# KIEL WORKING PAPER

## Potential efficiency gains from the introduction of an emissions trading system for the buildings and road transport sectors in the European Union

No. 2249

*Wilfried Rickels, Christian Rischer, Felix Schenuit, Sonja Peterson*

Kiel Institute for the World Economy
ISSN 1862–1155

KIEL WORKING PAPER NO. 2249 | MAY 2023

# POTENTIAL EFFICIENCY GAINS FROM THE INTRODUCTION OF AN EMISSIONS TRADING SYSTEM FOR THE BUILDINGS AND ROAD TRANSPORT SECTORS IN THE EUROPEAN UNION

*Wilfried Rickels, Christian Rischer, Felix Schenuit, Sonja Peterson*

In the European Union (EU), a second emissions trading system (EU ETS2) covering buildings, road transport and small energy and industrial installations is expected to be introduced from 2027. Until 2030, however, EU ETS2 will not be a separate pillar of EU climate policy, but will support Member States in meeting their national targets under the Effort Sharing Regulation (ESR). If there are net regional shifts in emission reductions within the EU ETS2, for example, if companies in one-member state buy in aggregated terms net allowances, this must be compensated for at the national level. We study the EU ETS2 for the year 2030 using the general equilibrium model DART. In our analysis, the introduction of an EU ETS2 generates about a quarter of the efficiency gains of a comprehensive emissions trading system, assuming that nation states use the flexibility mechanisms of the ESR and compensate for regional abatement leakage through interstate emissions trading. However, this is only true if there is no extensive price stabilization in the EU ETS2. Our analysis suggests an EU ETS2 allowance price of around EUR 300/tCO2. Stabilizing the EU ETS2 price at the envisaged intervention price of 45 EUR/tCO2 would require about 415 million additional allowances and thus imply additional emissions of the same amount in 2030 alone.

**Keywords:** European Union Climate Policy, Emissions Trading, Computable General Equilibrium Model

**JEL:** Q54, Q58

**Wilfried Rickels**
Kiel University
Kiel Institute for the World Economy
Kiellinie 66
24105 Kiel, Germany
*Email: wilfried.rickels@ifw-kiel.de*

**Christian Rischer**
Kiel Institute for the World Economy
Kiellinie 66
24105 Kiel, Germany
*Email: christian.rischer@ifw-kiel.de*

**Felix Schenuit**
German Institute for International Security Affairs
Ludwigkirchplatz 3-4
10719 Berlin
*Email: Felix.Schenuit@swp-berlin.org*

Sonja Peterson
Kiel Institute for the World Economy
Kiellinie 66
24105 Kiel, Germany
Email: sonja.peterson@ifw-kiel.de

**Potential efficiency gains from the introduction of an emissions trading system for the buildings and road transport sectors in the European Union**

Wilfried Rickels*, Christian Rischer, Felix Schenuit, Sonja Peterson

**Abstract**

In the European Union (EU), a second emissions trading system (EU ETS2) covering buildings, road transport and small energy and industrial installations is expected to be introduced from 2027. Until 2030, however, EU ETS2 will not be a separate pillar of EU climate policy, but will support Member States in meeting their national targets under the Effort Sharing Regulation (ESR). If there are net regional shifts in emission reductions within the EU ETS2, for example, if companies in one member state buy in aggregated terms net allowances, this must be compensated for at the national level. We study the EU ETS2 for the year 2030 using the general equilibrium model DART. In our analysis, the introduction of an EU ETS2 generates about a quarter of the efficiency gains of a comprehensive emissions trading system, assuming that nation states use the flexibility mechanisms of the ESR and compensate for regional abatement leakage through interstate emissions trading. However, this is only true if there is no extensive price stabilization in the EU ETS2. Our analysis suggests an EU ETS2 allowance price of around EUR 300/tCO2. Stabilizing the EU ETS2 price at the envisaged intervention price of 45 EUR/tCO2 would require about 415 million additional allowances and thus imply additional emissions of the same amount in 2030 alone.

JEL: Q54, Q58

Key Words: European Union Climate Policy, Emissions Trading, Computable General Equilibrium Model

Wilfried Rickels, Christian-Albrechts-Universität Kiel und Institut für Weltwirtschaft, Kiel, Kiellinie 66, 24105 Kiel, wilfried.rickels@ifw-kiel.de

Christian Rischer, Institut für Weltwirtschaft, Kiellinie 66, 24105 Kiel, christian.rischer@ifw-kiel.de

Felix Schenuit, Stiftung Wissenschaft und Politik, 13357 Berlin, Felix.Schenuit@swp-berlin.org

Sonja Peterson, Institut für Weltwirtschaft, Kiellinie 66, 24105 Kiel, sonja.peterson@ifw-kiel.de

## 1 Introduction

The European Union (EU) reduced its greenhouse gas emissions by 24 percent in 2021 relative to 2005 (EEA 2022a). The European Emissions Trading System (EU ETS), which originally covered about 40 percent of emissions, primarily in the energy and industrial sectors, played a significant role in this. Here, emissions were reduced by 37 percent (if the UK emissions covered by the EU ETS until 2021 are also taken into account, the reduction is 44 percent). In comparison, emissions in the 27 EU states (EU27) outside the EU ETS in the sectors covered by the so-called Effort Sharing Regulation (ESR) fell by only 13 percent in the same period (EEA, 2022b). In the future, the ESR sectors will be complemented by a second emissions trading system, which will cover emissions from the road transport and buildings sectors in particular. However, the EU ETS2 does not replace the binding national reduction targets for 2030, but "only" serves as an instrument to achieve these targets, at least for a transitional period. Unlike the existing EU ETS1, the EU ETS2 will therefore continue to depend on where emission reductions take place, and it will be necessary to use the existing flexibility mechanisms in the ESR, such as emissions trading between countries, to achieve the ESR targets in a cost-effective way.

A comprehensive $CO_2$ market and single $CO_2$ price for all EU emissions is the efficient solution—separate markets imply that reduction targets are not achieved cost-effectively (Böhringer et al., 2006, Böhringer et al., 2009). Burmeister and Peterson (2016) show for the 2020 reduction targets that welfare gains could be realized in the EU if there is an opportunity to shift emission reductions from the ESR sectors to the EU ETS1. Accordingly, opportunities for more flexible crediting of emission reductions between sectors and systems may help to achieve emission targets more efficiently. However, there are arguments for only gradually integrating sectors or markets if there are significant differences in marginal abatement costs (Rickels et al., 2019). In particular, the road transport and buildings sectors have higher abatement costs than the power and industrial sectors, and immediate integration of these sectors would significantly increase the price in the EU ETS1. Accordingly, other schemes, such as the free allocation of allowances, whose phase-out is aligned with the current EU ETS1 structure, would also likely need to be adjusted. Böhringer et al. (2014) show that differentiated $CO_2$ abatement costs, taking into account trade effects, justify temporarily differentiated markets. Differentiated prices may also be useful to achieve dynamic efficiency in abatement costs for long-lived goods such as cars or building heating, especially if market participants have myopic preferences or limited planning horizons.

