Policy Contribution
Issue n˚06/21 | March 2021

A whole-economy carbon price for Europe and how to get there

Ottmar Edenhofer, Mirjam Kosch, Michael Pahle and Georg Zachmann

OTTMAR EDENHOFER (ottmar.edenhofer@pik-potsdam.de) is Director of the Potsdam Institute for Climate Impact Research

MIRJAM KOSCH (mirjam.kosch@pik-potsdam.de), Potsdam Institute for Climate Impact Research

MICHAEL PAHLE (michael.pahle@pik-potsdam.de), Potsdam-Institute for Climate Impact Research

GEORG ZACHMANN (georg.zachmann@bruegel.org) is a Senior Fellow at Bruegel

Executive summary

THE EUROPEAN UNION'S PLAN for climate neutrality by 2050 reopens the question of the role carbon pricing can and should play. Carbon pricing should not – and ultimately cannot – only be an enforcement tool or backstop that ensures targets are met, while the heavy-lifting of decarbonisation comes from directed technological change policies. Instead, a technology-neutral carbon price must become the main element, providing signals for decarbonised operations, investment and innovation in all sectors. This would guarantee cost-effective emission cuts, provide a clear path to net-zero and is a requirement for international cooperation and a global carbon pricing regime. Carbon pricing must therefore be at the core of EU climate policy.

HOWEVER, INTRODUCING A UNIFORM, credible and durable carbon price across all sectors right away is politically and institutionally challenging. Moreover, policies to address other market failures will continue to affect significantly the impact of carbon pricing. The role of carbon pricing should therefore be strengthened gradually, taking these considerations into account.

CURRENT CLIMATE POLICIES SHOULD thus be further developed within a three-part framework. First, a separate emissions trading scheme should be introduced for the transport and heating sector to prepare the sectors for integration into the EU emissions trading system, and to manage distributional implications. A carbon price balancer would manage price differences between the two systems in the short term. Second, a carbon price stabiliser (a price floor and price ceiling) should be implemented for both systems to manage price expectations and ensure price convergence between the two systems in the long run. Third, complementary policies (carbon price amplifiers) should be strengthened or put in place to trigger investment and innovation, helping policymakers to commit credibly to enforcing the cap and addressing other market failures. This approach would ensure convergence on a uniform, credible and durable carbon price for the whole economy.

Recommended citation
Edenhofer, O., M.Kosch, M. Pahle and G. Zachmann (2021) 'A whole-economy carbon price for Europe and how to get there', *Policy Contribution* 06/2021, Bruegel

bruegel

1 Carbon pricing's current role: an emissions-reduction backstop

For the European Union to reach climate targets of a 55 percent greenhouse gas emissions cut by 2030 compared to 1990, and climate neutrality by 2050, it will need to carry out a fundamental regulatory overhaul. Among the initial steps will be plans to increase the cost of greenhouse gas emissions in different sectors by revising the EU emissions trading system (ETS)[1] and possibly extending it to the transport and heating sectors[2], revising the energy taxation directive[3] and taxing the carbon content of imports[4]. These plans must deal with complex and interlinked technical, legal, political and economic issues.

Carbon pricing currently functions as an enforcement mechanism; technology policies are the core policies, and carbon pricing complements them

For consistency in the EU's approach, a paradigmatic question must first be answered: what role should carbon pricing play in the new policy mix? Arguably, carbon pricing as currently implemented through the EU ETS functions as an enforcement mechanism[5]. Emission cuts and innovation are meant to come mainly from policies and measures to induce directed technological change – such as standards and subsidies. Technology policies are thus the core policies, and carbon pricing complements them. The ETS by means of its cap serves to ensure that climate targets are achieved: its primary objective is to address the compliance problem in case technology policies cannot deliver sufficient emission reductions and a gap arises.

A major side effect is that carbon prices are (artificially) kept at a moderate level as additional policies reduce the demand for emission allowances. For achieving the EU's 2020 target of a 20 percent emissions cut, the enforcement function was not put to the test because structural shifts[6] and complementary polices[7] caused emissions to fall while carbon prices were still low (at least up to the reform in 2018). Much of the emission reductions observed within sectors covered by the ETS in the past decade were driven by technology policies. In particular the policy-driven increase in wind and solar deployment between 2009 and 2019 replaced about 350 terawatt hours (TWh) of electricity generation[8], while EU eco-design standards might have saved up to 480 TWh[9]. Based on the emissions intensity of the EU fuel mix in 2009, generating these 830 TWh would have caused 300 million tonnes of carbon dioxide emissions. These emissions, avoided thanks to technology policies, correspond to almost 80 percent of the reduction in emissions covered by the ETS in this period.

The much tougher targets for 2030 and 2050 raise doubts about whether this approach to reducing emissions can continue to be effective in the coming decade:

1 See www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-eu-emission-trading-system-(ets).

2 See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12656-Updating-Member-State-emissions-reduction-targets--Effort-Sharing-Regulation-in-line-with-the-2030-climate-target-plan.

