



# Speeding up the decarbonisation of European industry

Assessment of national and EU policy  
options



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# Speeding up the decarbonisation of European industry

## Assessment of national and EU policy options

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Delft, CE Delft, August 2022

Publication code: 22.220237.099

Climate / Policy / Carbon dioxide / Industry / Emissions / Europe / ETS / National / International / Policy measures / Effects

Client: AirClim

Prepared for the ETX Consortium.

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## **Acknowledgement**

The study has received funding from the LIFE programme of the European Union. The project also acknowledges the generous support of the European Climate Foundation.

## **Legal Notice**

This publication, corresponding to deliverable ‘C5.4 Report on overlaps between the EU ETS and national carbon pricing schemes’, is financed by the European Commission through the LIFE programme and the European Climate Foundation. It is the overarching goal of the LIFE programme to act as a catalyst for changes in policy development and implementation by providing and disseminating solutions and best practices to achieve environmental and climate goals, and by promoting innovative environmental and climate change technologies.

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# Summary

On 14 July 2021, the European Commission launched the Fit for 55 package to step up in Climate Ambition, as part of the European Green Deal. The Fit for 55 package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the EU target of at least 55%. In this study we have analysed what this package would mean for the most carbon intensive industrial sectors and what type of policy support is required to assure that industry would contribute to the overall reductions and remain competitive in the long run.

## Lack of decarbonisation in most carbon intensive sectors so far

Industrial GHG emissions in the EU are largely regulated by the EU ETS. The EU ETS is often considered as an effective policy instrument that has reduced overall CO<sub>2</sub> emissions with 41% in 2021 compared to 2005 levels. However, the major part of these reductions have been caused by reductions in the power generation sector and have rather been caused by other factors (e.g. renewable energy support). In the six most carbon intensive sectors (cement, iron and steel, refineries, fertiliser, other basic chemicals and paper/pulp) the reductions have been very modest. When corrected for changes in production levels, we could not detect any improvement in the aggregated carbon efficiency over the 2013-2019 period in those sectors.

The decarbonisation process in EU's carbon intensive industries must thus be intensified drastically in order to assure a future for those sectors under EU's ambitious climate policies. The proposed changes to the EU ETS under the Fit for 55 agenda imply that industry should be carbon neutral by 2040. For the six energy intensive sectors there are plenty of technical options available to decarbonise, even though many of these options need to scale up to the level of the EU market.

Supportive climate policies at the member state level and EU level could incentivise the deployment of low carbon technologies in the most carbon intensive sectors and are thus an important cornerstone of policy reforms to speed up the decarbonisation process in industry. In the past such additional policy schemes have often been hampered by the claim that there would be a 'waterbed effect' in the ETS. Additional emission reductions under a fixed ETS ceiling would then imply just more room in other sectors to increase their emissions. However, the introduction of a market stability reserve has invalidated this argument, as additional reductions that would increase the surplus of allowances are cancelled permanently. In addition, they may stimulate politicians to agree on more stringent ETS targets and the cancellation of allowances by Member States. Therefore we conclude that additional policies are useful to consider for speeding up the transition to a low carbon industry in the EU.

## Auxiliary policies at the member state level

At the national member state level we have identified interesting examples of a few successful policy and business developments in:

1. Carbon price floors.
2. Carbon taxes on top of the ETS.
3. Phase-out of certain production processes.



#### 4. Public-private partnerships.

Ad 1) In the Netherlands, a **carbon price floor** has been introduced that provides investment security for industry by introducing a minimum CO<sub>2</sub> price for emissions above a predefined reduction path. This must assure that industry contributes equally to the national CO<sub>2</sub> policy reduction plan. Subsidies schemes have been introduced to allow companies to reduce their emissions at lowest costs so that impacts on competitiveness are minimised. These subsidies are being paid by an increase in the Sustainable Energy Surcharge of companies.

Ad 2) Industry in Estonia, Finland and Slovenia is not only participating in the ETS but also falling (for most emissions) under a **national CO<sub>2</sub> tax regime**. A few other countries (e.g. Sweden) have also introduced CO<sub>2</sub> taxes for industry but exempted companies participating in the EU ETS – often after intensified lobbying from the industrial sector claiming that double taxation would be disastrous to their competitive position. However there is no double taxation in practice as the majority of emissions in the ETS still receive free allowances. The big advantage of schemes on top of the ETS (even though tariffs in e.g. Estonia are very modest) is that they are forcing industry to continuously try to lower their carbon emissions. Tax revenues could be earmarked for subsidies to industry to decarbonise.

Ad 3) Other national policy plans that are interesting to investigate are related to a **phase-out of certain production routes**, as has been proposed in Germany through the phase-out of coal in electricity production by 2038 the latest. Such long-term plans give clarity to the market and investors and stimulates innovation and deployment in alternatives. Phase-out of certain production routes could also be an interesting part of national (or EU-wide) industrial policy, for example in the field of cokes-based blast furnace steel making or in the semi-wet process cement kilns.

Ad 4) Finally a case study on the transformation of Swedish steel from carbon to hydrogen based production method served as an example where a crucial decarbonisation technology was introduced from a private sector with public participation. Such **public-private partnerships** could serve as a blueprint for other sectors as well that aim to speed up their decarbonisation process.

### EU policy reforms

Next to national carbon policy reforms, we have investigated what can be done at the EU level to increase the decarbonisation process in energy intensive industries by focussing on two policy instruments: the **EU ETS and the Industrial Emission Directive (IED)**. Within the EU ETS, the level of ambition can be increased by either rebasing the cap (e.g. allowing for a one-off reduction) or increasing the linear reduction factor, or a combination of both. However, an increased ambition in the industrial sector should probably be accompanied by support schemes to prevent overheating of the carbon market due to short supply. Support schemes could take the form of carbon contracts for differences, investment subsidy schemes or a system of conditional lending.

Within the EU ETS legislation, also the role of free allocation could be reconsidered, resulting in a more timely end of free allocation in the EU ETS. Free allocation may be more precisely connected to alleged carbon leakage claims and made conditional on the willingness to invest in low carbon production routes. In addition, the system of benchmarks



should be updated to be based on (substitute) products to lower the amount of free allowances granted to relatively polluting production processes.

For the Industrial Emission Directive, there exist numerous possibilities to include carbon reduction technologies into the cost-effectiveness considerations so that co-benefits with air pollution measures are properly factored in and more measures are classified as Best Available Technology. This would reduce air pollution and greenhouse gas emissions simultaneously and thus create a double benefit.

In this study we conclude that it is risky to rely only on the EU ETS to speed up the decarbonisation of industry. In the past (2013-2019) we have not been able to detect any aggregated decarbonisation in the most carbon intensive sectors in the EU. Although prices for carbon allowances are nowadays much higher, the price signal can be further intensified by lowering free allowances in the ETS and/or raising the level of ambition. In addition, technical requirements that reap the co-benefits between air pollution reduction and CO<sub>2</sub> reduction should become an integral part of the EU industrial policies. At the member state level, CO<sub>2</sub> taxes, CO<sub>2</sub> price floors, CO<sub>2</sub> standards and conditional subsidy schemes (eventually through public-private partnerships) could be important elements of an industrial policy that is adhering to the climate targets set in the Paris agreements and providing companies a competitive future in a rapidly decarbonizing world.



# 1 Introduction

## 1.1 Background of this study report

On 14 July 2021, the European Commission launched the Fit for 55 package, also known as the package delivering the European Green Deal. The Fit for 55 package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with both the EU target of at least 55% greenhouse gas emission reduction in 2030 and the goal of climate neutrality in 2050, as laid down in the European Climate Law. Although the Fit for 55 package contains ambitious proposals that will affect industry in several ways, results from the past leave room for doubt that it will be sufficient to speed up the decarbonisation of industry to such an extent that the targets for 2030 and 2050 will actually be achieved. Apart from the implementation of the Fit for 55 proposals, if and when adopted, more action by Member States may be necessary to ensure a full and timely decarbonisation of the EU's heavy industry.

Therefore, AirClim has commissioned to CE Delft a study that gives an overview of both the policies EU Member States can implement nationally and EU policies they can advocate to enhance and speed-up the decarbonisation of the industry sector. In this report the results of our research are presented.

## 1.2 Demarcation and methodology

The scope of this study will be limited to the fossil-based, energy-intensive industry. We focus on the largest emitters: iron and steel, cement and lime, fertilisers, other chemical industries, refineries, pulp and paper.

Given the restrictions in time and size of the report, the study has been carried out mainly on the basis of existing literature, complemented by CE Delft's in-house knowledge on relevant policies both on EU and national level, industrial production processes and related decarbonisation options.

## 1.3 Reading guide

The next chapter presents a brief overview of the emission reductions in heavy industry that have been achieved so far, mainly through the EU's Emission Trading System (ETS). Chapter 3 will treat four case studies of national policies in EU Member States that could function as a blueprint for further action. In Chapter 4 we assess a number of specific existing EU policy instruments and indicate what adjustments could improve their effectiveness in speeding up the decarbonisation in EU heavy industry. Finally, Chapter 5 will present our conclusions, focusing on concrete policy recommendations on both EU and national level.



# 2 State of affairs in decarbonisation of EU industry

## 2.1 Introduction

There is a general consensus that EU industry may have started to decarbonise its processes, but that progress up-to-now probably has been limited – and is not in line with the ambitious targets for 2030 and the (even more ambitious) reductions required to stay within the 1.5 degree Celsius commitment from the Paris Agreement. In this chapter we will analyse the progress in decarbonisation of European industries in more detail. First, in Section 2.2 we provide general trends in emissions and will argue to what extent these are policy induced. We will argue that progress in energy intensive industries to decarbonise has been very poor so far. Then, in Section 2.3 we will briefly investigate if there are *technological* barriers that could explain the poor performance so far and that could hamper acceleration of the speed to decarbonise in the future.

## 2.2 Decarbonisation of EU industry in the past years

### 2.2.1 General emission trends

CO<sub>2</sub> emissions from the selected industry sectors have declined by 20% over the 2008-2019 period, from 647 Mton to 517 Mton, see Figure 1<sup>1</sup>. After a strong decline in 2009 due to the global financial crisis, emissions have remained essentially flat over the 2009-2019 period, with minor year-to-year fluctuations.<sup>2</sup> A linear fit over the 2009-2019 period yields an average annual reduction of 1.1%. This is below the average reduction factor of companies participating in the ETS (which has been 1.74% of 2005 emissions, see below). Can we therefore conclude that EU industry is lagging behind? This will be elaborated in the next few subparagraphs.

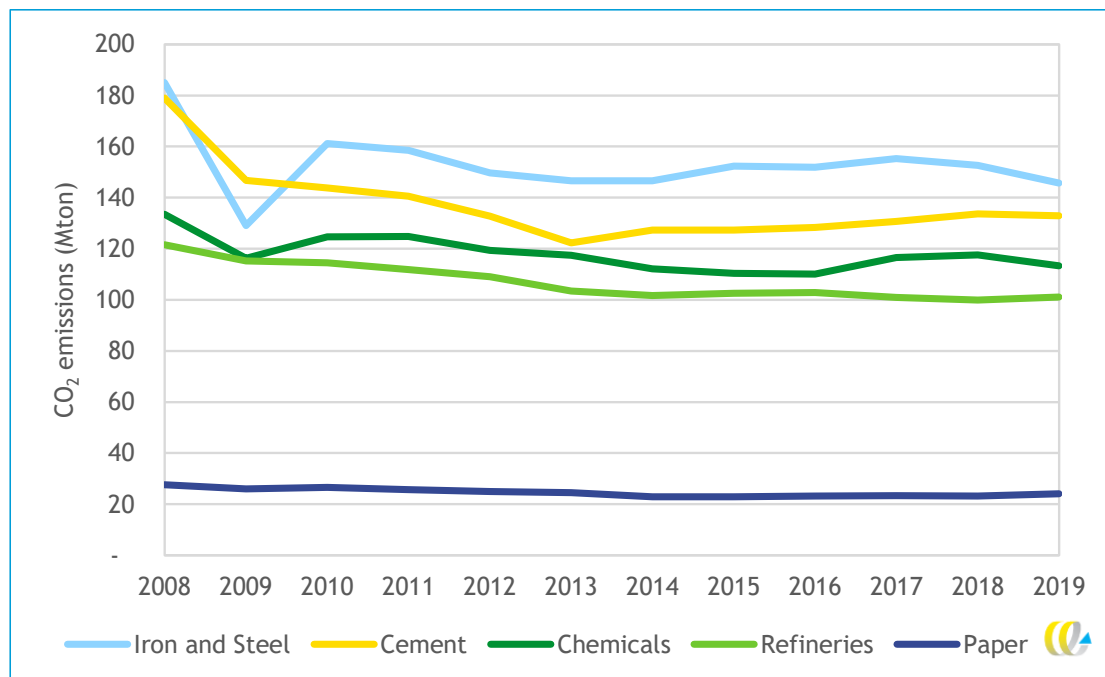
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<sup>1</sup> Fertilisers and other chemical industry sectors are excluded from this number due to scope changes in 2013, but show similar declines in the post-2013 period.

