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Achieving Zero Emissions Under a Cap-And-Trade System

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Highlights[1]

- Current estimates of marginal abatement costs suggest that achieving zero or net-zero emissions requires much higher carbon prices than ever experienced.
- Depending on how well they are addressed, competitiveness and distributional effects de facto pose a limit to the levels that carbon prices can reach.
- Steeply growing carbon prices and related side effects call for packages of accompanying measures and policies.
- This policy brief presents multiple policy options to keep carbon prices in check and achieve zero emissions in time.

1. The authors have drafted this paper upon invitation of the European Commission for the purpose of distribution in the context of the Florence Process Carbon Market Workshop 2020. The views expressed in this paper are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

1. Introduction

Given the pressing need to advance climate change mitigation, a growing number of governments is committing to achieving net-zero GHG emissions. The EU, the United Kingdom, New Zealand and California, for example, currently aim to achieve climate neutrality by 2050 (or before) (ICAP, 2020). A cap-and-trade system, i.e. an emissions trading system (ETS) with a fixed cap, is progressively leveraged to support this type of goal by achieving an emissions reduction target by a certain time, at minimum cost. Nonetheless, the elimination of emissions within the next 25 or 30 years raises questions about the use of technologies that are not yet commercialized, the viability of rapidly increasing carbon prices – much higher than those of which we have experience – and the related policy responses. The present note discusses these issues.

2. Net Zero Requires Substantially Higher Carbon Prices

A zero emissions target raises the question of what carbon prices can be expected and what their implications are. The highest marginal abatement costs in regulated sectors give an indication of what the maximum level reached by allowance prices could be. Estimates of these costs can be considered indicative upper bound values for the value of the last allowance surrendered.[2] They are only *indicative* values because, for the same technology, marginal abatement costs vary in specific situations (i.e. estimates refer to averages, but variation can be significant).[3] They are *upper bound* values because marginal abatement costs could turn out to be lower by virtue of unanticipated technological progress (plausible in a time span as long as 30 years). To give an idea of the order of magnitude of these costs, Burke *et al.* (2019) report recent estimates for full decarbonisation of different sectors in the UK. In 2050, the highest marginal abatement cost for the electricity sector reaches £120/tCO_2 (≈ €135; ≈ $145), for some energy-intensive industrial sectors it is well over £160/tCO_2 (≈ €180; ≈ $195), and for aviation, it exceeds £200/tCO_2 (≈ €225; ≈ $245).[4] In simulations for the EU long-term decarbonisation strategy, the modelling applies a stylised carbon price as high as €350 to achieve net-zero emissions in 2050, the year by which the EU wants to achieve climate neutrality (European Commission, 2018a; European Commission, 2018b). Compared with these numbers, the current carbon prices in ETSs around the world[5] would need to grow 10 times or more in the next 30 years in order to achieve zero emissions at minimum cost.

3. High Carbon Prices Raise Competitiveness and Distributional Concerns

Experience with carbon pricing to date shows that even modest carbon prices can be problematic because of their possible undesirable *side effects*. By increasing final prices of carbon-intensive goods, carbon prices raise two main kinds of possible issues. One concerns the negative effects on the international competitiveness of firms in energy-intensive, trade-exposed sectors and ensuing carbon leakage. The other concerns the regressive impact on real household incomes and, more generally, unfair

2. Fuss *et al.* (2018) and Acworth *et al.* (2017) call it *terminal allowance price.*

3. On the interpretation and use of marginal abatement cost curves, see Kesicki and Ekins (2012).

4. Most marginal abatement cost estimates considered in Burke *et al.* (2019) are from CCC (2019).

5. www.icapcarbonaction.com/en/ets-prices

distributional effects.[6] Depending on how well these issues are addressed, they *de facto* pose a limit to the levels that carbon prices can reach.

The empirical evidence on ***competitiveness effects and carbon leakage*** does not confirm expectations of substantial negative (average) effects. Most models used in ex-ante simulations are unable to capture some aspects of the real world; in particular, the fact that when carbon prices are significantly higher than elsewhere, they are usually accompanied by compensatory or technology support measures, as well as the fact that there may be untapped opportunities for economic gain through emissions reductions and that carbon prices lead to realising those – a result known as Porter Hypothesis (Porter and van der Linde, 1995). On the other hand, most existing empirical applications do not capture possible effects of carbon prices on structural variables such as closure and opening of regulated plants (Verde, 2020). In this regard, fewer works look at the impact of carbon prices on foreign direct investments of regulated firms or on holdings of tangible fixed assets as indicators of industrial relocation. So far, those that have done so have found only modest effects if any (e.g., Aus dem Moore *et al.*, 2019; Koch and Mama, 2019; Borghesi *et al.*, 2018). Overall, the empirical evidence on the effects of climate policies on international competitiveness is relatively reassuring (Dechezleprêtre and Sato, 2017). However, real-world carbon prices are far lower than those needed for deep decarbonization, not to mention full decarbonisation. Therefore, extrapolating this result to inform expectations about the effects of potentially much higher carbon prices in the future would be difficult to justify.

