carbon tax levels are now slightly lower in scenarios *A1, A2* and *B* relative to the regular scenarios. We find the opposite effects if we assume a lower depreciation rate and report no changes in carbon emission prices for scenario *C* since these prices are assumed in this scenario.

Assuming higher (Armington) substitution elasticities between imported and domestic products makes the economy more open, decreases the marginal costs to abate carbon emissions and leads to lower emission levels relative to the regular scenarios, all things being equal. As a result, we find that the targeted emission reduction leads to a smaller welfare loss in scenarios *A1, A2* and *B* relative to the reference scenario but also that the welfare gain from international trade in ESR quotas is somewhat smaller in scenario *C*. We also find that slightly lower carbon tax levels are now needed to incentivise the additional carbon emission reductions in scenarios *A1, A2* and *B*. We find the opposite effects if we assume lower substitution elasticities between imported and domestic products.

Assuming higher substitution elasticities between bundles of capital and labour and bundles of energy products in production leads to slightly lower welfare losses in scenarios *A1, A2* and *B* and a slightly higher welfare gain in scenario *C* relative to the reference scenario. The higher substitution elasticity increases the opportunities to substitute capital and labour for energy use and lowers the marginal abatement costs, all else being equal. Consequently, slightly lower carbon tax levels are needed to incentivise the additional carbon emission reductions in scenarios *A1, A2* and *B*. We find the opposite effects occur if we decrease the substitution elasticity.

Assuming larger autonomous energy-efficiency improvements in the use of all energy products also leads to slightly lower welfare losses in scenarios *A1*, *A2* and *B* and a slightly higher welfare gain in scenario *C* relative to the reference scenario. The reduced energy use results in lower carbon emissions already present in the reference scenario and, in turn, leaves a smaller emission gap to close in scenarios *A1*, *A2*, *B* and *C*. In scenarios *A1* and *A2*, the smaller emission gap leads to a slightly lower maximum carbon tax level, whereas it leads to a slightly higher carbon tax level in scenario *B*. The reduced energy use also results in the additional policies leading to a larger emission reduction. Reducing or removing the additional policies then implies that the carbon tax has relatively more carbon emission reductions to incentivise. We find the opposite effects if we assume lower autonomous energy-efficiency improvements.

Assuming a higher ESR-quota unit price decreases the welfare gains from trade in these certificates in scenario *C* as additional and more expensive domestic carbon abatement options are now incentivised. We find the opposite effects if we assume a lower quota price and report no changes in results for scenarios *A1*, *A2* and *B* since no trade is allowed in these scenarios.

**Table 6** Piecemeal sensitivity analysis

| | | $CO_2$ emission price (SEK per tonne $CO_2$) | | | | Welfare (% change from reference case) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Scenario | | | | Scenario | | | |
| | | *A1* | *A2* | *B* | *C* | *A1* | *A2* | *B* | *C* |
| Regular scenarios | | 0 – 8,300 | 0 – 18,906 | 7,476 | 2,000 | -0.6 | -0.6 | -0.3 | 0.5 |
| Depreciation rate of fixed capital | High | 0 – 7,224 | 0 – 17,011 | 7,447 | 2,000 | -0.6 | -0.5 | -0.3 | 0.6 |
| | Low | 0 – 9,142 | 0 – 20,334 | 7,559 | 2,000 | -0.6 | -0.6 | -0.4 | 0.4 |
| Armington elasticity | High | 0 – 7,045 | 0 – 15,974 | 6,871 | 2,000 | -0.4 | -0.3 | -0.2 | 0.3 |
| | Low | 0 – 10,548 | 0 – 24,229 | 8,172 | 2,000 | -0.8 | -0.9 | -0.5 | 0.7 |
| Substitution elasticity KL vs E | High | 0 – 8,155 | 0 – 18,507 | 7,472 | 2,000 | -0.6 | -0.6 | -0.3 | 0.5 |
| | Low | 0 – 8,474 | 0 – 19,406 | 7,481 | 2,000 | -0.6 | -0.6 | -0.4 | 0.5 |
| AEEI | High | 0 – 8,150 | 0 – 18,698 | 7,499 | 2,000 | -0.6 | -0.5 | -0.3 | 0.5 |
| | Low | 0 – 8,463 | 0 – 19,130 | 7,450 | 2,000 | -0.6 | -0.6 | -0.4 | 0.5 |
| ESR-quota unit price | High | 0 – 8,300 | 0 – 18,906 | 7,476 | 3,000 | -0.6 | -0.6 | -0.3 | 0.4 |
| | Low | 0 – 8,300 | 0 – 18,906 | 7,476 | 1,500 | -0.6 | -0.6 | -0.3 | 0.5 |

