Received: 6 September 2021 | Revised: 9 June 2022 | Accepted: 23 June 2022

DOI: 10.1002/wcc.796

OVERVIEW

WIREs CLIMATE CHANGE WILEY

Allocation, allocation, allocation! The political economy of the development of the European Union Emissions Trading System

Misato Sato[1] | **Ryan Rafaty**[2,3] | **Raphael Calel**[4] | **Michael Grubb**[5]

[1]Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, UK

[2]Climate Econometrics, Nuffield College, University of Oxford, Oxford, UK

[3]Institute for New Economic Thinking at the Oxford Martin School, Oxford, UK

[4]McCourt School of Public Policy, Georgetown University, Washington, District of Columbia, USA

[5]Institute for Sustainable Resources, University College London, London, UK

Correspondence
Misato Sato, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, UK.
Email: m.sato1@lse.ac.uk

Funding information
Economic and Social Research Council, Grant/Award Number: ES/N016971/1; ESRC Centre for Climate Change Economics and Policy, Grant/Award Number: ES/R009708/1; Grantham Research Institute on Climate Change and the Environment; H2020 Environment, Grant/Award Number: 681228

Edited by: Simone Pulver, Domain Editor and Mike Hulme, Editor-in-Chief

Abstract

The European Union's pioneering carbon Emissions Trading System, the EU ETS, has inspired countries around the world to launch their own CO_2 markets. This paper analyses the evolution of the EU ETS from a political economy perspective, emphasizing the interaction of economic principles and political interests at pivotal moments, and showing how each compromise changed the scope for future design choices. We focus on the allowance allocation issue, which provides a window into the complex tug-of-war between economic efficiency and the politics of distribution. Our account highlights the dynamic nature of CO_2 market reform, and provides lessons that can help inform the design of more stable and effective CO_2 markets in the future.

This article is categorized under:

Climate Economics > Economics of Mitigation

The Carbon Economy and Climate Mitigation > Policies, Instruments, Lifestyles, Behavior

KEYWORDS

allowance allocation, carbon pricing, emissions trading, EU ETS, industry lobby, political economy

1 | INTRODUCTION

The European Union became a CO_2 market pioneer when it launched the EU Emissions Trading System (EU ETS) in 2005. Several histories have already been written of Europe's flagship climate policy (e.g., Böhringer, 2014; Gulbrandsen et al., 2019; Laing et al., 2014; Martin et al., 2016; Narassimhan et al., 2018), often wrestling with the question of

whether the EU ETS has been a success or a failure. What is still lacking, though, is a "[m]ore 'real world' political economy analysis [...] to understand how political forces [...] act as strong intervening variables that affect instrument design, implementation and effectiveness" (Gulbrandsen et al., 2019, p. 427). Our study, therefore, does not ask whether the EU ETS has been a "success" or a "failure," but what its many successes and failures can teach us about the design and implementation of more robust CO_2 markets in the future.

The long-running fight over how to allocate CO_2 allowances provides a window into the political economy of the EU ETS, and is the focus of this review. EU policy makers made a political calculation that, to neutralize industry opposition, they would initially need to give CO_2 emissions allowances to polluters for free based on their historical emissions—allocation based on "grandfathering." Advice from economists had emphasized, too, that the outcome would be cost-effective regardless of how allowances were allocated (Hahn & Stavins, 2011; Montgomery, 1972). This design choice would end up profoundly altering both the political landscape and the economic understanding of emissions trading. Politically, the rents that accrued to industry through free allocation not only led some industries to support rather than oppose the ETS, but also created a lobby to preserve those rents (Fuchs & Feldhoff, 2016). Meanwhile, the fact that some of the biggest polluters ended up profiting the most (Cludius, 2018) also sowed the seeds for public outcry and reform (Paterson, 2013). Economically, focus shifted from the static cost-effectiveness of emissions trading towards the effects that allocation rules could have in a dynamic setting. There was growing recognition that adjusting free allocation volumes over time can create incentives for polluters to emit more in the present to obtain more free allocations in the future (Neuhoff, Martinez, & Sato, 2006; Rosendahl, 2008).

The decisions in earlier phases to grandfather allowances made national regulators the targets of intense lobbying. Although lobbying was intended mainly to ensure that each firm would have enough allowances to compete, this rent-seeking exercise ultimately contributed to crippling system-wide over-allocation (Quirion, 2021), which depressed CO_2 prices and helped to paralyze the EU ETS for many years. Economists had advised that longer commitment periods would reduce uncertainty for investors, but this backfired as the system lacked the necessary flexibility to address the excess supply of allowances within commitment periods (Grosjean et al., 2016). It is only after many iterations of political compromise and economic refinement that reform efforts have begun bearing fruit. After many years of depressed carbon prices, 2022 saw allowance prices hike to above €90/tCO (Figure 1).