<sup>2</sup> The data show both ETS and non-ETS participants in those industrial sectors. Recent data from the EUTL shows that in 2020 and 2021 emissions in at least the EU ETS sectors decreased considerably.



Figure 1 - CO<sub>2</sub> emissions of selected key sectors of EU industry in 2008-2021



Source: Eurostat, calculations by CE Delft.

## 2.2.2 Main policy instrument: EU Emissions Trading System (EU ETS)

Greenhouse gas emissions of the industrial sectors under scrutiny are for the largest part (> 95%) regulated by the EU ETS.<sup>3</sup> Through the EU ETS over 11,000 installations and companies are regulated in electricity generation, aviation and energy intensive industrial sectors in 31 countries.<sup>4</sup> The EU ETS is the first international cap-and-trade program for carbon dioxide (CO<sub>2</sub>), which additionally partially prices nitrous oxide and perfluorocarbons. Overall, approximately 36% of EU's GHG emissions are covered by the EU ETS (EC, 2021e). For a long time, the EU ETS (consisting of the EU27, Iceland, Liechtenstein and Norway) was the largest carbon trading scheme in the world, only recently surpassed in volume by the Chinese national ETS.

Annually, companies participating in the EU ETS have to surrender emission allowances equal to their emissions of last year. They can buy emission allowances at public auctions or trade allowances with other companies. However, the large majority of industrial emission credits are granted for free, because most of the sectors are deemed to be at risk of 'carbon leakage' through a standard calculus. Free allocation is limited on the one hand by benchmarks that determine the maximum amount of free allowances per unit of production, and on the other hand the yearly decreasing cap that gives every year less

<sup>3</sup> There is no official information to what extent industrial emissions are covered by the EU ETS. A study in the Netherlands found out that over 92% of industrial emissions were covered by the EU ETS (Langeler, 2016). Using publicly available data we estimate that at the level of the EU refineries, cement and fertilisers have all of their emissions covered by the EU ETS, while the percentage of the organic chemicals and iron and steel is well above the 90% (in-house information CE Delft).

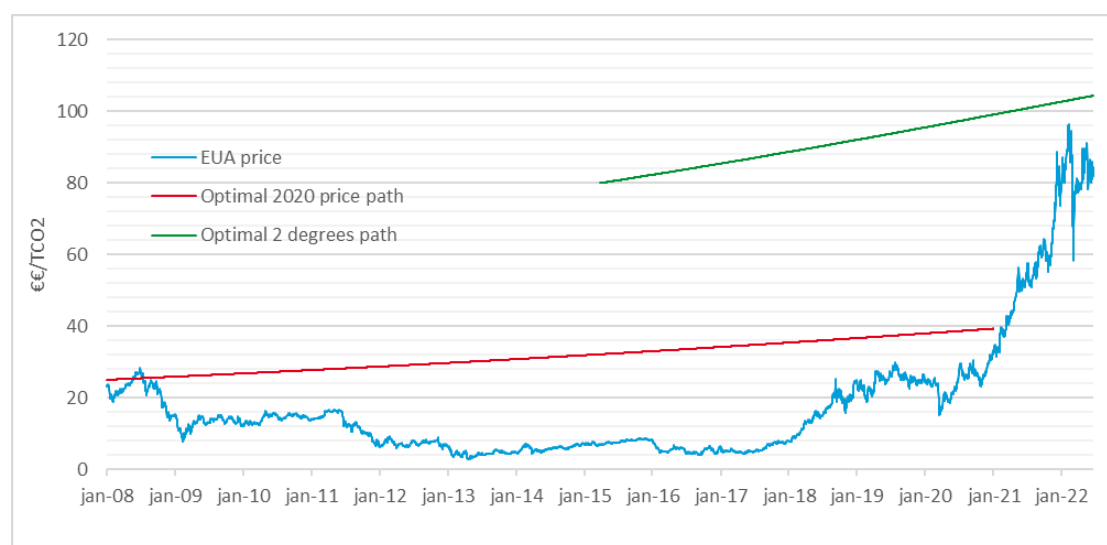
<sup>4</sup> The EU27 plus Iceland, Liechtenstein, Norway and the UK (2005-2020).

emission allowances for free.<sup>5</sup> Between 2013-2020 emissions decreased every year with 1.74% per year of the (corrected) 2005 emissions. From 2021 and on this ‘linear reduction factor’ is increased to 2.2%. As the reduction is fixed compared to 2005 emissions, in relative terms, the emission reduction increases every year. The EEA reports that in 2021 emissions in the EU ETS were 41% lower than in 2005.<sup>6</sup>

### 2.2.3 Analysis: effectiveness of the EU ETS for industry

The emissions cap in the ETS guarantees that long-term emissions decline. The decreasing availability of allowances should result in rising prices that generate a price signal for decarbonisation. To some extent this has taken place. Figure 2 shows the daily price at the spot market for EU allowances.

Figure 2 - Spot price for an emission allowance on the EU ETS market, €/tCO<sub>2</sub> 2008-2022



Source: EUA: SendeCO2, optimal price paths, analysis CE Delft.

We see here that for a long time prices on the EU ETS market remained very low. Between 2013-2018 prices were below the € 10/tCO<sub>2</sub>, and between 2008-2020 prices were always below the € 30/tCO<sub>2</sub>, despite the fact that politicians at the start of the systems agreed for emission trading on the basis of an impact assessment that predicted a cost-effective price of € 39/tCO<sub>2</sub> in 2020 (see red line in the figure based on EC, (2008) But it just never got there.

However, since the beginning of 2021, after the publication of the European Climate Law (and after the insight that COVID was not going to ruin our economies), prices of CO<sub>2</sub> started to increase drastically. However, it should be noted that the prices are still below a predicted price path to a 95% reduction of emissions in the EU (green line in the figure, based on the central price path in (CE Delft, 2018)).<sup>7</sup> **Therefore, price development in the**

<sup>5</sup> Additionally, between 2013-2020 companies received less allowances due to a cross sectoral correction factor to assure that total emission allowances did not exceed the targets.

<sup>6</sup> [EEA : Total greenhouse gas emission trends and projections in Europe](#) (EEA, 2021)

<sup>7</sup> The green line, with associated reduction of EU’s emissions of 95% by 2050, should be considered to be more in line with a 2 degrees scenario than with a 1.5 degree scenario. The latter scenario would imply even higher prices. However, due to technological progress, prices may now factually be lower than estimated in 2018.



ETS has always been below what is deemed to be necessary in the light of goals in 2020 and 2050. However, it should be noted that the prices are still below a predicted price path to a 95% reduction of emissions in the EU (green line in the figure, based on the central price path in (CE Delft, 2018)).<sup>8</sup>

The *empirical* effectiveness of the EU ETS at reducing emissions has been thoroughly covered in literature, although studies that assess the impacts up to and including the entire 3<sup>rd</sup> trading period (2013-2020) are still relatively scarce. A literature review by Öko-Institut finds that there is agreement that the EU ETS has had an effect at reducing carbon emissions, above and beyond what would be expected from autonomous improvements in efficiency (Öko-Institut, 2015). There is however a large bandwidth in outcomes, with some studies claiming a large effect and some studies only a minor effect. The main cause for this uncertainty is the lack of a clear counterfactual: how much would emissions have been reduced without EU ETS?

While the price signal of EU ETS should have had an impact (of uncertain magnitude) on reducing emissions, most of the observed emission reductions in ETS sectors are due to the results of other policies:

1. EU wide and national policies for renewable energy production including the falling costs of renewable energy as the result of larger deployment.
2. National targets for coal phase-out.
3. Other EU policies that have CO<sub>2</sub> emissions reduction as a side effect such as energy saving policies.

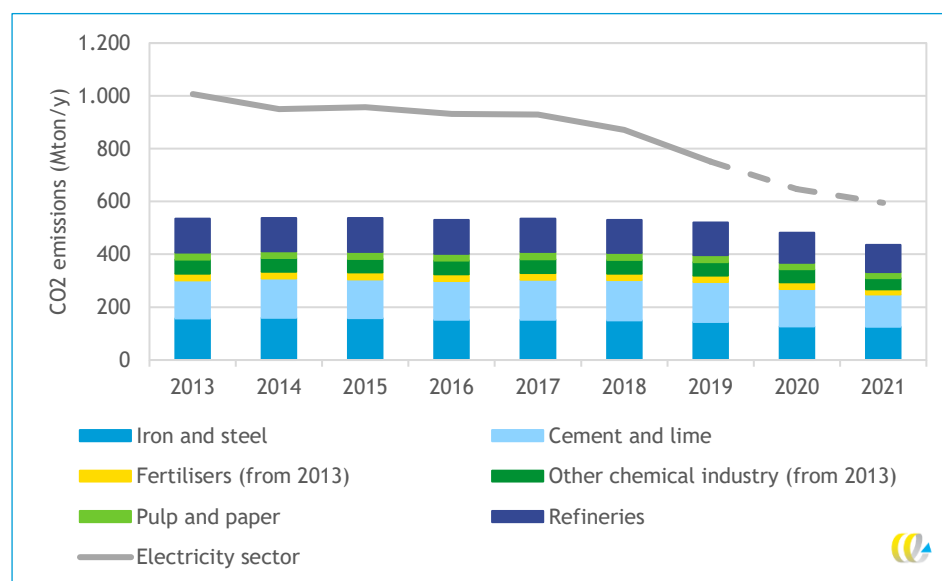
Most of these policies have been targeted at the electricity sector. The historic CO<sub>2</sub> emissions of the electricity sector and the focus industry sectors are displayed in Figure 3. The figure shows that emission reductions in the electricity sector are far greater than the observed reductions in industry.

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<sup>8</sup> The green line, with associated reduction of EU's emissions of 95% by 2050, should be considered to be more in line with a 2 degrees scenario than with a 1.5 degree scenario. The latter scenario would imply even higher prices. However, due to technological progress, prices may now factually be lower than estimated in 2018.



Figure 3 - Historic CO<sub>2</sub> emissions in the EU ETS from selected key sectors in comparison to electricity sector<sup>9</sup>



Source: EU ETS Data Viewer (industry), Eurostat (electricity sector), analysis CE Delft. Data for 2020 and 2021 for the electricity sector have not been available in Eurostat and are estimated by us by means of extrapolation on the basis of EUTL figures of fuel combustion.

We have shown in Section 2.1, Figure 1, that the industry emissions of the six sectors (ETS and non-ETS installations) have decreased by 20% in 2008-2019. Emissions of the electricity sector have decreased by 34% (despite increasing production), with an acceleration from 2017 onwards.<sup>10</sup> The emission reductions in the electricity sector are for the largest part the result of supporting policies, such as:

- The Renewable Energy Directive promotes the generation of renewable electricity, displacing electricity from fossil, thermal plants leading to subsidy schemes in the Member States.
- The Energy Efficiency Directive promotes more efficient appliances, leading presumably to lower electricity usage (without figuring in potential rebound effects).
- The Industrial Emissions Directive sets limits to air, soil and water pollution, leading to a gradual phase-out of the most polluting plants, which are often also the oldest and least efficient and most carbon-intensive plants.
- National policies such as energy saving, renewable energy or coal phase-out policies have helped to reduce electricity demand and divert the generation from coal, the most polluting fossil fuel commonly used for electricity production, to renewables.