3 See www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-energy-taxation-directive.

4 See www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-carbon-border-adjustment-mechanism.

5 California's cap-and-trade programme has been referred to as a "backstop". See James Bushnell, 'Can Climate Efforts Be the "Everything Policy Store"?' Energy Institute Blog, UC Berkeley, 19 January 2021, https://energyathaas.wordpress.com/2021/01/19/can-climate-efforts-be-the-everything-policy-store/.

6 Economic growth was significantly lower than expected and the rise of China accelerated the decline in the share of industry in EU GDP.

7 Such as renewables support systems and energy efficiency regulations. Moreover, the acceptance of international credits into the EU ETS increased the effective cap.

8 Bruegel calculations based on Eurostat.

9 See https://ec.europa.eu/energy/sites/ener/files/documents/eia_ii_-_overview_report_2016_rev20170314.pdf for the years 2020 vs. 2010. This is however likely an overestimation of the policy effect as the baseline unrealistically does not imply any technological improvement at all.

1. First, while technology policies have performed well in the past in terms of developing clean technologies and bringing them to the market, they are not tailored to efficient investment and operation of these technologies large scale, as needed now. These policies are also of limited effectiveness in phasing out carbon-intensive technologies head on. In particular, standards are very susceptible to rebound effects: if, for example, the cost per kilometre falls, the distance travelled typically increases. Bans would be the only option to stop usage of dirty technologies completely, but are complex to administer and also have substantial political cost.
2. Second, if new emissions-cutting technologies, for instance in the industry sector, are more complex or cannot yet be known, regulation leaves too little room for flexibility and innovation. Regulators picking winners and losers risk making more mistakes and increasing policy costs considerably.
3. Third, the fact that carbon pricing makes policy costs much more transparent is essential to have an open debate about the true costs of ambitious climate targets. Otherwise, there is a considerable risk of future push back when original cost expectations turn out to be too low.

Furthermore, carbon pricing is starting to actively drive decarbonisation already, and its bite will only be felt more. With the decreasing effectiveness of technology policies combined with more stringent targets, carbon prices are bound to rise considerably[10], implying that the carbon price will move beyond just playing a disciplining or backstop role. This has already been seen in a small way. Since the 2018 ETS reform[11], allowance prices have risen to levels that have induced noticeable fuel switching (coal to gas) in the electricity market and related emission reductions. In other words, carbon pricing is now playing a measurable role in actively phasing out coal (Bushnell *et al*, 2021; Abrell *et al*, 2020). Carbon pricing is therefore pushing more and more into the foreground. In this context a new approach is needed to guide the adjustment to this situation of the policy mix.

2 Carbon pricing's future role at the core of climate policy

Making carbon pricing the real core of climate policy ultimately requires a uniform, credible and durable carbon price – the economic first-best approach (Nordhaus, 2011). To get there, carbon pricing first must apply to a broader range of carbon emission sources (in particular including transport and heating). All additional climate policies then need to be designed with reference to the carbon price, and carbon prices need to be managed through stabilising mechanisms. Putting carbon pricing at the core of climate policy in this way would bring the following benefits:

1. Increased efficiency in the face of much higher policy costs: with harder-to-reach mitigation goals, costs can be expected to increase considerably. It will become increasingly important for economic growth and intergenerational equity reasons to achieve emissions reductions efficiently.
2. A clear path to net zero: A credible emissions cap makes the costs and challenges of

10 Preliminary modelling by the Potsdam Institute for Climate Impact Research suggests that carbon prices will rises to levels well above €100/tonne by 2030; see also Ariadne Project (2020) on the implications of more ambitious 2030 targets.

11 See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0410&from=EN.

climate targets transparent, and thereby reduces risk (and hence capital costs) for investors.

3. Fostering an international move towards a global carbon price regime: if the EU wants to lead in establishing a global carbon price regime, it must set an example and put carbon pricing at the centre of its climate policy.

However, several preconditions necessary to attain this first-best solution are not yet met.

From the point of view of offering efficient incentives for mitigation, the EU ETS should only be extended to other sectors if they have first been made 'allowance-market ready'. As the European Commission's outline climate plan for 2030[12] emphasises, lessons from the ETS suggest that the development of new allowance markets requires setting up functioning monitoring, reporting and verification systems. Insights from Germany's new ETS (Box 1) corroborate this. The buildings and transport sectors, therefore, should be subject initially to a separate ETS, with integration into the EU ETS after a transitional period[13].

A high carbon price for the buildings and transport sectors would primarily fall on households, implying equity-related social concerns that need to be managed

Moreover, from a political point of view, extending the ETS to other sectors would have considerable distributional and competitiveness implications. Because emissions cuts in the buildings and transport sector are relatively costly, extending the ETS would imply a considerable increase in the carbon price. For electricity and industry, this could lead to concerns about competitiveness and job displacement, for example from accelerated coal phase outs. Meanwhile, a high carbon price for the buildings and transport sectors, which would primarily fall directly on households, implies equity-related social concerns within and between EU countries. Experience from Germany's new ETS (Box 1) points to the political and regulatory challenges related to ensuring fairness.