At the same time, it makes sense to combine quantity and price controls, especially when there is considerable uncertainty about abatement costs and thus the expected $CO_2$ prices in an emissions trading system (Murray et al. 2009, Goulder and Schein 2013, Burtraw et al. 2020). Although the EU ETS1 has a price intervention mechanism (Article 29a), it has not led to intervention despite significant price spikes in the past and is therefore of limited use in its current form to control the price in the EU ETS1 (Willner and Perino 2022). In the EU ETS1, the main adjustment mechanism is a quantity trigger. Depending on the amount of allowances in circulation, allowances are transferred to or released from a market stability reserve (MSR), which can have a destabilizing effect, especially in the case of shocks expected by market participants (Perino et al. 2022). Instead, the MSR in the EU ETS2 is linked to a fixed price trigger (EUR 45/tCO2, in 2020 prices) in addition to a quantity trigger, which should lead to the release of additional allowances. Various studies show that $CO_2$ prices of well above 100 EUR/t$CO_2$ are necessary to achieve the planned emission reductions in the road transport and building sectors (Kalkuhl et al. 2023). Accordingly, the release of additional allowances from the MSR would have to be substantial if the price in the EU ETS2 is to remain close to the price trigger. This would significantly increase scarcity in the future, which in turn cannot lead to a credible price stabilization for bankable allowances. In the medium term, therefore, the injection of allowances from $CO_2$ removals will be necessary if prices are to be credibly stabilized without increasing net emissions (Rickels et al. 2020). This issue will become politically relevant sooner than is often assumed: In the recent EU ETS1 reform, the European Commission committed to submitting a report by 2026 examining the integration of $CO_2$ removals into the EU ETS1. The upcoming discussions on the 2040 target, as well as the end of the allocation of new allowances at the end of the 2030s (Rickels et al. 2022), will give further impetus to this debate and extend it to the EU ETS2.

## 2 The EU Effort Sharing Regulation and the new emissions trading system

Reduction commitments in the EU vary by sector. Companies in the energy, industry, aviation, and soon shipping sectors have an aggregate target that is met through the existing EU-wide emissions trading system (EU ETS1).[1] For the sum of all other emissions, including those from households, small businesses and farms, national emission reduction targets are set across the EU. Individual countries plan to achieve these targets using a variety of instruments, including regulatory measures, $CO_2$ taxes and subsidies. The national targets are negotiated as part of the EU's climate policy—more economically developed countries with a higher gross domestic product (GDP) take on more ambitious reduction targets—and are set out in the Effort Sharing Regulation (ESR) mentioned above. They are complemented by the Land Use, Land Use Change and Forestry (LULUCF) Regulation, also with national targets (from 2026) and an overall EU target of -310 Mt$CO_2$ (European Parliament and Council, 2023a).[2]

In 2022, the reduction target for the ESR sectors was tightened from 30 percent to 40 percent compared to 2005, and the national targets and annual emission allocations ("AEAs") were tightened accordingly with an adjusted methodology and calculation (European Parliament and Council, 2023b). The legally binding targets, differentiated by Member State, were one of the key elements that were contested in the legislative process in the past. The resulting gradation of ambition is seen as an important prerequisite for less climate-ambitious countries to agree to the legislative packages (Runge-Metzger and van Ierland 2019). This is the second time that country-specific targets have been raised

[1] By 2026, the inclusion of waste incineration is also under consideration (EC 2023).

[2] We use the term $CO_2$ in the article for simplicity, even though other greenhouse gases are emitted, especially in the ESR, which are converted to $CO_2$ units and accordingly the correct term would be $CO_{2equvi.}$

in the context of the ESR, and Figure 1 shows the considerable variation in reduction targets across countries, and thus already implicitly the potential for efficiency gains through flexible implementation of the overall emissions commitment.

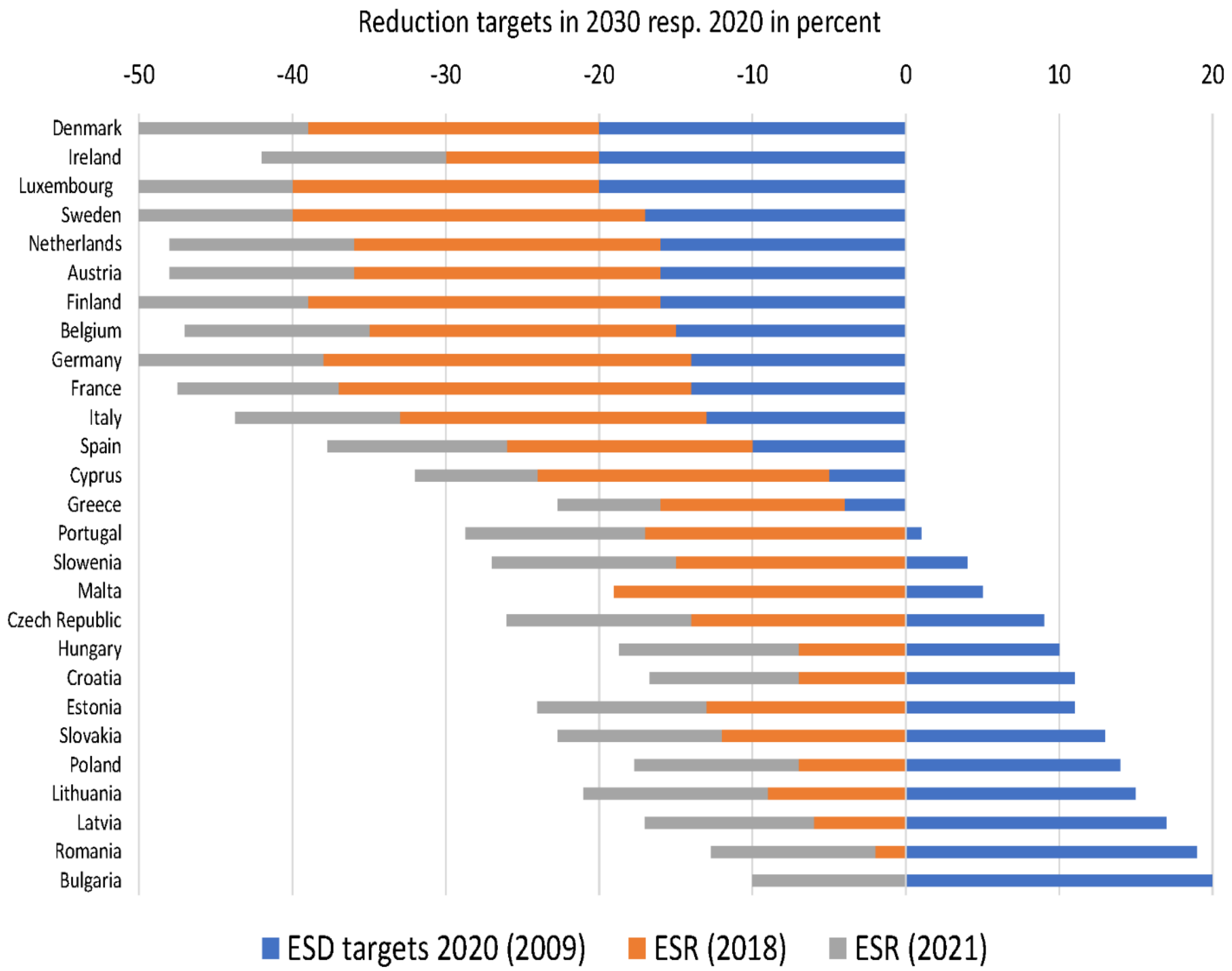


**Figure 1: Development of Effort Sharing Targets (im Vergleich zu 2005)**
*Note: Own presentation, based on data from EEA (2022c) and the corresponding regulations (ESR and ESD). Figures are rounded.*

