MASTER THESIS

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„The Future of EU Carbon Pricing: Should Non-ETS Sectors be included into the EU ETS"

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Abstract:

The new von der Leyen commission in its European Green Deal (European Commission 2019) has committed itself to push for even more ambitious 2030/2050 carbon reduction targets. Many EU countries, however, already encounter great difficulties reaching their respective existing national targets for the non-ETS sectors, i.e. transport, heating and agriculture (European Environment Agency (EEA) 2018).[1] Therefore, one policy proposal in the European Green Deal is to include those non-ETS sectors into the ETS. Such a reform, proponents argue, would cap the overall amount of carbon emissions in a cost-efficient way by creating a single price for carbon inside the EU. This paper tries to predict the effect such a reform would have on the price of carbon. Ultimately, this effect will depend on a political compromise that would have to determine the new ETS emissions cap as well as the distribution of emission allowances between the member states. In the worst-case scenario, the cap would be set too high and would thus undo the progress that was made over the last decade fixing the existing ETS. In the best-case scenario, the cap would be set strictly in accordance with the (current or more ambitious) 2030/2050 targets, which would result in a significant rise of the ETS allowance price by bringing in competition households and industry. A credible carbon leakage protection for EU industry would therefore be the minimum pre-requisite for the inclusion of non-ETS sectors.

Abstract (German):

Die EU Kommission versucht mit ihrem "European Green Deal" ambitioniertere 2030/2050 Emissionsziele zu erreichen. Da viele Mitgliedsstaaten aber Probleme haben die bereits bestehenden Ziele zu erreichen schlägt die Kommission unter anderem vor zu prüfen ob es von Vorteil wäre jene Sektoren die bisher nicht im EU Emissionshandel (EHS) erfasst waren, hauptsächlich Transport, Wärme und Landwirtschaft, zu integrieren. Befürworter dieser Reform argumentieren, dass somit kosteneffizient Emissionen eingespart würden. Diese Abhandlung analysiert mittels Rekalibrierung eines einfachen Optimierungsproblems, welches von Richard Tol (2008) definiert worden ist, abzuschätzen welchen Effekt so eine Reform auf den Zertifikatspreis innerhalb des EHS haben würde um somit zur aktuellen Diskussion beitragen und Politikempfehlungen abgeben zu können.

[1] See also: https://www.leopoldina.org/uploads/tx_leopublication/2019_Stellungnahme_Klimaziele_2030_Final.pdf.

Pledge of Honesty:

On my honour as a student of the ‘Diplomatische Akademie Wien’, I submit this work in good faith and pledge that I have neither given nor received unauthorized assistance on it.

Alexander Krenek, BSc

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Introduction

Despite the fact that the two most important emitters of carbon, the United States of America and China, are likely to increase their carbon emissions till 2030,[2] the EU commission is pushing for even more ambitious 2030/2050 carbon reduction targets (European Commission 2019). In order to be successful, carbon pricing has to play a central role in this attempt. At the moment, however, there is not a single price of carbon in the EU. The EU-wide Emission Trading System (ETS) mainly covers emissions from energy production and heavy industry, while for the rest of the emissions, mainly stemming from transport, heating and agriculture, member states have individual direct or indirect carbon prices.

Sweden for example has an explicit carbon tax (direct carbon price)[3] while almost all other member countries have some form of fuel tax which can be regarded as an indirect carbon tax for the transport sector. With regard to these non-ETS sectors, EU member states agreed to the so-called "Effort Sharing Decision" (ESD) (Decision No 406/2009/EC of the European Parliament and of the Council of 23.4. 2009) and the ensuing Regulation (Regulation (EU) 2018/842 of the European Parliament and of the Council of 30.05 2018), which lists the individual carbon reduction efforts each country is expected to achieve by (2020) 2030. Those individual member state reduction efforts together with the EU-wide reduction effort within the ETS sectors is depicted in figure 1. The individual reduction efforts for the non-ETS sectors range from 0% for Bulgaria to 40% for Luxembourg. The existing ambitious reduction targets for countries like Luxembourg and Germany will be very difficult to meet by 2030.

[2] See for example UNFCCC model simulations: https://www4.unfccc.int/sites/br-di/Pages/GHGProjections.aspx; however, the effect of the COVID-19 induced economic downturn cannot yet be yet accounted for.
[3] See the official web page of the government of Sweden: https://www.government.se/carbontax.

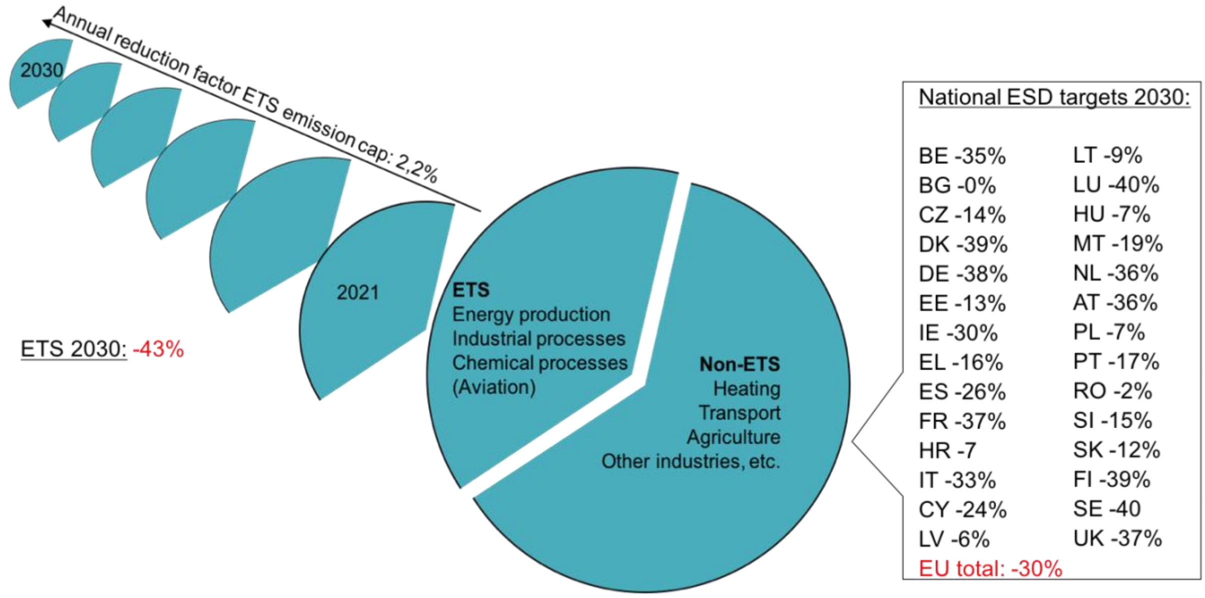

Figure 1. Current EU emission reduction plans for 2030; ETS Directive 2003/87 and Regulation 2018/842, first published in Krenek (2020).

That is the reason why in the fall of 2019 Germany decided to introduce a *national* emission trading system for its non-ETS sectors.[4] This German approach is the third carbon pricing option depicted in table 1, which lists all the different sources of carbon emissions. Those sources of carbon can be divided into two overall categories: production-based emissions and imported-product/consumption-based emissions. The production-based emissions can then be further divided into those covered by the EU ETS and those that are not, i.e. the non-ETS sectors. Below the sources of carbon all the six possible different reform options regarding carbon pricing are listed and ascribed to the relevant source of carbon. While Germany opted for the third option this paper focuses on the fourth option because the overall challenges for most of the countries to effectively reduce carbon emissions remain. That is why the EU Commission, in its European Green Deal, next to a border carbon adjustment (BCA), proposed evaluating *the inclusion of all the non ETS sectors into the EU ETS*, which would result in one single price of carbon for the whole EU.

[4] See the official statement of the German government: https://www.bundesregierung.de/breg-de/themen/klimaschutz/nationaler-emissionshandel-1684508.

Production- and consumption-based CO_2 emissions + possible reform options

Production-based emissions + direct HH emissions		Consumption-based emissions
ETS*: • Installations > 20MW thermal input • Refining of mineral oil • Production of coke • Metal ore roasting • Production of pig iron or steel • Production of aluminum • Production of cement clinker • Production of lime • Production of pulp and paper • Production of acids • Production of hydrogen • Etc. • (Aviation)	Non-ETS**: • Transport (HH[1]) • Heating (HH) • Agriculture • Other industries • (Service sector) 2. national CO_2 taxes? 3. national ETS ? 4. Inclusion into EU ETS? – EU-wide inclusion – national inclusion	CO_2 footprint of all products consumed by EU citizens (CO_2 of domestic production – exports + imports) 5. Border Carbon Adjustment? 6. Rebates for EU exports?
1. Price floor/ price corridor within the ETS?		

*Directive 2003/87, Annex I; **Regulation 2018/842, [1]HH = households

Table 1. Production- and consumption-based CO2 emissions + possible reform options.

In theory this would be the most (cost-) efficient way to curb carbon emissions. It would also, in theory, guarantee meeting whatever targets the EU member states agree upon because the overall emission cap would be fixed, i.e. the overall amount of pollution/emissions would be set beforehand, and it would be prohibited to emit any amount of carbon without acquiring the respective amount of CO_2 allowances (certificates).

There are, however, reasons why this approach is not only complex but also problematic. Chapter 1 will discuss the existing literature regarding the inclusion of non-ETS sectors into the ETS. It will discuss advantages and disadvantages of including non-ETS sectors. Many problems mentioned in the literature, however, are mainly administrative in nature. For example, an Agora report (Matthes 2019) criticizes that every attempt to include the non-ETS sectors would be too time consuming given the very short time horizon to reduce carbon emissions. Chapter 2 of this paper, however, wants to analyze a more general problem arising from the effect such a reform would have on the price of carbon, i.e. the new single price of carbon. This paper tries to analyze this effect by employing a simple optimization model by Tol (2008), which he used for analyzing carbon prices in the second trading period of the ETS (2008-2012). The novelty of this paper will be to assume that any potential future compromise regarding the inclusion of non-ETS sectors into the ETS would never be more stringent in its overall reduction targets as was agreed in Regulation 2018/842. In other words: Every agreement to include all national non-ETS sectors into the ETS would result in the same kind of exemptions and sweetheart deals agreed on in Regulation 2018/842. Thus, this paper will collapse all the national non-ETS reduction targets with the ETS-sector reduction targets.

The data for this model (reduction targets + allocation share of emission allowances to the member states, i.e. how many emission allowances every member state will get annually to sell at an auction) are gathered through analysing the legal text of Regulation 2018/842 as well as the ETS Directive 2003/87. Thus the reduction targets in Regulation 2018/842 will change the overall cap of the existing ETS. The individual targets in Regulation 2018/842 will be reflected by the different distribution of allowances in the newly expanded ETS. A country like Germany would thus receive a very limited amount of allowances in relation to its actual emissions from non-ETS sectors while Bulgaria will receive allowances for all its emissions from its non-ETS sectors. But the sum of these allowances will reflect the new single combined EU reduction target. An interesting by-product of this approach will be the impact such a reform would have on the distribution of money and burden inside this new, enlarged ETS. Finally, the model requires carbon emissions estimations up to 2030 from EU Member States for their ETS as well as non-ETS sectors as well as 'added value' of EU Member States ETS and non-ETS sectors. The UNFCCC will be the source for the emission data and Eurostat data are used for the 'added value' of EU member state sectors. Chapter 3 will derive policy implications based on the model outcome, followed by the Conclusion.