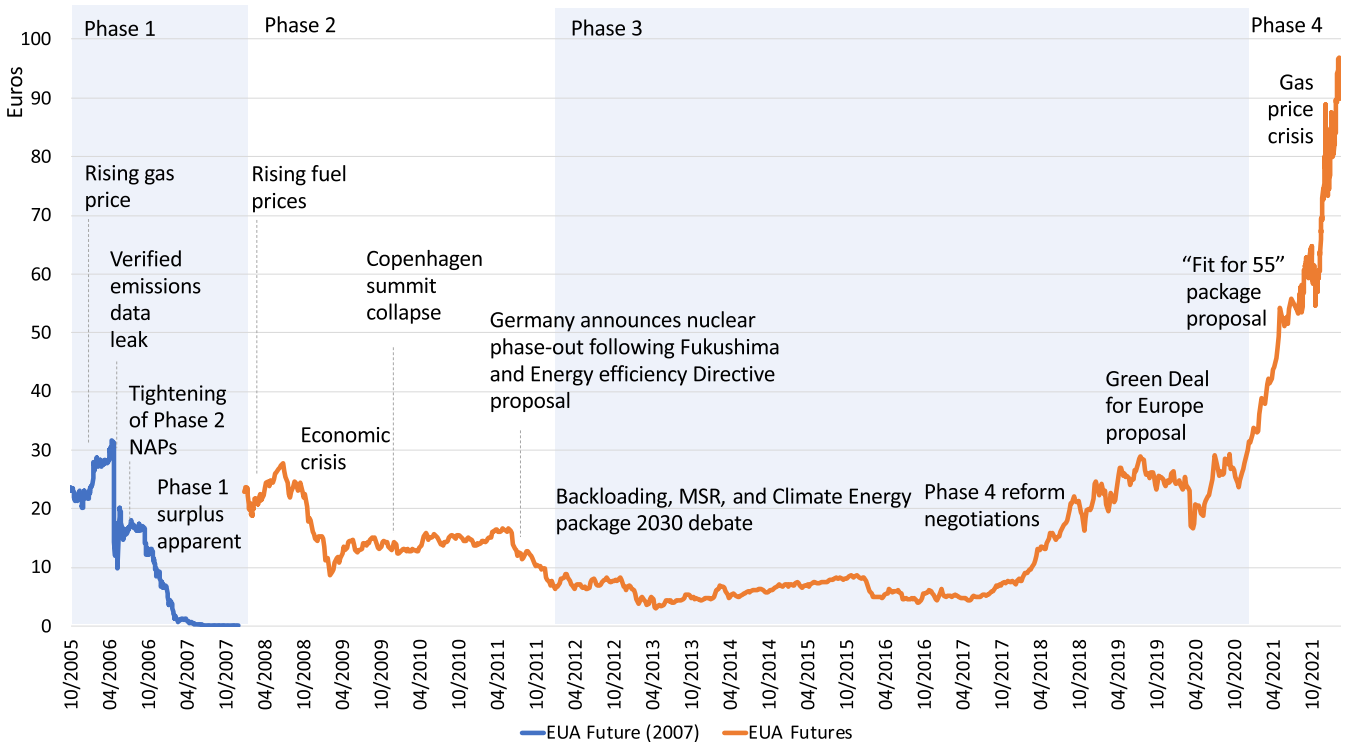

FIGURE 1 EUA futures prices and major events *Source*: European Energy Exchange (EEX) and EEA for EUA Futures 2007. ICAP Allowance Price Explorer and Member for EUA Futures Series

The reality of allowance allocation is not purely a matter of economic principle, nor of interest-group politics. It is a complex tug-of-war between environmental ambition, principles of aggregate economic efficiency, and the politics of distribution. Each compromise alters the scope for future design choices—both by changing the political landscape, and by changing the stream of incoming data that expert advice would be based on. In this article, we document patterns of bargaining between bureaucrats, politicians, and corporations.[1] Our aim is to show the logic of the compromises that were made and to draw out the political and economic lessons that were learnt along the way.

Today, all emissions trading systems covering industry offer some form of exemption or "compensation" in the form of free allocation, which to varying degrees enable emitters to carry on with limited adjustment. We hope that our analysis of the EU's experience will allow economists and policy makers around the world to see the "long game" of allowance allocation in a new light, and to apply some of the lessons to their own political contexts to chart a more direct course towards allocations informed by our now road-tested and refined economic understanding.

We start with the origins and design of the EU ETS (Section 2) and then critically review its evolution during Phases 1–4 (Section 3) by reviewing both the economic and political literatures on EU ETS developments, drawing out the lessons learned along the way. We then survey the literature evaluating the EU ETS impacts on carbon leakage and low carbon innovation to discuss the key remaining challenges (Section 4), We conclude by considering the most important lessons for designing more robust CO_2 markets in the future (Section 5).[2]

2 | ORIGINS AND DESIGN OF THE EU ETS

2.1 | Origins

The EU ETS was born out of the failed efforts to pass an EU-wide carbon tax in the early 1990s. Despite granting numerous concessions to industry and Member States—for example, a diminished starting tax rate and broad exemptions for energy-intensive industries—the proposal failed to secure support from all of the Member States in the European Council in 1992. Some made their support conditional on equivalent action in other OECD countries, which of course was not forthcoming. Since fiscal measures legally require unanimous support from EU Member States, each country effectively had veto power. It ultimately proved impossible to agree on a carbon tax, and not only because of concerns about costs and distribution, but also due to more fundamental misgivings about giving the EU fiscal powers (Braun, 2009).