# 6. Concluding discussion

With the Fit for 55 package, the EU has developed a comprehensive and ambitious climate-policy framework that rests on what essentially are three separate cap-and-trade systems – EU ETS, ESR and LULUCF. In the EU ETS, the trading decisions are delegated to the emitting entities. Their interest in making profits is likely to guide them towards the cost-effective allocation of emission abatements. The ESR and the LULUCF regulations place obligations on the member states' governments and, to enhance the cost effectiveness of the policy, allow them to trade ESR-quota units and LULUCF credits, respectively. However, the current Swedish climate policy prevents the government from fully engaging in such emissions trading, prescribes larger domestic emission reductions than demanded by the Swedish ESR obligations, implies relatively strong incentives for some adjustments (e.g., switching to biofuels and electricity in transport) and low or no incentives for some other abatement options. As a result, Swedish households incur additional costs.

We have used a computable general equilibrium model of the Swedish economy to assess the economic consequences of various changes in Sweden's climate policy while keeping the overall climate ambition constant. More precisely, we study the effects of reaching Sweden's current national emissions targets by (i) reducing the biofuels standard and instead increasing current (positive) tax rates and (ii) reducing the biofuels standard and applying a more uniform domestic carbon taxation regime to reach the same national emission target. We also study the cost savings of a policy reform (iii) that reduces the biofuel standard, implements a carbon-tax regime that provides more accurate incentives for fuel switching (in transport) and avails itself of the flexibility mechanism allowed under the ESR. Here, the domestic carbon tax is set equal to the international price on ESR-quota units (assumed to correspond to SEK 2,000 per/tonne $CO_2$), and Sweden buys emission-quota units not only to fulfil its ESR obligation but also to attain the same overachievement as planned under the current policy.

The results indicate that a policy that reduces the biofuel standards while raising the current positive carbon tax rates to reach our national emission targets will create high petrol and diesel prices (compare scenarios *A1* and *A2* in Table 3 and Table 5). To a large extent, such price increments can be avoided by introducing a more accurate and uniform national carbon tax. The benefit of the latter step is equivalent to an income increase of 0.22% in 2030 (compare scenarios *A2* and *B* in Table 3).

However, retaining national emission targets will nonetheless impose additional costs on Swedish households. The model results presented above indicate that abolishing our national emission targets and buying emission-quota units from other member states represents substantial cost savings for Sweden and will not only fulfil our ESR obligation but attain the same overachievement that Sweden's current policy implies, thereby substituting cheaper abatements in other member states for more expensive ones in Sweden. Given the assumed price on ESR-quota units, the cost savings corresponds to an increase of 1.1% in the Swedish household's income in 2030 (compare scenario *A1* with scenario *C* in Table 3). The sensitivity analysis conducted indicates that this conclusion is robust.

These assessments do not capture any adjustment costs of moving from one equilibrium to another and may, therefore, underestimate actual cost savings. Perhaps more importantly, the analysis does not account for the any benefits of Swedish climate policy. The Swedish policy has been motivated by an ambition to generate various demonstration effects, accelerate technological development and facilitate international negotiations. We leave it to the reader to judge if any values foregone by Sweden, by being less of a forerunner, outweigh the quantified increase in Swedish households' welfare. It should be noted that an EU-wide cost-benefit analysis of the policy reform should also consider the trade gains accruing to the member states that sell emission-quota units to Sweden.

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# Comment on D. von Below, B. Carlén, S. Mandell & V. Otto: Climate policy in Sweden in the light of Fit for 55

**Shon Ferguson**

## Introduction

National targets for reductions in greenhouse gas emissions represent a significant policy intervention in many countries, including Sweden. There is much at stake, affecting both economic welfare and the environment. It is crucially important that policymakers fully understand the implications of the policy options in their efforts to achieve these targets. The authors' analysis of the economic implications of the Swedish government's current climate policies compared to alternative scenarios is, therefore, both a timely and important contribution to this work.