All these concerns could in principle be managed through complementary measures including financial transfers to poorer households and mechanisms to ensure industrial competitiveness, but efficiency is only ensured in a system that is optimally designed. Alternatively, differential pricing may be optimal (Abrell *et al*, 2018). Here again, a transitional period with two separate emissions trading systems would allow for more time to develop carefully the complementary measures, using two dedicated revenue streams – from the auctioning of allowances in the different systems. This would help to create the preconditions for efficient uniform carbon pricing when the two systems are integrated later on, and should reduce political opposition to a uniform carbon price across all sectors.

From a regulatory point of view, policymakers face a commitment problem in that they cannot commit credibly to long-term targets. As firms (probably rightly) anticipate that governments will not allow future carbon prices to rise too high, firms are not buying and banking volumes of allowances that would increase current carbon prices to the level needed for an efficient decarbonisation price path (Salant, 2016). As long as this problem persists and no suitable commitment devices can be implemented (Brunner *et al*, 2012), additional policies will be needed to support the carbon price.

From an economic point of view, other relevant market failures and externalities also need to be addressed by additional policies. Examples are underinvestment in innovation and infrastructure by companies because they cannot reap the full value of these activities; potential short-sightedness of consumers in terms of failing to take into account long-term cost savings from buying electric cars and other durable energy-efficient goods[14]; and the fact that tenants pay for the heating fuels, but have no direct influence over the choice of heating system (principal-agent problem).

12 See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562.

13 Such a period could also help to observe and understand price formation and market behaviour in an upstream ETS, not least in light of open questions about the EU ETS (Friedrich *et al*, 2020a).

14 See for example the European Automobile Manufacturers' Association/Potsdam Institute for Climate Impact Research initiative on the decarbonisation of freight transport: https://acea.be/uploads/press_releases_files/ACEA_CV_CEOs-PIK_joint_statement.pdf.

Box 1: Lessons from the new German emissions trading system

In 2021, Germany's new emissions trading scheme (Brennstoffemissionshandel, BEH) for fuel combustion not regulated under the EU ETS went into operation. It started with a fixed price of €25/tonne of CO2, which will rise to €55/tonne by 2025. From 2026, allowances will be auctioned within a price corridor (€55-€65). Whether the price corridor will be sustained beyond 2026 will be decided in 2024 after an evaluation of the first phase of the system, and also depends on policy development at EU level. The strategy of the current government is to integrate the BEH into a new system to be implemented at EU level.

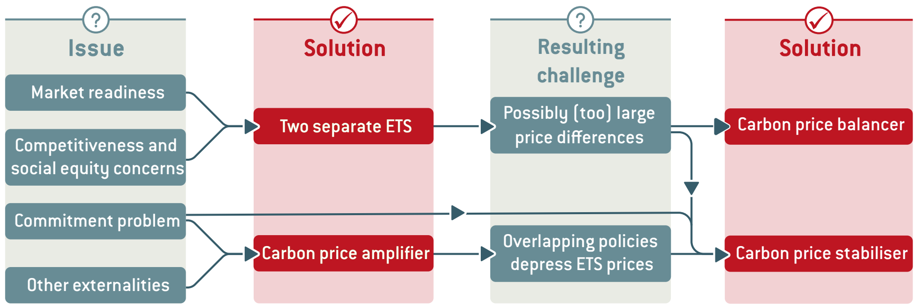
A first major lesson from the BEH concerns the institutional set-up of an upstream system, and relatedly, the lead time for achieving 'market readiness'. The BEH was implemented as an upstream system to make use of existing energy taxation monitoring, verification and reporting infrastructure and rules. However, two important amendments were necessary (Edenhofer *et al*, 2019): (1) Fuels currently exempted from taxation, such as waste, must be included. This in general requires national law. Moreover, having both upstream and downstream systems (such as the current EU ETS) in place leads to double taxation when plants covered by the ETS use fuels that are already taxed under the BEH. Accordingly, rules and related legislation needs to be developed to clearly separate the two systems. (2) Exemptions from the BEH for selected industries, justified by potential carbon leakage needed to be dealt with. German legislators came up with provisional solutions for both issues to get the system up and running within a year. But the fast-track process led to considerable drawbacks in regulatory quality, in particular related to the scope of monitoring rules (risk of loopholes) and industry exemptions. Because carbon pricing operates at the margin, such drawbacks can impair its efficiency. Accordingly, the regulation underpinning a new upstream system at the EU level should be carefully crafted in good time, notably including transparent and evidence-based deliberation about potential industry exemptions. It could take 3-4 years (Matthes, 2019) to achieve market readiness in this sense.

A second major lesson from the BEH concerns the role of distributional impacts for agreeing on the price level. The financial impact on low-income households and commuters in particular was one of the key aspects in the policy debate preceding the adoption of the 2019 German climate policy package. Even though a number of proposals were made for suitable social balancing, notably a lump-sum per capita redistribution of all the revenues from selling allowances, politicians eventually decided to redistribute only a relatively small share of the revenues. However, they agreed on a price level considerably lower than suggested by economic analysis – presumably in anticipation of substantial political push back against higher prices and respective distributional implications. This shows the connectedness of equity (distributional impacts) and efficiency (price level), and suggests that by better planning for the distributional impacts, a price level closer to the efficient level could have been achieved. A main take-away for a new EU system is therefore that deliberation about managing the distributional impacts should start as early as possible, and a substantial share of revenues should be used for redistribution/social balancing. This is a further caution against extending the EU ETS (compared to starting with a separate system first), because the distributional challenges between and within sectors are considerably more complex to manage in a combined system.