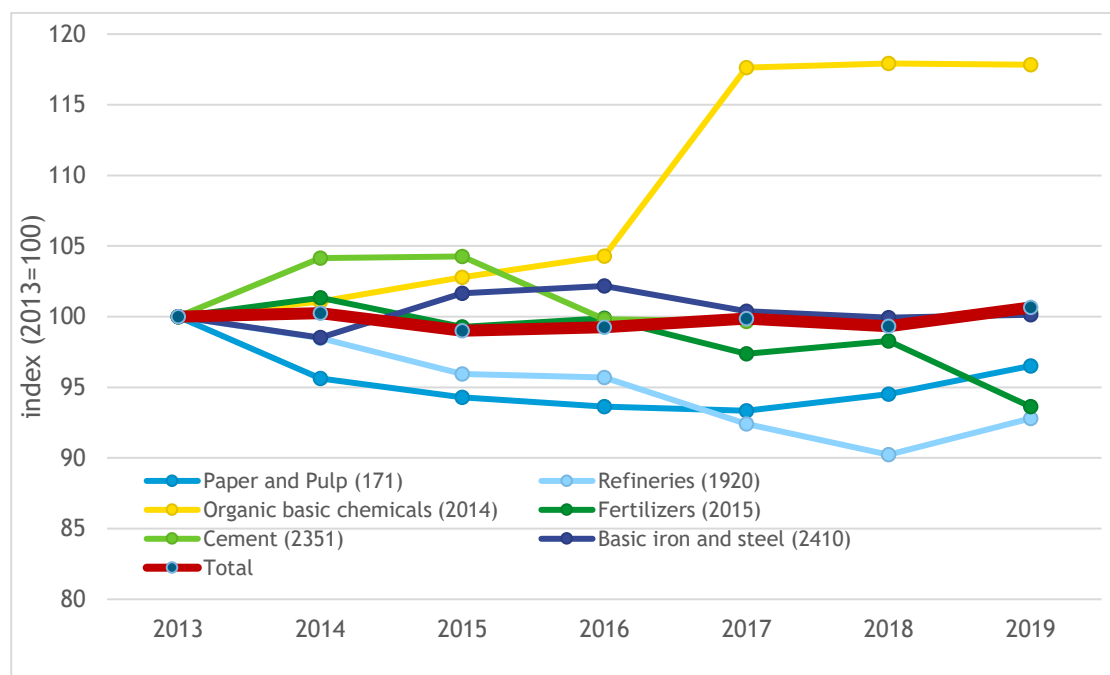
In order to evaluate the developments within the six chosen sectors we can compare their developments in emissions in the EU ETS with the volume of production, obtaining a measure of relative efficiency (efficiency per unit of production) using a methodology that

<sup>9</sup> Extrapolation for electricity sector estimated by keeping the share of electricity generation emissions in total emissions from fuel combustion constant at the 2019 share of 78.6%.

<sup>10</sup> Figure 2 shows that after 2020, emissions of the industrial sector have started to decrease more substantially. The cause of this decline may be due to either the high prices in the ETS or the impact of the COVID pandemic. As Eurostat data on total CO<sub>2</sub> emissions have not yet been released, we cannot estimate if the decline was similar for non-ETS firms (which may point at COVID as the cause of the decline).

was developed in CE Delft (2019).<sup>11</sup> Figure 3 shows that developments between sectors vary greatly. While refineries and fertiliser improved their efficiency with about 1% per annum, cement and iron and steel did not show any improvements in the relative efficiency. Petrochemicals became more carbon intensive over the course of time, which may reflect the production of more carbon intensive products within the sector. When the six sectors are lumped together, we cannot observe any improvement in carbon efficiency: the carbon intensity of production in 2019 is just similar as in 2013.

Figure 4 - Index numbers of Implicit carbon efficiency, 2013-2019 (2013=100), EU27 (2020)



Data: Eurostat (Volume index of production, Production value from [sbs\_na\_ind\_r2]), EUTL, own calculation using methodology as outlined in CE Delft, 2019.<sup>12</sup>

This is another sign that the EU ETS may in the past not have been the right instrument to guide industry towards decarbonisation. Reductions observed, as in Dechezleprêtre et al., (2018) may just be the result from reductions in volume of production due to unfavourable global market conditions rather than improvements in the way of production.

<sup>11</sup> Relative efficiency tells us something if the policy had success in reducing emissions by investing in technologies to reduce emissions per unit of product. This is one of the intentions of an EU ETS. The other intention is that carbon intensive products become more expensive and that demand for such products is thus reduced. Relative efficiency does not tell anything about the success of this latter intention. The price increasing signal may have been weakened by free allocation, even though economic theory teaches us that not average costs but marginal costs are put forward into product prices (and on the margin the cost of an additional unit includes a carbon price).

<sup>12</sup> Assumption and data treatments: EUTL to NACE sector definition from European Commission and additional analysis by CE Delft. For cement and fertiliser for the years 2018-2019, index numbers on volume index of production have been based on the Eurozone instead of EU27.



## 2.2.4 Causes of ineffective EU ETS

A major reason why EU ETS has provided an insufficient price signal for the decarbonisation of industry is the free allocation mechanism, where companies supposedly exposed to international competition receive (very large of the vast majority of) the required emission allowances for free. In the early years of the ETS, companies received generous free allocation, often more than the actual emissions of the company. Moreover, free allocation was based on a one-time benchmarking using historic production levels. After the 2008 financial crisis, companies continued to receive the same amount of free allowances even though their production levels had shrunk considerably. This oversupply led to a long period with low prices.

The discussion on the need for free allocation to prevent carbon leakage has boiled down to the question whether industries would be able to pass through the costs of buying ETS allowances to their customers without losing significant market share (Dimanchev, 2016). If they are, the risk of carbon leakage can be considered minimal. Free allowances for the electricity sector have been abolished precisely because electricity producers in the EU do not compete outside Europe and hence are able to fully pass through ETS-related costs. Since it is complicated to establish independently to what extent companies are able to pass through their costs, the Commission has effectively been assuming that industry sectors under the ETS were unable to pass through any costs, which has resulted in a vast overallocation of free allowances (Dimanchev, 2016). Notwithstanding the methodological challenges, research has been performed on the ability of industries to pass through the opportunity costs related to the free allocation of ETS allowances, for instance by CE Delft and Öko-Institut (Healy et al., 2015). This study found that significant cost pass-through could be observed in several sectors, in particular cement, iron & steel and refineries. This has not only led to muting the carbon price signal for industry, but also allowed particularly the steel and cement sectors to generate billions in windfall profits.

Another reason for a less effective EU ETS has been the low prices that have prevailed on carbon markets between 2009-2020. In principle, low carbon prices in itself may not impede investments, if companies would factor in future price rises in the ETS market. But it seems that many companies were expecting that a world of low carbon prices would last indefinitely. This has taken away incentives to invest in low carbon technologies.

## 2.3 Main decarbonisation options per subsector

Sometimes, it is argued that the lack of decarbonisation in industry is due to the fact that not enough technologies are available for full decarbonisation. However, this argument does not hold true. All sectors under consideration can be made fully carbon neutral with techniques and technologies known today, as is extensively described in the literature (see e.g. (CE Delft, 2021, EP, 2020, IEA, 2022)). Technology roadmaps are typically a combination of demand reduction, long term solutions and potential intermediate steps. In the iron and steel sector, for example, demand reduction for virgin steel should come from circular economy measures reducing the demand for primary steel. For the remaining part of primary steel that still has to be made there are long-term solutions available such as ore reduction with green hydrogen.

Although most of the technologies to rapidly decarbonise are mature, most have not been applied at a large scale yet. There are significant engineering challenges to be solved in the scale-up process, which is not impossible, but requires time and resources. Additionally, many processes must change from using fossil fuels to the use of electricity or hydrogen, requiring new large-scale infrastructure. Shortages in regional labour markets may inhibit



the large-scale investments required, especially in the short-to medium term (Lankhuizen *et al.*, 2022).

In addition to technologies to decarbonise the core production process, the demand for certain end products will have to fall because of changing markets. The demand for virgin product can drastically be reduced if circular economy policies are implemented effectively. This reduction in demand would greatly aid decarbonisation, decrease resource depletion and free up labour resources that can be used in the rapid transformation to carbon neutrality.

## 2.4 Conclusions

So far energy intensive industries have given little signs of decarbonisation. The main policy instrument has been the EU ETS. Low prices and plenty provision of free allowances have hampered companies in finding solutions to quickly decarbonise. This lack of decarbonisation is in the end a hindrance to industry that may not be viable when the EU seeks to increase its climate ambition. Another element is that it is jeopardizing the social fairness of the overall transition. The less industry, especially highly polluting industry, is contributing, the more other sectors (and taxpayers) have to contribute instead in order to reach EU wider targets and objectives.

For the most energy intensive sectors there are plenty of technical options available to decarbonise, even though many of these options still need to be applied in practice and scaled up to the level of the EU market. In the next Chapter we will investigate to what extent auxiliary policy instruments additional to the EU ETS can be beneficial to give companies the right impetus to start to follow a path of rapid decarbonisation. In Chapter 4 we will give account how existing EU policies can be modernised to better incentivise energy intensive industries towards a path of rapid decarbonisation.





# 3 Complementary national policies

## 3.1 Introduction

Although the empirical evidence is mixed, energy intensive industry have so far not been very successful in decarbonising their production processes. Many Member States have stepped up and have introduced additional policy instruments on top of the EU ETS for companies to provide additional incentives to apply low carbon technologies. In this chapter we will provide a few case studies of such policy instruments:

1. Carbon price floor in the Netherlands (Section 3.2).
2. CO<sub>2</sub> taxes in other EU countries (Section 3.3).
3. Standards and duties such as the phase-out of coal-fired power stations in Germany as blueprint for phasing out other types of heavy industry (Section 3.4).
4. Public-private partnerships such as the transformation of Swedish steel from carbon to hydrogen based production method (Section 3.5).

## 3.2 Carbon levy and subsidies in the Netherlands

In the Netherlands, a national carbon levy on top of the EU ETS is in operation since January 2021. The levy applies to all installations in the EU ETS plus some companies that do not participate in the ETS but have nonetheless substantial GHG emissions: waste incinerators and one large emitter of N<sub>2</sub>O.

The imposed CO<sub>2</sub> levy is limited by two ways:

1. Rate: the CO<sub>2</sub> levy acts as a yearly increasing CO<sub>2</sub> price floor and the levy will only be paid if the ETS price is below the minimum price of the levy of that year.
2. Base: the CO<sub>2</sub> levy will only be paid for the emissions that are above the ‘reduction path’.

Both elements will be described in more detail below.

### 3.2.1 Rate of Dutch carbon levy

The CO<sub>2</sub> minimum price starts with € 30.48/t CO<sub>2</sub> in the year 2021 and will increase each year by € 10.73 until a rate of € 127/tCO<sub>2</sub> for emissions above the ceiling will be reached in 2030. The law does not prescribe what will happen after 2030. Legally this would imply that the tax would end but this is unlikely to occur in reality as the law may be renewed.