In fact, the ESR and LULUCF regulations provide for certain flexibility mechanisms in terms of saving, borrowing, and trading AEAs to efficiently achieve compliance. For example, the ESR Regulation allows Member States to sell a surplus of their emission reduction in the ESR sectors to other Member State (Peeters and Athanasiadou, 2020; Runge-Metzger and Van Ireland 2019). There are ex ante restrictions on tradable quantities that limit the extent to which member states can trade allowances allocated to them (10 percent and 15 percent of annual allocated emissions in the 2021-2025 and 2026-2030 periods, respectively). Ex post, after determining the extent to which actual ESR emissions deviate from targets, there are no limits on trading among member states (Yougova, 2023; Gores et al., 2023). To date, Germany, Malta, and Ireland have purchased AEAs, with Germany purchasing 11 million AEAs from Bulgaria, the Czech Republic, and Hungary (BMWK, 2022a, EEA, 2022a), Malta purchasing 1.4 million AEAs from Bulgaria (Gores and Graichen, 2018; Cilia, 2018), and Ireland purchasing approximately 4 million AEAs (EEA, 2022a), each for compliance with the 2020 target. Under the overall increased reduction level for the 2030 target year, it is reasonable to expect that domestic trading will become more important, especially if there is more regional relocation of emission reductions through the EU ETS2.

In addition, LULUCF credits can be used to offset ESR emissions. This link is bidirectional, meaning that emissions in the LULUCF sector can also be offset by additional reductions in ESR emissions (Peeters and Athanasiadou, 2020; Jensen, 2023).[3] However, LULUCF credits can only be included in the ESR if they result from net negative LULUCF emissions, i.e. $CO_2$ removal and storage, e.g. through afforestation, must exceed other emissions in the LULUCF sector (Pisarski et al., 2021). The amount of LULUCF credits that can be used by a nation state to offset ESR emissions is limited to the respective maximum amount of total net $CO_2$ removals as defined in Annex III of the ESR Regulation. The absolute cap for the two commitment periods is 262.2 $MtCO_2$ (split equally over the two periods) which would need to be realized as net removal on top of the 310 $MtCO_2$ removal target to be transferred to the ESR to compensate for emissions reductions. In practice, the actual total amount would be smaller since it appears unlikely that state-specific demand for LULUCF coincides with the state-specific caps (defined in Annex III of the ESR).

Finally, certain Member States can use EU ETS1 allowances to make up for shortfalls in emission reductions in the ESR sectors. Countries that are at risk of a gap between their own cost-effective reductions and their GDP-based targets, or that have not received free allocations (Malta), have access to this flexibility. Thus, Belgium, Denmark, Ireland, Luxembourg, Malta, the Netherlands, Austria, Finland and Sweden can use this flexibility. The total number of allowances for all countries under this flexibility is limited to 100 million for the ten-year period 2021-2030 (EU Commission, 2021; Romppanen, 2020).[4] The Commission's evaluation of the national energy and climate plans (2020) shows that the total volume (2021-2030) would be 64.1 $MtCO_2$ so far—Belgium (26.8 $MtCO_2$), Austria (18.7), Finland (17.9) and Malta (0.7) have already specified the use of this flexibility; Denmark, Ireland and Luxembourg have not yet done so (see EU Commission, 2021). However, overachievement of ESR targets cannot be transferred to the EU ETS1, i.e. the link is one-way.

From 2027, a second, additional emissions trading scheme (EU ETS2) will be introduced for the buildings, road transport and small energy and industrial installations sectors (not

[3] While all countries can use this flexibility, Member States with relatively high agricultural emissions are less restricted under Annex III of the ESR Regulation (Herold et al., 2021, Runge-Metzger and Van Ierland 2019; Romppanen, 2020). Splitting this flexibility over two periods halves access to each (Yougova, 2023).
[4] Malta, Luxembourg, and Ireland can access this flexibility to the greatest extent, equivalent to 7 percent (Malta) and 4 percent of 2005 emissions (see Annex II ESR; Runge-Metzger and Van Ierland, 2019; Yougova, 2023).

covered by EU ETS1). Figure 2 shows the estimated distribution of emissions between EU ETS1, the new EU ETS2 and the remaining ESR emissions. The start of implementation of the EU ETS2 may be delayed to 2028 due to extremely high energy prices (Duwe et al., 2023). Under EU ETS2, all allowances are auctioned. Distributors of fuels used for purposes listed in Annex III of the new ETS Directive are required to purchase allowances for their emissions (upstream approach). Final consumers are not directly involved in the EU ETS2 (EU Parliament and Council, 2022; Frenz, 2022; Duwe et al., 2023; Duma et al., 2022).

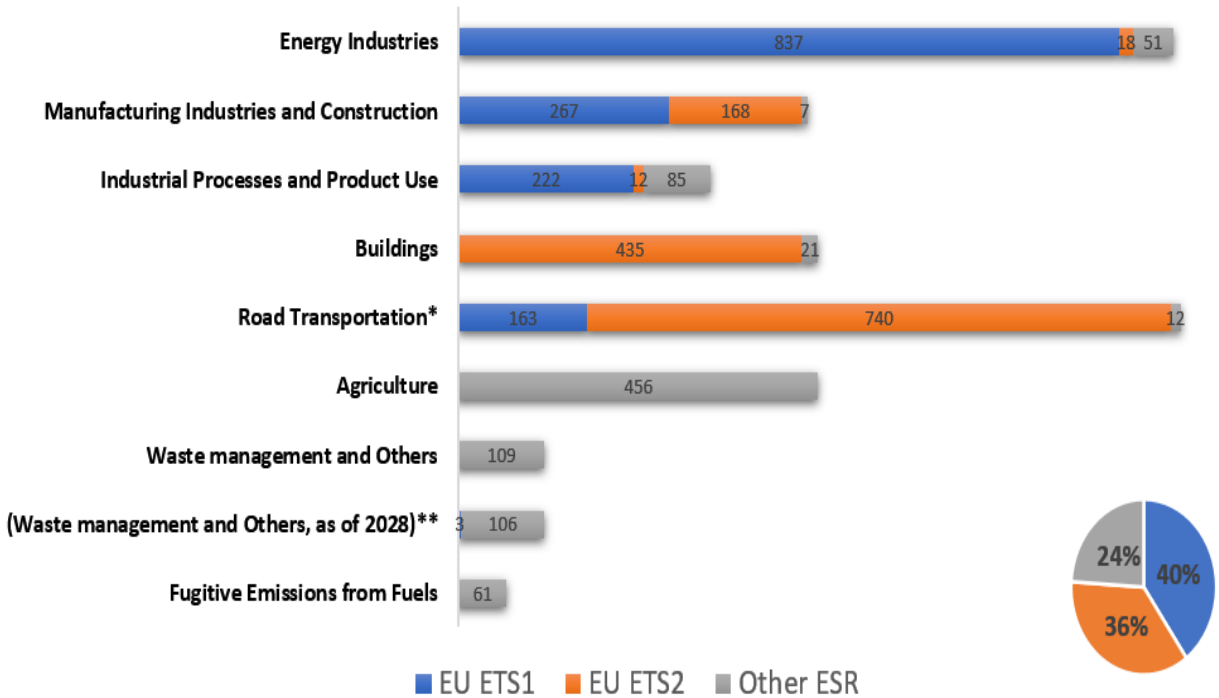


**Figure 2: Distribution of emissions by ETS1, ETS2 and other ESR, based on 2021 emissions.** Note: Own presentation, based on the data and allocation distribution of the Expert Council on Climate Issues (2022), Öko-Institut (2021), and Pause et al. (2023). Emissions data are from EEA (2023). Figures in MtCO2eq.