3 A policy mix that gradually puts carbon pricing at the centre

Taking into account the considerations we have outlined, a sequencing approach should be pursued that strengthens the role of carbon pricing over time[15]. Figure 1 gives an overview of how the problems we have outlined match the solutions we propose. The first set of solutions gives rise to new challenges, for which we propose a second set of solutions.

Figure 1: Problems to tackle and their solutions



Source: Bruegel/PIK.

The solutions shown in Figure 1 correspond to three design elements for the overall carbon pricing system: the carbon price balancer, stabiliser and amplifier (Figure 2).

3.1 Carbon price balancer

The main reason for implementing a separate ETS for buildings and transport would be to allow for a transitional period to make an upstream system allowance-market ready, and to have two initially separate revenue streams that can be used to address the very different policy issues in the two systems (industry: competitiveness; households: distributional, see Box 1). At the same time, carbon prices in the two systems are likely to diverge because of different marginal abatement costs – signalling economic inefficiency[16]. Moreover, price divergence can create new distributional concerns related to the different financial burdens from carbon pricing in the different sectors. Therefore, a mechanism is needed to link the two systems and contains price differences, in order to manage the political and economic trade-offs. We call this the carbon price balancer.

The straightforward instrumental mechanism to implement the balancer is the linking of the two systems. Linking needs to be introduced gradually so convergence takes place over time. Two design aspects are important in this: (1) how and when is the carbon price balancer triggered, and (2) how are initial restrictions on linking implemented and determined? On the first aspect, a maximum price differential should be established, with the balancer triggered when this threshold is exceeded. On the second aspect, there are several options to restrict linking (Quemin and de Perthius, 2019), but a quantitative restriction of the volume of tradable allowances (quota) seems to be the easiest to manage. How the level of the quota is set is crucial, since the effect of any given quota on prices in both systems is uncertain. For these reasons, the quota should be set depending on market prices in both systems, eg through a

15 To ensure consistency, extending emission pricing to transport and heating has to be thought together with the planned reform of the Energy Taxation Directive.

16 Relatedly, the liquidity in each system is apparently lower than it would be in one overarching system. However, this is only temporarily, and the volume of the new EU-wide market would likely be large enough to ensure efficient price formation.

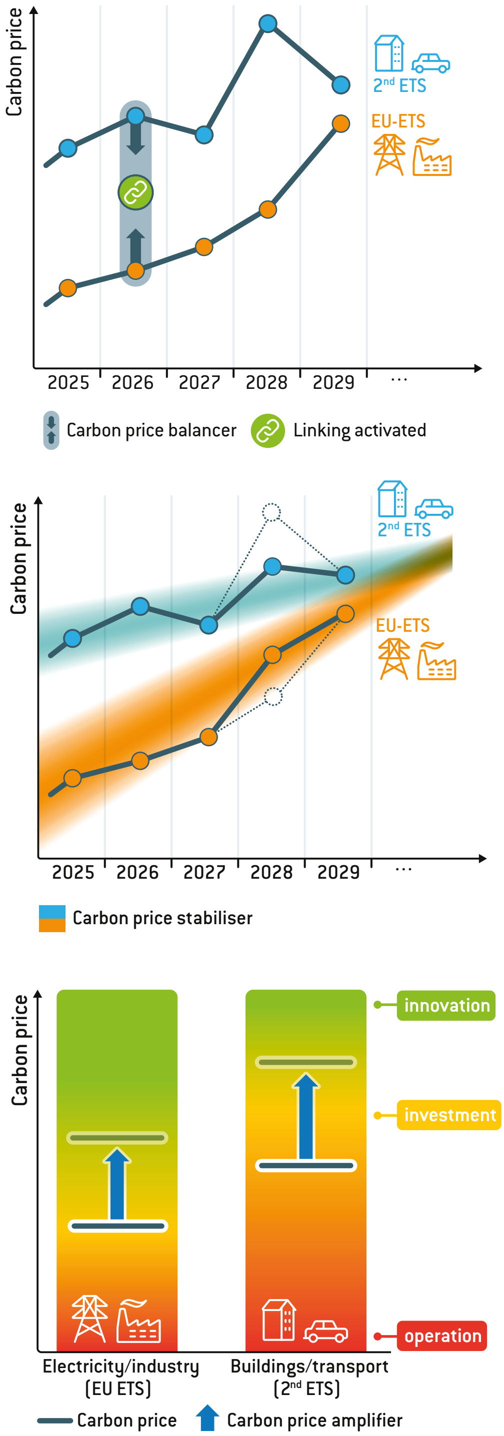
price differential-responsive supply schedule (Burtraw *et al*, 2020). This guarantees an automatic adjustment process – the higher the price difference, the higher the quota.

Figure 2: Carbon pricing system design

To build-up market readiness and properly manage distributional issues, start with two separate emissions trading systems but use a carbon price balancer (linking) to manage price differences between the two systems in the short run.

To address the commitment problem, strengthen the role of carbon pricing and ensure price convergence between the two systems in the long run, implement a carbon price stabiliser (price collar) in both systems.