Chapter 1

If the literature on pros and cons of including non-ETS sectors would have to be summarized the following picture would emerge: From a theoretical, long-term and cost-efficient point of view including the non-ETS sectors would be the sensible option to pursue if the reduction of carbon emissions is the primary policy goal. From a practical, legal, political, and short-term point of view including non-ETS sectors might not be the best option to pursue. The way forward becomes even less clear if next to the reduction of carbon emissions, growth and inequality are considered equally important fields of policy.

Cost efficiency

Reducing carbon emissions at the lowest cost possible should be the guiding principle of every carbon mitigation strategy. It will thus be the minimization problem states have to solve in Chapter 2 of this paper. One of the most prominent economists focusing on the cost-effectiveness of carbon mitigation policies is Christoph Böhringer. Over the years Böhringer and his colleagues researched cost-effectiveness of existing EU carbon pricing policies as well as cost-effectiveness of a potential regional and sectoral expansion of emission trading and of course the cost-effectiveness of border carbon adjustments, which are also featured in the European Green Deal (European Commission 2019). In his paper, Böhringer (2014a) outlined an optimal EU carbon mitigation design. This design is based on three demands. The first demand is that the EU should push for international (global) binding mitigation policies/treaties. However, even in the absence of such binding treaties the second demand argues for unilateral EU carbon reductions. The third demand states that every carbon mitigation must be cost-efficient. The obvious conclusion of Böhringer (2014a) that carbon mitigation via forced GDP or population reductions are non-viable policies rings especially true amid the current COVID-19 crisis. The only way forward is to design policies that reduce carbon and energy intensity of consumption and production, fuel switching to less carbon intensive fuels and/or carbon capture/storage. In order to guarantee cost-effectiveness marginal costs for each pollutant must be equalized. This equalization happens in a decentralized cap-and-trade system that covers all pollutants and all sectors of society. Such a system would create one single price of carbon or carbon equivalents. Market forces would ensure the most cost-effective carbon mitigation given an overall reduction target (the “cap”). Böhringer (2014a) by quoting the work of Tinbergen (1952) goes on to say that such a cost-efficiency is not given if the number of (policy) targets does not match the number of policies. Having more targets than policies might make targets incompatible while having more policies than targets might lead to costly overlaps. The latter is true with regard to the EU. Inside the EU there are at least two separate 'markets' for carbon emissions, i.e. the ETS and the non-ETS 'market'. But the situation is actually worse than that because the 'market' for non-ETS emissions is divided up by the number of EU member states, each with a different reduction target and a different cost of abatement. Germany for example (see Figure 1) has an existing reduction target of 38% but is certainly more energy efficient compared to Bulgaria. The more energy efficient a country is the higher are the marginal costs of abatement because all the cheaper abatements options have already been exhausted. The reduction target for Germany's non-ETS sectors is high although its cost of abatement is also high. This is a classic example of cost-inefficiency. The situation gets even worse because member states, with the exception of Germany do not have a national emission market but a variety of control-and-demand measures. Böhringer (2014a) also writes about overlapping regulations at the EU level. The existence of an EU-wide 'renewable energy target' parallel to the ETS also creates overlaps and thus inefficiencies. In conclusion it can be said, that the division between ETS-emissions and non-ETS emissions, the division of non-ETS emissions between member states, the overlapping national regulations to achieve the national non-ETS targets, and the overlapping regulations at the EU level cause massive cost-inefficiencies.

Countries incentives for sectoral expansion of the ETS

In their paper on sectoral and regional ETS expansion Böhringer et al. (2014b), even under very favorable assumptions, find that not necessarily all countries would benefit of such an expansion. It is clear, however, that the combined cost of all participating countries is minimized when all sectors are included into the ETS. A second, very intuitive but important result of their model is that the price within the ETS may change if non-ETS sectors are included but only within a "price corridor". The lower bound of this price corridor is the lowest national abatement cost for non-ETS sectors and the upper bound is the highest national abatement cost for non-ETS sectors. For example, if the marginal abatement cost for Germany's non-ETS sectors is €80 and the marginal abatement cost for Bulgaria is €30 then the inclusion of all national non-ETS sectors would cause the ETS price to change but only in a corridor of €30-80. A final result of Böhringer et al. (2014b) is that in the absence of a global ETS, costs are drastically reduced the more sectors are included into a regional ETS such as the EU ETS.

From a theoretical perspective it is clear that in total, EU member states would benefit from an ETS expansion. Unfortunately, the reality is more political as described in Böhringer et al. (2014b). The problem is not so much a redistributive one. There is redistribution in the existing Regulation (2018/842) for the non-ETS sectors (see also figure 6). There is redistribution in the existing distribution of allowances in the ETS (see also figure 5). There would be redistribution from wealthier countries to less wealthy countries in an (sectoral) enlarged ETS (see also figure 7). This redistribution, a result of initial/annual distribution of allowances (e.g. Germany does get fewer allowances compared to its projected emissions while Bulgaria gets more allowances compared to its projected emissions) would be perfectly fine from an efficiency point of view. Following the Coase theorem (1960) the initial distribution of allowances/permits does not influence cost-effectiveness, but it may lead to redistribution, an outcome that might even be considered desirable (e.g. redistribution from Germany to Bulgaria).

The relevant trade-off, from a political point of view, is between cost savings and more centralization. *How large would cost savings induced by an enlarged ETS would have to be in order for member states to give up at least indirect taxation competencies to the EU?*

Upstream market participants

If direct household emissions were subject to an enlarged ETS, who would have to buy emission allowances? In the current EU ETS framework for direct emissions from specific installations allowances have to be bought by the management of those installations. In the case of transport or heating the installation would be the car or a furnace. It is obvious that households could not be asked to participate in an auction to bid for allowances. In the New Zealand ETS the point of regulation is upstream, i.e. emissions from fossil fuels are priced higher up in the supply chain, e.g. at the point of production or import (Kerr and Duscha 2014). The Californian ETS is a mixed system in which both, up- and downstream approaches are present. Some sectors, for example the chemical industry, are regulated downstream whereas the transport sector is regulated upstream (Bragadottir, et al. 2015). The Californian example proves that such a mixed system is feasible. The problem is that the legal framework of the directive 2003/87/EC would have to be amended in order to allow the inclusion of upstream regulation. Such an upstream regulation would be essential as otherwise the administrative burden would be unbearable. According to Bragadottir et al. (2015) there are several options to price emissions upstream in regard to fuel: fuel suppliers, refineries, warehouse keepers, etc. They argue that, subjecting fuel suppliers, etc. to the EU ETS would indirectly include the transport sector and in consequence also heating sector into the ETS. They also argue that costs would be passed on to the consumer as is the case within the electricity market. A huge problem, however, is potential double taxation. If gas/oil/coal importers/distributors have to buy ETS allowances would energy producers who transform gas into electricity still have to buy allowances as well? Solving this issue with rebates/refunds etc. would add significantly to compliance costs.

What Bragadottir et al. (2015) do not address is the potential problems caused by the fact that there are only very few oil refineries/importers in the EU (Kemfert, Schmalz und Wägner 2019). Oil or fossil fuel refineries would be large buyers with the potential to influence prices. If on the other hand for specific administrative reasons a more mid-stream approach would be preferable it should be emphasized that in Germany alone there are more than 1000 gas-distributors and around 5000 traders of mineral-oil products (Matthes 2019). Currently only 1870 German installations are subject to the ETS.

Finally, in Europe there are huge regional and, more importantly, seasonal spikes in fuel/heating consumption. Such an uneven demand would further exacerbate the problem of volatile allowances prices.

Volatile prices

Volatile allowances prices are one of the most criticized points in Kemfert's et al. (2019) discussion about the pros and cons of including non-ETS sectors into the ETS. They describe the danger of lock-in effects. Companies have to know what costs they will face in coming decades to make the necessary (technological) investments. If prices are low at one point in time, companies will not invest, and if prices are high, companies might just try to cope in the short-term, hoping for the prices to drop again.

This price volatility in an enlarged ETS would also hurt households. Families and low-income households with tight budgets cannot be expected to deal with such fluctuations adequately. Finally, states also have to prepare stable annual budgets.

State budgets

Should the cost of emitting carbon for e.g. driving a car be additional to the existing fuel taxes or not? If fuel distributors are subject to an enlarged ETS and if those costs are passed on to the consumer there would be few arguments left to support fuel taxes. This point is discussed at length in Bragadottir et al. (2015). Although their focus lies on Nordic ETS member countries, the argument is still a universal one (Kletzan-Slamanig und Köppl 2016).

If fossil fuel is subject to the ETS and member states keep their conventional fuel taxes, the whole argument in favor of including more sectors into the ETS falls apart. However, Bragadottir et al. (2015) try to argue that current fuel taxes to a large extent are not so much carbon taxes but exist mainly for fiscal purposes. According to them, adding a carbon price on top of those revenue-generating taxes need not be a huge issue. The authors describe Sweden as the Nordic country with the highest tax rate on carbon emissions in the transport sector (€124/tCO2). However, Austria has an indirect carbon tax of gasoline of more than €200/tCO2 (Kletzan-Slamanig and Köppl, 2016, p. 49). If double taxation is to be avoided, those fuel/carbon taxes would have to be abolished. Abolishing conventional fuel/carbon taxes would take away 10% of Nordic countries revenues. Those revenues would have to be compensated by selling allowances in open auctions. It would thus introduce a huge element of uncertainty into governments budgetary processes. Another short/medium-term problem would arise because of the difference of current tax rates and the current allowance price (€25/tCO2). Even if it can be assumed, as demonstrated in Chapter 2, that the inclusion of non-ETS sectors would lead to an increase in allowances prices, the effect on transport in the first few years might be counter-productive as the new allowance price would first have to rise beyond €200/tCO2 in order to affect the transport sector in Austria. Finally, and as already mentioned, financing member states' budgets is seen as a core element of national sovereignty. Every reform that would alter the way states have to budget their expenses would face fierce opposition.

Time and legal barriers

The think tank AGORA produced an in-depth analysis on the potential of emission trading for the German non-ETS sectors in the lead-up to Germany's national emission trading system (Matthes 2019). It carefully analyzed the administrative, legal, and time-related problems of creating a national ETS, an enlarged EU ETS with voluntary participation, and an enlarged EU ETS for all member states. Matthes (2019) states that every substantial change in the ETS directive (2003/87/EC) or the ESR (2018/842) would need four years' time to be completed, assuming it has the necessary political backing by member states. There are, however, other legal and technical processes that cannot be done simultaneously. Supportive national legislation requires the final text of the amended regulation and directive. New trading processes would have to be set up after the amendment of respective legal texts. Thus, under the best circumstances, with the necessary political support, an EU-wide expansion of the ETS would require between five and six years.

A voluntary inclusion of individual member states' non-ETS sectors is unfortunately also a difficult task. A problematic point for both, the EU-wide expansion and the individual inclusion is the wording in the ETS that seems to prohibit the inclusion of upstream-participants:

> "1. From 2008, Member States may apply emission allowance trading in accordance with this Directive **to activities** and to greenhouse gases which are not listed in Annex I, taking into account all relevant criteria, in particular the effects on the internal market, potential distortions of competition, the environmental integrity of the EU ETS and the reliability of the planned monitoring and reporting system, provided that the Commission, in accordance with delegated acts which the Commission is empowered to adopt in accordance with Article 23.
> 2. When the inclusion of additional activities and gases is approved, the Commission may at the same time authorize the issue of additional allowances and may authorize other Member States to include such additional activities and gases."
> (Directive 2003/87/EC, Article 24(1)(2))

Article 24 is the best existing legal framework for expanding the ETS. As argued above, however, an inclusion of non-ETS sectors would require an upstream approach, but that seems incompatible with the wording of this Article. It clearly states that *activities* are the subject of any possible extension. The *activities* as specified in Annex I describe processes like refining oil that are directly responsible for emitting greenhouse gases. Thus, Article 24 clearly only speaks of extending the downstream concept that is the core of Directive 2003/87/EC. Legal scholars, however, might argue about whether or not this wording is to be interpreted strictly according to the letter of the law or according to the intent of the legislator. If this paragraph of Article 24 of the ETS directive 2003/87 is interpreted according to the intent of the legislator, a change of this paragraph might not be necessary to include non-ETS sectors with an upstream approach into the ETS on a voluntary basis. In such a case, however, chances are high that this interpretation will be challenged.