In 1997, as the Kyoto Protocol was being signed, attention in Europe shifted *to* the idea of creating an EU-wide emissions trading system. At the urging of the US government, the Kyoto Protocol's binding emissions commitments for industrialized countries had been accompanied by provisions to create CO_2 trading mechanisms (Ovodenko & Keohane, 2012). One of these mechanisms would allow an industrialized country to purchase some of the emissions quota from another industrialized country. But after the UNFCCC meetings in Buenos Aires in 1998 and Marrakech in 2001, it became clear that the UNFCCC would be unable to create strong international enforcement mechanisms for this CO_2 market.[3] Since the set-backs at the 1998 meeting, the European Commission had a rapid change in personnel with skeptics being replaced by supporters of ETS (Paterson, 2012) who played a dominant role as policy entrepreneurs for the development of the emissions trading directive (Braun, 2009). The pushing and planning started for an EU-level quota sharing arrangement that would fall under the jurisdiction of the European Court of Justice. It was taken for granted that it would end up with an ETS (Skjærseth & Wettestad, 2008).

The idea had several crucial advantages. Under EU law, such a program would be considered an environmental policy rather than a tax policy. Its passage only required the approval of a weighted majority of Member States. Blocking an emissions trading system would therefore have required opposition from a unified bloc of relatively large and populous countries. In addition, the idea garnered the support of some industry lobby groups and financiers as well as NGOs, leading to an unlikely but powerful coalition that included many that had fiercely opposed the original EU carbon tax proposal (Ikwue & Skea, 1994; Paterson, 2012). Whereas a carbon tax would have involved large fiscal transfers from industry to government, this could be easily avoided in an emissions trading system by giving allowances to polluters for free.[4] A key feature of emissions trading, in this respect, was that authority over allowance allocation decisions could be devolved to the national governments, which not only ameliorated concerns about giving the EU new fiscal powers, but seemed to coincide with general principles of "subsidiarity," leaving Member States to sort out appropriate allocation internally (van Zeben, 2014).

Shortly after, the United States pulled out of the Kyoto Protocol, leaving in its wake a climate leadership vacuum that many European policymakers were eager to fill (Wettestad, 2005). The emissions trading proposal was drafted in 2001 and submitted to the EU Council of Ministers and the European Parliament. After more than a year of negotiations between the European Parliament and key stakeholders—both industrial and political—the Emissions Trading Directive was formally adopted in October 2003, with trading set to commence in 2005 (European Parliament and Council of the European Union, 2003).

2.2 | Program design and scope

In designing the EU's CO_2 market, EU policymakers took inspiration from the US sulfur dioxide (SO_2) trading system, which was widely considered a success (Stavins, 1998). The US trading system had reduced SO_2 emissions from coal plants at less than half the cost projected by the US government (Ellerman et al., 2005).[5] But it would prove challenging to translate the cap-and-trade concept into a multinational program to control CO_2 emissions.[6]

The central design features of the early EU ETS were as follows. It is built on the legal base of industrial pollution control, capping emissions from large facilities, not companies per se. It puts a cap on the collective emissions of all power plants and industrial facilities that meet certain production capacity criteria (see Section 2.3). Each EU Member State allocates some number of European Union Allowances (EUAs) to each of the plants in their country, with each EUA granting its owner the right to release 1 ton of CO_2. At the end of the year, an auditor verifies the annual emissions for each plant, after which the plant's operator has to surrender the corresponding number of EUAs to the national regulator.

Under conventional pollution control policies, each plant would have no incentive to reduce its emissions below the quota it was allocated. In the EU ETS, however, if it is unusually cheap for one company to cut its emissions below its initial allotment of EUAs, it can turn a profit by doing so and selling its surplus EUAs to another company for which CO_2 abatement is costlier. The second company would find it cheaper to purchase the EUAs rather than to cut its own emissions. Trading will thus redistribute EUAs in such a way that the emissions target, given by the total number of EUAs in circulation, is achieved at the lowest total cost.[7] The market price of EUAs will gravitate towards the lowest marginal cost of abating one additional ton of CO_2 anywhere in the regulated sector.[8]

The EU ETS was implemented in sequential phases (see Figure 1). The pilot phase (Phase 1, 2005–2007) was followed by a second trading phase timed to coincide with the First Commitment Period of the Kyoto Protocol (2008–2012). The legal structures of EU ETS and Kyoto Protocol were in fact coupled: cross-border exchanges of EUAs were matched by transfers of national "Assigned Amount Units" under the Kyoto Protocol (Tuerk et al., 2009). The EU ETS was thus the first legally binding international CO_2 market, providing polluters with incentives to seek emission reductions wherever they would be cheapest, even across national borders.