Unfair ***distributional effects*** of carbon prices are also very important: if not properly addressed, they could equally result in the rejection of any carbon pricing instrument that imposes prices deemed unacceptable by the public. Here, the available empirical evidence concerns almost exclusively the effects of carbon and energy taxation, not of ETSs. However, while the transferability of these results to the case of an ETS is not perfect, it is high given similar effects on final prices. This evidence clearly shows that increases in energy or carbon prices are inequitable. Typically, carbon taxation is regressive because poorer households spend larger shares of their income on energy goods (the degree of regressivity depending on consumption and income levels across income distribution), and the resulting electricity price increases are the most regressive (Verde and Pazienza, 2016). The problem is exacerbated by differences in financial capacity for adopting low-carbon technologies. Poorer households have less financial space to make investments that would allow them to reduce their carbon footprint. Last but not least, households with incomes from carbon-intensive sectors are at risk of being severely affected (Winkler, 2020; Vona, 2019).

4. Policy Packages and Negative Emission Technologies can Reduce Pressure on Carbon Pricing

Steeply growing carbon prices and related side effects call for packages of accompanying measures and policies. There are many levers that can be used to keep carbon prices in check and achieve zero emissions in time (Hepburn *et al.*, 2020; Tvinnereim and Mehling, 2018). First, distinct sets of measures can be considered for directly addressing competitiveness and distributional effects. Free allowance allocation, linking with other ETSs and border carbon adjustments, for example, all offer options for the safeguard of international competitiveness. As regards distributional effects, the revenues from auctioning allowances may be used to counterbalance regressive effects (the simplest option being returning equal lump-sum payments on a per capita basis – as proposed

6. In the context of deep decarbonisation, stranded assets is a third relevant issue for its political economy implications and the stability of financial systems (Rozenberg *et al.*, 2020).

by many well-known economists[7]), while dedicated economic support and professional training should be provided to the workforce of negatively affected sectors. Second, a range of companion policies may be used for reducing emissions beyond what (even substantial) carbon prices alone can be expected to deliver long-term.[8] They include regulatory standards (for production processes and products, but also for finance, city design, land and forest management), investment subsidies, public investments, public procurement, new financial instruments (including contracts for differences discussed in Section 5) as well as additional carbon pricing policies (including consumption charges, also discussed below) (Krogstrup and Oman, 2019; Burtraw *et al.*, 2018; HLCCP, 2017).

While typically not cost-effective in abating emissions in the short term, companion policies play a key role in meeting long-term climate goals. Market failures associated with technological change, notably knowledge spillovers and learning-by-doing, provide strong rationales for policies targeting innovation (R&D) and adoption of low-carbon technologies in tandem with carbon pricing (Fisher *et al.*, 2017; Dechezleprêtre and Popp, 2015; Acemoglou *et al.*, 2012). The time necessary for big plants, infrastructures, as well as outcomes of R&D programmes to be usable, also justifies early-targeted public intervention before carbon prices reach levels that might trigger those. In theory, in the absence of uncertainties regarding the future trajectory of carbon prices and assuming all operators were forward-looking (with horizons as long as 30 years), these extra policies would not be needed. In practice, however, neither of the two assumptions seem plausible (Vogt-Schilb and Hallegatte, 2014; Vogt-Schilb *et al.*, 2018). Further, there is an increasing skepticism about the effectiveness of carbon prices in driving consumption and investment decisions where carbon costs only represent a fraction of the economic value involved (Hepburn *et al.*, 2020). Regulatory standards can be more effective in such cases.