The legal challenges are even more severe. Suppose that the wording of Article 24 could easily be altered and individual member states decide to 'transfer' their non-ETS sectors into the ETS. The complex Regulation 2018/842 would either have to be altered significantly if not all member states decide to 'transfer' their non-ETS sectors or decide to transfer only some non-ETS sectors. If all member states decide to 'transfer' their non-ETS sectors, Directive 2003/87/EC would have to be amended by the content of Regulation 2018/842. This is the hypothetical scenario that will be simulated in Chapter 2.

It can be concluded that any major sectoral expansion of the EU ETS would need a significant amount of time, even under the best circumstances. Given that the fourth ETS trading period will start in 2021 and will end 2030, it is doubtful that such a major reform will happen before the end of 2030. If the political will for such an extension exists, it is likely to enter into force not before the start of the fifth trading period.

Social dimension

As with most forms of environmental taxation, the social dimension is crucial to consider because environmental taxation tends to be regressive, i.e. poorer households tend to pay more "carbon-related-taxes" as a proportion of their income than richer households (Horowitz, et al. 2017).[5] One of the most extensive meta studies on the topic of distributional effects of carbon taxation was conducted by Wang et al. (2016). The authors of this study also come to the conclusion that carbon taxation, at least in developed countries, tends to be regressive. However, they caution not to generalize and encourage to look at all of the many facets of carbon taxation. Although they support the overall notion that carbon taxes tend to be regressive, they emphasize that this is true only to a rather weak extent. One of the main criticisms in their meta study is that positive effects of carbon taxation are insufficiently accounted for. Things like improved air quality in less congested cities as a result of less traffic, etc. should be taken into consideration as well. Finally, all authors agree that, whether a carbon tax or carbon pricing in general is regressive or not depends on the specific carbon tax/carbon pricing design. The design influences distribution ex-ante as well as ex-post. While ex-ante exemptions of carbon taxation (e.g. for certain sectors), as is the case with 'free allowances' in the EU ETS, will produce fewer harmful effects for economic growth, it will also make such instruments less effective in terms of reducing carbon emissions. The best way to reduce potential negative effects of carbon taxation, however, is ex-post. This simply means that revenues of this carbon taxation/pricing are used accordingly (Wang et al. 2016). How those revenues are spent is of course fiercely debated. Adequate carbon pricing of transport and heating, two of the most important non-ETS sectors will be regressive and a heavy financial burden for many households. This is why revenues have to be recycled no matter what form of carbon pricing policymakers decide upon. Proper revenue recycling, i.e. using the revenues is also paramount from a political point of view. The French yellow vest movement, if not caused, was nevertheless sparked by the increase of fuel taxes that had the intent of reducing transport

[5] This debate, however, is not settled. See for example Horowitz et al. (2017).

emissions to achieve the respective national 2030/2050 targets. If carbon taxation is to be politically sustainable, it has to be demonstrated that prices of other necessities of life decrease. In the dynamic New Keynesian model, Krenek et al. (2020) use the revenues from an EU-wide carbon pricing to reduce 1:1 social security contributions, thus stimulating employment. Reducing social security contributions alone, however, would not help the poor and unemployed. Frondel (2019) in his study on how best to recycle revenues in the case for Germany makes two suggestions. The first option is a "per capita refund". This idea is appealing because of its simplicity. Revenues would be split by the number of persons and distributed accordingly. Based on three specific examples of poor households, a one-person pensioner household, a one-person unemployed household and a poor three-person household, he demonstrates that on average, and strongly dependent on the extent of car usage, a per-capita refund would compensate for the increase in costs. Wealthier households, however, that actually own their home, furnace, etc. and have the means to invest into cleaner technologies are likely to make a profit. From an environmental perspective this effect would be positive, but from a distributional perspective, this approach is problematic. The second suggestion of Frondel (2019) is to reduce the national tax on electricity. Their argument that a national tax on electricity parallel to the energy-producing companies being subject to the ETS amounts to double taxation is valid. However, reducing the tax on electricity alone would not make the three households better off than the per-capita refund, but the industry would profit as well. Industry receiving assistance is a topic that will be discussed in Chapter 3 in the context of carbon leakage, but it is obvious that there will be a political fight regarding the question who should get what share of the revenues of carbon taxation (pricing).

The topic of revenue recycling is so important in the context of including non-ETS sectors into the ETS because it makes it more difficult. In the case of a national carbon tax, revenue collection is clear cut and revenues are predictable. Revenue collection in an enlarged ETS is theoretically also clear cut. A government receives a certain annual amount of allowances that have to be sold in an auction, but the question on how many allowances each country should receive has the potential to spark huge debates because the stakes are now higher. Households are now directly affected by EU carbon pricing and in some form, they have to receive a refund in order to accept the increase in the cost of heating and transport. A public debate on how (poor) households of rich countries may finance per capita refunds in poorer countries is political poison. Finally, as described above, revenues are less predictable. Including non-ETS sectors into the ETS would increase the percentage of the part of national budgets coming from an EU fiscal instrument enormously. This means that a very large amount of money necessary for revenue recycling is volatile. This makes national budget planning more difficult.

Abrupt price changes

As mentioned in the beginning of Chapter 1, the inclusion of non-ETS sectors seems especially complicated in the short run. At the moment, most national taxation schemes do not base their tax rates on the carbon content of the respective tax base. Taking the Austrian example, we can see that at the moment the implicit carbon price for gas is €50,30/tCO2, the implicit price for heating oil is €19,20/tCO2, the implicit carbon price for diesel is €158,50/tCO2, the implicit carbon price for petrol is €207,80/tCO2 and the implicit carbon price for coal is €19,10/tCO2 (Kletzan-Slamanig and Köppl 2016, p. 49). The initial adjustment, negative or positive, to one single new price of carbon within the EU ETS would be considerable for all types of fossil fuels. A national (tax-) approach could slowly converge different carbon prices to one final price and would thus be less abrupt.

Chapter 2

As a reaction to the proposed emission reduction targets by the European Commission for the year 2020, for the ETS as well as the non-ETS sectors, three member states tabled counter-proposals.

- Ireland was concerned with the cost of reaching its national target for the non-ETS sectors. It thus proposed to allow for purchasing ETS allowances to cover non-ETS emissions.
- With Poland it was the other way around. Poland had not to worry about its distinctly low national target but feared too high a price inside the ETS. It thus proposed using/selling non-ETS allowances in the ETS.
- Sweden, however, proposed the complete separation between ETS and non-ETS sectors but wanted to allow for trading between national non-ETS sectors.

The combination of all three proposals is of course equal to an inclusion of all national non-ETS sectors into the EU ETS. Tol (2008) used a simple model to analyze the effect all four scenarios would have on carbon prices and challenged quite openly the technical competence of the European Commission. The simplicity of the model allows it to be used for the purpose of this paper. It will indicate what effect an inclusion of non-ETS sectors would have on the carbon price. It allows for testing the following hypotheses:

Hypothesis 1: If member states would decide to include the non-ETS sectors into the ETS, a political compromise, similar to the one reached in Regulation 2018/842, would lead to undermining the effort of the last decade to get rid of an oversupply of allowances by flooding the market with too many allowances.

Hypothesis 2: If member states would decide to include the non-ETS sectors into the ETS, strictly enforcing the respective 2030 goals, the single price of carbon would drastically increase, creating problems such as carbon leakage and bringing into stark competition households and industry.

Model structure and properties[6]:

Tol (2008, p. 3-5) describes a market for tradable emission reduction permits with I (J) countries. Countries are either indexed by "I" or "J", depending on whether they have less or

[6] For a full picture of the model, it might be useful to also read Tol (2005).

more allowances (A) than actual emissions (E). The core idea of Tol's model is that countries try to minimize the cost of abatement (C). Every member state that has fewer allowances than its actual carbon emissions (E>A) is indexed with "I" and has to solve the following minimization problem:

$$min_{R_i,P_i} C_i = \alpha_i R_i^2 Y_i + \pi P_i \ \ , s.t.\ R_i E_i + \ P_i \geq \ E_i - A_i \tag{1}$$

"R" is the proportional emission reduction, meaning that R ∊ [0,1]. "E" are emissions, so that "RE" denotes a percentage of a country's emissions, e.g. 10% of total emissions of Country "i". "Y" is gross domestic output, and "P" denotes the quantity of allowances bought ***or*** sold. "A" are the allowances a country receives (annually) to either use it or sell it. Although it is true in reality that member states receive annual emission allowances that they can sell at auctions, it is definitely a stark simplification that they also act in this model as the (potential) buyers on behalf of their industries. In reality, it is single installations/companies that have to buy allowances, each with a distinct cost-curve. This aggregation, however, is necessary because it would be impossible to simulate all the buyers in this model. As mentioned above, Germany alone has 1870 installations that are currently subject to the ETS. This number, even with an upstream approach, would drastically increase if non-ETS sectors were to be included.

If a country has received fewer allowances than it is emitting (E>A), it is indexed with "I" and has two options: First, it can reduce emissions at a cost of αRY, with "α" as a country-specific cost parameter. The quadric form of "R" indicates that the relationship between the quantity of reduced carbon and the respective cost in terms of GDP is not linear – the marginal abatement costs are increasing. Secondly it can buy allowances on the market at price "π", i.e. the allowance price.