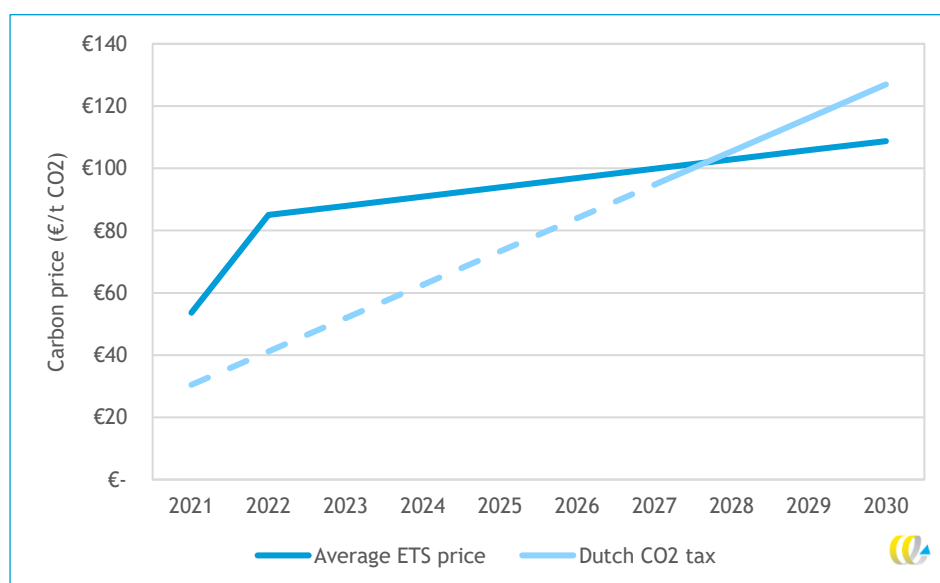
One should know that the present price in the ETS is already way above the CO<sub>2</sub> minimum price. If the current price levels within the EU ETS would be transferred to the future on the basis of an annual growth rate of 3.5%, it is likely that the CO<sub>2</sub> levy will not be paid by Dutch industry (see Figure 5) at least until 2027 as the rate of the CO<sub>2</sub> levy will be below the price development in the ETS market.<sup>13</sup> In the years after, the price impact will be relatively small.

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<sup>13</sup> This 3.5% is the price of which CO<sub>2</sub> prices in the Netherlands, to be taken into account in SCBA, must be increased every year.



Figure 5 - Forecast on the development of price for an EUA in the EU ETS and the CO<sub>2</sub> tax rate (dotted line it will not be levied, fixed line it will be levied)



### 3.2.2 Tax base of Dutch carbon levy

The CO<sub>2</sub> tax in the Netherlands is a baseline-and-credit system. Emissions above the levy-free baseline will need to pay the levy. Emissions below the levy-free base will not be taxed but constitute a credit ('dispensatierecht') that can be traded with other companies through bilateral trades. No official trading platform will be established.

The baseline to determine the levy-free base is formed for each installation by three components:

1. The benchmark in the EU ETS,  $B_j$  of sector  $j$  in which the company is classified.  
The benchmark expresses the CO<sub>2</sub> emissions of the 10% most efficient firms of a sector per unit of physical output. Within the EU ETS over 50 product benchmarks have been established which are currently being updated. The CO<sub>2</sub> levy for the years 2021 and 2022 will be based on the present EU benchmark (from the year 2008) updated with a 0.2% annual improvement. From 2023-2026 the new updated EU benchmarks will be used that will be established at the end of 2020 (or beginning 2021). From 2027-2030, the updated EU benchmarks from 2025/2026 will be used. It is expected that the first update will result in more stringent benchmarks as the annual improvement of 0.2% is expected to be a minimum value and the real improvement may be higher.
2. An annual reduction factor,  $R$  that is similar across all products. The annual reduction factor starts with a factor 1.2 in 2021 and decreases every year with 5.7% so that the levy-free base decreases from 120% min 2021 to 69% (of the emissions in 2015). This implies that the reduction of the levy-free base is linear.
3. The activity level,  $A_i$  of company  $i$ . The CO<sub>2</sub> levy will be based on the actual activity level, or, in some cases, on historical activity levels, in volumes not values.<sup>14</sup> Companies can ask for using the 'expected activity level' as a base. Next year, eventual changes in baseline credits (dispensatierecht) with the realised activity level will be settled. The activity levels will largely follow the reporting to the new phase of the ETS and are different for each benchmark.

<sup>14</sup> Some exemptions have been formulated if actual activity level is lower than 15% of the historical activity level.

The baseline for each company  $i$  is then formed by multiplication of each of these three components :

$$\text{Levy free baseline} = B_j * R * A_i$$

Emissions below the baseline will not be taxed. Only emissions above the baseline will be taxed. If sectors will not reduce their emission intensities compared to 2018, the most energy intensive sectors will see that between 40-48% of their emissions will be taxed in 2030 (CE Delft, 2021).

To assist companies in reducing their carbon emissions, substantial support schemes (e.g. subsidies) for low-carbon technology development and deployment have been opened for industry, such as the Sustainable Energy Transition Incentive Scheme (SDE++) subsidy or the energy investment allowance (EIA) tax allowance. These may encourage the adoption of emerging low-carbon technologies that may achieve significant cost-efficient emission reductions in the long run. As the OECD (ongoing) concludes in its policy review: “Carbon pricing and technology support are not substitutes but mutually reinforcing policy instruments, as strong future carbon prices help create demand for new low-carbon technologies developed with the help of technology-specific support.”. The carbon price thus acts as a stick for companies that do not want to take the carrot. It is in this light also important to notice that the subsidies are largely paid by companies through an increase in the Sustainable Energy Surcharge (ODE), even though energy intensive companies will be able to attract more subsidy than they would pay for (and companies with lower carbon emissions pay more to the surcharge than they will benefit from subsidies).

The new government has announced in 2021 that it will increase the overall reduction target to -55% compared to 1990, with industry securing an additional reduction of 4 Mt GHG (around 28% additional reduction).

### 3.2.3 What we can learn from the Dutch experience

The Dutch case study teaches us that the main reason to install the carbon levy was to assure the industry contributes equally to the reductions required to achieve the national CO<sub>2</sub> policy reductions. In addition, the instrument was to offer investment security to investors by securing a stable price path for CO<sub>2</sub>. The plenty availability of subsidy schemes should assure that the actual cost increases for companies are absent to small so that the level playing field with respect to foreign competition is expected to be maintained.

Industry lobby against the CO<sub>2</sub> tax was unsuccessful because of the largescale availability of subsidies undermined the story that industry would merely loose from installing a carbon tax. Therefore, politicians could point out that companies willing to decarbonise did not have to have a competitive disadvantage as they would not have to pay for the carbon tax. This was made possible by the tax-free base that was included in the carbon levy.

Finally, the insight that industry would not face any additional carbon costs in the next 4-5 years ahead, paved the road for acceptance of a carbon tax. However, in the light of the recent ETS price increases, price floors may not offer additional incentives to decarbonise.



### 3.3 National CO<sub>2</sub> taxes for industrial sectors in other countries

#### 3.3.1 Overview of national CO<sub>2</sub> levies

In addition to the Netherlands, several other OECD states have implemented national CO<sub>2</sub> taxes for the industrial sector. In some of these countries the national CO<sub>2</sub> tax only covers non-EU ETS industrial sectors, thereby supplementing the EU ETS, while in others, ETS-participants are also required to pay the national carbon levy. Table 1 summarises the state of affairs as of July 1<sup>st</sup>, 2018, based on the OECD report ‘Taxing Energy Use’ (OECD, 2019).

Table 1 - OECD countries with a national CO<sub>2</sub> tax for the industrial sector

Country	Price (€/tonne CO <sub>2</sub> )	Scope	EU ETS-participants exempt?
Denmark	23	Solid, liquid and gaseous fossil fuels	Yes
Estonia	2	Thermal energy	No
Finland	62	Solid, liquid and gaseous fossil fuels	No
Iceland	30	Natural gas and mineral oils	Yes
Ireland	20	Solid, liquid and gaseous fossil fuels	Mostly
Norway	53	Natural gas and mineral oils	Mostly
Slovenia	17	Solid, liquid and gaseous fossil fuels	No
Sweden	110	Solid, liquid and gaseous fossil fuels	Yes
Switzerland <sup>^</sup>	83	Solid, liquid and gaseous fossil fuels for stationary use	Yes <sup>^</sup>

Notes: For countries with a different currency than the euro, prices in euro’s were calculated using conversion rates from July, 2018.

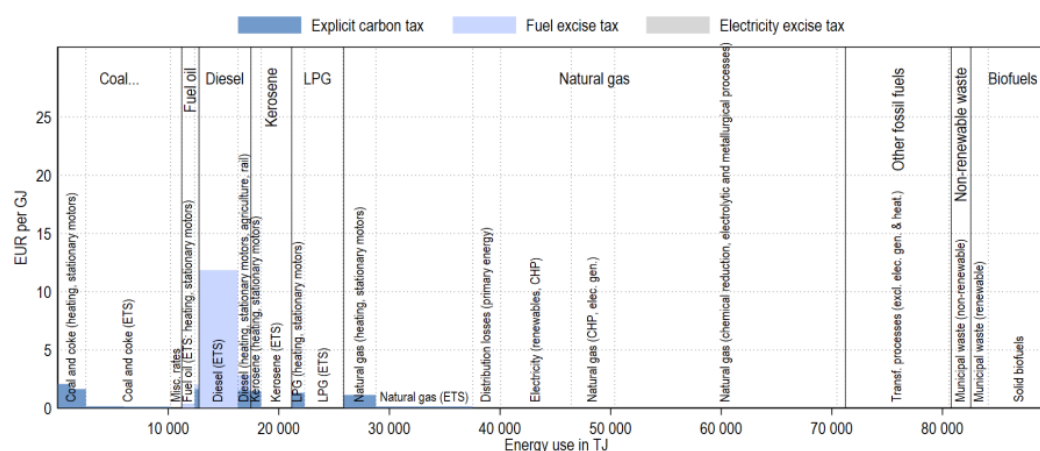
\* Switzerland is not part of the European Union and has its own ETS, the Swiss ETS. Since 2020, however, the Swiss ETS and the EU ETS are fully linked. We therefore regard Swiss industrial players to be part of the same system. EU ETS participants can ask to be exempt from the national Swiss scheme.

As becomes clear from Table 1, national CO<sub>2</sub> taxes for the industrial sector are quite common. Furthermore, we can witness large differences in tax rates: from a mere ‘symbolic’ € 2/tonne CO<sub>2</sub> in Estonia to more than € 100/tonne CO<sub>2</sub> in Sweden. However, countries that have exempted their industries already participating in the EU ETS, such as Sweden, have in general higher rates than countries that do not exempt the industries that participate in the ETS (as in Estonia).

These exemptions have originated from the wish to avoid taxing the same CO<sub>2</sub> emissions twice – something that was in many cases brought forward by industrial lobby groups. The result from these and other scope restrictions is that a large fraction of the industrial sector does not pay the national carbon levy. Accounting for scope restrictions for instance shows that the effective carbon tax paid by Irish industries is very small indeed (see Figure 6).



Figure 6 - Effective carbon tax paid by the industrial sector in Ireland, 2018



Source: (OECD, 2019).Source: (OECD, 2019).

Two countries jump out that do not exempt ETS-participants from the explicit carbon tax in any way. These are Slovenia and Finland. We provide a brief elaboration on the energy- and carbon tax structures adopted by these countries. In addition we briefly elaborate on the Swedish case that has led to a very high tax rate but full exemptions to industry participating in the EU ETS.

### 3.3.2 Carbon tax in Finland

Finland is the first country in the world introducing a carbon tax in 1990 (Bavbek, 2016). In 2011, the Finnish government carried out a major revision of its energy taxation framework in order to better reflect environmental aspects and the CO<sub>2</sub> content of fuels in energy taxation. Since the reform, the Finnish energy tax consists of three supplementary parts:

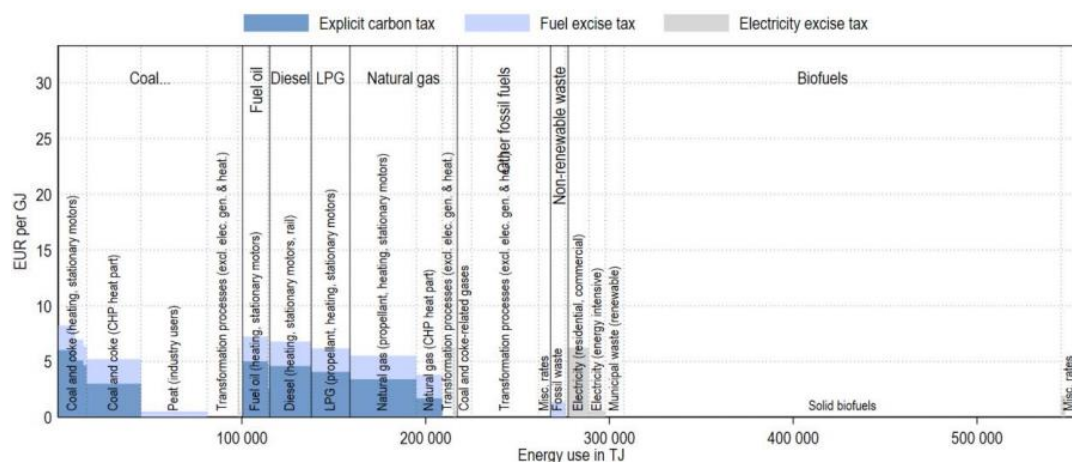
1. The Energy Content Tax, essentially an excise duty.
2. The Carbon Tax, which depends on the carbon content of the energy carrier.
3. The Strategic Stockpile Fee, which depends on the energy content of the carrier.