To address the commitment problem and other externalities, use a carbon price amplifier (additional policies) to trigger investment and innovation. This implies that implicit carbon prices (resulting from companion policies) are higher than explicit carbon prices.



Source: Bruegel/PIK.

3.2 Carbon price stabiliser (price floor and price ceiling)

While the role of the carbon price balancer is to prevent high price differences between the two systems in the short term, the carbon price stabiliser, implemented through a price corridor (floor and ceiling prices that would trigger automatic market intervention if the carbon price moves either above or below), would manage the expectations of market participants about the long-term price trend (Edenhofer *et al*, 2019). This would make the system more stable politically and economically, and make allowance prices more predictable (Flachsland *et al*, 2020). More specifically, the stabiliser would (1) reduce price uncertainty for firms; (2) act as a safeguard against discretionary regulatory interventions in reaction to prices that politically are deemed too high or too low (Friedrich *et al*, 2020b); and (3) set the timeline for convergence between the two systems. A carbon price stabiliser can also act as a hedge if the individual caps for both systems are set inefficiently considering the relative marginal abatement costs in both systems (Abrell and Rausch, 2017).

Moreover, a floor price has significant implications for the design and implementation of carbon price amplifiers (see next section). Since a price floor stops the price falling below a certain level, it is not necessary to manage the interaction of overlapping policies at EU or member state level (see Burtraw *et al*, 2020). A price floor would prevent additional policies under an ETS reducing demand for allowances and thus their price, which would have the consequence that emissions go up elsewhere, reducing or even neutralising the net emission reduction of additional policies. Moreover, if the floor is sufficiently high and gradually rises over time, it sends a strong and credible signal in favour of investing in low-carbon technologies. It can thus, at least partially, alleviate the commitment problem.

A sufficiently high and gradually rising price floor sends a strong and credible signal in favour of investing in low-carbon technologies

In contrast, the price ceiling has two objectives. First, it prevents discretionary interventions in case allowance prices breach the politically acceptable maximum level – and related speculation that could distort allowance prices. But in case mitigation costs to achieve future targets exceed the price ceiling, additional allowances must be injected into the market, implying that the ETS can no longer ensure that the targets will be met. To compensate for this, auction revenues or more stringent emission standards could be used to incentivise investment in green technologies. In any case, this should only be temporary. If the price stays at the ceiling for a long period, the ceiling should be raised – preferably using a rule-based procedure.

Second, the price ceiling may preserve different allowance prices in the two systems in light of market participants' anticipation of their future integration. That is, if allowance prices in either system are considerably lower than the anticipated future single allowance price in an integrated system, market participants might buy and bank lower-priced allowances for future use, driving up short-term prices. The greater the difference between the prices, the more buying and banking can be expected in the system with the lower price. This opportunity for arbitrage could reduce and potentially even equalise the price gap right away, rendering futile an approach involving two systems with temporarily different prices. Unless banking of allowances is restricted, implementing a price ceiling can stop allowance prices rising beyond the politically acceptable level in each system as a consequence of this effect.

In the EU ETS, a stability mechanism is already in place: the Market Stability Reserve, which involves removals and introduction of allowances based on the extent of market surplus. But this poses a number of risks (Perino *et al*, 2021): it could actually destabilise the market, put the ETS on a path of micromanagement and patchwork rules, and hamper linking. Accordingly, the Market Stability Reserve should be developed into a price-based mechanism by adjusting the supply of allowances based on prices[17].

Finally, it might be politically difficult to establish exact minimum and maximum price levels for each year ('hard collar'). A 'softer' price-management mechanism (eg establishing

17 Doing this would also make obsolete the vague provision in the ETS Directive (Art. 29a) about adjusting supply in case of sharp and sustained rises in price (Article 29a of the ETS Directive. The credibility of this provision has been contested by the market. See https://carbon-pulse.com/121452/.

a supply function for less/additional allowance allocation at very low/high prices, as in place in the Regional Greenhouse Gas Initiative, one of the state-level emission trading systems in the US, could provide almost the same benefits as a strict version at potentially lower political cost[18].

3.3 Carbon price amplifier

Carbon price amplifiers (complementary policies) are intended to address other market failures and the commitment problem, ensuring investment and innovation in low-carbon technologies at the dynamically efficient level[19].

Two major considerations need to be taken into account when designing complementary policies. First, additional policies can cut demand for allowances and depress allowance prices. As we have shown, the carbon price stabiliser (specifically the price floor) can limit this effect and ensure that the carbon price rises over time. Notably, EU countries with more ambitious national targets can implement additional policies without needing to manage the interaction. Second, for the design of additional policies it is important to distinguish between the two reasons that could be behind them. Policies that address other market failures that prevent the carbon prices from having its full impact can, in general, be designed independent of the carbon pricing policy. In contrast, instruments that are necessary because of carbon prices that are temporarily too low (the commitment problem) would overlap with either of the two ETS. In practice it is hard to separate these two functions for any given policy, which typically addresses both issues. For pragmatic reasons, in the following we do not differentiate between the different reasons for policies.