If a country receives more allowances than its actual emissions (E<A), it is indexed with "J" and has to solve the following problem:

$$min_{R_j,P_j} C_j = \alpha_j R_j^2 Y_j - \pi\, R_j E_j + \pi P_j \ \ , s.t.\ P_j \geq \ E_j - A_j \tag{2}$$

Assuming that country "j" would receive P excess allowances and that it will sell all its excess allowances (P=E-A), then P is negative because E<A. Thus, the overall cost (C) is reduced by πP. Furthermore, country "j" has the option to actively reduce its emissions (R>0), then of course it can sell additional allowances to the price π but at the same time will incur costs of

αRY. Tol (2008, footnote 3) shows that the second problem is de facto the same as the first problem (with the exception that the first $E_j - A_j$ allowances are available without emission reduction costs):

$$C_j = \alpha_j R_j^2 Y_j - \pi\, R_j E_j + \pi P_j = \alpha_j R_j^2 Y_j + \pi\left(P_j\, - R_j E_j\right) = \alpha_j R_j^2 Y_j + \pi P_j' \; for \; P_j' \coloneqq P_j - R_j E_j \rightarrow min_{R_j, P_j} C_j = \alpha_j R_j^2 Y_j + \pi P_j' \;\; s.t. R_j E_j + P_j' \geq \; E_j - A_j \tag{3}$$

Once the minimization problem is specified, it can be solved with deriving the first order conditions from the Lagrange function for problem (1) and (2):

$$\boldsymbol{L_1} = \alpha_i R_i^2 Y_i + \pi P_i - \lambda(R_i E_i + P_i - E_i + A_i) \tag{4}$$

$$\boldsymbol{L_2} = \alpha_j R_j^2 Y_j - \pi\, R_j E_j + \pi P_j - \lambda(P_j - E_j + A_j) \tag{5}$$

The first order conditions are:

$$\frac{\partial \mathrm{L_1}}{\partial \mathrm{R_i}} : \; 2\alpha_i R_i Y_i - \lambda E_i = 0 \tag{6}$$

$$\frac{\partial \mathrm{L_1}}{\partial \mathrm{P_i}} : \; \pi - \lambda = 0 \tag{7}$$

$$\frac{\partial \mathrm{L_1}}{\partial \lambda} : \; R_i E_i + \; P_i - E_i + A_i = 0 \tag{8}$$

$$\frac{\partial \mathrm{L_2}}{\partial \mathrm{R_j}} : \; 2\alpha_j R_j Y_j - \pi E_j = 0 \tag{9}$$

$$\frac{\partial \mathrm{L_2}}{\partial \mathrm{P_j}} : \; \pi - \lambda = 0 \tag{10}$$

$$\frac{\partial L_2}{\partial \lambda} : \; P_j - E_j + A_j = 0 \tag{11}$$

This is a linear system of six equations with seven unknowns, but by introducing the market clearing condition that demand must equal supply, this becomes a linear system of seven equations with seven unknowns:

$$\sum_{i=1}^{I} P_i + \; \sum_{j=1}^{J} P_j - \; \sum_{j=1}^{J} R_j E_j = 0 \tag{12}$$

This allows for solving for the permit price π:

$$\pi = \lambda = \frac{\sum_{i=1}^{I}(E_i - A_i) + \sum_{j=1}^{J}(E_j - A_j)}{\sum_{i=1}^{I} E_i^2 \big/ 2\alpha_i Y_i + \sum_{j=1}^{J} E_j^2 \big/ 2\alpha_j Y_j} \tag{13}$$

This equation allows for an easy addition of countries (no matter if they belong to the “I” or “J” category):

$$\pi^* = \lambda^* = \frac{\sum_{i=1}^{I}(E_i - A_i) + \sum_{j=1}^{J}(E_j - A_j) + E_{I+1} - A_{I+1}}{\sum_{i=1}^{I} E_i^2 / 2\alpha_i Y_i + \sum_{j=1}^{J} E_j^2 / 2\alpha_j Y_j + E_{I+1}^2 / 2\alpha_{I+1} Y_{I+1}} \quad (14)$$

The beautiful thing of this addition is of course that it must not necessarily be a country that is added to this trading mechanism. It can also be an additional sector with respective emissions and allowances. This property of this model is exploited for the purpose of this paper. The idea is to calculate the (average) allowance price for an unchanged ETS for the fourth trading period (2021-2030) and then to calculate it again with all sectors of the economy included. The permit price is very intuitively a function of the total difference between the sum of allowances and the sum of emissions and the cost of abatement in terms of GDP.

Important is the calculation of α_i and α_j that determine the country-specific cost curve. For this purpose, both the formulae and the respective explanations of Tol (2005) and Tol (2008) have to be studied because the notation as well as the explanation of just one paper alone would be too imprecise to fully understand the intention of the author:

$$\alpha_i = 1.57 - 0.17\sqrt{\left(\frac{E_i}{Y_i} - min_i \frac{E_i}{Y_i}\right)} \quad (15)$$

Tol (2005) makes this country-specific cost parameter dependent on the relative energy efficiency per € GDP. It is relative to the most energy efficient member state ($min_i \frac{E_i}{Y_i}$). The idea behind this is that the cost of abatement is the biggest for countries that are already (relatively) energy efficient. If Sweden is the most energy efficient member state, then $\sqrt{\left(\frac{E_i}{Y_i} - min_i \frac{E_i}{Y_i}\right)}$ would equal zero and the cost parameter for Sweden would be 1.57. Now all the parameters of the country specific cost curve $\alpha_i R_i^2 Y_i$ are well-defined. Tol (2005 and 2008) calibrated this equation to allow for country-specific abatement costs to vary between certain boundaries. A 10% emission cut (R=0,1) would imply an abatement cost of 1,57% (1,38%) of GDP for the most (least) energy efficient member state and an 80% (85%) emission reduction would completely ruin the respective economy (Tol 2005, p.275-276).

Figure 2 shows a representative abatement cost curve of Romania, calculated by the World Bank. It impressively demonstrates the non-linear relationship between emission reductions and respective costs.

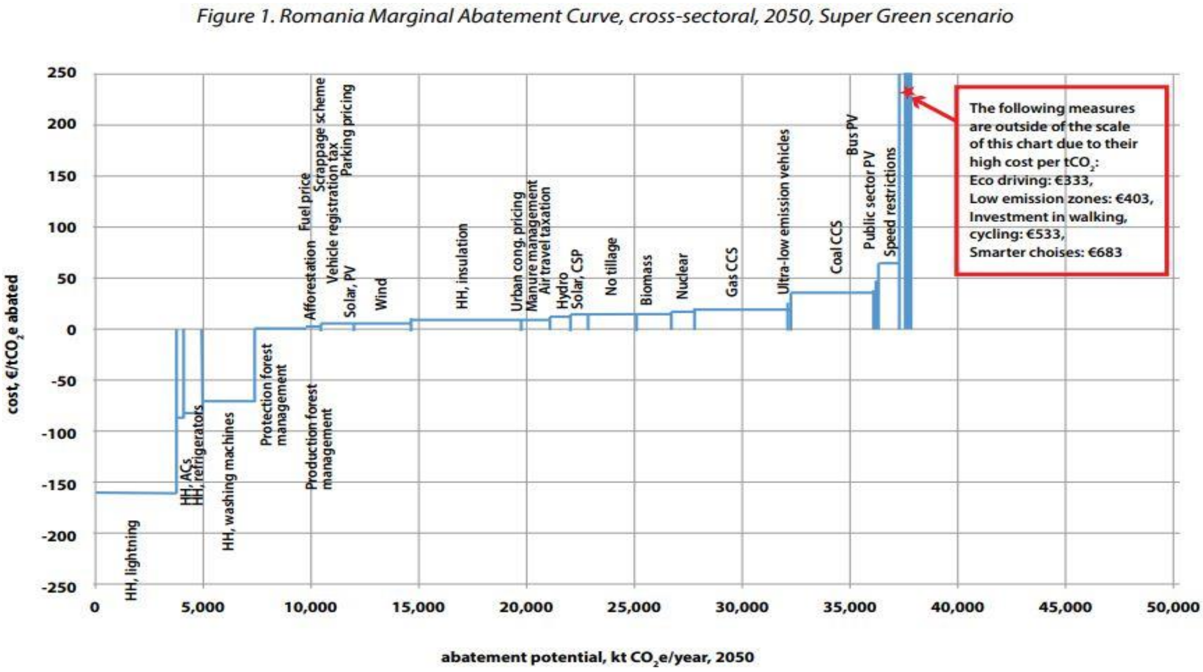

Figure 2. Romania Marginal Abatement Cost Curve, cross-sectoral, 2050, Super Green scenario. Data from http://documents.worldbank.org/curated/en/859881468197634735/pdf/103914-WP-P145943-PUBLIC-Dissemination-Note-Marginal-Abatement-Cost-Curve-Analysis.pd.

Data: sources and composition

The main contribution of this paper is the calibration of Tol's model (2008), described above, with the data necessary to simulate a situation, wherein in the fourth trading period non-ETS sectors are included into the ETS. It is very important to emphasize that the amount of extra-allowances = an enlargement of the overall ETS emissions cap, is derived from the Regulation (2018/842) that governs non-ETS sectors. ***The annual national (up to 2030) targets of Regulation (2018/842) are translated into tradeable allowances for the enlarged ETS.***

The legal texts, Directive 2003/87/EC and Regulation 2018/842, have to be carefully reviewed to come up with the total amount of allowances countries will receive during the fourth trading period (2021-2030). Thus, the legal texts will provide for $\mathbf{A}_i$ of Tol's model (2008). Finally, *the model is not dynamic*: there is one single trade and not continuous trades in every of the 10 years of the fourth trading period (2021-2030). Thus, all values have to be cumulative. Expected emissions per country have to be summed up, allowances for each country have to be summed up, etc. Thus, the estimated single price of carbon is the average price of carbon for the whole fourth trading period.

ETS-Allowances (A_i) derived from Directive 2003/87/EC

The starting point of all calculations is not the Directive itself but the 'Report from the Commission to the European Parliament and the Council: Report on the functioning of the European carbon market' (COM 2018, 842 final). In this report (p.17) the annual emission caps for the years 2013-2020 are listed. The total amount of allowances for the year 2020 amounts to 1.816.452.135 allowances.

Article 9(2) of Directive 2003/87/EC then states that "starting in 2021, the linear reduction factor shall be 2,2%." From those two pieces of information the total quantity of emission allowances for the fourth trading period is derived.

Dividing up the total amount of emissions for every member state

Allowances are divided into an "auction share" and a "free allocation share" (see also figure 3). Article 10(1) states, "From 2021 onwards, and without prejudice to a possible reduction pursuant to Article 10a(5a), the share of allowances to be auctioned shall be 57%." Article 10a(5a) makes this percentage a little flexible but for the purpose of this paper it is assumed to be inflexible.

Free allocation share (43%)

The "free allocation share," and this was a major evolution of the ETS, is distributed to companies, i.e. single installations according to their risk of carbon leakage. Carbon leakage will be discussed in Chapter 3 in more detail. The problem is that in our model, states are the actors, not companies. Fortunately, the European Union Transaction Log aggregates the total amount of "free allocations" per country.[7] A necessary simplification is that it is assumed that the amount of "free allocations" per country does only change because of the annual decrease (2.2%) in the ETS cap. Nobody knows if there are major shifts in industry structure that would radically change the country specific share of "free allowances." For the next 10 years, however, it is reasonable that this will not be the case.

[7] https://ec.europa.eu/clima/ets/

Auction share (allowances to be auctioned) (55%)

Article 10(2) states, “The total quantity of allowances to be auctioned by each Member State shall be composed as follows:

(a) 90% of the total quantity of allowances “to be auctioned” being distributed amongst Member States in shares that are identical to the share of verified emissions under the EU ETS for 2005 or the average of the period from 2005 to 2007, whichever one is the highest, of the Member States concerned;

(b) 10% if the total quantity of allowances “to be auctioned” being distributed amongst certain Member States for the purposes of solidarity, growth and interconnections within the Union, thereby increasing the amount of allowances that those Member States auction under Point (a) by the percentages specified in Annex IIa.”

The percentages according to Annex IIa are: Bulgaria (53%), Czech Republic (31%), Estonia (42%), Greece (17%), Spain (13%), Croatia (26%), Cyprus (20%), Latvia (56%), Lithuania (46%), Hungary (28%), Malta (23%), Poland (39%), Portugal (16%), Romania (53%), Slovenia (20%), and Slovakia (41%).

Those instructions are very clear cut. The first step is to find out whether verified emissions for each of the member states are higher in 2005 compared to the emissions of (2005+2006+2007)/3. Then a distribution key has to be calculated based on those values that totals 100%. Based on this key, 90% of the 55% of the total amount of allowances in the ETS are distributed to member states, and 10% of the 55% of the total amount of allowances are distributed according to the percentages of Annex IIa.