The CO<sub>2</sub> tax is a flat tax with a fixed rate; it does not have a rate that depends on the EU ETS price like the Dutch CO<sub>2</sub> levy. Under the Finnish CO<sub>2</sub> tax, biofuels and fossil fuels are treated differently. Biofuels are classified in three categories on which the tax rate is dependent:

- biofuels that fail to meet sustainability criteria are subject to the same CO<sub>2</sub> levy as fossil fuels;
- sustainable biofuels (first generation, agricultural origin) are subject to 50% the tax rate of the CO<sub>2</sub> levy on equivalent fossil fuels;
- second-generation biofuels (waste, lignin cellulose, etc.) are fully exempt from CO<sub>2</sub> tax.

As mentioned before, Finnish ETS-participants are not exempt from the national CO<sub>2</sub> tax. As a result, a significant portion of industrial energy use is taxed by its CO<sub>2</sub> content (see Figure 7).

Figure 7 - Effective carbon tax paid by the Finnish industrial sector, 2018



Source: (OECD, 2019).Source: (OECD, 2019).

Remaining gaps in the chart above (after accounting for the biofuel classification system) are explained by the following exemptions to the general tax:

- fuels used for heating in combined heat and power (CHP) generation receive a 50% reduction in the carbon tax rate;
- industrial use of peat products benefits from a reduced energy content tax and are not subject to the carbon tax;
- coal and coke related gases are not taxed.

In addition, Finnish energy-intensive industrial firms still receive significant energy tax refunds to safeguard them from international competition. These refunds only apply to the excise duties paid and not to the CO<sub>2</sub> taxes paid. Energy-intensive firms used to be eligible for a 85% tax refund if their energy tax expenditures exceed 0.5% of their value added. No tax expenditures were refunded for the first € 50,000 in paid taxes. Since 2021, the tax refunds are slowly phased out. At the moment of writing this report (July, 2022) refunds are only available for companies whose energy tax expenditures equal more than 1.7% of their value added. By 2025, the tax refund mechanism for energy-intensive industry will disappear completely to better align the tax system with Finland's goal of becoming climate neutral by 2035.

There is general consent that such taxes are necessary to support Finland's pledge to cut net greenhouse gas emissions to zero by 2035. They are supported by sectoral targets for deploying electric vehicles, phasing out coal generation, and oil-based space heating.

### 3.3.3 Carbon tax in Slovenia

Slovenia has three different mechanisms by which energy and its CO<sub>2</sub> content are taxed:

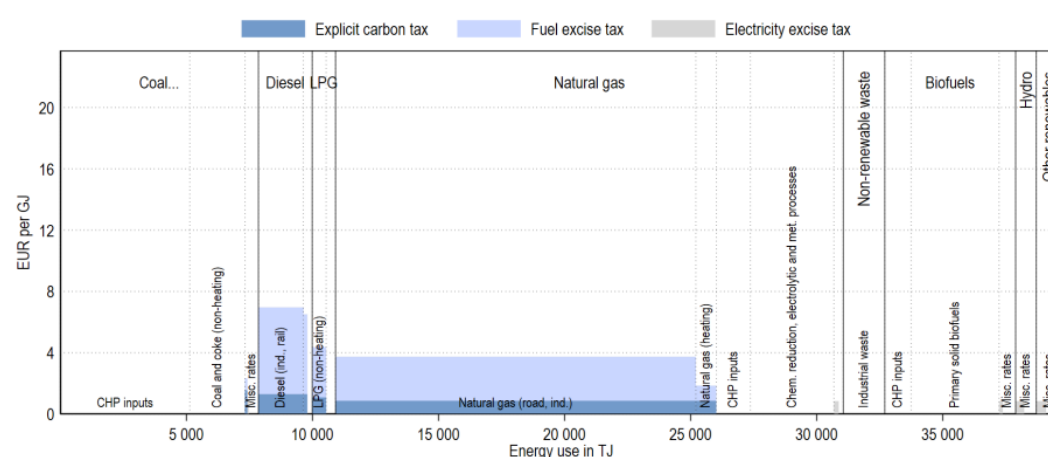
1. An energy tax that applies to the energy content of solid, liquid and gaseous fuels.
2. A carbon tax that applies to the same energy use cases as the energy tax.
3. A separate tax on electricity usage.

The Slovenian carbon tax was introduced in 1996 and does not apply to 'small operators' – installations whose CO<sub>2</sub> emissions are below 25 kt/year – which is the same threshold as in the EU ETS (and for the carbon levy in the Netherlands). As is the case in Finland, combined heat and power plants (CHP plants) and biofuels are taxed differently than fossil fuels.

In Slovenia, all biofuels are exempt from the carbon tax, even if the biofuel is produced from low quality feedstocks. CHP plants are also fully exempt from the carbon tax. In addition natural gas used in chemical reduction, electrolytic and metallurgical processes are not taxed, and neither is coal used for non-heating purposes.

The above list of exemptions leaves three main applications that are not exempt from the carbon tax – even if the corresponding emissions fall under the EU ETS: the use of diesel, LPG and natural gas for heating and non-heating purposes (see Figure 8).

Figure 8 - Effective carbon tax paid by the Slovenian industrial sector, 2018



Source: (OECD, 2019).Source: (OECD, 2019).

In the recently published Integrated National Energy and Climate Plan, the Slovenian Government announced a gradual increase of the national carbon tax to at least € 30/tonne (Republica Slovenija, 2021). In the recently published Integrated National Energy and Climate Plan, the Slovenian Government announced a gradual increase of the national carbon tax to at least € 30/tonne (Republica Slovenija, 2021).

### 3.3.4 Carbon tax in Sweden

Together with Finland, Sweden is one of the earliest countries in the world to introduce CO<sub>2</sub> policy targets. The main instrument to keep CO<sub>2</sub> emissions down became a CO<sub>2</sub> tax, as first proposed by the Swedish Society for Nature Conservation in 1988. This was approved in June 1990 by a large majority in Parliament and became effective in January 1991.

Tax rates for industry have been revised in various rounds. Initially the tax rate was set 250SEK/tCO<sub>2</sub> – equivalent to € 33/tCO<sub>2</sub>.<sup>15</sup> With the introduction of the carbon tax, existing energy taxes were subsequently cut by 50% and the two tax mechanisms co-existed side by side (Bavbek, 2016). Various industrial sectors (such as power, steel, other metals, mining, cement, lime, refineries, chemical industry and even the forest industry) were exempt from the tax, while others were eligible for a lower tax rate of 50%. From 1993, after successful lobbying to compensate for the economic crisis in 1991, this was further lowered to 25%.

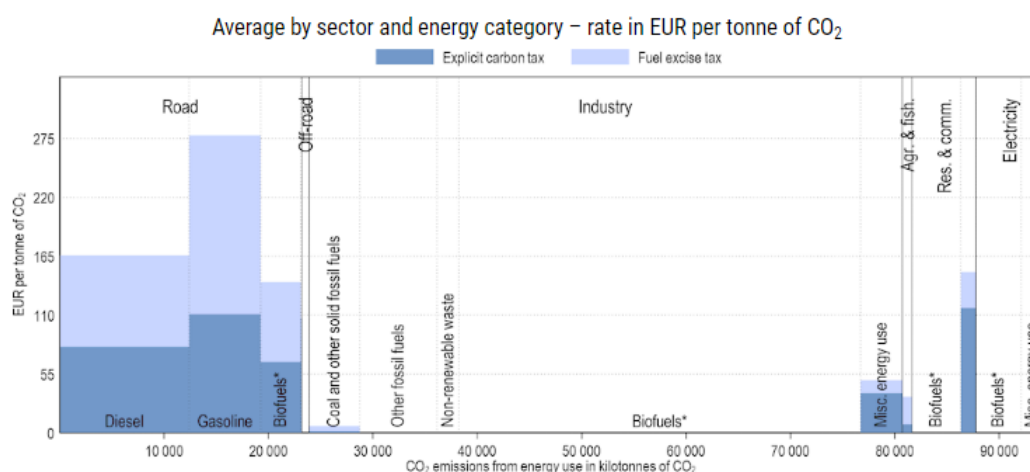
<sup>15</sup> Using the average ECU/SEK exchange rate of 1991, source Eurostat.



With the introduction of the EU ETS in 2005, it was observed that the ETS largely interfered with this tax, so the tax was abolished for all companies participating in the EU ETS – a situation that has continued up-to-date.

The CO<sub>2</sub> tax in Sweden therefore largely had influences on heating of buildings, implying that the use of oil was replaced by better insulation, heat pumps and more district heating. In district heating segments, the CO<sub>2</sub> tax implied to switch fuels from coal, oil and gas to biomass and waste. Within industry, emissions remains largely untaxed, as was evidenced by the OECD (2019) tax report.<sup>16</sup>

Figure 9 - Effective carbon tax paid by the Swedish industrial sector, situation 1 July 2018



### 3.3.5 What we can learn from the CO<sub>2</sub> taxes in other countries

The examples show that many countries have installed direct CO<sub>2</sub> taxes. Many of these countries have exempted industry that participates in the ETS from these taxes, but the examples in Estonia, Finland and Slovenia show that this is not carved in stone: there are countries that combine an EU ETS with national carbon taxes for industry. Many of the countries also have lowered energy taxes for industry. In Sweden it can be argued that this somehow went wrong: first companies were given lower energy taxes in exchange for a carbon tax and subsequently they were being exempt through participation in the EU ETS.

## 3.4 Phase-out of industrial production methods as alternative to price instruments

### 3.4.1 Introduction

Section 3.3. identified what countries can do additional to the ETS. It became clear that additional taxes on top of the ETS are common in quite some countries and that industry

<sup>16</sup> The pulp and paper industry, the most important industrial sector in Sweden, has cut its emissions considerably because of the use of biomass-based wastes instead of fossil fuels. This was partly the result of stricter environmental regulations so they were no longer allowed to throw away biomass waste into lakes or on land. This shows that also other regulations instead of carbon taxes can have substantial impact on the carbon emissions of a sector.





doesn't always need to be exempt from such taxes. However, countries can also formulate additional policies to speed up decarbonisation of their industries, such as:

- emission limit values;
- phase-out of certain types of production within industry;
- long-term agreements with industry on decarbonisation;
- subsidies.

Here we will investigate the option of phasing out certain types of production within industry. We will describe the German phase-out of coal fired power plants as an example.