This principle was extended further by coupling the EU ETS to the other carbon offset mechanisms established under the Kyoto Protocol: the Clean Development Mechanism (CDM) and Joint Implementation (JI). Though highly contentious, the ETS Linking Directive allowed European polluters to purchase international credits and use them to meet their obligations under the EU ETS (Convery, 2009). The share of Kyoto credits that EU ETS companies could use for compliance were limited to meet "Supplementarity" obligations under the Kyoto Protocol, which meant these international offsets are intended as supplementary to domestic emissions reductions of Member States—the latter were to remain the principal focus.

The EU ETS was well-aligned with the Kyoto Protocol, both in the choice of trading phases[9] and in its integration with the CDM. Yet the Emissions Trading Directive was explicitly designed as a European legal instrument that could operate independently, thus establishing an enduring emissions trading system in Europe that protected it from the vagaries of the global politics that undermined the continuation of the Kyoto Protocol. The discrete trading phases also created moments to periodically revisit old design choices in light of new experience (Convery, 2009). "Learning-by-doing" was written into the EU ETS' DNA.

Institutionally, the design of the EU ETS was negotiated between the European Parliament and the European Commission—the bureaucracy serving the Member States—and final decision rested with the Council of Ministers representing the Member States. The European Commission was a central actor, together with the policy network they established, in the design process (Braun, 2009), and would become a central actor in the administration of the program. In the allocation process, the Commission's role was initially to oversee it and ensure that national governments comply with standards and criteria established under Annex III of the Emissions Trading Directive, including the

requirement that the total quantity of allowances must accord with each Member State's Kyoto Protocol emissions target (Convery, 2009). This meant that the key distributional questions associated with allocation would be resolved by the Member States. As we shall see later, this would change radically after the first two phases.

In terms of scope, the EU ETS caps the collective CO_2 emissions of more than 12,000 power plants and industrial plants in 31 countries—28 EU countries[10] as well as Iceland, Liechtenstein, and Norway. Fuel combustion (primarily for power generation) accounts for nearly 70% of emissions, while refineries, cement, iron and steel, and chemicals together account for another 20%, according to verified emissions in 2013–2017. In 2012, the program was extended to cover 1400 airlines operating in the EU.[11] Emissions from road transportation, agriculture, and residential sectors, which are composed of many smaller mobile or non-point source emissions, are all exempted, though consumers in those sectors do see the impact of CO_2 pricing on electricity prices.

3 | EVOLUTION OF THE EU ETS

3.1 | Phase 1, 2005–2007

Phase 1 was designed as a pilot program. The goal was not only to establish a market price for CO_2, but to build administrative capacity within the EU Commission, within national governments, and within industry, ahead of the Kyoto Protocol's first commitment period (2008–2012). Meanwhile, the European Commission prevented firms from holding onto unused EUAs and use them for compliance in subsequent phases (a practice known as "banking").[12] This move was intended to prevent any allowance allocation problems, whatever they might be, to be automatically carried over into Phase 2. The emission caps for Phase 2 would be set to ensure compliance with Kyoto Protocol targets, and those targets would have been compromised if firms could start using excess EUAs left over from the pilot phase.

The ban on banking lowered the stakes somewhat, yet the allocation of CO_2 allowances ahead of Phase 1 still became an early and pivotal point of contention. Economists had laid out the advantages of auctioning allowances to the highest bidders, and the disadvantages of "grandfathering" them (i.e., giving plants allowances for free in rough proportion to their historical emission levels) (Cramton & Kerr, 2002). However, the politics strongly favored free allocation, since it avoided transfers from the polluters to the governments and thus more clearly differentiated the ETS from tax instruments. The Commission imposed a constraint that national governments could auction no more than 5% of EUAs.[13] Almost all EUAs were distributed for free according to the allocation rules set by each country's National Allocation Plans (NAP; Betz et al., 2004).

This allocation process made national governments the targets of the domestic business lobbies that were often concerned more with unfair treatment vis-à-vis their competitors in other Member States, rather than competition from the United States or China.[14] Since there had been few previous attempts to collect installation-level CO_2 emissions data, too, there were substantial informational asymmetries between national regulators and polluters. Many NAPs were consequently produced on the basis of very little information and were subject to intense rent-seeking and lobbying, especially from the largest firms and trade associations in the most polluting sectors (Cludius, 2018; Hanoteau, 2014; Thomas, 2021). Perversely, the fact that NAPs were based on historical baseline emissions that were to be updated over time also introduced a theoretical "moral hazard," where plants might be incentivized to emit more in the short-term in the expectation of getting more free allowances in the future (Grubb & Neuhoff, 2006).