Modernization fund

Article 10(1) also states that “2% of the total quantity of allowances between 2021 and 2030 shall be auctioned to establish a fund to improve energy efficiency and modernize the energy systems of certain member states as set out in Article 10d (‘the Modernisation fund’).” Article 10d goes into detail on how to use those funds, and Annex IIb lists the percentages according to which the funds ought to be distributed: Bulgaria (5,84%), Czech Republic (15,59%), Estonia (2,78%), Croatia (3,14%), Latvia (1,44%), Lithuania (2,57%), Hungary (7,12%), Poland (43,41%), Romania (11,98%), and Slovakia (6,13%).

Those countries receive money and not allowances, but because those countries could buy the respective allowances with the money they receive, for the purposes of the model, it was assumed that those countries receive the allowances.

New entry reserve and innovation fund

For both the "new entry reserve/buffer" and the "innovation fund" a small amount of allowances is set aside. The reserve buffer gives allowances to new market entrants and receives allowances from businesses that go out of business. If the assumption holds that the number of new market entrants is equally distributed among member states, it is reasonable to distribute this new entrants reserve according to the general "auction share" allocation mechanism. The same is true with the innovation fund. Allowances are sold in order to finance innovational projects of EU industry. Article 10a(8) clearly states that financed projects ought to be in "geographically balanced locations within the territory of the Union." This implies that funds will be roughly equally distributed among member states. Therefore, the same assumption as with 'the Modernisation fund' is made. The distribution key, however, is also in line with the general "auction share" allocation mechanism.

"Poland bonus"

Finally, the EC Report (COM 2018, 842 final, p. 27) states that certain member states are allowed to transfer so called "Article 10c" allowances that were not used in period 2013-2017 to the period 2021-2030. The only country that has a significant amount of those unused allowances, however, is Poland. Thus, the total amount of Polish allowances in our model is increased by additional 113,3 million allowances.

The total distribution of ETS allowances used for Tol's model (2008) is displayed in figure 3. The country specific distribution relative to expected emissions is displayed in figure 5.

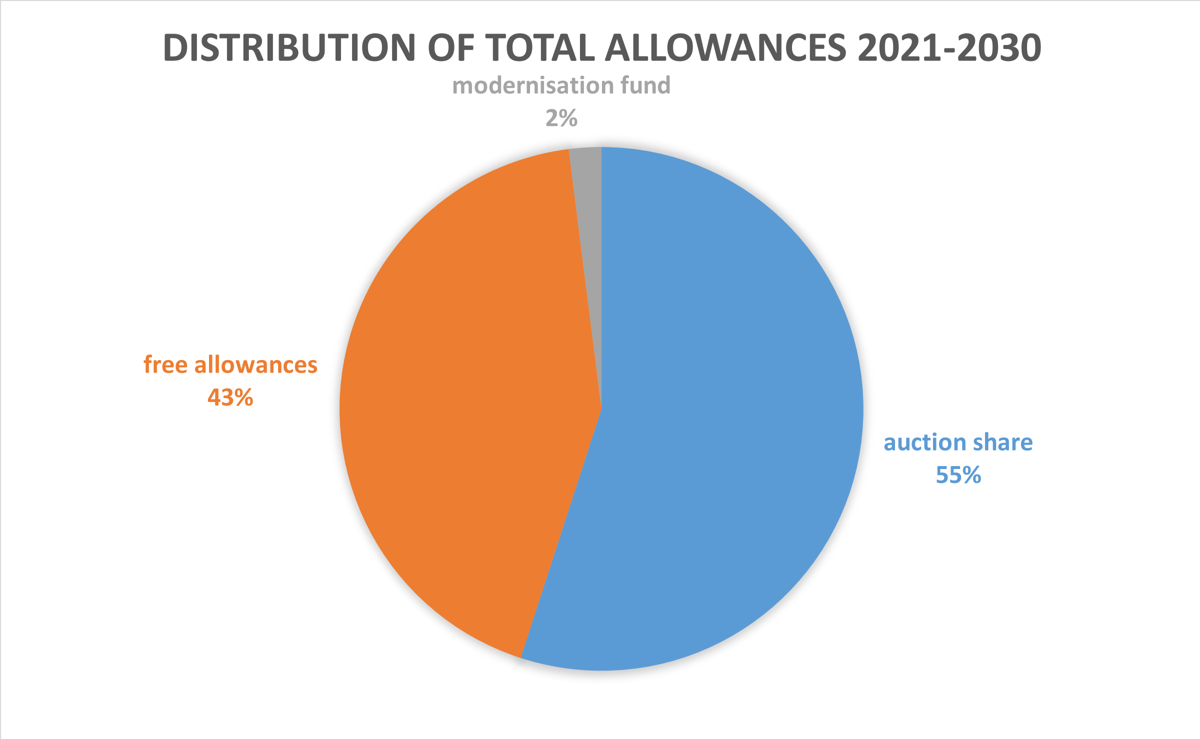

Figure 3. Distribution of Total Allowances 2021-2030. Data derived from the ETS Directive 2003/87/EC.

Non-ETS-Allowances (A_i) derived from Regulation 2018/842

This Regulation determines the national reduction targets (2021-2030) as a percentage of a member state's emissions in 2005. The number, however, of details, exceptions and exemptions in this Regulation are indicative of a hard-fought political process. The most important adjustments are accounted for in this paper. What becomes clear is that all the exceptions and exemptions in Regulation 2018/842, if used by member states to their fullest extent, will have one of two consequences:

1.) The goal of reducing 40% of emissions, relative to the base year 1990, will not be reached.
2.) The goal is reached but in a non-linear way, i.e. member states will pollute more than their annual targets (defined by a liner reduction facto similar to the ETS) in order to have a steep reduction at the end of the fourth trading period.

To picture the problem, figure 4 shows two 2030 scenarios. The first 2030 scenario shows the situation if allowances within the ETS are reduced as planned and national targets are reached without using all the exemptions and exceptions of Regulation 2018/842. The second scenario (2030 adj.) shows the situation if allowances in the ETS are reduced as planned but all the exemptions of Regulation 2018/842 for non-ETS sectors are made use of. As we analyze a 10-year period, “ESR adjustment” in Figure 4 is the total amount of (emission) exceptions divided by 10, i.e. if all exceptions are used equally over this 10-year period, EU emissions relative to the base year 1990 will not be 60%, but 63,3%.

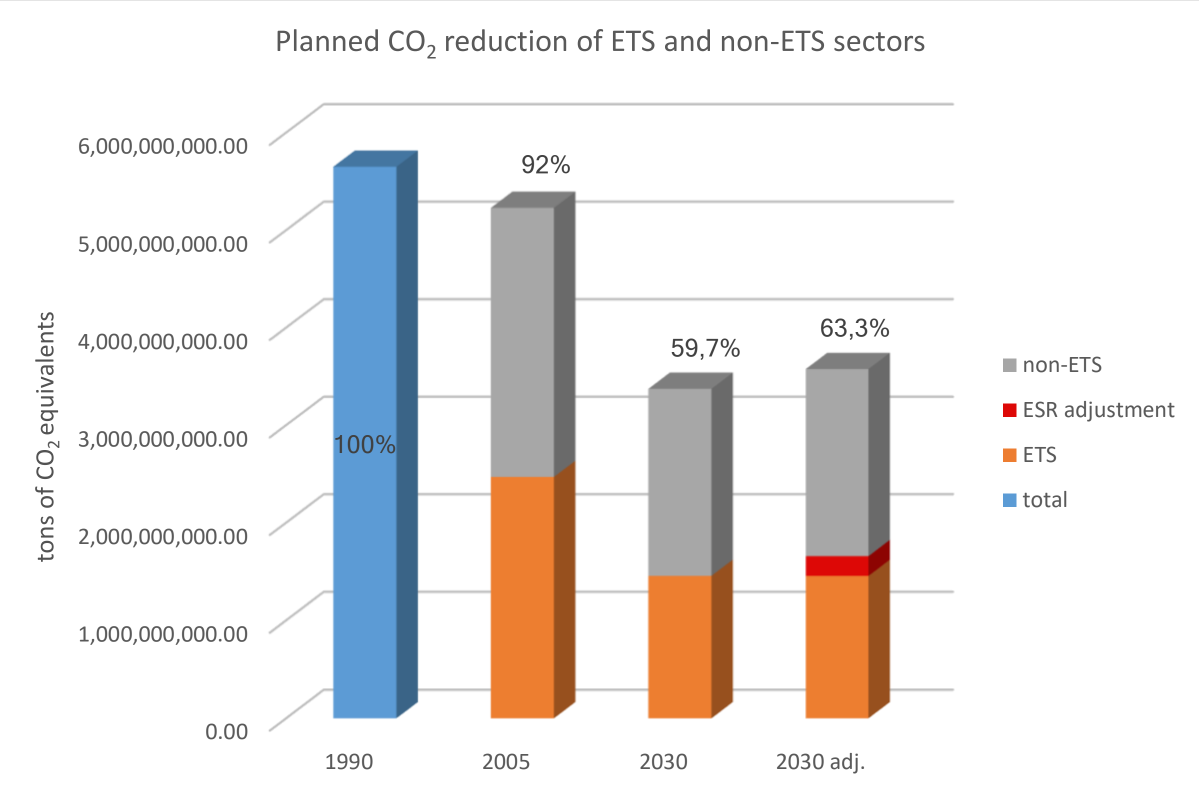

Figure 4. Planned CO2 reduction of ETS and non-ETS sectors. Data from own calculation, using historic carbon emissions accessed from the Eurostat database, projected emissions derived from the UNFCCC model; reduction efforts derived from Directive 2003/87/EC and Regulation 2018/842.

Adjusted allocation

As already shown in the introduction in Figure 1, the national targets vary strongly. Together (this still includes the UK because there is no information on if and how the UK would participate/cooperate in future 2030/2050 reduction efforts) the reduction of 28 non-ETS sectors, compared to 2005 should amount to 30%. Together with a 43% reduction of the ETS sectors, relative to 2005 emissions, the combined (ESR+ETS) target of 40%, relative to 1990 emissions ought to be reached.

The national ESR reductions as stated targets in Annex I of Regulation 2018/842 are as follows: Belgium (35%), Bulgaria (0%), Czech Republic (14%), Denmark (39%), Germany (38%), Estonia (13%), Ireland (30%), Greece (16%), Spain (26%), France (37%), Croatia (7%), Italy (33%), Cyprus (24%), Latvia (6%), Lithuania (9%), Luxembourg (40%), Hungary (7%), Malta (19%), Netherlands (36%), Austria (36%), Poland (7%), Portugal (17%), Romania

(2%), Slovenia (15%), Slovakia (12%), Finland (39%), Sweden (40%), and United Kingdom (37%).

The total number of allowances for all 10 years is calculated as outlined in Article 4(1,2) of Regulation 2018/842:

> "1. Each Member State shall, in 2030, limit its greenhouse gas emissions at least by the percentage set for that Member State in Annex I in relation to its greenhouse gas emissions in 2005, determined pursuant to paragraph 3 of this article.
> 2. Subject to the flexibilities provided for in Articles 5,6 and 7 of this Regulation, to the adjustment pursuant to Article 10(2) of this Regulation and taking into account any deduction resulting from the application of Article 7 of Decision No 406/2009/EC, each Member State shall ensure that its greenhouse gas emissions in each year between 2021 and 2029 do not exceed the limit defined by a **linear trajectory** starting on the average of its greenhouse gas emissions during 2016, 2017 and 2018, determined pursuant to paragraph 3 of this Article and ending in 2030 on the limit set for that Member State in Annex I to this Regulation. The linear trajectory of a Member State shall start either at five-twelfths of the distance from 2019 to 2020 or in 2020, whichever results in a lower allocation for that Member State."