### 3.4.2 Initiative to phase-out coal-fired power stations in Germany

On July 3<sup>rd</sup>, 2020 Germany adopted the phase-out of all coal-fired power plants by 2038 the latest into law (BUMV, 2022). Under the plan, less CO<sub>2</sub>-intensive hard coal plants would be phased out first, in favour of lignite plants, a fuel that is mined domestically. In 2007 Germany had already made a plan to close all remaining hard coal mines by 2018 (Spiegel International, 2007). The newly formed coalition strives to expedite the phase-out to 2030 (SPD, Grünen, et al., 2021). However, this must be read intentional and is not formally captured in a law. The electricity shortfall from the coal phase-out is to be covered by additional renewable energy generation and new hydrogen ready gas plants as backup. The deployment of renewable energy should be accelerated further by streamlined permitting, more ambitious grid expansion, obligations for rooftop solar and a target to use 2% of land for onshore wind (SPD, Grünen, et al., 2021). On July 3<sup>rd</sup>, 2020 Germany adopted the phase-out of all coal-fired power plants by 2038 the latest into law (BUMV, 2022). Under the plan, less CO<sub>2</sub>-intensive hard coal plants would be phased out first, in favour of lignite plants, a fuel that is mined domestically. In 2007 Germany had already made a plan to close all remaining hard coal mines by 2018 (Spiegel International, 2007). The newly formed coalition strives to expedite the phase-out to 2030 (SPD, Grünen, et al., 2021). However, this must be read intentional and is not formally captured in a law. The electricity shortfall from the coal phase-out is to be covered by additional renewable energy generation and new hydrogen ready gas plants as backup. The deployment of renewable energy should be accelerated further by streamlined permitting, more ambitious grid expansion, obligations for rooftop solar and a target to use 2% of land for onshore wind (SPD, Bündnis 90/Die Grünen, et al., 2021).

#### Effects

The coal phase-out above all provides clarity to the market and investors, even when not (yet) captured in law. It is a clear signal to economic operators that coal has no future, so no new investments are to be made and there is room for political deals if closure dates can be brought forward. Governments and NGO's can be certain that coal will be phased-out in time, regardless of changes in the economics of coal versus alternatives.

In addition, a coal phase-out requires that alternative energy supplies are secured in a timely matter and thus gives room for further stimulation of renewable energy. Conversely, the success of the German Energiewende made clear that alternative sources will indeed be available.

As more nations have concrete plans for the phase-out of coal power, policy support for further measures grows. With every country announcing a coal exit, the pressure on the remaining countries increases.

National coal phase-outs can contribute to lower CO<sub>2</sub> emissions, despite the alleged 'waterbed effect' in the ETS (see Chapter 4). In addition, article 12(4) of the ETS directive



allows Member States to cancel allowances unilaterally in the ETS in order to avoid the increase of excess allowances (see also Chapter 4).

### 3.4.3 Phasing out production processes as possible element of industry policy

The phase-out of coal fired electricity plants could serve as a blueprint for other industrial sectors. For each industrial sector a plan should be made to investigate what the alternatives are to the most carbon intensive production route. If this carbon intensive production route is not affected enough by carbon pricing alone, phasing out could be an option. To limit carbon leakage, candidate installations should either be at low risk of carbon leakage or should be included in the proposed carbon border adjustment mechanism (CBAM, see Section 4.2.1 for an in-depth explanation), which initially covers cement, iron and steel, aluminium, fertilisers, and electricity<sup>17</sup>.

Examples of technologies where a phase-out could be considered are blast furnaces for steel production and (semi-)wet process cement kilns. More broadly a general ban on the use of coal in industrial installations could be considered as well as end-dates for the use of fossil fuels for the production of hydrogen, ammonia, and methanol. In theory, such a ban could be extended to the CBAM scheme by introducing a ban on products made with certain production routes, e.g. steel produced in coal-fired blast furnaces. The effectiveness of such inclusion in CBAM would crucially hinge on the potential of ‘resource shuffling’: if producers are capable to shift exports of cleaner products to the EU and more polluting products to other countries, the effectiveness of production based product bans could be disappointing.

In addition, there may be additional negative impacts for consumers and the economy. Therefore, such policy plans should be carefully considered before such plans are to materialise. Such impact assessment is beyond the scope of the present study.

## 3.5 Public-Private partnerships as examples

### 3.5.1 Introduction

In addition to tax measures, standard setting, also cooperation between governments and companies can serve as an example for decarbonisation of energy intensive industries. Governments or government agencies can work together with private companies in projects that are too risky for private companies alone. There are many examples where such cooperation has failed to materialise and public-private partnerships have been used to abolish more stringent policies. However, there are also positive examples, and the transformation of Swedish steel serves here as an example.

### 3.5.2 Transformation of Swedish steel from carbon to hydrogen based production method as an example

#### Description of initiative

In 2016 the Hybrit initiative was announced by Swedish steelmaker SSAB, Swedish mining company LKAB and Swedish energy company Vattenfall. The three companies aimed to create the first fossil-free value chain from mining to finished steel (Pei et al., 2020).

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<sup>17</sup> [Carbon Border Adjustment Mechanism : Questions and Answers \(EC, 2021a\)](#)



The main pillar of Hybrit (short for Hydrogen Breakthrough Ironmaking Technology) is to replace the widely-used coal-based blast furnace ironmaking process by new hydrogen reduction technology. The ore is reduced to pig iron sponged iron by hydrogen and subsequently melted and refined into steel by electricity. (Pei et al., 2020). The main pillar of Hybrit (short for Hydrogen Breakthrough Ironmaking Technology) is to replace the widely-used coal-based blast furnace ironmaking process by new hydrogen reduction technology. The ore is reduced to pig iron sponged iron by hydrogen and subsequently melted and refined into steel by electricity.

The three companies act like private companies, but some of them (LKAB<sup>18</sup>, Vattenfall<sup>19</sup>) are owned by the Swedish state. At the start of Hybrit in 2016, the ETS price was low, providing little financial incentive to start decarbonizing steel. The decision for Hybrit was instead taken based on long-term vision and strategy.

After two years of feasibility studies with the support of the Swedish Energy Agency, the decision was made in 2018 to construct a pilot plant. The Swedish Energy Agency awarded subsidies of roughly 50M€<sup>20</sup> and construction begun in 2018. The facility was finished in 2020 and produced the first fossil-free steel. A full-scale commercial plant is planned for 2026. (SSAB, 2022)

## Effects

The Hybrit project has been widely covered as a showcase for green steel production. Uptake of important decarbonisation technologies can be accelerated by showing it can be done.

For a long time, coal-based production routes with CCS were seen as the most promising decarbonisation option for steel production, see for example Eurofer's 2013 roadmap (Eurofer, 2013). The development of hydrogen direct reduction was deemed to be very uncertain. In recent years however, there has been a noticeable shift away from carbon-based production routes towards the hydrogen based route. For a long time, coal-based production routes with CCS were seen as the most promising decarbonisation option for steel production, see for example Eurofer's 2013 roadmap (Eurofer, 2013). The development of hydrogen direct reduction was deemed to be very uncertain. In recent years however, there has been a noticeable shift away from carbon-based production routes towards the hydrogen based route. A striking example is Dutch steel factory Tata Steel IJmuiden, which announced in 2021 to abandon its plans for CCS in favour of hydrogen-based steelmaking (TaTa Steel, 2021). Other major steelmakers active in Europe such as ArcelorMittal (2021), ThyssenKrupp (S&P, 2020), Salzgitter (Hydrogen Central, 2021) and Liberty Steel<sup>21</sup> have also announced plans to produce steel using hydrogen.

This also inspires policy makers to be more ambitious and creates demand for green steel from environmentally-conscious customers (automakers, wind turbine manufacturers, builders).

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<sup>18</sup> 100% owned by Swedish state: [LKAB, ongoing; Homepage, LKAB in brief](#)

<sup>19</sup> 100% owned by Swedish state: [Vattenfall Group: Shareholder and shareholder's meeting](#)

<sup>20</sup> <https://bioenergyinternational.com/swedish-energy-agency-awards-record-funding-to-hybrit/>

<sup>21</sup> [Liberty Galati to invest in low-carbon DRI and EAF facilities](#)



### 3.5.3 Possible industry policy

The development of technology, and consequently also of industry decarbonisation policy, can be accelerated by demonstrating key breakthrough technologies at commercial scale. In practice, this could be done by launching a series of EU-level tenders which offer subsidies across the technology development cycle: from feasibility study, through pilot plants for sub-installations to a first full-scale commercial plant.

Examples of other crucial decarbonisation technologies that could be fast-tracked are climate neutral cement plants, green ammonia plants, synthetic kerosene plants, electric crackers for plastics production and all-electric paper mills and glass factories.

## 3.6 Waterbed effect in the ETS

An often heard argument is that national policies on top of the ETS do not make sense, as the ETS can be regarded as a waterbed: if you reduce emissions more quickly in one place, emissions will grow in other places. This is because the total emission reduction of the ETS is fixed (with the linear reduction factor, see Section 2.2).

However, the waterbed became punctured with the introduction of the Market Stability Reserve (MSR) in 2019 (Perino, 2018). Since the introduction of the MSR, allowances can be included in a special reserve if the total number of allowances exceeds a set limit. More specifically, under Fit for 55 proposals, 24% of the Total Number of Allowances in Circulation (TNAC) will be placed in the MSR when the TNAC exceeds 833 million allowances. Allowances placed into the MSR reduce the auction volume in the next year.

Each year, from 2023 and on, the allowances placed into the MSR are capped by being equivalent to the total allowances that have been auctioned in the previous year. Any excess allowances will be destroyed permanently.

Under Fit for 55, the Commission also proposes to further cap the number of allowances in the MSR at 400 million (EC, 2021b). When more than these 400 million allowances flow into the MSR, the surplus is destroyed. In this way, any additional CO<sub>2</sub> reduction has actually the result of lowering the total cap.<sup>22</sup>

Based on a recent review of the MSR by ERCST we predict that the TNAC will still exceed the set limit in 2030 under implementation of Fit for 55. Based on a recent review of the MSR by ERCST, (2021) we predict that the TNAC will still exceed the set limit in 2030 under implementation of Fit for 55. Moreover, since the TNAC is also likely to exceed the threshold in the years up to 2030, the number of allowances banked at the start of 2030 can be assumed to be equal to 400 million. This entails that every additional allowance that flows into the MSR, will subsequently be cancelled. However, it is important to note that not all allowances that are unused as a result of national policies will flow into the MSR: in a given year only 24% of the overshoot is admitted into the MSR.<sup>23</sup> If the TNAC exceeds the threshold in the following year too, 24% of the 76% of the remaining rights will be cancelled. This process continues as long as the TNAC exceeds the threshold. When we assume that the TNAC exceeds the threshold up to 2032 (based on (ERCST, 2021) one can

<sup>22</sup> In practice, allowances can also flow out of the MSR again if the number of allowances in circulation falls below a set limit: 100 million allowances are to be released from the MSR if the total number of allowances (TNAC) is below 400 million EUAs. In a given year, the MSR therefore leads either to an additional reduction in emissions or to more permitted emissions.

<sup>23</sup> Under the Fit for 55 plans, at present the limit is set at 12%.



calculate that around 50-60% of national emission reductions will have a permanent impact (see for the calculation method (Perino, 2018)). This percentage will be larger if there will be less excess allowances.

Another argument why the existence of a waterbed effect in the ETS is based on a superficial argumentation is reflected that the level of the cap itself is determined in a political process and that politicians have changed the cap quite often. Policy makers can propose a more ambitious path to reduce the cap if it is clear that such tightening would generate little resistance because reduction plans are already in place. As an example, it is likely that the proposed 4,2% annual cap reduction of the ETS that was proposed under Fit for 55 would not have gathered the same level of political support if no country would have plans to phase-out coal.

Finally, if national governments are concerned for the alleged waterbed effect, the ETS Directive allows them under Article 12(4) to unilaterally cancel allowances for forced closure of electricity generation installations. For industrial installations no such procedures have been formulated yet.

### 3.7 Conclusions

In many cases governments have taken action for their industry to decarbonise on top of the EU ETS. In this paragraph we have provided examples of such actions:

- price floor in the Netherlands;
- carbon taxes in Finland and Slovenia;
- phase-out of coal fired power plants in Germany;
- public private partnership in Swedish steel.

We have shown that such additional policies are possible and do imply additional reductions to the cap of the ETS, thanks to the establishment of the ETS Market Stability Reserve. However, the ETS is also undergoing major revisions, which will be discussed in Chapter 4.

# 4 Reforming EU policies

## 4.1 Introduction

In this chapter we assess several adjustments that could be applied to EU policies in order to accelerate the decarbonisation of energy-intensive industry in the EU. We consider both existing legislation and legislation that has been proposed by the Commission but not yet adopted, such as elements of the Fit for 55 package that was presented in July 2021.