The emissions trading system officially launched on January 1, 2005. The new emissions cap was expected to force electricity producers to shift their generation mix from coal-fired to gas-fired plants, which would reduce emissions at relatively low cost. As natural gas prices rose in 2005; however, the marginal cost of abatement in the electricity sector rose, too. In the first year of trading, the EUA price consequently increased from €10 to €30. While some industries were alarmed that CO_2 prices might go even higher, but these early price developments reassured many observers that the EU ETS would provide a robust CO_2 price.

Things changed unexpectedly when the first year's emissions data started to leak out in 2006.[15] Many industries and governments knew that their own emissions were significantly lower than their allotted EUAs, but they soon discovered that the same was true of many others, too. By late 2006 it had become apparent that more EUAs had been distributed for Phase 1 than industry would plausibly need, and the price of EUAs plummeted (see Figure 1). A surplus of about 280 million EUAs was left by the end of 2007, equivalent to just under 3% of total emissions (Anderson & Di Maria, 2010).

Some observers wrote off the EU ETS as a failure when the EUA (spot) price crashed to zero, but the pilot phase also provided a demonstration of the real-world potential of this new kind of climate policy mechanism. Faced with rising gas and EUA prices, utilities had found alternative ways of cutting emissions, including fuel-switching from less efficient brown coal to more efficient hard coal plants (Neuhoff, 2008). The first published academic assessment credited the EU ETS with cutting Europe's CO_2 emissions that year by about 90 million tons (Ellerman & Buchner, 2008)—a modest, but not insignificant, achievement at this early stage.

The pilot phase demonstrated some of the real-world difficulties, as expected. Some economists had predicted, but few stakeholders had understood, that the system would generate windfall profits for some emitters. This subsequently proved accurate, particularly for electricity generators (more in Section 3.2). Utilities also actively engaged in the CDM and JI to increase their profits (Michaelowa, 2013), resulting in billions of euros of windfall profits which came at the expense of consumers. The bad political optics of having rewarded polluters in this way would later become an important counter-weight to industry lobby groups that wanted to freeze the system in place.

As Phase 1 drew to a close, there was plenty of scrutiny and blame for the public failures. Environment ministries, perhaps unaccustomed to handling market sensitive data, were heavily criticized for the chaotic way in which data were released. The Commission was criticized for preventing the "banking" of allowances. Letting firms hold onto EUAs and use them for compliance in subsequent phases might have mitigated the price crash, but had ensured that Phase 1 was a self-contained 3-year experiment.

3.2 | Phase 2, 2008–2012

The design of Phase 2 incorporated several lessons learned during Phase 1. One important improvement was the use of credible installation-level emissions data to guide the formulation of the Phase 2 NAPs. These data had been generated by reporting and verification procedures in Phase 1, and are one of the underappreciated benefits of the pilot phase. The Commission also raised the limit to let countries auction up to 10% of their allowances in Phase 2.

Another critical design feature of Phase 2 was that it would run concurrently with the Kyoto Protocol's First Commitment period. Because Member States had already agreed to the emission reduction commitments under the Kyoto Protocol, the Commission had a legal basis to curtail the NAPs. National governments projected sharply rising emissions, and submitted NAPs proposing only modest relative cutbacks (Betz et al., 2006). Their proposals would have resulted in an aggregate emissions increase of around 5% relative to 1990 levels. This was inconsistent with the EU's Kyoto target of an 8% reduction. In addition, these proposals were so close to "business-as-usual" emission projections that they presented an obvious risk of another price collapse (Neuhoff, Ahman, et al., 2006).

The European Commission had learnt a number of lessons from Phase 1. Armed with better emissions data, and drawing also on rapid academic evaluation of the NAPs presented to the Commission shortly before its Decision (Grubb & Neuhoff, 2006), the Commission announced the results from its review of the first ten NAPs in November 2006—they rejected nine as inadequate, approving only the United Kingdom's plan.[16] The Commission required that national governments reduce their caps by another 10% to be compatible with the Kyoto Protocol emissions target for the EU.

The announcement came as a shock to many. An agitated German Economics Minister announced that his government would challenge the Commission's decision, but a few weeks later Chancellor Merkel overruled him. Germany was hosting the G8 Presidency in 2007 and Merkel had made climate change a high priority. She could scarcely claim the mantle of global climate leadership and decry the United States' abdication of responsibility, while at the same time suing the European Commission in order to loosen emission limits on German industry. As Germany backed off and withdrew its threat of legal challenge, so did the other Western European countries. If multiple Member States had brought legal challenges, it might have crippled the EU ETS. Instead, the Commission now had a window of opportunity to enact its proposal to cut back the national allocations on the grounds of Kyoto compliance.

The confrontation was not over, though. The new Eastern European Member States had been in the process of joining the EU while the EU ETS was designed. They were thus faced with a new regulatory system into which they had had little input, and which had not been fully incorporated into the EU Accession package. The Commission rejected several Eastern European countries' NAPs on grounds they constituted illegal subsidies through over-allocation. The new Member States felt that the dominant Western European countries had forced the EU ETS on them without considering their interests.[17] Even after the European Court of Justice sided with the Commission, some Eastern European

Member States continued to challenge the ruling for years. The Polish NAP, for instance, was only finalized in April 2010, after some amendments of the internal allocation of EUAs, but with no change to the national emissions cap.