Based on this information, the annual number of allowances for national non-ETS sectors was calculated. The starting point is the average number of emissions from 2016 and 2017. For some countries, the information on 2018 emissions was not yet publicly available. The endpoint is calculated by subtracting the percentage, specified in Annex I, from the 2005 number of emissions. The linear trajectory between this start- and endpoint produces the number of allowances for every of the 10 years. The sum of those 10 years is shown in Figure 6, titled "adjusted allocation."

LULUCF

The first "flexibility" (exception) is the extra amount of carbon that member states are allowed to emit if their "**l**and-**u**se, **l**and-**u**se **c**hange and **f**orestry" policy fulfills certain criteria. The idea is that additional net (carbon) removals from categories such as afforested land, deforested land, managed cropland, managed grassland, managed forest land, and managed wetland should enter, more as they already are, the equation. Under Article 7, states may claim up to 280 million tons of CO_2 equivalents. It seems odd, however, that claiming CO_2 net-removals is subject to a specific key (Annex III) and not to a standardized accounting method. According to this specific key, countries can claim net removals up to the amount in brackets: Belgium (3,8 million tons of CO_2 equivalents), Bulgaria (4,1), Czech Republic (2,6), Denmark (14,6), Germany (22,3), Estonia (0,9), Ireland (26,8), Greece (6,7), Spain (29,1), France (58,2), Croatia (0,9), Italy (11,5), Cyprus (0,6), Latvia (3,1), Lithuania (6,5), Luxembourg (0,25), Hungary (2,1), Malta (0,03), Netherlands (13,4), Austria (2,5), Poland (21,7), Portugal (5,2), Romania (13,2), Slovenia (1,3), Slovakia (1,2), Finland (4,5), Sweden (4,9), and United Kingdom (17,8).

Annex IV adjustment

The next "adjustment" can be found in article 10(2): "The amount contained in Annex IV shall be added to the annual emission allocation for the year 2021 for each member state referred to in that Annex." The amount adjusted pursuant to Article 10(2) are as follows: Bulgaria (1,6 million tons of CO_2 equivalents), Czech Republic (4,4), Estonia (0,1), Croatia (1,1), Latvia (1,7), Lithuania (2,1), Hungary (6,7), Malta (0,7), Poland (7,4), Portugal (1,6), Romania (11), Slovenia (0,1), and Slovakia (2,1).

Safety reserve

The safety reserve of 105 million tons of CO_2 equivalents, described in Article 11, can be used under very specific conditions. It is impossible to predict what country will be the one to take advantage of this reserve. For simplification, those 105 million allowances were distributed among member states according to their relative 2005 emissions.

Allowances from previous years

One of the most important things to consider is the fact that member states will be allowed to transfer unused allowances from previous trading periods into the fourth trading period. The source for unused non-ETS (ESR) allowances is the report of the European Environment Agency (EEA 2018).

Emissions (E_i) for the fourth trading period 2021-2030

In stark contrast to calculating allowances for the period 2021-2030, future emissions have to be estimated by model simulations. The main methodological issue in this regard is that most models already included the effect an increasing ETS price will have on the volume of emitted carbon. Tol's model (2008) is dependent on the fact that there are fewer allowances than emissions. The difference between allowances and emissions, given the cost of abatement will produce the price in the emissions' market. In this regard, especially the overly optimistic model of the EEA is problematic. Studying the year by year estimations up to 2030 one can see that especially in the non-ETS sectors abrupt decreases can be found. Luckily, there is also the UNFCCC model with three sets of assumptions. In one model specification, it only predicts a low ETS price and not much success in the non-ETS sectors. Thus, this UNFCCC model fits better for the purpose of this paper.

Another and related uncertainty is the share of future ETS (ESR) emissions of total emissions (ETS+ESR). Assuming that carbon reduction within ETS sectors is more successful compared to non-ETS sectors, then the share of ETS emissions in total emissions will decrease. To account for that variation, every result will be presented in two variants:

1.) The share of current ETS emissions in total emissions stays the same till 2030: 42%.
2.) The share declines to the lowest value any of the models is predicting: 40%.

Because in both the EEA models and the UNFCCC models the ETS price will reduce emissions, one additional and very simple "model" is used. The model "constant" in Figure 8 is simply assuming a continued "status quo" of the year 2017 for all 10 years in the fourth trading period (2021-2030). Its simplicity makes it very easy to understand the effect the inclusion of non-ETS sectors would have on the price. It assumes that we have no carbon pricing today and in the next year, which is basically all 10 years combined, two forms of ETS are introduced, one that covers the current ETS sectors and one that covers all sectors. It is encouraging that this model does not change the overall effect, it only emphasizes it – in fact it produces very similar results compared to using the UNFCCC emission predictions. By using 11 different sets of country emissions for the years 2021-2030, the broadest spectrum possible is covered. This approach can be viewed as a sensitivity analysis.

GDP/added value (Y_i)

If one would want to use Tol's model to simulate the entry of a new country into an ETS, it would be very easy to ascribe to this new country its GDP. Total current GDP and emissions per country are very accessible. However, we simulate the entry of non-ETS sectors. Differentiating emissions and GDP between ETS and non-ETS sectors is difficult. There is no such category in the Eurostat database as "ETS sectors" or "non-ETS sectors". As shown in Table 1, the EU ETS does not cover whole sectors but certain activities. One activity of one sector could be subject to the ETS while another activity of this sector is not subject to the ETS. Furthermore, those activities, described in Annex I of the ETS Directive 2003/87/EC, are only included if the respective, carbon emitting, installation is large enough. The problems for calibrating Tol's model in this regard are as follows:

1.) There is no "ETS category" in the statistical databases.
2.) There is no GDP/sector only added value/sector, which is close enough.
3.) The sectors for added value/sector are NACE classified.
4.) The emissions/sector are CRF classified.

Thus, for the calibration of this model, Annex I activities have to be translated into NACE (sub-) sectors and NACE sectors have to be translated into CRF sectors with the so-called "correspondence list," provided by Eurostat.[8]

Results

If Emissions (**E**$_i$), ETS and non-ETS Allowances (**A**$_i$) and GDP/added value (**Y**$_i$) are known descriptive statistics, as well as the end result of Tol's model (2008) can be depicted the following way:

1.) Current ETS design continued in the fourth trading period.

Figure 5 shows the cumulated ETS allowances a country receives in the fourth trading period (2021-2030) relative to its predicted cumulated emissions.

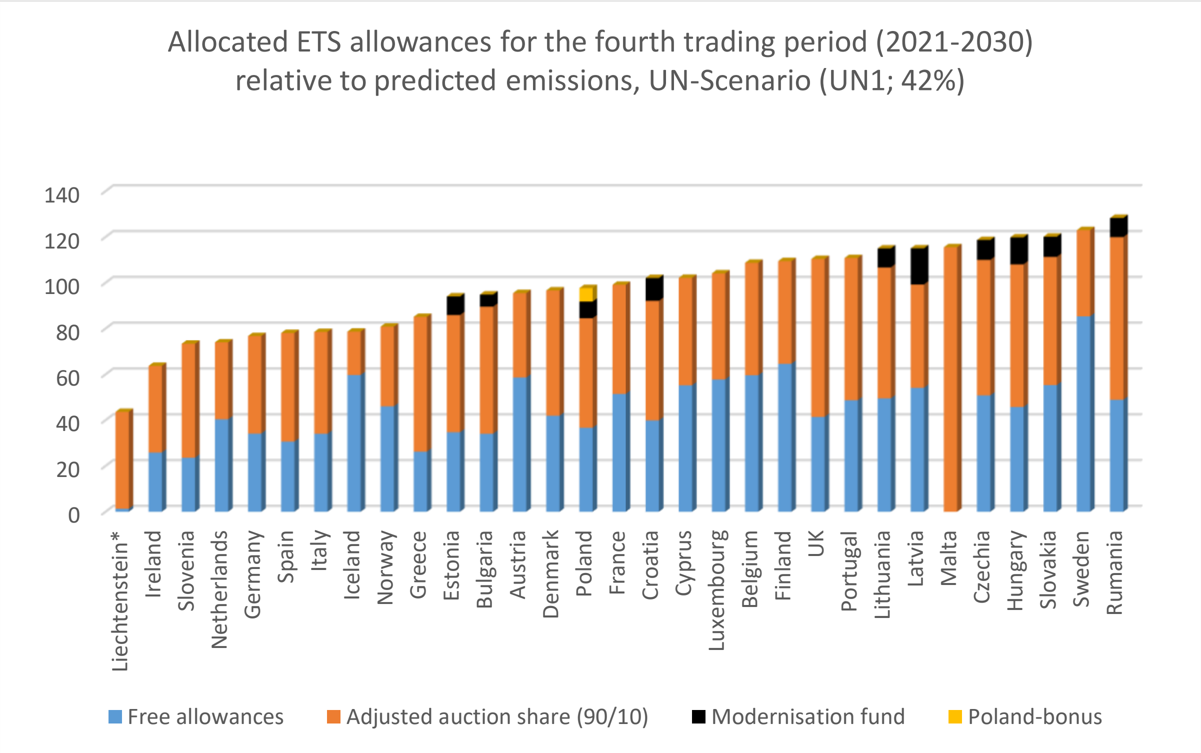

Figure 5. Allocated allowances for the fourth trading period (2021-2030). Data from own calculation; allowances derived from ETS directive 2003/87/EC; emissions derived from UNFCCC model.
*Poor quality of Liechtenstein's sector specific emissions' data; the separation of emissions between ETS and non-ETS sectors of Sweden is to be regarded as a rough approximation.

[8] https://ec.europa.eu/eurostat/de/web/products-manuals-and-guidelines/-/KS-RA-09-004-A

For figure 5, emissions are taken from one of the UNFCCC model specifications, and the share of ETS emissions in overall emissions is assumed to stay at 42%.

Figure 5 shows the input necessary to determine the average ETS price for the fourth trading period. The final calculations are done two different ways:

a.) With "Poland bonus"

b.) Without "Poland bonus"

The intention is to demonstrate how much a seemingly small (one-off) change to the total amount of allowances can influence the average price for a time span of 10 years.

Figure 5 makes the price determination intuitive. All member states to the left of Croatia have fewer allowances compared to their emissions – they have to buy allowances or have to reduce their emissions. All member states to the right of Croatia have more allowances than emissions – they can sell their spare allowances and could further reduce their emissions to sell even more allowances.

The blue bars are the free allowances (allocations) companies within member states receive because they fulfill the carbon leakage criteria. As this distribution is uniform it cannot be influenced politically. What can be influenced is the distribution of the "auction share" and the "Modernisation fund". The "Poland bonus" is another distributional measure. Overall, a clear picture emerges. The ETS is also a tool of redistribution. Relative to emissions, western EU member states tend to have fewer allowances allocated to them while eastern EU member states tend to have more allowances allocated to them. Before Brexit, the UK also seems to have struck a good deal regarding the distribution of allowances.

2.) Current ESR, i.e. non-ETS design continued in the fourth trading period.

Figure 6 shows the cumulated non-ETS allowances a country receives in the fourth trading period (2021-2030) relative to its predicted cumulated emissions. For Figure 6 emissions are taken from the same UNFCCC model as in Figure 5. In Figure 6 the share of ETS emissions in overall emissions is also assumed to stay at 42%.