Negative emission technologies (NETs) are also an important piece of the puzzle to achieve climate neutrality.[9] NETs, such as bioenergy with carbon capture and storage, biochar and direct air CCS among others, will play an important role in climate stabilization especially in the second half of this century, but some of them will probably start to be used well before 2050 (IPCC, 2018; European Commission, 2018). The opportunities offered by NETs are also of potential interest to cap-and-trade systems aiming at zero emissions or – precisely if carbon removals were allowed for compliance – *net-zero* emissions. In principle, carbon removals from NETs could offset regulated emissions whose abatement is more expensive or just technically not feasible (Burke *et al.*, 2019). However, such use of carbon removals deserves careful reflection. First, the environmental integrity of a cap-and-trade system would need to be preserved. Second, costly abatement opportunities are also in non-ETS sectors, so negative emissions could be used toward offsetting those. Third, and perhaps most importantly, carbon removals may be best used to *reduce* the existing stock of GHG emissions in the atmosphere – thus making up for excessive emissions in the past – rather than to let some sectors keep emitting.

7. https://www.econstatement.org/

8. As these policies affect allowance demand and, hence, allowance prices, mechanisms such as a price floor or a market stability reserve help maintain the desired balance between instruments.

9. For a review of NETs, see Fuss *et al.* (2018), Minx *et al.* (2018) and Nemet *et al.* (2018).

5. Policies are Available to Support Existing Carbon Prices and Unlock Additional Abatement[10]

A carbon price signal will continue to serve as the main driver for decarbonisation toward 2030 and in the decades that follow. A key challenge for ETSs on that path will be balancing risks of carbon leakage, concerns about industrial competitiveness, and incentivising deep decarbonisation. Free allocation as a means of mitigating leakage risks and preserving competitiveness will face constraints in the decades ahead, as allowance budgets decline in step with more stringent reduction targets. This may prompt a need for a free allocation reform to preserve remaining allowance budgets and target them toward industries that are most vulnerable to carbon leakage, such as a ***tiered approach*** that ties allocation to level of leakage risk. This tension is most acute for systems where industrial emissions at risk of leakage make up a significant share of the allowance budget.[11]

Reforming free allocation may help safeguard industrial competitiveness and prevent carbon leakage, but it may not adequately incentivise upstream and downstream mitigation opportunities that will be necessary to achieve climate neutrality. This is largely because free allocation blunts downstream price signals and can distort low-carbon investment. The challenge is particularly true for demand-side abatement opportunities such as recycling, resource efficiency, and creating markets for low-carbon products, which require the carbon price to be reflected in the product price of carbon-intensive goods. These factors suggest that new methods of providing leakage protections that further incentivise upstream and downstream abatement should be explored. Two such options are ***border carbon adjustments*** (BCAs) and ***consumption charges***. These two pricing mechanisms could be implemented as part of an ETS or externally to a carbon market. Other policies could complement carbon pricing to further support decarbonisation by targeting additional challenges upstream and downstream.

Alternative Carbon Pricing Mechanisms

BCAs apply tariffs or other measures to imported goods based on their embedded GHG emissions and/or rebates for domestic exports to markets that have not established comparable constraints on their emissions. They are intended to level carbon costs between the implementing jurisdiction and trading partners, thereby providing protection against carbon leakage and allowing for a phase-down of free allocation for the sectors covered by the BCA. Requiring industries to purchase their own allowance needs while better enabling them to reflect carbon costs in product prices would incentivise abatement opportunities across the production and value chain. However, BCAs are complex instruments with legal implications under World Trade Organization (WTO) rules, necessitating careful attention to design.[12]

10. The section reflects a synthesis of a forthcoming ICAP publication on carbon leakage and deep decarbonization (Acworth et al., 2020).

11. The California Cap-and-Trade Program, for example, covers about 80% of the state's emissions and industrial allocation is only about 12% of the cap.

12. See for example Mehling et al. (2017), Carbon Trust (2010), Cosbey et al. (2012), Mehling et al. (2019), and Cosbey et al. (2019) for an extensive discussion of BCA design.

Design choices entail trade-offs between the effectiveness of the BCA against carbon leakage on one side and the scheme's WTO compatibility[13] and administrative feasibility on the other side. This is particularly true for the BCA's scope and the determination of embedded carbon on which to base the adjustment. Furthermore, the composition of industrial sectors will also affect the choice of BCA design. Empirical evidence shows that most of the leakage protections offered by a BCA can be secured through an imports-only system, but this may not hold for sectors in the implementing jurisdiction that are major net exporters (Cosbey et al., 2012). While export rebates could strengthen the BCA, such an approach poses greater legal uncertainty (Cosbey et al., 2019; Mehling et al., 2019). A similar trade-off exists in how best to adjust prices at the border. If the adjustment is based on actual emissions, the abatement incentive is directly tied to lowering the cost of the adjustment the imported goods will face, but this poses legal and methodological challenges (Kortum & Weisbach, 2017). These challenges likely require relying on default values (benchmarks), but the most technically/legally feasible benchmarks (e.g. average emissions intensity of the sector in the jurisdiction implementing the BCA) would generally provide the weakest leakage protections.