*From 2026, emissions from N2O and CH4 from maritime transport are to fall under EU ETS1.

**Commission presents a report on the feasibility of including waste incineration in EU ETS1 from 2026, from 2028.

The EU ETS2 reduction target for 2030 is 43 percent below 2005 levels. The new allowances auctioned each year decrease linearly, as in the EU ETS1, with emissions attributed to the EU ETS2 in 2024 used to calculate the linear reduction factor (LRF) (Gores et al. 2023). The initial LRF is 5.1 percent (based on 2024) and is expected to increase to 5.38 percent. However, more allowances will be auctioned initially to ensure sufficient liquidity in the market. This so-called "frontloading" amounts to 30 percent of the auction volume in the first year and will be deducted from the auction volumes in subsequent years. Frontloading therefore does not increase total emissions.

Similar to the EU ETS1, the EU ETS2 is complemented by a Market Stability Reserve (MSR). The ETS2 MSR is endowed with a volume of 600 Mt$CO_2$ allowances, but these are "extra", i.e. the auction volume until 2030 is not corrected for this volume and a release of allowances from the ETS2 MSR would increase emissions in the EU ETS2 (Gores et al. 2023). However, allowances from the initial supply in the ETS2 MSR become invalid after 2030. The allowances in the ETS2 MSR are subject to a quantity trigger and a price trigger, as in the EU ETS1. The quantity trigger is based on the amount of allowances held by market participants. If this quantity is above 440 million allowances, 100 million allowances from future auction volumes will flow into the ETS2-MSR; conversely, 100 million additional allowances will be auctioned if the quantity of allowances held by market participants is below 210 million allowances (EU Parliament and Council, 2022). If the allowance price rises above EUR 45/t$CO_2$ for two consecutive months, 20 million allowances will be released; if the price doubles (period: six months), 50 million allowances will be released; if it triples, 150 million allowances will be released (EU Parliament and Council, 2022). However, the EU Commission can lift these restrictions by means of an implementing regulation (Gores et al., 2023), which on the one hand indicates the still provisional and experimental character of the EU ETS2, but at the same time also shows that with corresponding political pressure, stronger intervention in the EU ETS2 to stabilize prices is possible.

The experimental nature of the EU ETS2 is also reflected in the fact that it is not a separate pillar of EU climate policy until 2030, but is intended to serve as a tool to help Member States achieve their national targets under the ESR (Duwe et al., 2023; Erbach and Foukalová, 2023; cf. Schlacke et al., 2022). Thus, the emissions covered by the EU ETS2 remain under the ESR targets and the responsibility of Member States' responsibilities for compliance. If there are net regional shifts of emission reductions within the EU ETS2, e.g. if companies of a member state buy in aggregated terms net allowances, the ERS target still has to be met at the national level. The member state would then have to compensate for increased emissions in the EU ETS2 emissions attributed to the country by i) stronger emissions reduction in the ERS sectors not covered by the EU ETS2 and/or ii) using the flexibility mechanisms described above to offset the "additional" emissions in the EU ETS2 by purchasing AEA allowances, and/or iii) using $CO_2$ removals from the LULUCF sector. Thus, there is a direct pricing of a share of ESR emissions through the EU ETS2, but a kind of double regulation through the crediting of emissions in a cross-border emissions trading system against national targets (Duwe et al., 2023). Accordingly, until 2030, Member States have the option to opt their sectors out of the EU ETS2 if a national system with $CO_2$ taxes at least as high as those in the EU ETS2 is in place (EU Parliament and Council, 2022; Gores et al., 2023). All in all, these considerations show that there are still many open questions regarding the implementation of the EU ETS2 and the coordination with national $CO_2$ pricing systems.

## 3 Effects of the EU ETS2

To discuss the impact of the EU ETS2, we analyze different scenarios using the Dynamic Applied Regional Trade model (DART). DART is a multi-regional, multi-sector, global and recursive dynamic general equilibrium model (Klepper et al., 2003; Winkler et al., 2021). The advantage of using such an equilibrium model is its ability to capture not only the direct domestic multiplier effects of a $CO_2$ price, but also the indirect effects via changes in international energy prices and trade flows (Klepper and Peterson, 2006). We use a version of DART calibrated to the GTAP10 dataset (Aguiar et al., 2019) with a base year of 2014 and IEA (2020) emissions and GDP data, and updated to IEA (2022) renewable energy data. DART covers $CO_2$ emissions from fossil fuel combustion, which is the core of EU climate policy. Other greenhouse gases and the LULUCF sector are not covered. The time horizon for the present analyses is 2030, which is the target year of the first Nationally Determined Contributions (NDCs) submitted under the Paris Climate Agreement, as well as the current EU reduction targets under the Green Deal. All results below, summarized in Table 1, are for the year 2030.

In the **reference scenario**, countries and regions outside the EU (e.g. the USA, Canada, or Africa) reach their NDCs (see Böhringer et al., 2021 for a description of these NDCs in non-European regions). For EU countries/regions (which in DART are DEU: Germany and FRA: France as individual countries and SCA: Scandinavia, BLX: Benelux + Ireland, SEU: Southern Europe, and EEU: Eastern Europe as aggregated regions), we assume an emissions trading scheme in the energy sector and energy-intensive industry (EU ETS1). We translate the Green Deal target of a 43 percent reduction compared to 2005 into a reduction target of 25.9 percent compared to the 2014 calibration year. Outside the EU ETS1 sectors, each EU country/region achieves the ESR (2021) target as shown in Figure 1, again translated into reductions compared to 2014. This is achieved through regional $CO_2$ prices that apply uniformly to all ESR sectors in the respective country/region.

In this reference scenario, there are seven $CO_2$ prices in the EU: one in the EU ETS1 and six in the ESR sectors of the six DART EU countries/regions. The $CO_2$ prices reflect the different abatement costs both across countries and across the energy and industry sectors aggregated in the EU ETS1. In this scenario, the EU ETS1 $CO_2$ price in 2030 is 79 EUR/t$CO_2$, which is lower than the current EU ETS1 price (which has been above 100 EUR/tCO2 at times). This is partly because an EU ETS price of around 5 EUR/tCO2 is already implicit in the GTAP dataset, and partly because the aggregate production functions in EU ETS1 ignore various real frictions. The ESR targets imply much higher prices in the reference scenario than in the EU ETS1, and national $CO_2$ prices range from just under 91 EUR/t$CO_2$ to around 502 EUR/t$CO_2$ in the EEU and in both, SCA and DEU, in 2030, respectively (see Table 1). Note that the model does not reflect all inefficiencies of the current system, firstly because it implicitly assumes regional emissions trading in the ESR sectors in the aggregated EU regions, and secondly because in reality the ESR sectors are subject to numerous regulations that are far from a uniform $CO_2$ price. These results therefore confirm that it would be (statically) more efficient to reduce less emissions in the ESR sector and reduce more emissions in the EU ETS1 than is the case in the EU.