Even as the price of EUAs had collapsed in Phase 1, the price of EUA futures had risen as high as €25. As Phase 2 got underway in 2008, EUA prices again climbed to €30 (Figure 1). Despite the Commissions best efforts, though, multiple factors combined to drive another, and more enduring, price decline. First, as the 2008 global financial crisis turned into economic crisis in the Eurozone, industrial output declined sharply, reducing emissions and the demand for allowances in Europe. The national caps had been set well below "business-as-usual" emissions levels in the United Kingdom, Italy, Spain and Germany, but the gap was much reduced. This was perhaps the most significant cause of emissions reductions during Phase 2 (Bel & Joseph, 2015; Koch et al., 2014). A second factor was the glut of carbon offsets issued under the CDM and JI. The early prospect of fetching €30 for a ton of avoided CO_2 proved huge draw for developers all over the world, who locked in projects that would yield far greater volumes of carbon offsets than had been anticipated (Grubb et al., 2011). Third, ambitious energy policies—including energy efficiency and particularly renewable energy policies in Germany and Spain—provided a separate mechanism for forcing power companies to cut emissions. Given that power companies had been historically important net buyers of EUAs, these domestic policies significantly reduced aggregate demand for allowances. EU emissions fell by 11% from 2008 to 2009, resulting in a surplus of around 80 million EUAs. CO_2 prices that had been projected to rise towards €40/tCO_2 instead declined (Figure 1). The price did not collapse as it had in Phase 1, though, this time cushioned by rising energy prices and the new provision permitting polluters to bank unused EUAs for future compliance.

Another important blow came in 2009, however, when the much-anticipated Copenhagen summit underdelivered. The EU had promised to strengthen its 2020 emissions target from 20% to 30% reduction in the event of a global climate deal. The failure in Copenhagen therefore had the knock-on effect of undermining expectations for Phase 3 of the EU ETS. This reduced the value of Phase 2 allowances as a means of future compliance, and the price halved to below €10/tCO_2 (Figure 1). Even so, evidence suggests that EU ETS did reduce CO_2 emissions during Phase 2 by roughly 10% (Bayer & Aklin, 2020; Dechezlepretre et al., 2018).

Several key lessons from Phases 1 and 2 informed the design of Phase 3.[18] First, many firms, particularly in the electricity sector, had earned windfall profits by raising prices even while receiving their allowances for free (Ellerman et al., 2016; Sijm et al., 2006). This weakened the political case for "grandfathering." An influential Carbon Trust (2008) report made clear that the economic logic of "grandfathering" to protect domestic industries, too, was less clear-cut than had been previously portrayed. It had been expected that polluters would be unable to pass on the CO_2 price to their customers (e.g., due to intense foreign competition), so they would need free allocations just to be able to maintain their profit margins (see upper left-hand point of Figure 2). Without free allocation, the companies would have to pay

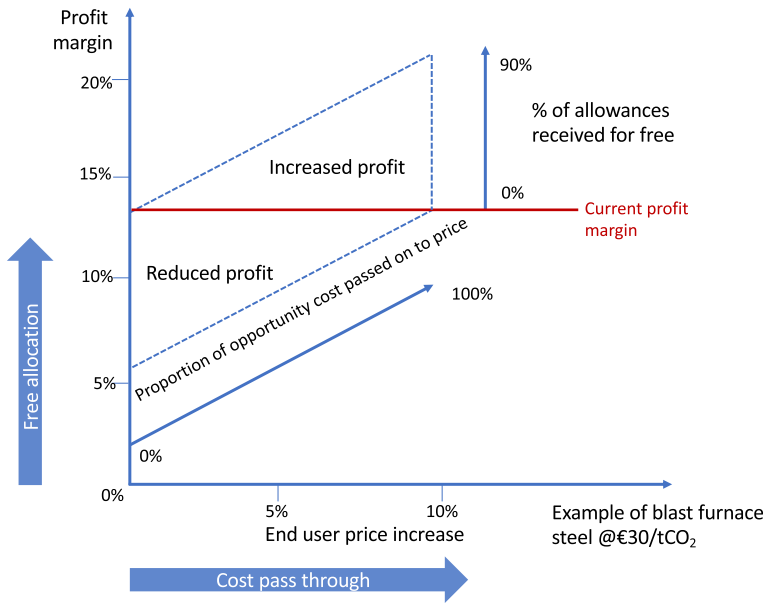

FIGURE 2 Relationship between profit/loss, free allocation and cost pass through, in the example of primary steel making in Europe. CO_2 price assumed to be €30/tCO_2. *Source*: Carbon Trust (2008), as presented in Grubb (2014)

for all its emissions and face severely reduced profit margins (the bottom left-hand corner). However, it turned out that some polluters were able to pass through a large share of the cost after all, particularly electricity producers. These companies did not need to pay to obtain the allowances, yet could generate billions of euros of windfall profits by charging higher prices to consumers (top right-hand corner).