## Discussion

The paper begins by comparing and contrasting Sweden's emission reduction goals with the EU's "Fit for 55" package. The authors highlight that nearly all of Sweden's emission reductions in the Effort Sharing Regulation (ESR) sector are expected to be made in road transport. The authors' calculations suggest that emission reductions using the biofuel blending mandate ("reduktionsplikten") may be extremely costly. Moreover, Sweden runs the risk of requiring ESR quota units to meet its Land Use, Land-Use Change, and Forestry (LULUCF) obligations, which would be a relatively costly solution compared to much cheaper abatement measures, e.g. increasing carbon storage in Sweden.

According to economic theory, the most efficient way to reduce emissions in an economy is to ensure that the marginal cost of abatement in each sector is equal to the marginal damages from emissions. A regulator could achieve this 'first-best' outcome via a Pigouvian tax on emissions that is applied uniformly across all sectors. In reality, this is a difficult task due to market imperfections and other complications. In the case of Sweden, however, the disproportionate focus on abatement in road transport is also policy-induced since current policy interventions depart drastically from the equivalent of a uniform tax. Using a simple graphical approach, the authors illustrate the damage to economic welfare when the abatement of marginal costs is not equal across sectors.

The authors apply a Computable General Equilibrium (CGE) model of the Swedish economy in order to analyse the differences in GDP, abatement costs and economic welfare. CGE models have their drawbacks, as they have many moving parts and are, in some cases, sensitive to the chosen parameters. For example, any model would probably be sensitive to assumptions about future abatement costs across the various industries. However, I would argue that a CGE model is a suitable approach because it captures the many direct and indirect impacts of policies on various sectors and is the standard in this field. Their main conclusion is that more flexible alternative policies resembling something closer to a uniform carbon tax would boost GDP and economic welfare. Their results seem reasonable and are in line with their theoretical predictions.

I completely agree with the author's argument that Sweden's current approach to reducing emissions in the ESR sector is highly inefficient. The authors provide rigorous estimates of the cost of reducing emissions in the transport sector. In terms of abatement alternatives, they cite evidence for the relatively low cost of abatement in the LULUCF sector and projected ESR quota unit price. It should also be noted that they spend less time discussing alternative domestic abatement in the ESR sector, probably because these alternatives are less feasible. Based on the most recent statistics available (Statistics Sweden, 2023), emissions due to waste and the heating of buildings were only 2% and 3% of Sweden's total territorial emissions in 2021, respectively, which leaves little room for further emission reductions. Emissions from Swedish agriculture in 2021 were 14% of the total and have remained roughly constant over time. The majority of emissions in Swedish agriculture not related to land use are caused by biological processes (Swedish Board of Agriculture, 2012), making abatement difficult to implement and monitor.

One potential criticism of the authors' analysis is that in its focus on efficiency, it has ignored the importance of positive externalities that Sweden provides via 'demonstration effects'. I would argue, however, that the previous government's policy to increase the biofuel blending mandate in order to meet domestic emission targets in the road transport sector also suffered from a lack of demonstration effects, as it is highly dependent on imports. In the most recent statistics from the Swedish Energy Agency (2022), 92% of the raw materials for biodiesel in 2020 were imported. Similarly, 88% of the raw materials for ethanol were also imported. Such a high degree of import dependency makes an inefficient policy also very deficient in terms of demonstration effects.

One interesting result is the significantly negative effects on the agriculture and forestry sector in some of the scenarios. Even though these sectors are not directly affected by ESR policies, agriculture and forestry are both sensitive to the price of fuel. Although landowners in Sweden could stand to gain from increased demand for biofuel, the higher demand will probably be met by increased imports. In addition, the price of biofuel feedstocks is determined by international commodity markets. The CGE model used in the analysis does not explicitly model the land market, leaving a need for further research and a more in-depth analysis of the impact on the return to landowners.