Accordingly, those countries that have access to the possibility of transferring allowances from the EU ETS1 to the ESR (see Chapter 2) should do so.

In the **comprehensive ETS scenario**, EU targets are efficiently met under a comprehensive emissions trading scheme. This results in a uniform $CO_2$ price of EUR 155/t$CO_2$ and EU welfare gains relative to the reference scenario (measured as the Hicksean Equivalent Variation, a measure of aggregate economic welfare that accounts for price changes better than GDP) of 1.8 percent, ranging from 0.2 percent in the SEU to 4.7 percent in the EEU, are realized. In this scenario, more emissions are avoided in the sectors assigned to the EU ETS1. Accordingly, the emissions in the ERS sectors are 290 Mt$CO_2$ higher than in the reference scenario.

In the **ESR-ETS scenario**, there is a second ESR-wide emissions trading scheme. The price in the EU ETS1 changes very little due to equilibrium effects and amounts to 77 EUR/tCO2. In the ESR ETS, the simulations result in a price of 307 EUR/tCO2, which is significantly higher than the uniform $CO_2$ price in a comprehensive ETS. Thus, this scenario achieves only about 40 percent of the efficiency gains of the comprehensive ETS scenario.

In the **ETS2 scenario**, a European emissions trading system is assumed to be introduced in the transport and building sectors. To the extent possible in the model, this corresponds to the road transport and building sectors as envisaged in the EU ETS2. However, the representation of the road transport sector in DART does not exactly match the coverage envisaged in EU ETS2 (see Figure 2), as the transport sector is less disaggregated in DART and includes emissions from aviation and shipping. Due to the lack of information, the ESR targets are divided between these ETS2 sectors and the remaining ESR sectors according to their emission shares in the base year 2014. The targets in the remaining ESR sectors are achieved through regionally differentiated $CO_2$ prices. In the EU ETS2, a $CO_2$ price of 297 EUR/t$CO_2$ is achieved (similar to the ESR ETS scenario). However, as the national $CO_2$ prices for the remaining ESR sectors vary significantly, only about 25 percent of the efficiency gains of the overall ETS scenario can be achieved here. In the ETS2 scenario, companies in Eastern and Southern Europe sell in net terms allowances (53 Mt$CO_2$ and 58 Mt$CO_2$, respectively), which are purchased by companies in Germany (47 Mt$CO_2$), France (22 Mt$CO_2$), Benelux (21 Mt$CO_2$) and Scandinavia (20 MtCO2). The resulting deficits in the ESR emissions of nation states could only be partially compensated in Scandinavia by increased reductions in the remaining ESR sectors at minimal cost (in Scandinavia the $CO_2$ price in the remaining ESR sectors is 296 EUR/tCO2 compared to 297 EUR/t$CO_2$ in the EU ETS2); for all other countries the marginal cost of abatement in the ESR outside the ETS2 is higher than the ETS2 price, and accordingly it is more efficient to buy the corresponding AEA allowances from Eastern and Southern Europe. In addition, there is also the possibility to compensate the shortfall by transferring carbon removals from LULUCF to ESR. For Germany, however, the cap of 11.15 Mt$CO_2$ (for the period 2026 to 2030) would not allow for a complete compensation; for France, however, the cap would allow so (29.1 MtCO2).

**Table 1. Results of DART-Analysis**

| | reference | Comprehensive-ETS | ESR-ETS | ETS2 | ETS2-Max* |
|---|---|---|---|---|---|
| | Welfare effects relative to reference scenario | | | | |
| FRA | x | 2,5% | 0,8% | 0,6% | (5,3%) |
| GER | x | 2,6% | 0,1% | 0,1% | (3,7%) |
| BLX | x | 1,1% | 0,1% | 0,1% | (3,8%) |
| SEU | x | 0,2% | 0,2% | 0,1% | (1,8%) |
| SCA | x | 2,5% | 1,0% | 0,6% | (5,3%) |
| EEU | x | 4,7% | 4,1% | 2,6% | (1,1%) |
| EU | x | 1,8% | 0,7% | 0,5% | (3,2%) |
| | $CO_2$-prices (in EUR /t$CO_2$) | | | | |
| FRA | 428 | x | x | 633 | 622 |
| GER | 501 | x | x | 633 | 624 |
| BLX | 438 | x | x | 588 | 583 |
| SEU | 213 | x | x | 296 | 288 |
| SCA | 500 | x | x | 834 | 944 |
| EEU | 89 | x | x | 68 | 67 |
| Full-EU | x | 155 | x | x | x |
| EU-ETS1 | 79 | x | 77 | 76 | 68 |
| ESR-ETS | x | x | 307 | x | x |
| EU-ETS2 | x | x | x | 297 | 50.56 |
| | emissions in ESR (in Mt$CO_2$) | | | | |
| FRA | 152 | 220 | 180 | 174 | 229 |
| GER | 178 | 287 | 233 | 225 | 299 |
| BLX | 135 | 195 | 161 | 156 | 203 |
| SEU | 428 | 461 | 364 | 370 | 515 |
| SCA | 93 | 139 | 118 | 113 | 143 |
| EEU | 228 | 199 | 157 | 175 | 239 |

*Welfare effects in the scenario ETS2-Max are not comparable to other scenarios since additional cost for compliance with ERS targets are not included.

The modeled $CO_2$ price in the EU ETS2 in the ETS2 scenario would thus be significantly higher than the targeted intervention price of 45 EUR/t$CO_2$. However, if the intervention price were to be seen as a kind of ceiling price, a considerable amount of additional allowances would be required. This question is examined in the **EST2-Max scenario**, where the $CO_2$ price is kept at 45 EUR/tCO2 (in 2022 prices: 50.56 EUR/tCO2). Emissions in the EU ETS2 are 415 Mt$CO_2$ or about 40 percent above target in this scenario. The reported welfare values are highest here because in the simulations the additional emissions with the additional allowances have no welfare impact and it is not investigated what additional costs would arise if these allowances were generated by additional reductions in the remaining ESR sectors or by $CO_2$ removals in the LULUCF sector (with net emissions then unchanged). Accordingly, the welfare effects in the ETS2-Max scenario only show the extent to which a lower abatement level has an impact via lower abatement costs.

In the ETS2-Max scenario, ESR emissions are above the ESR target in all countries/regions (compare column with reference scenario) and the ESR deficit cannot be compensated by AEA trading at the national level. Similarly, national prices are above the intervention price in all countries/regions, so offsetting the higher EU ETS2 emissions in the remaining ESR sectors would be costly, especially considering that the cumulative deficit of 415 $MtCO_2$ is roughly equivalent to the magnitude of agricultural emissions of 456 $MtCO_2$ in the ESR (see Figure 2). Our analysis has no information on the marginal cost of $CO_2$ removal in the LULUCF sector, but extending the already ambitious net removal target of 310 $MtCO_2$ by an additional 415 $MtCO_2$ to offset ESR emissions under the maximum price seems ambitious (apart from the fact that the current limits on flexibility between ESR and LULUCF would not allow a transfer of this magnitude; see Chapter 2). For Germany alone, this results in a shortfall of 121 $MtCO_2$ in national ERS targets, of which only 11.15 $MtCO_2$ could be compensated by additional $CO_2$ removals in LULUCF. Accordingly, the ETS2-Max scenario requires additional interventions in the sectors within the EU ETS2 and thus implicit $CO_2$ prices above the intervention price.