To ensure long-term convergence on a uniform carbon price, these complementary policies should be designed to mimic carbon pricing as well as possible[20]. To this end, we define three main criteria, which can be thought of as a checklist for policy design:

- Direct link to carbon pricing: complementary policies must be linked to the carbon price so that they are automatically phased-out when carbon prices reach sufficient levels. This also implies more transparent abatement costs.
- Formulation in terms of emissions: complementary policies should be formulated in terms of carbon emissions so that they address the climate externality directly. Again, this enhances transparency of abatement costs.
- Competitive element: to ensure that the cheapest abatement options are chosen, complementary policies need to incentivise competition between different abatement technologies and suppliers.

To conclude, we discuss the specific design requirements for technology subsidies and performance standards, and provide selected examples.

18 Furthermore, concerns have been voiced that a strict price collar could be speculated against. While early research for the US suggests that such speculation could indeed be profitable (Stocking, 2012), more analysis and better market data is need to confirm this finding. See eg Quemin and Pahle (2021).

19 See eg Kalkuhl *et al* (2020), who proposed taxes on carbon-intensive investments as an alternative when carbon prices are too low.

20 Carbon pricing increases the cost of polluting technologies and exploits three abatement channels: higher prices (i) lead to lower demand, (ii) make cleaner technologies relatively cheaper leading to cleaner operations (fuel switch), and (iii) incentivise investment and innovation in low-carbon technologies. Carbon pricing is also technology neutral, ie the cheapest abatement options will prevail. From an economic efficiency perspective, the main problem with additional policies is that they do not stimulate demand reduction (in the case of subsidies) or only to a lower extent (in the case of standards). Also, in the case of subsidies, additional revenues need to be raised to cover the expenses. However, good policy design can ensure that subsidies and standards possess at least some of the economic attributes of carbon pricing. Finally, in combination with an output tax, standards and subsidies can – depending on certain assumptions – become equivalent to a carbon price (Holland, 2012).

3.3.1 Amplification through subsidies

For subsidies, a direct link to carbon pricing requires that the subsidy level needs to decrease with an increasing carbon price: the additional payments necessary to make low-carbon alternatives competitive with high-carbon products decrease as the carbon price rises. When the carbon price is sufficiently high, the required subsidy drops to zero[21]. Given uncertainty about future carbon prices, a subsidy that depends on the carbon price also transfers the price risk from investors to governments[22]. This policy design thus also creates an incentive for governments to increase the future carbon price in order to reduce payments.

Further, the formulation in terms of emissions reductions requires that the unit payment for subsidies depends on the expected abatement. This allows the cheapest abatement option to be chosen within a category that is qualified to receive the subsidy. This would be a major change compared to the current practice since it is common practice that subsidy payments depend on other measures such as square meters, megawatt hours or units. While this is often easier in terms of implementation, it does not guarantee long-term instrument convergence.

Finally, competition can be ensured through competitive auctions, which guarantee that the cheapest abatement options will be subsidised. They should in general be technology neutral, unless other externalities are present, implying that substantial cost reductions through technological learning or network effects can be expected for a certain technology.

Current proposals in this area include, for example, carbon contracts for difference (Richstein, 2017). Firms can offer their expected abatements in competitive auctions. The payments relate to a pre-defined future carbon price path and the actual carbon price in the EU ETS. When carbon prices become sufficiently high, the subsidy policy can be phased-out. Other examples include the Dutch subsidies for Sustainable Energy Transition (SDE++)[23] and a proposal for a fund to subsidise interest rates on loans depending on the future carbon price and sustainability criteria (Edenhofer *et al*, 2020).

3.3.2 Amplification through tradable performance standards

With tradable performance standards, the value of certificates automatically adjusts to the carbon price: a higher carbon price makes the clean alternative more profitable, and thus reduces the value of tradable certificates. When the carbon price is sufficiently high, the performance standard becomes non-binding.

A performance standard aimed at reducing emissions should be formulated in terms of emission intensity. This ensures that standards primarily aim to reduce carbon emissions. Efficiency-related (volumetric) standards run counter to the carbon price amplifier concept because they do not address emission reductions head on, and don't have long-term convergence built in.

Finally, it is crucial to allow for trade between regulated entities. If performance standards are not tradable, large carbon price differentials are made permanent, implying very high abatement costs and missing out on cheap abatement options. In contrast, implementation of performance standards in the form of tradable certificates ensures that the cheapest abatement option within the category regulated under the performance standard will be used first. Firms that beat the standard can generate revenues from selling certificates (Löfgren *et al*, 2020).

Within the EU, the most prominent examples of standards are the CO_2 emission performance standards for cars and vans, formulated as carbon emissions per kilometre for new vehicles. Manufacturers can pool their fleets to meet the standard on average, agreeing on compensatory payments within each pool. For the sake of cost transparency though, this

21 See eg Abrell and Kosch (2020) on premiums for renewable energy in the electricity market.

22 If the carbon price remains low, investors receive a higher subsidy. If the carbon price is high, the subsidy decreases. Depending on the design of the policy, investors might even be obliged to pay the difference to the state in case the carbon price is higher than the defined level of the subsidy.

23 See https://english.rvo.nl/subsidies-programmes/sde.

should be developed into a tradeable programme. Likewise, existing efficiency standards in the building sector should be reformulated in terms of emission intensity, and developed into a tradable programme similar to, for example, France's white certificate system[24].