What instantly becomes obvious when looking at Figure 6 is the fact that without transferring allowances from the previous periods, almost every country would have less than 100% of its emissions covered, i.e. every country would be forced to trade with countries that have less costs of abatement or would have to reduce (drastically) their emissions. It can also be speculated if it is a coincidence that Malta receives roughly the same amount of Annex IV allowances as its negative balance of allowances from previous trading periods. LULUCF are substantial for Ireland and Denmark.

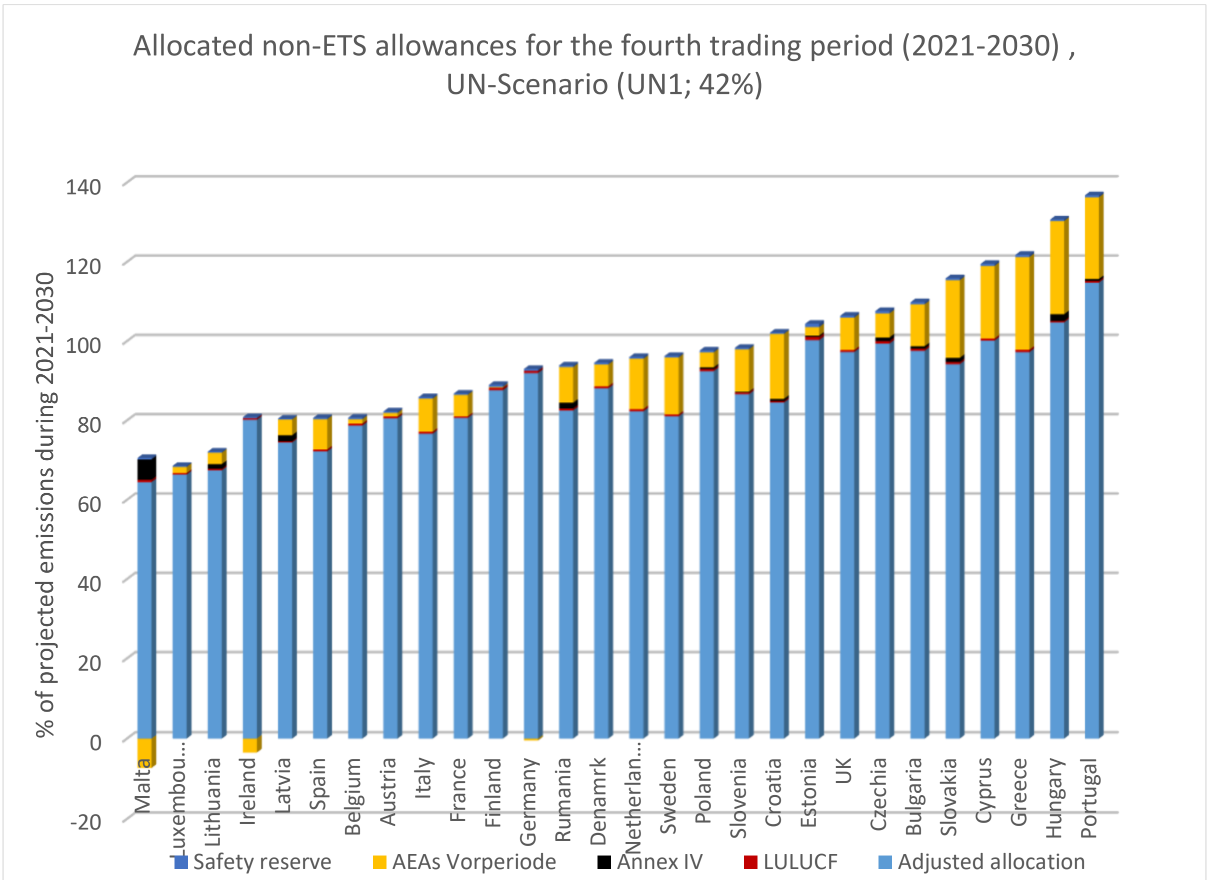

Figure 6. CO2 allocations relative to estimated emissions in non-ETS sectors 2021-2030. Data from own calculation; allowances derived from ESR Regulation 2018/842; emissions derived from the UNFCCC model; the separation of emissions between ETS and non-ETS sectors of Sweden is to be regarded as a rough approximation.

3.) Combining ETS and non-ETS allowances relative to their emissions, i.e. creating an enlarged ETS

Figure 7 perfectly demonstrates the concept of political compromise. It shows the result of a long bargaining process. It depicts how many ETS and non-ETS allowances member states receive relative to their total emissions in the years 2021-2030. This is the aggregation that is used for the final calculation of the average allowance price of an enlarged EU ETS. As with calculating the average future price for an ETS that is not enlarged (with and without "Poland bonus") the price calculations for an extended ETS are done in two variants:

a.) Including all the ESR exceptions = simulating that in a potential inclusion of non-ETS sectors into the ETS there would be also a lot of (political) compromises that would result in granting many exemptions to member states.

b.) Excluding all the ESR exceptions = simulating a strict commitment to achieve the 2030 goals without cutting corners.

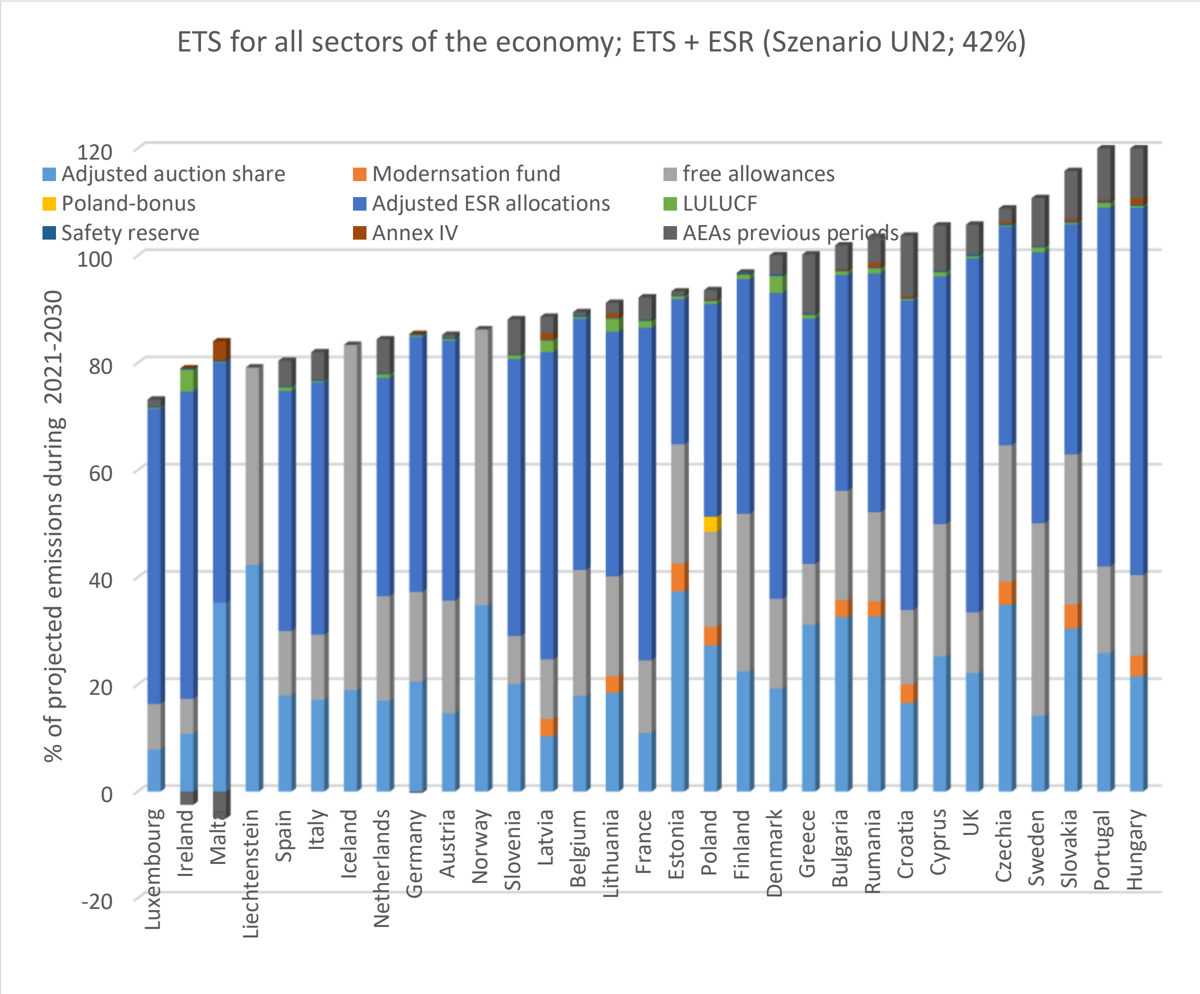

Figure 7. ETS for all sectors of the economy. Data from own calculation; allowances derived from Directive 2003/87/EC and Regulation 2018/842; emissions derived from the UNFCCC model; Poor quality of Liechtenstein's sector specific emissions' data; the separation of emissions between ETS and non-ETS sectors of Sweden is to be regarded as a rough approximation.

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One price of carbon in the EU

Figure 8 depicts the average price of an EU ETS for the fourth trading period (2021-2030). It depicts 44 scenarios to account for the uncertainty of the approach outlined in this paper. The scenarios depict 11 different model predictions regarding the future development of carbon emissions in the year 2021-2030. Those 11 models are divided into EEA models, UNFCCC models, and the simple case of assuming the status quo (KONSTANT). Furthermore, the uncertainty regarding the development of the share of ETS emissions in overall emissions is accounted for by assuming the minimal (40%) and the maximal case (42%). For every of the 11 emission scenarios, four ETS designs are simulated. The continuation of the current ETS design without the "Poland bonus" (blue); the continuation of the current ETS design including the "Poland bonus"; the inclusion of all non-ETS sectors into the ETS without the compromises of the ESR (green); the inclusion of all non-ETS sectors into the ETS but accounting for the compromises of the ESR (purple).