While BCAs aim to capture the cost of emissions in the production of goods, ***consumption charges*** aim to restore price signals on the *use* of emissions-intensive goods. Unlike BCAs, consumption charges are not aimed at levelling discrepancies in carbon pricing between trading partners. Both mechanisms may ultimately take the form of a benchmark multiplied by the weight of a covered product and a price, but a key distinction is their respective point of application. Also known as a "Climate Contribution" or "Inclusion of Consumption", a specific type of consumption charge has been suggested as alternative to BCA that would seek to maintain free allocation for leakage-vulnerable sectors under its scope for leakage protections while passing on costs not reflected in domestic production farther down the industrial value chain (Neuhoff et al., 2016). While the application of consumption charges places the focus on downstream mitigation opportunities, the use of benchmarks for free allocation could maintain incentives for production efficiency. To our knowledge, no jurisdiction to date has implemented consumption charges on carbon-intensive industrial materials. However, different variants of consumption charges have been introduced in other sectors (see Munnings et al. 2016 for an overview).

Under the "Climate Contribution" model, domestic firms that produce products under the scope of the consumption charges would receive free allowances based on recent or actual levels of output and a product-specific benchmark (known as output-based allocation). These same firms would have to report their production volumes and would be held liable for the consumption charges due. Producers would either pay the charges themselves or reflect the charges in their pricing at the point of sale for intermediate consumption. Duty-suspension arrangements provide an option for qualifying firms to forego consumption charges if their materials or the subsequent product will be exported. The liability for imported materials subject to consumption charges would be equivalent to domestically produced products. Ensuring compliance would require integrating the liability for relevant product categories in the implementing jurisdiction's existing tariff system and establishing accounting and reporting systems that are not overly burdensome relative to obligations for domestic producers.

As an internal charge resembling a value-added tax that would be assessed equivalently on domestic production and like imports, consumption charges may

13. There may be paths to a WTO-compatible BCA through the WTO General Agreement on Tariffs and Trade (GATT), which requires equal treatment of "like" goods, or through Article XX, which grants exceptions to GATT obligations based on environmental protection and other grounds (Mehling et al., 2019).

prove more robust to WTO challenges than BCA, depending on the BCA's design. They may also be administratively simpler, given that many jurisdictions already have extensive experience with value-added and excise taxes, along with the infrastructure to collect them. However, limiting the scope to only the most emissions-intensive industrial commodities would ignore the importation of carbon-intensive goods farther down the value chain and could fail to adequately address carbon leakage, given that domestic consumption would be priced along the value chain (Ismer et al., 2016). This suggests that the scope should be extended to imports that contain high levels of industrial materials covered by the consumption charges. The level of administrative complexity would depend on the threshold of covered material a product may contain for inclusion in the system of consumption charges and data availability.

A key challenge with consumption charges is the scheme's leakage protections would depend on future levels of free allocation. If declining free allocation outpaces abatement from industrial sectors, continued discrepancies in carbon pricing among key trading partners could still trigger leakage risk. Furthermore, as price discrepancies are not levelled at the border, their potential to incentivise abatement outside of the implementing jurisdiction may be limited. Trading partners would have little reason to phase out free allocation if they would face consumption charges for their exports to a jurisdiction implementing consumption charges on top of their own domestic carbon price.

Policies to Complement Carbon Pricing in Decarbonisation

Deep industrial decarbonization will require additional complementary policies beyond carbon pricing. Funding to support the deployment and development of ***low-carbon technologies*** for industry are an example of policies that can be targeted both upstream and downstream. Upstream support focuses on research and development and other inputs to stimulate the supply of new technologies, while downstream support focuses on the diffusion of promising technologies. The market for low-carbon technologies in sectors such as transport, buildings, and energy is far more advanced than in emissions-intensive industry, owing to more concerted government policies spanning decades (Åhman et al., 2017; IEA, 2019). But emissions-intensive industry presents challenges with technology uptake: comparatively higher capital costs, depending on the scale, with long investment cycles and higher risks, among other factors (Åhman et al., 2017). Because these industries produce globally traded goods, support mechanisms are also more likely to face WTO challenges than more domestically oriented sectors.