Even though the figures should be interpreted cautiously due to the rather coarse modeling of the EU ETS2 in DART, the comparison within the emissions ESR between the reference scenario and the scenario ETS2 or ETS-Max in Table 1 allows rough conclusions for the necessary efforts of the member states to reach their ESR targets.

## 4 Discussion and Conclusion

In order to achieve the ambitious emission reduction targets for 2030 set out in the Fit for 55 package, the EU has decided to expand the emissions trading instrument. The existing emissions trading scheme (EU ETS1), which covers emissions from the energy and industrial sectors within the EU27, will be complemented by a second emissions trading scheme (EU ETS2), which will primarily cover emissions from the road transport and buildings sectors. The motivation for a transnational emissions trading system is to achieve reductions where abatement is cheapest. In principle, this makes national reduction targets obsolete, but they remain in place in their current form. Based on previous experience in EU climate policy, where distributional dimensions play an important role in ranking the ambition levels of individual member states (Runge-Metzger and von Ierland 2019), there is considerable insistence on differentiation or demands for compensation payments. This is reflected in the current design of the EU ETS2, as shifts in abatement in the corporate sector create corresponding credits or deficits in existing national targets, which have to be compensated, for example, through emissions trading at the state level. Accordingly, nation states with relatively low abatement costs will experience an inflow of funds from nation states with high abatement costs, both at the corporate and the state level. Thus, there will be an ex-post distributional effect if nation states have to compensate surpluses or deficits resulting from the EU ETS2 through interstate emissions trading. Desired distributional effects could be better achieved by an ex ante distribution of auction volumes (or auction revenues in the case of centralized auctions). Given the uncertainty of abatement costs and the relatively small number of actors in intergovernmental emissions trading, an ex-ante distribution without subsequent offsetting of emissions against national targets appears superior. However, even with the ex-post distribution chosen now, nation states should use the flexibility mechanisms to realize the efficiency gains of the EU ETS2.

To assess the EU ETS2, we examine different scenarios in the general equilibrium model DART. Both the current EU climate policy and a fully comprehensive emissions trading system are used as points of comparison. In the current system, there is only the EU ETS1 and all other emissions are regulated by national and different policies. Both the variation in national (implicit) $CO_2$ prices and the difference from the EU ETS1 price show the inefficiency of the existing system. By comparison, a comprehensive emissions trading system achieves emissions reductions at minimum cost, with more reductions in the energy and industrial sectors. The introduction of a second emissions trading system for road transport and buildings can be a possible intermediate step towards such a comprehensive emissions trading system.

In our model, the introduction of an emissions trading system based on the EU's plans for the EU ETS2 in the road transport and buildings sectors generates about a quarter of the efficiency gains of a comprehensive emissions trading system relative to the year 2030. However, this calculation is only a rough approximation of the planned EU ETS2 and does not include allowances from the EU ETS2 Market Stability Reserve (MSR). The ETS2 MSR has both a volume trigger and a price trigger, which release different amounts of additional allowances from the MSR for auctioning depending on the volumes in the market or the level of the $CO_2$ price. In our calculations, 415 $MtCO_2$ allowances would need to be auctioned extra to stabilize the $CO_2$ price at the intervention price of 45 EUR/tCO2 (in 2020 prices).

In our simulations, companies in Southern and Eastern Europe sell net allowances under the EU ETS2 to all other EU countries. In turn, there is also a surplus of ESR reductions for these countries from the EU ETS2 which would allow them to reduce correspondingly less in ESR sectors outside the EU ETS2, to offset emissions in the LULUCF sector, and/or sell annual emissions allowances to other Member States. In our simulations, the volumes sold in 2030 correspond to 14 percent (Southern Europe) and 23 percent (Eastern Europe) of the annual emission allocation in the ESR sectors.

In addition, there is the possibility that Member States take accompanying national measures for the sectors in the EU ETS2 (with corresponding efficiency losses). Also in this variant, Member States could rely on a price mechanism that allows them to implement higher prices than in the EU ETS2 (EU Parliament and Council 2022). It is still unclear how this could be implemented and whether the national prices would then function as a kind of minimum price, with companies in the member state paying the difference between the EU ETS2 price and the minimum price as a kind of tax (comparable to the former climate levy in the EU ETS1 sectors in the UK). If the implicit national minimum prices were lower than the prices in the reference scenario (see Table 1), there would still be efficiency gains from trading (albeit lower than in the EU ETS2 scenario without national restrictions).

The introduction of the EU ETS2 will be accompanied by the introduction of a Social Climate Fund, which will be endowed with EUR 86.7 billion for the period from 2026 to 2032 (65 billion through auction revenues and further contributions through national resources) and will support climate-friendly measures and investments (European Parliament, 2022b; Art. 15, European Parliament and Council 2023c). Distributing revenues from CO2 pricing back, for example in the context of per capita reimbursement, is an important building block for the acceptance of a price-based climate policy (e.g., Klenert et al. 2018). To allow the incentive effect of CO2 prices in the EU ETS2 to work, expenditures from the climate social fund should focus on transfer payments or at least be limited to subsidies that do not distort marginal incentives but address market entry problems (Antoniou and Strausz 2017).

The extent to which additional measures are needed will also depend on the $CO_2$ price realized in the EU ETS2. In principle, it is efficient to combine quantity control with price control when there is considerable uncertainty about abatement costs. However, the current intervention price (45 EUR/t$CO_2$, in 2020 prices) is well below the price level in the EU ETS1, so that a higher intervention price seems reasonable with a view to an economically necessary alignment of abatement costs across the different pillars of EU climate policy. In addition, it makes sense not to set a fixed intervention price, but to aim for a discretionary price stabilization in order not to completely eliminate uncertainty for companies about future abatement costs (Rickels et al. 2022).

Regardless of the design of price stabilization, additional allowances must be offset by additional reductions in other sectors or additional $CO_2$ removals if net emissions are to remain unchanged. However, with declining emissions in all sectors, both the EU ETS1 and the ESR, it will become increasingly difficult to offset lower emission reductions in one sector with higher emission reductions in another. Accordingly, the LULUCF sector will become more important in achieving atmospheric $CO_2$ removals. Currently, the crediting of net negative emissions from LULUCF into ESR is cumulatively limited to 262.2 MtCO2 by 2030, but this would be in addition to the removal target of 310 MtCO2 to offset emissions within ESR. Although the Commission's modeling assumes a significant expansion of the LULUCF sink by 2050 (European Commission 2020), projections to 2030 indicate that the opposite trend is likely, with a significant decline in sink performance (Herold et al. 2021). Accordingly, a credible price control in the EU ETS2 (and potentially also in the EU ETS1) by $CO_2$ removal allowances will require to include further methods of natural $CO_2$ removal such as for example accelerated weathering or coastal seagrass restoration into the LULUCF, as well as to integrate technical options for $CO_2$ removal into the EU climate policy.