## Final remarks

The results suggest that there are difficult trade-offs associated with alternative approaches to reaching Sweden's interim ESR emission targets. Business-as-usual policies will not reach the ESR target, and reaching the target using only the biofuel blending mandates would be very costly (and probably dependent on imported biofuel feedstocks). The most economically efficient approach to meeting the ESR target entails purchasing ESR quota from other countries, which would arguably tarnish Sweden's reputation as a climate policy forerunner.

Looking beyond interim ESR targets, one obvious next step would be to study alternative policy scenarios for reaching net zero emissions in Sweden. Given the evidence suggesting that abatement in the LULUCF sector is much cheaper than in transport, an analysis of alternative policies in the LULUCF sector would be of great interest with respect to Sweden's net-zero targets. This would again require explicit modelling of the LULUCF sector, which has been left up to future research.

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# Comment on D. von Below, B. Carlén, S. Mandell & V. Otto: Climate policy in Sweden in the light of Fit for 55

**John Hassler**

## Components of Climate Policy

Climate policy contains a wide array of measures. These can be classified into three different groups, each containing a specific aim:

1. Direct emission reductions: carbon dioxide ($CO_2$) taxes, emission trading systems and technology standards are all examples of policies in this group.
2. Facilitation of a smooth transition to climate neutrality. This is a broad group containing, among other elements:

   (i) industrial policy to help the development and adoption of green technologies.

   (ii) labour market training for individuals working in the fossil fuel industry.

   (iii) support to households particularly affected by higher fossil fuel prices.

   (iv) streamlined permission processes for green infrastructure.

   (v) schooling and training to provide necessary new competences.
3. Encouraging and pushing the rest of the world to participate in the green transition.

A successful climate policy must consist of measures from all the above areas. Measures directly aimed at reducing $CO_2$ emissions (group 1) can likely not be replaced by subsidies to green technologies (group 2). While such subsidies do increase the use of green and climate-friendly products, it is far from clear that older 'dirty' products will be out-competed by these policies, at least not at a sufficiently fast pace (IMF, 2020 and Hassler et al., 2020) At the same time, policies aiming to create a smooth transition (group 2) are necessary for maintaining political legitimacy for regulation that increase the cost of emissions. Finally, future emissions reductions in the Nordic countries, and the EU as a whole, will be pointless if other countries cannot be successfully persuaded to introduce ambitious climate policies.

## Fit for 55 and being a forerunner

For some time, the Nordic countries have aimed at being forerunners in adopting ambitious climate policies. This has resulted in the introduction of $CO_2$ taxes and ambitious (at least in a relative sense) national targets for $CO_2$ emissions, i.e., policy measures pertaining to group 1. When the Fit for 55 package comes into effect, EU legislation will have substantially narrowed the gap between policies in the Nordic Region and in the EU in relation to measures for phasing out $CO_2$ emissions. However, some important differences remain. According to Fit for 55, in 2030, Sweden will receive ESR quota units corresponding to 50% of its emissions in 2005. In each year leading up to 2030, a linearly falling number of units are received. The Swedish national emissions target for the ESR sector in 2030 is more rigorous, requiring an emission reduction of 61% by 2030.[43]

Under EU regulations, Sweden is allowed to purchase ESR quota units from other member states to satisfy the required reductions if domestic emissions are larger than the quota units received. The reason for allowing such trade is the same as for EU ETS allowances trading, namely that such trade enables the marginal cost of emission reductions to equalise across member states, despite the fact that the requirement for emission reductions may differ quite significantly between countries (from 10% in Bulgaria to 50% in the Nordic countries, Germany and Luxembourg). However, Swedish law permits only limited use of such trade and other supplementary measures, including, for example, increased uptake of $CO_2$ in land and forestry and the creation of negative emissions using carbon capture and storage (CCS) in heat and power plants using non-fossil fuels.

43. Swedish law states the required emission reduction relative to 1990 at 63%. This translates to a reduction of 61% relative to 2005. To facilitate comparisons, I will express all emission reductions relative to 2005.