In the next section we treat some possible adjustments to the current ETS (stationary ETS or ETS-I). After that, we look into the Industrial Emissions Directive (IED). In each case, we briefly discuss the concrete impact of the adjustment on the steel sector by way of example, including possible practical or technical barriers to implementation. In the final section we present the policy recommendations that follow from our analysis.

## 4.2 Emission Trading System (ETS)

### 4.2.1 Current state of affairs regarding adjustments

Since its inception in 2005, the EU ETS has developed into one of the main instruments of the European Union to reduce greenhouse gas emissions, especially CO<sub>2</sub>. Currently in its fourth trading period, the system has been adjusted and refined several times. As we have seen in Chapter 2, the EU ETS has worked suboptimally in the past, partly due to overly generous free allocations and low prices due to no rebasing to reflect reduced production levels since the 2008 financial crisis. This does not mean that the ETS is a flawed instrument that will never deliver carbon reductions. On the contrary: the EU ETS has been changed and can be changed further to improve its effectiveness. Important adjustments that were made for the 3<sup>rd</sup> and 4<sup>th</sup> trading period included:

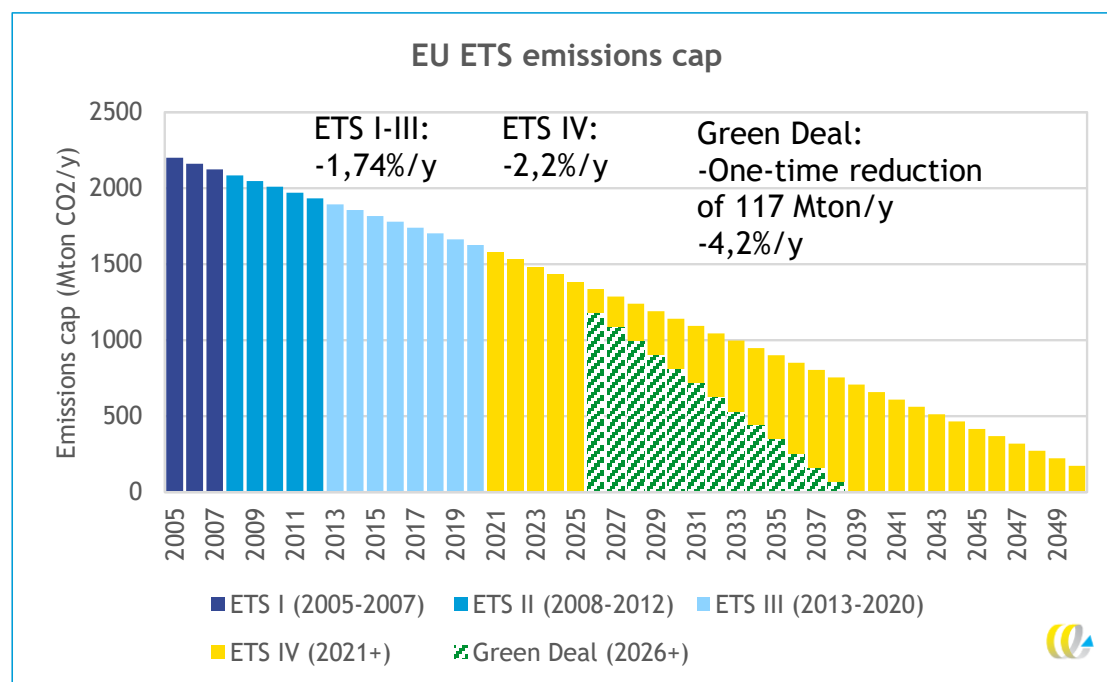
- Harmonised EU wide allocation rules instead of Member States deciding on allocation.
- End of free allocation for the electricity sector from 2013 onwards.
- Introduction of product-specific benchmarks for free allocation in 2013 and update of the benchmarks for the period 2021-2030.
- Phasing out free allocation for sectors at a low risk of carbon leakage from 2026 on and better alignment of free allocation with actual production levels.
- Delayed auctioning (backloading) of 900M allowances, shifting them from 2014-2016 to 2019-2020 (EC, 2021b).
- The introduction of the Market Stability Reserve (MSR) in 2019, which limits the amount of allowances in circulation and feeding the 900 backloaded allowances into the MSR rather than bringing them on the market.
- Increase of the linear reduction factor of the annual emissions cap from 1,74%/y in the 3<sup>rd</sup> trading period (2013-2020) to 2,2%/y in the 4<sup>th</sup> (2021-2030).

In 2021, when the fourth trading period just started, the Commission proposed additional adjustments in the Fit for 55 package to align the Climate policy network with the Paris agreements. These include an increase of the linear reduction factor to 4.2%/year and a one-off reduction of the cap of 117M allowances leading to an overall reduction of 61% emissions in the ETS compared to 2005. When adopted these adjustments imply that the



amount of allowances that becomes available annually will reach zero around 2040<sup>24</sup> as shown in Figure 10. Note that the share of allowances that can be allocated for free has been limited at about 43% of the annually available allowances (57% is being auctioned), so the amount of freely allocated allowances decreases at about the same pace as the cap itself.<sup>25</sup>

Figure 10 - Linear annual reduction factors of the ETS emissions cap



Furthermore, the Commission proposed a Carbon Border Adjustment Mechanism (CBAM), initially covering the sectors cement, iron and steel, aluminium, fertilisers and electricity production (EC, 2021d). The latest amendments to the CBAM legislation extended the scope to also include organic chemicals, plastic polymers, hydrogen and ammonia.<sup>26</sup> For these sectors, free allocation will be phased out while the CBAM will be phased in, as both mechanisms are meant to prevent carbon leakage and they cannot exist in parallel under WTO rules<sup>27</sup>. Finally, the Fit for 55 package includes a revision of the MSR. A second update of the industrial benchmarks for the period 2026-2030 was already announced for ETS IV. According to this revision proposal, the percentage of the allowances in circulation to be

<sup>24</sup> Not taking into account the proposal to include maritime shipping into the ETS as well, which would postpone this moment with a few years due to the additional allowances covering shipping emissions being added into the system.

<sup>25</sup> There have been included some provisions that would may make the actual share of free allocation a bit higher at the expense of auctioning.

<sup>26</sup> After the transition period, the coverage may be extended to more sectors and products. The implementation of organic chemicals and polymers is intended to be subject to further assessment still about technical specificities.

<sup>27</sup> The exact timeline of CBAM phase in and free allocation phase out is at the moment of writing this study still not settled. In the Commission proposal, the transition period would extend over 10 years (2026-2035), while the ENVI Committee of the European Parliament supports a shorter transition period of 5 years.

transferred to the MSR<sup>28</sup> would remain 24% also after 2023, instead of falling back to 12% under current legislation (EC, 2021c)'.

An element that received less attention during the last rounds of adjustments is the increased funding for industries to invest in innovative technologies. The ETS makes it more costly to maintain a fossil-fuelled production process, but it provides only limited sources of funding to invest in fossil-free technologies. Besides the national auction revenues that, under the Commission proposal, would have to be entirely spend on climate related purposes, the main instrument under the ETS for companies to receive funding for investments is the Innovation Fund. This Fund is aimed at supporting commercial demonstration projects of innovative low-carbon technologies and will provide around € 30-40 billion of funding in the period 2020-2030. The exact amount depends on the carbon price as the Innovation Fund is loaded with a small share of the auctioned allowances<sup>29</sup>.

#### 4.2.2 Adjustment: increasing the level of ambition

A first adjustment to the ETS could be an increase in the level of ambition. As a matter of fact, the European Parliament has been discussing whether a reduction target of -61% in the EU ETS in 2030 is ambitious enough given the fact that even more ambitious targets seem to be necessary to be in line with the Paris Agreement. This is also underlined in our analysis with reference to the optimal price levels, where present price levels in the EU ETS still seem to be below what is considered as 'optimal' (see Chapter 2). In addition, as the EEA indicates that in 2021 already 41% of the required reduction compared to 2005 has been realised, an additional reduction of only 20% in the coming nine years seems to be unambitious in the light of the urgent need to drastically reduce CO<sub>2</sub> emissions.

The level of ambition could be increased by either rebasing the cap (e.g. allowing for a one-off reduction) or increasing the linear reduction factor, or a combination of both. Adjustments in the MSR could also be considered as part of more ambition (see e.g. (Cludius & Graichen, 2022)). Important in this light is also to interpret the recent price hikes in the ETS market (see Figure 1) with price increases from roughly 5-10 €/t in 2012-2017 to 80-100 €/t in early 2022. Higher prices are generally expected to have a larger effect at reducing emissions as they incentivise investments in low carbon technologies. It is being debated to what extent this price surge has been the consequence of the adjustments made to the ETS and to what extent it reflects speculation on enhanced EU climate targets and consequential further price increases, following the publication of the September 2020 Climate Target Plan and the July 2021 Fit for 55 package by the Commission. Therefore it is still not clear to what extent such prices will prevail in the coming years.

Increasing the level of ambition implies that at a date sooner than 2040 there will be no more allowances issues in the ETS. If decarbonisation in industry does not keep up with the pace, the market may become short (or even dry) in the near future as not decarbonised industries continue to exert demand for allowances which are not issued any more. This may result in price hikes that cannot be sustained politically and may call for the abolishment of the EU ETS.

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<sup>28</sup> When the threshold of 833 million allowances in circulation is met.

<sup>29</sup> See [EC: Funding Climate Action : Innovation Fund, Policy Development](#)





Therefore, increasing the level of ambition must be accompanied with policies that help to prevent a melt-down of the ETS, such as:

- more subsidies to companies to decarbonise, e.g. by expanding the size, scope and coverage of the Innovation Fund;
- a system of lending where companies are given allowances for free conditional on investments for zero carbon technologies in the future;
- introducing Carbon Contracts for Difference for companies.

It is necessary here to state that from a technological point of view there is no obstacle to a rapid decarbonisation in the industry sector (see the analysis in Section 2.3).

### 4.2.3 Adjustment: reducing the amount of free allocation

There are several policy options in relation to the free allocation of ETS allowances that could be considered in order to improve the effectiveness of the ETS. Some of these policy options could also be combined.

**Phasing out free allocation.** For sectors covered by the CBAM this is part of the proposal, with different timelines currently negotiated by the EU institutions. For those sectors, CBAM forms an alternative protection against carbon leakage, as importers of products under the CBAM have to pay a levy that corresponds to the net carbon costs of EU producers<sup>30</sup>. For sectors outside the CBAM, this policy option does not offer an alternative protection against carbon leakage. In this option all allowances would be auctioned, which would generate additional revenues for Member States, which could be used for supporting industry in their efforts to decarbonise (CAN Europe et al., 2022).

**Better targeting free allocation.** Measures with this objective have already been legislated or proposed, such as benchmark updates, phasing out free allocation for sectors less exposed to carbon leakage and a better alignment to actual production. Further improvements could be to bring forward the phasing out of free allocation to less exposed sectors<sup>31</sup> and to impose stricter conditions for determining whether a sector is at risk of carbon leakage (see also (ECA, 2020)).

**Making free allocation conditional.** A special case of better targeting free allocation could be to attach conditions to the reception of free allowances. In this option, companies have to show that they have concrete plans towards decarbonising their production processes, including timeframes and/or milestones. In this approach the free allowances serve as financial support to realise these plans, instead of free support without any strings attached.

**Adjusting the benchmarks to be based on products.** The current benchmark system is based on production processes rather than products. This causes various problems for products that are (to a large extent) substitutes. For example, the current scheme allocates more emission permits to one ton of steel produced in the carbon intensive blast furnace than to a ton steel coming out of an electric arc furnace (EAF). A similar objection implies to cement where clinker based cement production is the norm of the system of benchmarks that steers free allocation. Cement manufacturers that base their product on recycled

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<sup>30</sup> The CBAM does not protect against export-related carbon leakage (raising from the fact that EU producers are still in a competitive disadvantage for products they export to third countries).