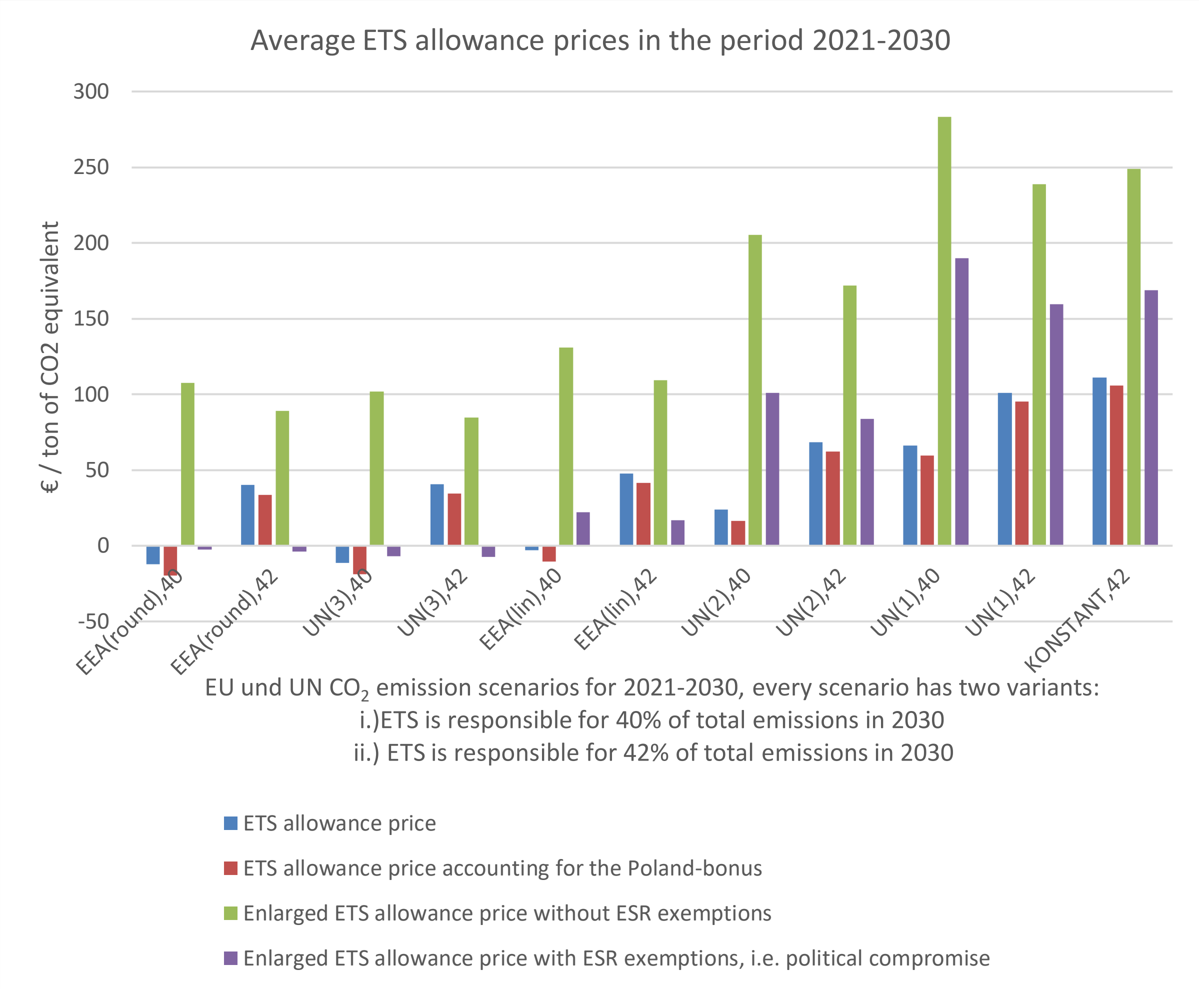

Figure 8. Average ETS allowance prices in the period 2021-2030. Data from own calculation.

The interpretation of figure 8 is clear cut. The five cases where current ETS-designs (red and blue) will produce negative prices (something that would not happen in the real world) are the result of very optimistic emission models that predict that the current ETS will drastically reduce industries' emissions in the next 10 years. That makes the usage of those models problematic for Tol's model (2008) because the price is a direct result of the difference between allowances and emissions. If there is no difference, i.e. if there are more allowances than emissions, then the price is negative.

However, this methodological detail does not change the overall, very clear picture that is presented in figure 8: including non-ETS sectors into the ETS will definitely increase drastically the allowance price (green scenario). If, as a result of a political compromise, as was the case with regard to Regulation 2018/842, the 2030 reduction targets are watered down, the inclusion of non-ETS sectors into the ETS would most likely still increase the allowance price, but certainly not by as much (purple scenario). The purple scenario, however, is susceptible to the variation of predicted emissions for the years 2021-2030. Although the more pessimistic UNFCCC scenarios (UN1 and UN2), as well as the status quo scenario (KONSTANT) are better fits for the usage of Tol's model (2008), the ambiguous effects of including non-ETS sectors with watered down emission reduction targets, as a result of a political compromise, could under certain scenarios lead to a steep decrease of the allowance price. Finally, the "Poland bonus" (red) always decreases the price relative to the scenario without it as it simply increases the amount of available allowances.

Chapter 3

Must the two hypotheses of this paper be rejected?

Hypothesis 1: If member states would decide to include the non-ETS sectors into the ETS a political compromise, similar to the one reached in Regulation 2018/842, would lead to undermining the effort of the last decade to get rid of an oversupply of allowances by flooding the market with too many allowances.

This hypothesis, that could represent a legitimate fear of environmental advocates, has to be rejected, at least partially. The (purple) scenario yields only lower prices in those emission scenarios that are not optimal for the calibration of Tol's model (2008). In those optimistic models current carbon reduction efforts are very successful, thus, reducing the overall amount of emissions, relative to allowances, i.e. *the effect of the carbon price had already an impact on the reduction of emissions*.

In cases where more suitable emission model predictions (UN1, UN2, KONSTANT) were used, a political compromise as the one in Regulation 2018/842, would lower the allowance price relative to the green scenario, but an inclusion of non-ETS sectors would still result in an overall increase of the allowance price. Thus, when using the realistic emission scenarios, Hypothesis 1 has to be rejected.

Hypothesis 2: If member states would decide to include the non-ETS sectors into the ETS strictly enforcing the respective 2030 goals, the single price of carbon would drastically increase creating problems such as carbon leakage and bringing into stark competition households and industry.

This hypothesis cannot be rejected. The inclusion of non-ETS sectors would lead to a drastic increase of allowance prices. Without measures, such as a functioning border carbon adjustment (Krenek et al. 2020) strong carbon leakage is a likely scenario. Finally, the increase of allowance prices as a result of including large household-related sectors begs the question what needs are more important[9] (industry or private housholds) and who should get what share, in what form, of the respective revenues.

[9] The transport and heating sectors include both households and companies and the agricultural sector is of course a purely commercial sector.

Policy implications/recommendations as a result of (not) rejecting the two hypotheses

1.) Reaching the EU 2030/2050 carbon reduction targets could be reached by including non-ETS sectors into the ETS. Even a political compromise that would water down those targets somewhat would not reduce allowance prices and thus the important signal for companies to produce differently and for consumers to consume differently, i.e. with less carbon intensity.
2.) Because the price is likely to increase drastically by including non-ETS sectors it is debatable if companies should be subject to such a high price. There are not just environmental but also other societal goals. What consequences would an average allowance price of almost €300 have? In Chapter 1 the necessity of revenue recycling was mentioned. If companies have to pay a carbon price of €300/tCO2 there would also have to be a revenue recycling for companies – only increasing the innovation fund would not be enough. In a combined ETS (ETS+ESR) there would be new political fights between households and industries about who should get how much, in what form, of the revenues. This fight would not only be fought between industries and households but also between households of different member states.
3.) The biggest threat that can be derived from the simple model analysis of this paper is the potential (increase) of carbon leakage. As outlined in Krenek et al. (2020) current carbon leakage provisions, i.e. the allocation of “free allowances” are subject to the same annual reduction factor as is the “auction share” (2,2% for the fourth trading period). Thus, the current carbon leakage protection gets less potent every year. If, as a result of including non-ETS sectors into the ETS the “single carbon price” jumps from €25/tCO2 to an average price between €100/tCO2 and €300/tCO2 carbon leakage in the form of companies shifting production to other jurisdictions with lower or no carbon prices or in the form of shifting new investments into those countries would be inevitable.
4.) This analysis might give support to the Swedish proposal, described at the beginning of Chapter 2. For the previous trading period the Swedish government proposed a strict separation of ETS and non-ETS sectors but “full trading” between non-ETS sectors. Thus emission reductions would occur in those national non-ETS sectors where it is cheapest. To stress the example of Germany and Bulgaria again: No matter the initial distribution of allowances, if the abatement costs in Bulgaria’s non-ETS sectors are less compared to Germanys emission reductions will happen in Bulgaria. This proposal might be a good compromise as it will not increase the existing carbon leakage risk for

the current ETS-sectors but would still increase efficiency in emission reductions in non-ETS sectors.

Conclusion

This paper sets out to answer the question of whether the inclusion of non-ETS sectors into the EU ETS is a policy worth pursuing. The European Commission in its Green Deal mentioned that reviewing this policy should be part of a strategy that will result in achieving even more ambitious 2030/2050 carbon reduction targets. Already the careful literature review of this paper indicates that this reform is problematic for a variety of mainly practical reasons. In theory, however, having one single cap-and-trade system, with one carbon price would result in the specified reduction of carbon in the most cost-efficient way. However, the negative immediate practical issues outweigh the theoretical long-term benefits of such a reform.

Households, car drivers, etc. could never directly be subject to the ETS. The only way to solve this problem is to use a so-called upstream approach whereby the importers or distributors of fossil fuel, etc. would have to buy allowances for the carbon content of their products. This upstream approach would greatly increase the number of participants in the ETS, making it much costlier to operate. The biggest issue, however, when combining an upstream approach for certain sectors and a downstream approach for others is double taxation. The importer of gas would have to buy allowances while the energy producer would have to buy allowances for burning the same gas in order to produce electricity. A system of refunds based on a complicated system of verification would be an administrative nightmare. The second problem inferred from the literature is the issue of financing member states national budgets. A large percentage of budgets is financed with energy levies. A member state would face two options: keeping taxes on fossil fuels, while the same fossil fuel is taxed again via the ETS or abolishing those taxes. The second option, however, leaves the question on how to receive the revenues from the ETS. As demonstrated in this paper, the ETS revenue (=allowances auctioned) allocation is the result of a political process. National budgets would, thus strongly depend on an unpredictable EU political process. The next reason why the inclusion of non-ETS sectors is not a good idea is that this reform faces serious legal hurdles. Even under the best of circumstances, i.e. a general political backing, the process of including non-ETS sectors would take at least five to six years. As with all forms of carbon taxation there would have to be revenue recycling. Taxing carbon of non-ETS sectors at the national level would result in a huge political debate on how best to spend the revenues. Should there be a per-capita refund, a subsidy for the poor and unemployed or should the revenues go to climate financing to increase the environmental effect of carbon pricing? This political debate would be much more difficult if it is held at the EU level.

The contribution of this paper to the discussion, however, is the utilization of Richard Tol's (2008) simple optimization model, that he used to analyse policy proposals regarding the ETS in 2008. The main result this model produces is the effect certain changes to the ETS have on the allowance price within the ETS in the upcoming 4th trading period of the ETS. The model is recalibrated with data derived from the relevant legal texts such as the ETS directive 2003/87/EC and the Effort Sharing Regulation 2018/842, emissions data from the UNFCCC, and the EEA. Other sectoral information was taken from the Eurostat database. The main challenge was to understand and quantify all the exceptions and exemptions in the legal texts that can be seen as the result of a political process. By analyzing how including non-ETS sectors would influence the allowance price the hypothesis that a political compromise, as seen in Regulation 2018/842, would result in a watered down carbon reduction target and thus a reduced price of carbon was tested. This hypothesis was rejected. Even a political compromise, as the one in Regulation 2018/842, would not change the fact that the inclusion of non-ETS sectors would lead to a increase in allowance prices. The second hypothesis that was tested was that the inclusion of non-ETS sectors, with strict carbon reduction targets, i.e. without a political compromise, would lead to a very steep increase of allowance prices and thus an increased risk of carbon leakage. The results of Tol's model, calibrated with the data for the fourth trading period (2021-2030) indicate that, an inclusion of non-ETS sectors, without a watered down carbon reduction target, would result in average allowance prices for this period to jump to at least €100/tCO2 (in some scenarios even approaching €300/tCO2). That is why the policy implication is that such a reform is a non-starter as long as the problem of carbon leakage is not properly addressed. One of the policy recommendations is to explore the possibility of establishing "full trading" for all 27(28) national non-ETS sectors. Such a reform would lead to an increase in cost-efficiency of emission reductions in non-ETS sectors, while not increasing the carbon leakage risk in those energy-intensive sectors that are currently covered by the ETS. Overall, it can be concluded that including non-ETS sectors into the existing ETS is something that should be discouraged.

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