## Acknowledgements

Christian Rischer acknowledges funding from the EU H2020 program under the OceanNETs project (869357), Felix Schenuit acknowledges funding from the German Federal Ministry of Education and Research under the CDRSynTra project (01LS2101A), Sonja Peterson acknowledges funding from the German Federal Ministry of Education and Research under the RETAKE project (03F0895K), Wilfried Rickels acknowledges funding from Volkswagen AG under an endowed professorship through the Stifterverband. We would like to thank Jakob Graichen, Thorsten Müller, and Jana Nysten for helpful comments.

## References

Antoniou, F., and Strausz, R. (2017). Feed-in subsidies, taxation, inefficient entry. Environ. Res. Econ. 67, 925–940. doi: 10.1007/s10640-016-0012-8

Aguiar, A., M. Chepeliev, E. Corong, R. McDougall und D. van der Mensbrugghe (2019), The GTAP Data Base: Version 10, *Journal of Global Economic Analysis*, 4(1), 1 (Retrieved from https://www.jgea.org/ojs/index.php/jgea/article/view/77).

BMWK (2022a), Deutschland erwirbt Emissionsberechtigungen für verfehlte Klimaziele zwischen 2013 bis 2020, https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2022/10/20221024-deutschland-erwirbt-emissionsberechtigungen-fur-verfehlte-klimaziele-zwischen-2013-bis-2020.html (27.03.2023).

BMWK (2022b), New EU climate policy in place: political agreement in finalizing the Fit for 55 climate package, https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/12/20221218-new-eu-climate-policy-in-place-political-agreement-in-finalising-the-fit-for-55-climate-package.html (18. Februar 2023).

Böhringer, C., S. Peterson, T. F. Rutherford, J. Schneider und M. Winkler (2021), Climate policies after Paris: Pledge, Trade and Recycle: Insights from the 36th Energy Modeling Forum Study (EMF36), *Energy Economics*, 103(2021), 105471.

Böhringer, C., T. Hoffmann und C. Manrique-de-Lara-Peñate (2006), The efficiency costs of separating carbon markets under the EU emissions trading scheme: A quantitative assessment for Germany, *Energy Economics*, 28(1), 44 (10.1016/j.eneco.2005.09.001).

Böhringer, C., A. Lange und T. F. Rutherford (2014), Optimal emission pricing in the presence of international spillovers: decomposing leakage and terms-of-trade motives, *Journal of Public Economics*, 110(2014), 101.

Böhringer, C., T. F. Rutherford und R. S. J. Tol (2009), THE EU 20/20/2020 targets: An overview of the EMF22 assessment, *Energy Economics*, 31(2009), 268 (https://doi.org/10.1016/j.eneco.2009.10.010).

Bundesbank (2015), Devisenkursstatistik Dezember 2015, https://www.bundesbank.de/resource/blob/695964/b333671744e02ceecbcf44492f977c71/mL/2015-12-devisenkursstatistik-data.pdf (06. April 2023).

Burmeister, J, S Peterson (2016). National climate policies in times of the European Union Emissions Trading System (EU ETS), Kiel Working Papers 2052, Kiel Institute for the World Economy (IfW Kiel).

Burtraw, D, C Holt, K Palmer, WM Shobe (2020), Quantities with prices: price responsive allowance supply in environmental markets. Resources for the Future, Working Paper (20-17), Washington D.C, https://www.rff.org/documents/2636/RFF_WP_20-17_Burtraw.pdf.

Cilia, R. (2018), Updated: Malta buying emissions allocations from Bulgaria costing €180,000 a year, Independent, https://www.independent.com.mt/articles/2018-11-05/local-news/Malta-purchases-annual-emissions-allocations-from-Bulgaria-costing-1-4-million-PN-MP-6736198891 (27. März 2023).

Duma, D., C. Postoiu und M. Catuti (2022), The impact of the proposed EU ETS 2 and the Social Climate Fund on emissions and welfare, Energy Policy Group.

Duwe, M., J. Graichen und H. Böttcher (2023), Can current EU climate policy reliably achieve climate neutrality by 2050?, Ecologic Institute und Öko-Institut.

EEA (2023), EEA greenhouse gases — data viewer, https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer (31. März 2023).

EEA (2022a), Trends and projections in Europe 2022, https://www.eea.europa.eu/publications/trends-and-projections-in-europe-2022 (27. März 2023).

EEA (2022b), Greenhouse gas emissions under the Effort Sharing Decision (ESD), https://www.eea.europa.eu/data-and-maps/data/esd-4 März 2023 (27. März 2023).

EEA (2022c), National progress towards greenhouse gas emission targets under the ESR, https://www.eea.europa.eu/data-and-maps/figures/national-progress-towards-greenhouse-gas (03. April 2023).

EC (Council of the European Union) (2023), Interinstitutional Files: 2021/0211(COD), 2021/0202(COD), https://data.consilium.europa.eu/doc/document/ST-6210-2023-INIT/en/pdf (05. April 2023).

Erbach, G. und N. Foukalová (2023), Review of the EU ETS, European Parliamentary Research Service.

Europäische Kommission (2021), Impact Assessment Report Accompanying the document Regulation of the European Parliament and of the Council amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2021:0611:FIN:EN:PDF (27. März 2023).

Europäisches Parlament und Rat (2022a), DIRECTIVE (EU) 2023/... OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of ... amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme, https://www.europarl.europa.eu/doceo/document/TA-9-2022-0246_EN.html (16. März 2023).

Europäisches Parlament (2022b), Deal on establishing the Social Climate Fund to support the energy transition, https://www.europarl.europa.eu/news/en/press-room/20221212IPR64528/deal-on-establishing-the-social-climate-fund-to-support-the-energy-transition (05. März 2023).

Europäisches Parlament und Rat (2023a), REGULATION (EU) 2023/…OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of amending Regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the Member States for 2030, and Regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review, https://data.consilium.europa.eu/doc/document/PE-75-2022-INIT/en/pdf (30. April 2023)

Europäisches Parlament und Rat (2023b), REGULATION (EU) 2023/...OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and Regulation (EU) 2018/1999, https://data.consilium.europa.eu/doc/document/PE-72-2022-INIT/en/pdf (30. April 2023).

Europäisches Parlament und Rat (2023c) Regulation of the European Parliament and of the Council establishing a Social Climate Fund and amending Regulation (EU) 2021/1060, https://data.consilium.europa.eu/doc/document/PE-11-2023-INIT/en/pdf (05. März 2023).

Eurostat (2023), HICP - all items, https://ec.europa.eu/eurostat/databrowser/view/teicp000/default/table?lang=en (06. April 2023).

Expertenrat für Klimafragen (2022), Prüfbericht zur Berechnung der deutschen Treibhausgasemissionen für das Jahr 2021, https://expertenrat-klima.de/content/uploads/2022/05/ERK2022_Pruefbericht-Emissionsdaten-des-Jahres-2021.pdf (31. März 2023).

EZB (2023), Euro-Referenzkurse, https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-usd.de.html (06. April 2023).

Fernández, G. M., J. Moss und A. Oger (2022), Stakeholder views on the proposed EU Emission Trading System (ETS) covering buildings, Publications Office of the European Union.

Frenz, W., 2022, Grundzüge des Klimaschutzrechts, 2. Auflage, Erich Schmidt Verlag.

Frenz, W., 2023, Reform des EU-Emissionshandels, In: *Natur und Recht* 45(2023), 175-178.