In industrial sectors that face greater outside competition, the evidence suggests that less of the CO_2 price was passed through (CE Delft and Oeko Institute, 2015; Hintermann et al., 2020; Neuhoff & Ritz, 2019). While free allocations had helped some industrial firms weather the financial crisis, the downsides of "grandfathering" had also become abundantly clear. Most firms would not be fundamentally disadvantaged by greater auctioning.

A second lesson was that it was harder for firms to make long-term plans and structural investments when trading phases were relatively short. There were signs that the political uncertainty associated with the start of each new phase was stymying low-carbon investments. Phase 3, it was decided, would run for 8 years. This decision also meant that the EU ETS would be in even greater need of a mechanism for managing the supply of allowances within a trading period, the lack of which had created so many problems in Phases 1 and 2. As we shall see, much of Phase 3 was spent trying to resolve this design problem.

A third lesson was that allowance banking during Phase 2 had provided greater flexibility to firms, and had helped to prevent another price crash. In reality banking had also contributed to lower prices after the failure of the Copenhagen summit, but allowance banking nevertheless became viewed as integral to the design of emissions trading moving forward.

Finally, the financial crisis raised questions about the legitimacy of emissions trading, including whether climate policy should be driven by the interests of financiers (Paterson, 2013). The decentralized CO_2 market, overseen by national regulators of varying capabilities and regulated by a patchwork of regulations, had invited fraud and speculation. This brought to light the need for stronger and better coordinated market regulation.

3.3 | Phase 3, 2013–2020

Even as Phase 2 was just beginning, EU lawmakers agreed that there would be a third phase of the EU ETS whether or not the negotiations for a new international agreement succeeded. Industry needed credible commitments from their governments in order to be able to plan ahead. The biggest change in the design of Phase 3 was that the allocation process became centralized under the European Commission. This would not have been politically conceivable in 2003 when EU ETS was first set up. However, Phase 2 had brought into full view the political nightmare of assessing and approving national allocation plans created separately by each national government in negotiation with their industries and solidified the Commission's fundamental belief in the superiority of EU level allocation rules to create space for less confrontational and more productive negotiations (Skjærseth & Wettestad, 2010). In addition, the perception that the State-by-State process was creating a "race to the bottom" undermined the EU's credibility in advocating for an ambitious deal at the Copenhagen summit. A centralized process strengthened the EU's claim to be able to deliver what is offered in global negotiations.

In March 2008 the European Council of Ministers agreed that the EU should aim to cut its emissions by 20% by 2020 (from 1990 levels), with the promise of a 30% reduction in the event of an acceptable global deal at the upcoming Copenhagen summit. A number of special derogations were also negotiated to alleviate objections from Eastern European Member States, including to allow them to reduce free allowances to power sector more gradually in Western European countries.[19]

This transitional agreement aside, the Phase 3 centralized allocation process represented a radical break from the past. There was more recognition that the previous focus on the political necessity of winning over industry support with free allocation had inadvertently produced politically unpalatable transfers from consumers to large polluters. This transformed the politics of free allocation. The economic arguments about the relationship between free allocation and profits now began to hold more sway (see Figure 2). The European Commission seized its opportunity to enact fundamental changes.

They made auctioning the default allocation mechanism in Phase 3, requiring 100% auctioning in the electricity sector. Exceptions would need to be targeted more narrowly to sectors that faced genuine concerns over competitiveness and might really relocate outside of the EU. The Carbon Leakage Decision established that only sectors with sufficiently high carbon-intensities and trade-intensities would continue to qualify for free allowances. Politically, the reliance on transparent and objective criteria to assess leakage risk at the sector level could be seen as a pragmatic move to limit

the influence of powerful companies that had previously secured advantageous allocations by negotiating with national governments.

The Carbon Leakage Decision also established another important principle: that allocation of CO_2 allowances should be "benchmarked" against best practices within sectors. In the early years of the EU ETS, economists had pointed out that awards on the basis of each facility's historical emissions created perverse incentives (Ellerman et al., 2007). Product benchmarks would encourage early action, and would in theory also limit political distortions of the allocation process.

Despite these promising design changes, Phase 3 was in for a rough start. The economic crisis that began in 2008, along with the influx of CDM credits, the success of renewable energy policies, and the failure of the negotiations in Copenhagen, had all combined to create an accumulated surplus of nearly 2 billion tons-worth of allowances, sufficient to cover business-as-usual emissions through to the end 2020. The CO_2 (spot) price nudged upward with each sign of action, and sunk with each setback,[20] falling as low as €3/tCO_2 in February 2013, just as Phase 3 was starting (Figure 1) (Wettestad & Jevnaker, 2016).