Where carbon price amplifiers already exist and carbon pricing doesn't, notably in the case of emission standards in the transport sector, it is important to point out that an additional carbon price is an essential complement. That is, it addresses mitigation channels not covered by standards[25]: It incentivises demand reduction (for example in terms of kilometres travelled), thus reducing the rebound effect[26], and creates incentives for phasing out older unregulated vehicles (Lin and Linn, 2019). This only underlines the general case for putting carbon pricing at the centre of the emissions-reduction effort: to achieve ambitious climate goals, a standards-only approach without carbon pricing is insufficient. However, standards can play an important bridging role, which becomes less important as the carbon price rises.

4 Summary

Putting carbon pricing at the centre of the EU climate policy architecture would provide major benefits. It would increase efficiency in the face of much higher policy costs, provide a clear path to net zero, and foster an international move towards a global carbon price regime. Obtaining these benefits requires a uniform, credible and durable carbon price – the economic first-best solution. However, several preconditions required to attain this solution are not yet met, which is why we propose a sequenced approach to ensure convergence of the policy mix on the first-best in the long run.

The starting point should be a separate emissions trading system for the EU buildings and transport sectors, but with a carbon price balancer that links the system with the existing ETS to ensure that large price differentials between the schemes do not arise. In addition, a carbon price stabiliser would manage the expectations of market participants by setting the broad path of convergence and safeguarding against volatile prices. Finally, carbon price amplifiers would ensure that the price gap required to prompt investment and innovation is filled.

Our proposal reconciles pragmatic considerations with a clear and coherent vision for the way forward. It would put the EU on a pathway leading up to first-best carbon pricing that can underpin economic decision-making. Such carbon pricing is necessary to make the European Green Deal a success, and also signals that policymakers are serious about delivering on their ambitious targets. In contrast, pursuing an unchanged approach will ultimately be a dead end. The next few years will be decisive for readjusting the policy mix that will take the EU through 2050, meaning EU climate policy is at a crucial juncture. The new policy mix must be in place by the end of this decade to ensure whole-economy carbon pricing can have its full impact in the 2030s and 2040s. Policymakers should make this the top priority in the ongoing reforms to make the policy mix fit for the Green Deal.

We thank Jan Abrell, Dallas Burtraw, Ulrich Fahl, Janik Feuerhahn, Christian Flachsland, Luke Haywood, Matthias Kalkuhl, Brigitte Knopf, Grischa Perino, Ben McWilliams and Guntram Wolff. This Policy Contribution builds on research conducted under the Kopernikus-Projekt Ariadne (FKZ 03SFK5A), funded by the German Federal Ministry of Education and Research. Funding is gratefully acknowledged.

24 See https://www.tse-fr.eu/sites/default/files/TSE/documents/doc/wp/2020/wp_tse_1167.pdf.

25 See eg Dimanchev and Knittel (2020) for the case of performance standards.

26 The rebound effect describes the empirically important finding that energy-efficiency improvements in an appliance/car/house often trigger increased use/mileage and weight/space of the asset, leading to much smaller energy savings.

References

Abrell, J. and M. Kosch (2020) 'The impact of carbon prices on optimal renewable energy support', *SCCER CREST Working Paper*, available at www.sccer-crest.ch/fileadmin/user_upload/Kosch_Abrell.pdf

Abrell, J. and S. Rausch (2017) 'Combining price and quantity controls under partitioned environmental regulation', *Journal of Public Economics*, 145: 226-242, available at http://dx.doi.org/10.1016/j.jpubeco.2016.11.018

Abrell, J., M. Kosch and S. Rausch (2020) 'How Effective Was the UK Carbon Tax? — A Machine Learning Approach to Policy Evaluation', *CER-ETH Economics Working Paper* 19/317, available at https://ideas.repec.org/p/eth/wpswif/19-317.html

Abrell, J., S. Rausch and G.A. Schwarz (2018) 'How robust is the uniform emissions pricing rule to social equity concerns?' *Journal of Environmental Economics and Management*, 92: 783-814, available at http://dx.doi.org/10.1016/j.jeem.2017.09.008

Ariadne Project (2020) *Wegmarken für das EU-Klimaziel 2030*, Ariadne-Kurzdossier, Kopernikus-Projekt Ariadne, available at http://www.pik-potsdam.de/de/institut/abteilungen/transformationspfade/projekte/ariadne/kurzdossier_eu-klimaziel2030

Brunner, S., C. Flachsland and R. Marschinski (2011) 'Credible commitment in carbon pricing', *Climate Policy*, 12(2): 255-271, available at www.tandfonline.com/doi/abs/10.1080/14693062.2011.582327

Burtraw, D., C. Holt, K. Palmer and W.M. Shobe (2020) 'Quantities with Prices: Price-Responsive Allowance Supply in Environmental Markets', *Resources for the Future Working Paper* 20-17, available at www.rff.org/documents/2636/RFF_WP_20-17_Burtraw.pdf

Bushnell, J., C. Gambardella, K. Novan and M. Pahle (2021) 'The joint impacts of carbon pricing and renewable generation on fossil generation profits in Germany', mimeo