# Analysis in the chapter

The article by von Below et al. discusses both the costs of setting stricter domestic targets for emission reductions and the associated costs of non-uniform emissions pricing. The latter includes variations between emitters within a country and between countries. The main aim of the article is to quantify these costs in the Swedish context. To this end, the authors use a detailed general equilibrium model to analyse the economic consequences of four different scenarios for achieving the nationally targeted 61% ESR reduction. Under current national policies (including the planned step-by-step increase in mandatory blend-in of biofuel in diesel and petrol to 66 and 28%, respectively, by 2030), ESR emissions will fall by 48%. Therefore, this scenario is a good reference point, although some additional policies may need to be enacted in order to achieve the 50% reduction required under Fit for 55.

The first of the four scenarios (*A1*) uses an increased $CO_2$ tax to reach the target of 61% emission reductions. The second scenario (*A2*) also uses a higher $CO_2$ tax but, in addition, removes the regulation on biofuel blend-in, instead setting it at a predicted minimum level of 15%. In the third scenario (*B*), a more uniform $CO_2$ taxation is introduced, implying, in particular, that the biofuel component in diesel and petrol is not taxed, while some other green subsidies are removed. In the fourth scenario (*C*), the uniform $CO_2$ tax is set exogenously and purchases of ESR quotas from other countries are used to reach the targeted emission reductions. The $CO_2$ tax and the ESR price are both set to SEK 2,000 per/ton $CO_2$, which is slightly lower than twice the current $CO_2$ tax rate. It should be noted that the final scenario requires changes to Swedish climate law since, as noted above, the law includes a self-imposed restriction on the number of such purchases allowed.

The model results show that quite significant increases in $CO_2$ tax levels are required to reach the Swedish target unless purchases of ERS quota units are used. In scenarios *A1* and *B*, the $CO_2$ tax must be increased to SEK 8,300 and 7,476 per tonne of $CO_2$, respectively. This is six to seven times the current $CO_2$ tax rate which is approximately SEK 1,190/t$CO_2$. The latter figure is also close to the current price of EU ETS allowances. Given that petrol and diesel produce 2.3 and 2.7 kg $CO_2$ per litre, the tax rate would be in the order of SEK 20 per litre if no non-taxed biofuel is included in the fuel mix. In scenario *A2*, the required $CO_2$ tax is more than twice as high at SEK 18,906/t$CO_2$, close to twenty times the current price of EU ETS allowances. Although the tax increase is approximately the same in scenarios *A1* and

*B*, the reduced blend-in of biofuel in the latter implies that price increases at the pumps would be much lower. Relative to the reference scenario, the diesel price doubles in scenario *A1* but increases only by 27% in scenario *B*.

Scenario *C* presents strong evidence that emission reductions in Sweden will come at a considerable cost. If ESR quota units can be bought at SEK 2,000 per tonne, close to half (42%) of the emission reduction required under Swedish climate law (61%) could be achieved by paying for emission reductions in other countries through purchasing ESR quota units. Given the uneven distribution of quota units, this is not a surprising result.

The analysis also shows that welfare and GDP fall substantially, relative to the outcome in the reference scenario if the 61% target is met without using the option of buying ESR quotas abroad. In scenarios *A1* and *A2*, the loss is equivalent to around 0.6% of income and GDP losses amount to 0.7% and 0.9% in 2030. If a more uniform policy is applied (scenario *B*), losses are about half as large (0.35% of income with a GDP loss of 0.4% in 2030). If purchases of ESR quotas are used instead, there is a resulting welfare gain of 0.49% and a GDP increase of a similar size.

# Comments and discussion

The article provides a comprehensive analysis of the domestic costs of setting stricter targets for emission reductions and how these costs can be reduced by applying more uniform $CO_2$ taxation and through purchasing emission reductions from other EU countries. The authors' analysis is thorough, and although modelling necessarily represents a simplification of reality, they provide credible answers to the important questions raised.

As noted by the authors, the more rigorous Swedish emission reduction targets imply that emissions in 2030 should be around five million tons lower than the Fit for 55 package requirements. The costs of these reductions are considerable relative to the amount of emission reductions. The reported GDP decrease of 0.7-0.9% implies that SEK 9,000 12,000 is lost for every ton of $CO_2$ abated.[44] The welfare losses are of a similar order of magnitude. These costs could be reduced if a more uniform taxation system is applied, but they are still substantial many times greater

44. GDP in 2030 in 2019 prices is SEK 6,135 billion in the analysis. 0.7 and 0.9% of GDP thus corresponds to SEK 42.9 and 55.2 billion.

than the expected cost of emission reductions abroad.