Gores, S. und J. Graichen (2018), Abschätzung des erforderlichen Zukaufs an Annual Emission Allocations bis 2030, https://www.oeko.de/fileadmin/oekodoc/Abschaetzung-des-Zukaufs-von-AEA-bis-2030.pdf (27. März 2023).

Gores, S., J. Graichen, A. Kemmler und P. Plötz (2023), Übersicht über die Vorschläge zu den EU-Zielvorgaben, Fraunhofer ISI, Öko-Institut e.V. und Prognos.

Goulder, LH and AR Schein (2013), Carbon taxes versus cap and trade: a critical review, Climate Change Economics 4(3): doi.org/10.1142/S2010007813500103.

Görlach, B., M. Jakob, K. Umpfenbach, M. Kosch, M. Pahle, T. Konc, N. aus dem Moore, J. Brehm, S. Feindt, F. Pause, J. Nysten und J. Abrell (2022), Ein fairer und solidarischer EU-Emissionshandel für Gebäude und Straßenverkehr, Kopernikus-Projekt Ariadne.

Herold, A., H. Böttcher, S. Gores und C. Urrutia (2021), 2030 Climate Target: Review of LULUCF Regulation: Background paper for the workshop of the ENVI Committee on 25/05/2021, Öko-Institut.

Jensen, L. (2023), Revision of the LULUCF Regulation: Strengthening the role of the land use, land-use change and forestry sector in climate action, European Parliamentary Research Service.

Kalkuhl, M, M Kellner, T Bergmann, K Rütten (2023). CO2-Bepreisung zur Erreichung der Klimaneutralität im Verkehrs- und Gebäudesektor: Investitionsanreize und Verteilungswirkungen. MCC-Arbeitspapier. https://www.mcc-berlin.net/fileadmin/data/C18_MCC_Publications/2023_MCC_CO2-Bepreisung_Klimaneutralit%C3%A4t_Verkehr_Geb%C3%A4ude.pdf

Klenert, D, L Mattauch, E Combet, O Edenhofer, C Hepburn, R Rafaty, N Stern (2018) Making carbon pricing work for citizens. Nature Clim Change 8, 669–677. https://doi.org/10.1038/s41558-018-0201-2

Klepper, G., S. Peterson und K. Springer (2003), DART97: A description of the multi-regional, multi-sectoral trade model for the analysis of climate policies, *Kiel Working Paper*, 1149.

Klepper, G. und S. Peterson (2006), Marginal abatement cost curves in general equilibrium: The influence of world energy prices, *Resource and Energy Economics*, 28(1), 23.

Murray, BC, RG Newell, WA Pizer (2009), Balancing cost and emissions certainty: an allowance reserve for cap-and-trade, Rev. Environ. Econ. Policy 3(1): 84–103.

Olesen, A. S., T. Kowalczewski, K. Kenney, V. Bellassen, N. Bird, M. von Unger, D. Eaton, S. Leistner, C. Tiriduzzi, M. D. Steinert und S. Gionfra (2021), Reviewing the Contribution of the Land Use, Land-use Change and Forestry Sector to the Green Deal, Publications Office of the European Union.

Öko-Institut (2021), Projektionsbericht 2021 für Deutschland, https://www.oeko.de/fileadmin/oekodoc/projektionsbericht_2021_bf.pdf (31. März 2023).

Pause, F., J. Nysten und J. Kamm (2023), Das *Fit for 55*-Paket und REPowerEU: Updates und das neue System der EU-CO2-Bepreisung: Green Deal *erklärt*, https://stiftung-umweltenergierecht.de/wp-content/uploads/2023/01/Stiftung-Umweltenergierecht_GreenDealerklaert_Update_CO2-Bepreisung_2023-01-31.pdf (31. März 2023).

Peeters, M. and N. Athanasiadou (2020), The continued effort sharing approach in EU climate law: Binding targets, challenging enforcement?, *Review of European, Comparative & International Environmental Law*, 2020(29), 201.

Perino, G, M Willner, S Quemin, M Pahle (2022), The European Union emissions trading system market stability reserve: does it stabilize or destabilize the market? Review of Environmental Econonomics and Policy, https://doi.org/10.1086/721015.

Pisarski, Z., P. Mzyk, I. Zborowska und M. Żaczek (2021), Analysis of Factors that Determine Inclusion of LULUCF into Realisation of EU Climate Policy Objectives 2021–2030 in the Non-ETS Sectors, *Environmental Protection and Natural Resources*, 32(2), 42.

Publications Office of the EU (2022), Binding annual greenhouse gas emission reductions by Member States (Effort Sharing Regulation) ***I Amendments (*) adopted by the European Parliament on 8 June 2022 on the proposal for a regulation of the European Parliament and of the Council Amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement (COM(2021)0555 — C9-0321/2021 — 2021/0200(COD)), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022AP0232&from=EN (02. April 2023).

Rickels W., C. Weigand, P. Grasse, J. Schmidt, und R. Voss (2019), Does the European Union Achieve Comprehensive Blue Growth? Progress of EU Coastal States in the Baltic and North Sea, and the Atlantic Ocean against Sustainable Development Goal 14, *Marine Policy*, 106(2019), 1 (103515).

Rickels, W, S Peterson, G Felbermayr (2019), Schrittweise zu einem umfassenden europäischen Emissionshandel, Kiel Policy Brief 127, Kiel Institute for the World Economy (IfW Kiel).

Rickels W., A. Proelß, O. Geden, J. Burhenne, und M. Fridahl (2021), Integrating Carbon Dioxide Removal Into European Emissions Trading, *Frontiers in Climate*, 3(2021), 1 (doi:10.3389/fclim.2021.690023).

Rickels, W, R Rothenstein, F Schenuit, M Fridahl (2022) Procure, Bank, Release: Carbon Removal Certificate Reserves to Manage Carbon Prices on the Path to Net-Zero, Energy Research & Social Science 94: 102858.Romppanen, S. (2020), The LULUCF Regulation: the new role of land and forests in the EU climate and policy framework, *Journal of Energy & Natural Resources Law*, 38(3), 261.

Runge-Metzger, A. und T. Van Ierland (2019), The Effort Sharing Regulation, in J. Delbeke und P. Vis (Hrsg.), Towards a Climate-Neutral Europe, 95-116, Routledge.

Schlacke, S., H. Wentzien, E.-M. Thierjung und M. Köster (2022), Implementing the EU Climate Law via the ‘Fit for 55’ package, *Oxford Open Energy*, 2022(1), 1.

Strambo, C., M.Xylia, E. Dawkins und T. Suljada (2022), The impact of the new EU Emissions Trading System on households, *SEI Policy Paper*, 06(2022), 3.

Willner, M and  G Perino (2022), An upgrade for the EU ETS: making Art. 29a and 30h fit for effective price containment. CEN Policy Brief, Center for Earth System Research and Sustainability (CEN) at University of Hamburg. https://www.cen.uni-hamburg.de/research/policy-briefs/bilder-docs/2200425-pcm-policy-brief-cen.pdf

Winkler, M, S Peterson, S Thube (2021), Gains associated with linking the EU and Chinese ETS under different assumptions on restrictions, allowance endowments, and international trade, Energy Economics 104: 105630,

Yougova, D. (2023), Revising the Effort-sharing Regulation for 2021-2030: 'Fit for 55' package, European Parliamentary Research Service.