Dimanchev, E.G. and C. Knittel (2020) 'Trade-offs in Climate Policy: Trade-offs in Climate Policy: Combining Low-Carbon Standards with Modest Carbon Pricing', *CEEPR Working Paper* 2020-020, available at http://ceepr.mit.edu/files/papers/2020-020.pdf

Edenhofer, O., C. Flachsland, M. Kalkuhl, B. Knopf and M. Pahle (2020) 'How the "Green Deal" Can Provide the Right Incentives: A Proposal for The Design of a Fund for Public Financing of Sustainable Businesses and Real Investments', *Discussion Paper*, available at https://ssrn.com/abstract=3673811

Edenhofer, O., C. Flachsland, M. Kalkuhl, B. Knopf and M. Pahle (2019) 'Optionen Für Eine CO2-Preisreform. MCC-PIK-Expertise für den Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung', available at http://www.mcc-berlin.net/fileadmin/data/B2.3_Publications/Working Paper/2019_MCC_Optionen_für_eine_CO2-Preisreform_final.pdf

Friedrich, M., E-M. Mauer, M. Pahle and O. Tietjen (2020a) 'From fundamentals to financial assets: the evolution of understanding price formation in the EU ETS', *EconStor Working Paper*, available at https://www.econstor.eu/handle/10419/225210

Friedrich, M., S. Fries, M. Pahle and O. Edenhofer (2020b) 'Rules vs. Discretion in Cap-and-Trade Programs: Evidence from the EU Emission Trading System', CESifo Working Paper No. 8637, available at http://www.cesifo.org/en/publikationen/2020/working-paper/rules-vs-discretion-cap-and-trade-programs-evidence-eu-emission

Holland, S.P. (2012) 'Emissions Taxes versus Intensity Standards: Second-Best Environmental Policies with Incomplete Regulation', *Journal of Environmental Economics and Management*, 63 (3): 375–87, available at https://doi.org/10.1016/j.jeem.2011.12.002

Kalkuhl, M., J.C. Steckel and O. Edenhofer (2020) 'All or nothing: Climate policy when assets can become stranded', *Journal of Environmental Economics and Management*, 100, 102214, available at https://doi.org/10.1016/j.jeem.2019.01.012

Lin, Y. and J. Linn (2019) 'Environmental Regulation and Product Attributes: The Case of European

Passenger Vehicle Greenhouse Gas Emissions Standards', *Resources for the Future Working Paper* 19-23, available at www.rff.org/documents/2326/WP_19-23_Lin_and_Linn.pdf

Löfgren, A., D. Burtraw and A. Keyes (2020) 'Decarbonizing the Industrial Sector: The Potential for Ambitious EU Member States to Use Flexible Performance Standards to Strengthen Carbon Price Signals', *Resources for the Future Report* 20-03, available at www.rff.org/documents/2442/Report_20-03.pdf

Matthes, F.C. (2019) 'Ein Emissionshandelssystem für die nicht vom EU ETS erfassten Bereiche: Praktische Umsetzungsthemen und zeitliche Erfordernisse', *Agora Energiewende Report*, available at www.oeko.de/fileadmin/oekodoc/Emissionshandelssystem-fuer-nicht-vom-EU-ETS_-erfassten-Bereiche.pdf

Nordhaus, W. (2011) 'Designing a Friendly Space for Technological Change to Slow Global Warming', *Energy Economics*, 33 (4): 665–73, available at https://doi.org/10.1016/j.eneco.2010.08.005

Pahle, M., D. Burtraw, C. Flachsland, N. Kelsey, E. Biber, J. Meckling, O. Edenhofer and J. Zysman (2018) 'Sequencing to Ratchet up Climate Policy Stringency', *Nature Climate Change*, 8(10): 861–67, available at https://doi.org/10.1038/s41558-018-0287-6

Perino, G., M. Pahle, F. Pause, S. Quemin, H. Scheuing and M. Willner (2021) 'EU ETS stability mechanism needs new design', *Chaire Économie du Climat Policy Brief* N°2021-1, available at https://www.chaireeconomieduclimat.org/wp-content/uploads/2021/02/PB-2021-01.pdf

Quemin S. and C. de Perthius (2019) 'Transitional Restricted Linkage Between Emissions Trading Schemes', *Environmental and Resource Economics*, 74:1–32, available at https://doi.org/10.1007/s10640-018-00307-6

Quemin S. and M. Pahle (2021) 'Financials threaten to undermine the functioning of allowance markets', forthcoming

Richstein, J.C. (2017) 'Project-Based Carbon Contracts: A Way to Finance Innovative Low-Carbon Investments' *DIW Berlin Discussion Papers*, available at http://www.diw.de/documents/publikationen/73/diw_01.c.575021.de/dp1714.pdf

Salant, S.W. (2016) 'What ails the European Union's emissions trading system?' *Journal of Environmental Economics and Management*, 80: 6-19, available at http://dx.doi.org/10.1016/j.jeem.2016.06.001

Stocking, A. (2012) 'Unintended consequences of price controls: An application to allowance markets', *Journal of Environmental Economics and Management*, 63(1): 120-136, available at https://doi.org/10.1016/j.jeem.2011.07.005