Are there benefits associated with the higher Swedish targets for emission reductions and the restrictions imposed on accessing the flexibility mechanisms? This is a difficult question to answer, in particular, if seeking quantitative answers. An oft-cited benefit is the demonstration effect – a forerunner may inspire others to introduce more ambitious climate policies. The authors clearly state that although such benefits may exist, they are not analysed in the article. Despite the difficulty involved, let me nevertheless provide a brief qualitative discussion about the potential demonstration effect of current Swedish policy.

As discussed above, climate policy is highly multifaceted, with many complementary parts. Given this, a strategic use of the demonstration effect should focus on areas of policy where the potential gain is high relative to the associated cost.

In the introduction to this publication, we noted that the Fit for 55 package sets binding limits for EU emissions for the entire future. Emissions from the old and the new emission trading systems, covering almost all fossil $CO_2$ emissions in the EU, will be in the order of 60 tonnes per EU citizen if the current and proposed rules are kept in place. After 2035, the sale of fossil fuel cars and vans will be banned. After 2044, no more emission allowances will be released to the market, meaning that at that point, the EU will have phased out the fossil fuel economy. With regards to domestic reduction of $CO_2$ emissions, the EU and all its member states do what is required under the Paris agreement. After the Fit for 55 package, there is, therefore, little remaining value in being forerunners when it comes to limiting domestic $CO_2$ emissions.

Note, however, that I focus here on reductions of $CO_2$ emissions. To stabilise the global climate, we need to greatly reduce emissions of other greenhouse gases, too, in particular methane. The Fit for 55 package does not include tools to reduce methane emissions from agriculture, which remain outside the sectors coved by emission trading. We also need to increase the uptake of $CO_2$ in land and forests and increase carbon capture and storage. To achieve this, systems providing economic incentives to households, forestry owners, farmers and industrial power plants need to be put in place. Despite the importance and undoubted potential of such measures, Sweden is here a laggard rather than a forerunner. Arguably, Swedish climate policy, with its strong focus on emission reductions in the transport sector and restrictions on the use of supplementary measures, is a reason for the laggardness. I believe this must change.

Group 2 of the climate policies outlined above contains measures to facilitate a smooth transition to climate neutrality. The Fit for 55 package forces a phasing out of the fossil fuel economy. But it must be replaced by a durable new green economy. Although the structural transformation is arguably not of historic proportions, it does require a policy. Sweden and the other Nordic countries may well have the ability to be forerunners here. However, in Sweden, slow processes for providing permissions for building infrastructure and new production facilities, such as in the mining industry, effectively act as a brake on the transition to climate neutrality. Lack of competent labour resources and housing in areas where new green industries are intended has a similar knock-on effect. In these cases, I believe that efficient legislation and governance are far more important than industrial subsidies.

Delivering a smooth transition is crucial. I am far more worried that the risk of popular dissatisfaction might lead to an unravelling of the Fit for 55 regulation, than that the Nordic countries will fail in their ambition to push the EU to adopt even more ambitious policies. The former could be catastrophic, the latter is not important in the overall picture.

Are there benefits to not using ESR quota trading with other countries? I find it difficult to see any. Clearly, the EU ETS is a success story, and few now think it is important to have policies targeting the distribution of emissions across countries within the system. The same approach should apply to emissions within the ESR sector. On grounds of fairness, Sweden and the other Nordic countries are obliged to be economically responsible for greater emission reductions. However, this does not presume that emission reductions are cheaper and can be achieved faster within their national borders. If Sweden and Bulgaria (for example) make a deal whereby Sweden pays for emission reductions in Bulgaria, then it represents a win-win situation. By reducing the overall costs of the transition, the risk that the Fit for 55 regulation unravels is also reduced. Within the EU ETS, an efficient market for trade in emission allowances has emerged. The ESR regulation requires that the emission quotas traders are the respective governments of the member states. Sweden and the other Nordic countries should actively develop a functioning and transparent market for trade in ESR quotas. This is another area where we could be forerunners.

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# About this publication

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