<sup>31</sup> Now only reaching 0 in 2030, see [EC: Climate Action ETS revision phase 4 \(2021-2030\)](#)



cement are therefore eligible for a much smaller amount of free allowances (if they would fall under the ETS anyway).<sup>32</sup>

The first three measures proposed would entail a proper assessment of the proportionality of the carbon leakage measures. The European Court of Auditors (2020) has questioned the provision of a general free allocation scheme as a carbon leakage protection measure as the measure presently is not targeted well enough. Such doubts were also earlier voiced in various publications (see e.g. (CE Delft, 2010). If companies would put forward the value of free allowances into their product prices, free allocation would merely imply windfall profits instead of proper protection against carbon leakage. It is therefore important to include a comprehensive assessment of the proportionality/justification of existing carbon leakage protection needed/better assessing the prevalence of carbon leakage

#### 4.2.4 Example: impacts of implementation for the steel sector

The impacts on the steel sector strongly depend on the decrease and speed of free allowances, the price of allowances and the effectiveness and indirect effects of CBAM. If CBAM is fully operational, competitive disadvantages for the steel industry should be minor to absent. However, when only the price signal from the EU ETS applies there is a risk that the steel sector will primarily turn towards CCS. Crucial here are the first demonstration projects that currently are being build and experiences that will be gained through that. ArcelorMittal is for example now piloting a project in Hamburg where by 2023 it will operate Europe's only direct reduced iron (DRI) EAF facility, testing the ability of green hydrogen to reduce the iron-ore and form DRI, then using that carbon-free DRI in the EAF in the actual steel-making process.

### 4.3 Industrial Emissions Directive (IED)

The Industrial Emissions Directive (IED) sets limits on pollution by stationary installations to air, soil and water. Installations have to demonstrate that they apply Best Available Technology (BAT) for the prevention of pollution in order to obtain and retain their environmental permits.

#### 4.3.1 Current state of affairs

On April 4<sup>th</sup>, 2022, the Commission published a proposal for a revision of the IED (EC, 2022b). In the Impact Assessment accompanying this proposal (EC, 2022a), the Commission acknowledges that the contribution of the IED to decarbonisation of the industry has been limited. This is mainly because interactions between GHG emission reduction possibilities and general pollution reduction possibilities have not sufficiently been taken into account and is illustrated by the fact that it is currently not possible to include Emission Limit Values (ELVs) in IED permits for GHG that are covered by the ETS.

In order to improve the IED's impact on decarbonisation the Commission has investigated a number of policy options, including on the Articles that limit the setting of energy efficiency requirements in IED permits (Article 9(2)) and prevent the inclusion of GHG limits in IED permits (Article 9(1)). Although the Impact Assessment concludes that deletion of Article 9(1) would likely result in GHG emissions reductions and may also have other

<sup>32</sup> In the proposal for the adjustment of the ETS, the European Commission wants to make the benchmark system in 2026 less dependent on processes and more linked to the products manufactured. However, no details are given on this benchmark reform. The Commission has also not a great track record in mid-term changes in the system of allocation in the ETS. E.g. in 2016 a similar change was announced in the Mid Term Review, and after a lot of debate, finally no changes were made to the system of allocation.



positive environmental impacts, it is discarded in the preferred policy package resulting from the Impact Assessment. Instead, a review of the impact of the IED and the ETS on the decarbonisation of industry and their synergies in 2030 is proposed. The main argument presented not to select deletion of Article 9(1) as a preferred policy is that it ‘may negatively affect the effectiveness and efficiency of the ETS market mechanism’, leading to ‘more carbon allowances being available for trading and hence reduced incentives for emission reductions across ETS sectors’.

### 4.3.2 Possible adjustments of the IED to speed up decarbonisation

It is a well-known effect that the application of innovative technologies in industry, partly incentivised by the ETS, has an impact on the ETS carbon market itself. When a new technology enters the market and is able to reduce emissions by a significant amount and/or across a large number of installations, the demand for ETS allowances by the industrial sector concerned will suddenly decrease. This in turn will relatively increase the supply of allowances for other sectors and dampen the price signal. Partly to correct for this effect, the Market Stability Reserve (MSR) has been introduced in order to stabilise the number of allowances available in the market.

Based on the Impact Assessment, is it probable that allowing for GHG ELVs in IED permits (i.e. deleting Article 9(1)) would have a significant positive effect on the decarbonisation of the industries involved. To respond to concerns related to the ETS market mechanism, it could be pointed out that the MSR will absorb the additional surplus of allowances that would become available if industries are obliged to apply innovative emission-reducing technologies. The number of allowances in circulation that triggers the transfer of allowances into the MSR is currently set at the absolute number of 833 million. In the period 2019-2023, the amount of allowances put into the MSR, if this threshold is being met, is 24% of the number of allowances in circulation (so minimum 200 million).<sup>33</sup> Thus, if the number of allowances in circulation increases, the MSR will absorb (and over time cancel) those surplus allowances. This alleviates the concern that adjustments to the IED would negatively impact the functioning of the EU ETS.

If ELVs for GHG would be allowed, the ambition level of the emission limits would be key for its impact on decarbonisation. In case the limits can be met by relatively simple energy saving measures without fundamentally changing the production process, this adjustment of the IED would have a limited impact on the ETS carbon market, but also a limited impact on industrial GHG emissions. In case the limits implicitly oblige industry to use entirely different production technologies, impacts on the EU ETS may be limited as the MSR prevents disruption of the carbon market. In the end, the effects of allowing ELVs for GHG in IED permits strongly depend on the question on what level of technology the principle of using BAT is applied. This can be clarified looking at the example of the steel industry.

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<sup>33</sup> Under current legislation this percentage would go back to 12% after 2023 (100 million allowances), but, as mentioned above, the Commission has proposed to extend the application of the 24% until 2030 as part of the Fit for 55 package. Both the IED revision and this MSR revision are currently being negotiated by the EU’s co-legislators, which improves chances for a parallel, mutually consistent adjustment of both instruments.



### 4.3.3 Example: impacts on the steel sector

The steel industry is highly energy-intensive and has contributed significantly to European industrial GHG emissions. At the same time, it is one of the few sectors in heavy industry where an entirely fossil-free production process has been proven and is already in use (see section on the Swedish steel industry, Section 3.4.).

An obligation to reduce GHG emissions by a limited amount could be met by replacing part of the coal by biomass, substituting pulverised coal firing by natural gas or biomass; or capturing part of the carbon emissions. A more strict obligation would not necessarily result in a large scale application of hydrogen technology, but could instead drive an investment wave in CCS or the closure of older steel plants.

## 4.4 Conclusions

In this chapter we have investigated two ways to adjust the existing EU policies to speed up decarbonisation. We have seen that both the EU ETS and the IED provides ample opportunities to further speed up the decarbonisation process. Within the EU ETS, the level of ambition can be increased by either rebasing the cap (e.g. allowing for a one-off reduction) or increasing the linear reduction factor, or a combination of both. However, an increased ambition in the industrial sector should probably be accompanied with support schemes to prevent overheating of the carbon market due to short supply, such as carbon contracts for differences, investment subsidy schemes or a system of conditional lending.

Another desirable option is to reconsider free allocation to industry. For industry falling under a CBAM a more timely reduction in free allowances could be considered. For other sectors the free allocation may be more precisely connected to alleged carbon leakage claims and made conditional on the willingness to invest in low carbon production routes. In addition, the system of benchmarks should be updated to be based on (substitute) products to lower the amount of free allowances granted to relatively polluting production processes.

For the Industrial Emission Directive, there exist numerous possibilities to include technologies to reduce carbon emissions in cost-effectiveness considerations so that co-benefits with air pollution measures are properly factored in and more measures are classified as Best Available Technology that would reduce air pollution and greenhouse gas emissions simultaneously.

## 5 Conclusions

On 14 July 2021, the European Commission launched the Fit for 55 package to step up in Climate Ambition, as part of the European Green Deal. The Fit for 55 package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with both the EU target of at least 55%.

This study concludes that the Fit for 55 package would imply that carbon intensive industrial sectors must drastically increase their efforts to decarbonise and that relying on the present EU ETS probably is not enough. The EU ETS has reduced overall CO<sub>2</sub> emissions with 41% in 2021 compared to 2005 levels. However, the major part of these reductions have been caused by reductions in the power generation sector and have rather been caused by other factors than the EU ETS (e.g. renewable energy policies and high energy prices). In the six most carbon intensive sectors (cement, iron and steel, refineries, fertiliser, other basic chemicals and paper/pulp) the reductions have been very modest. When related to the changes in production levels, we could not detect any improvement in carbon efficiency over the 2013-2019 period in those sectors. It is therefore risky to rely only on the EU ETS to guide the decarbonisation process of industry.

There are no technical barriers to a more rapid decarbonisation in the industry sector. Supportive climate policies at the member state level and EU level could incentivise the deployment of low carbon technologies in the most carbon intensive sectors and are thus an important cornerstone of policy reforms to speed up the decarbonisation process in industry. In the past such additional policy schemes have often been hampered by the claim that there would be a ‘waterbed effect’ in the ETS. Additional emission reductions under a fixed ETS ceiling would then imply just more room in other sectors to increase their emissions. However, the introduction of a market stability reserve has invalidated this argument, as additional reductions that would increase the surplus of allowances are cancelled permanently. In addition, they may stimulate politicians to agree on more stringent ETS targets. Therefore we conclude that additional policies are useful to consider for speeding up the transition to a low carbon industry in the EU.

At the national member state level we have identified interesting examples of a few successful policy and business developments in:

1. Carbon price floors.
2. Carbon taxes on top of the ETS.
3. Phase-out certain production processes.
4. Public-private partnerships.

Of these, the carbon price floor in the Netherlands is an interesting example of how additional incentives can be generated for industry already participating in the ETS. The carbon price floor in the Netherlands has been introduced in 2021 to provide investment security for industry by introducing a minimum CO<sub>2</sub> price for emissions above a predefined reduction path. This must assure that industry contributes equally to the national CO<sub>2</sub> policy reduction plan. Subsidies schemes have been introduced to allow companies to reduce their emissions at lowest costs so that impacts on competitiveness are minimised. These subsidies are being paid by an increase in the Sustainable Energy Surcharge of companies.

We also conclude that not only in Netherlands, but also in Estonia, Finland, and Slovenia additional CO<sub>2</sub> taxes to industry are present on top of their participation in the EU ETS.



Therefore, the often heard argument of industry that they cannot be taxed ‘double’ is invalid, as the majority of emissions in the ETS still receives free allowances and is thus subject to not any carbon price signal. The case studies in Finland and Slovenia show that it is very well possible to introduce carbon taxes next to the EU ETS.

Other national policy plans that have been investigated in this study are a planned phase-out of certain production routes, as has been proposed in Germany through the phase-out of coal in electricity production by 2038 the latest. Such long-term plans give clarity to the market and investors and stimulates innovation and deployment in alternatives. Phase-out of certain production routes could also be an interesting part of national (or EU-wide) industrial policy, for example in the field of cokes-based blast furnace steel making or in the semi-wet process cement kilns. A case study on the transformation of Swedish steel from carbon to hydrogen based production method shows that such transformations are feasible if companies are willing to reduce their emissions drastically.

Next to national carbon policy reforms, we have identified options to reform EU policies. For the EU ETS we have identified options to intensify the carbon price signal for industry.

The first option is to increase the level of ambition, given the fact that at present already 41% emission reduction has been achieved (compared to 2005). Therefore, the ambition of the EU ETS could presumably be increased to over the presently proposed 61%, although attention should be given to auxiliary support schemes (such as the Innovation Fund) to prevent overheating of the carbon market due to short supply.

Another important reform would be to lower and better target the provision of free allowances in the EU ETS. Free allocation may be more precisely connected to alleged carbon leakage claims and made conditional on the willingness to invest in low carbon production routes. In addition, the system of benchmarks should be updated to be based on (substitute) products to lower the amount of free allowances granted to relatively polluting production processes.

For the Industrial Emission Directive, there exist numerous possibilities to include technologies to reduce carbon emissions in cost-effectiveness considerations so that co-benefits with air pollution measures are properly factored in. The co-benefits between air pollution reduction and CO<sub>2</sub> reduction should become an integral part of the EU industrial policies. If more measures are classified as Best Available Technology, air pollution and greenhouse gas emissions would be reduced simultaneously.

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