Growing awareness of these challenges is leading to greater policy focus. For example, the EU ETS Innovation Fund will prioritize demonstration projects for industrial sectors for the first time starting 2021, and InvestEU envisions supporting successful projects from the Innovation Fund to scale up. Québec plans to combine reductions in free allocation with dedicated funding to support mitigation for EITE entities, along with significant additional budgetary support for EITE entities. The EU is also considering placing conditions on indirect cost compensation for Phase IV of the EU ETS that would require additional investment in low-carbon technologies and production processes to receive aid (European Commission, 2020).

There is also growing awareness – in large part thanks to the IPCC – that achieving climate neutrality entails the use of negative emission technologies, such as bioenergy with CCS, that could compensate for residual emissions from industry. Deploying such technologies at scale will require substantial public subsidies, in addition to other policies such as regulatory standards and reforms to carbon pricing, which is discussed in the previous section (Bednar, et al., 2019; Bellamy, 2018; Fajardy et al., 2019). But precisely how to cost-effectively incentivize negative emission technologies, which technologies to prioritize, and the resulting quantity of residual emissions is still an underdeveloped area of study (Bellamy, 2018; Fajardy et al., 2019).

Product carbon standards (PCRs) may be another tool with both upstream and downstream benefits, especially if the standards were made mandatory after an initial voluntary phase. PCRs for industrial commodities have not been extensively studied[14] but in essence would begin with labelling standards for certain industrial products linked to their emissions intensity, starting on a voluntary basis. Voluntary standards with labelling would empower consumers to choose lower-carbon options, which would help expand the market for climate-friendly goods and raise awareness of emissions embedded within the value chain (Neuhoff et al., 2018).

In a second phase, the implementing jurisdiction could establish mandatory PCRs. Such an approach would likely only take place in the later stages of an industrial decarbonization process, once there is enough capacity to produce low-carbon materials.[15] Mandatory PCRs would mean the sale of certain products would only be permitted in the implementing jurisdiction if they meet a certain threshold of emissions intensity.

Once mandatory, PCRs would help level the playing field between low-carbon and emissions-intensive materials, as both domestic producers and importers would need to comply to sell goods in the implementing jurisdiction (Chiappinelli, et al., 2019). However, as with other command-and-control approaches, the lack of flexibility associated with mandatory PCRs will likely result in economic inefficiency.

A policy more squarely aimed at deployment of promising technologies ***are carbon contracts for differences*** (CCfDs). CCfDs offer a way to reduce risk in capital-intensive projects by effectively guaranteeing a certain return for the incremental costs of an investment that delivers emissions reductions below the current best available technology or another benchmark.

As developed by Richstein (2017), CCfDs pay out the difference between a reference price (e.g. the yearly average allowance price) and a price agreed to in the contract, effectively guaranteeing a certain level of revenue for the incremental costs of the investment (see also Neuhoff et al., 2019, and Sartor & Bataille, 2019). If the reference price exceeds the contract price, the investor would pay back the difference.

Applying environmental criteria to public purchasing decisions, often referred to as ***green public procurement*** (GPP), offers another potentially impactful demand-side policy. GPP is attractive for many reasons:[16] As a significant portion of gross domestic product, governments can act on a large scale in delivering goods and services. This scale allows governments to create lead markets for low-carbon products where carbon prices alone are not sufficient, which in turn provides industries with credible incentives for both developing and deploying low-carbon technologies and processes. Governments can also factor implicit carbon prices into purchases that exceed market prices.

Lastly, given the importance of demand-side interventions to decarbonizing industry (Material Economics, 2018), the ***recycling and recirculation*** of materials is another promising area for policy innovation. While there are many reasons for low recycling rates even when it is economically attractive

14. For the most extensive proposal to date, see Gerres et al., (2019)

15. Analyses suggest this state will not be achieved until the mid-2030s at the earliest given the current state of technology development (Bataille et al., 2018).

16. See for example Chiappinelli and Zipperer (2017)

for consumers to do so,[17] there are policy interventions available that differ according to the sector and product in question. Waste from construction and demolition is a good example. Through local ordinances and codes, jurisdictions can require contractors or property owners to ensure such waste will be slated for reuse or recycling. Other regulatory measures could include landfill taxes or producer-responsibility policies, such as the European extended producer responsibility (EPR) system. Targets for waste reduction combined with waste management plans, along with community outreach and financial incentives, could also prove effective at boosting recycling.

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17. See Rissman et al. (2020), from which the examples given in this paragraph were drawn.

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