Were low prices really a problem at the time? Politically, with a major recession and the collapse of the global effort at Copenhagen, the ability to respond to business and political cycles likely saved the system. A CO_2 tax may have struggled, if not been repealed outright. Energy prices had been climbing since mid-2000s, and now people were suffering the consequences of a severe recession. CO_2 prices were so low that it stayed below the political radar. The EU ETS did not become a political target for managing the cost of living.

Soon after Phase 3 began, the implementation of the Carbon Leakage Decision also revealed a number of political miscalculations in its design. Energy-intensive industry had by then "woken up" and gotten organized and powerful both at national and EU levels (Wettestad, 2009), and their industry associations succeeded in getting their sectors qualified for free allocations. Having objective criteria to assess leakage risk had not prevented 156 sectors, representing 98% of emissions, from being included on the list of sectors entitled to free allocation. The cement industry provides an instructive example of how this happened. Around 2010 a major cement company was ready to back and promote an industry position to accept zero free allocation in Phase 3, on the condition that there would be an appropriate border-related charge. Yet, when the European Parliament tried to make this amendment to Phase 3, the cement lobby came out in unanimous opposition. It turned out that, after further private discussions, the cement producers had agreed that they could only support the proposition if it also applied to the steel industry—since they compete in the same construction markets—and the proposal was defeated.[21]

With the centralization of the allocation process and Brussels based business associations playing a more central role, many industrial sectors continued to secure substantial over-compensation (Martin et al., 2014). Setting benchmarks requires detailed technical knowledge and data on complex production processes, which gave industry an important informational advantage, and a great deal of influence in the development of benchmarks. The cement sector, to give one example, was able to influence the clinker benchmark to such a degree that it created incentives for cement makers to keep up, rather than to reduce, the use of clinker, the key carbon intensive input in cement production (Branger & Sato, 2017).

The EU ETS still did not have a mechanism to manage excess supply of EUAs within a trading period, so a proposal was made to temporarily restrict the supply of EUAs by postponing the sale of allowances to auctions that would take place later in Phase 3, a practice known as "back-loading." In total, 900 million allowances were back-loaded between 2014 and 2016. This made only a small dent in the supply glut and failed to raise price expectations (Koch et al., 2016), but the broad political support for this intervention signaled an appetite for creating a more permanent solution. The favored option that emerged was the Market Stability Reserve (MSR), which would enable more active management of the supply of allowances and thus protect the EU ETS from unexpected and sudden demand shocks.[22] The MSR began operating in 2019, placing the back-loaded allowances into the reserve instead of selling them at auction. Together, these two reforms managed to temporarily reduce the supply of allowances (Wettestad, 2014; Wettestad & Jevnaker, 2016). Coupled with rising industrial output and announcements about Phase 4 reforms that further bolstered confidence in the EU ETS, the CO_2 price once again rose above €20 by late 2018.

The success of the this "rescue mission" has been attributed to timing and compromises made at national and EU levels, as well as the fact that it was backed by key business actors (Jevnaker & Wettestad, 2017). This was in turn enabled by deliberate and concerted coalition-building efforts among interest groups garnering support from and close collaboration between businesses and environmental groups (Fitch-Roy et al., 2020).

The reforms adopted leading up to and during Phase 3 show policy makers beginning to navigate the political and economic trade-offs of a complex multinational CO_2 market. A centralized allocation process might avoid the "race to

the bottom" dynamic. Full auctioning of allowances in the electricity sector avoids windfall profits, while transparent risk assessment for industries to qualify for free allowances might better targets leakage protection and sectoral benchmarks might create incentives for early action. The longer trading phase and the creation of a mechanism to dynamically control the supply of allowances might help to stabilize price expectations and promote long-term planning. Collectively, these reforms speak to the increasing influence of economic principles as the guide for how the carbon market should be designed. However, there is also abundant evidence of a continuing political tug-of-war. Each reform created new opportunities for industry to exert influence, and at times they succeeded in undermining the reformers' ambitions.

3.4 | Phase 4, 2021–2030

The Phase 4 planning process began in 2015 with a reform package put forward by the European Commission. Facing historically low EUA prices, these reforms took aim at restoring long-term price expectations, and at bringing the EU ETS into alignment with EU's overall 2030 target to reduce CO_2 emissions by at least 40% below 1990 levels. Negotiations between the European Commission, Council, and Parliament were concluded in November 2017, and the new Directive entered into force in April 2018.

The reform package made important changes to shore up and to stabilize price expectations. It accelerated the tightening of the emissions cap, moving from an annual linear reduction of 1.74%–2.2%. The annual free allocation volume continues to decline in line with the overall cap (Figure 3).[23] It also made the MSR a permanent feature of the EU ETS and doubled the number of allowances to be set aside through the end of 2023. More of the revenue from allowance auctions would also be hypothecated to support innovation and modernization. In Phase 3, the revenue from the sale of 300 million allowances had been earmarked for demonstration projects. In Phase 4, the revenue from auctioning

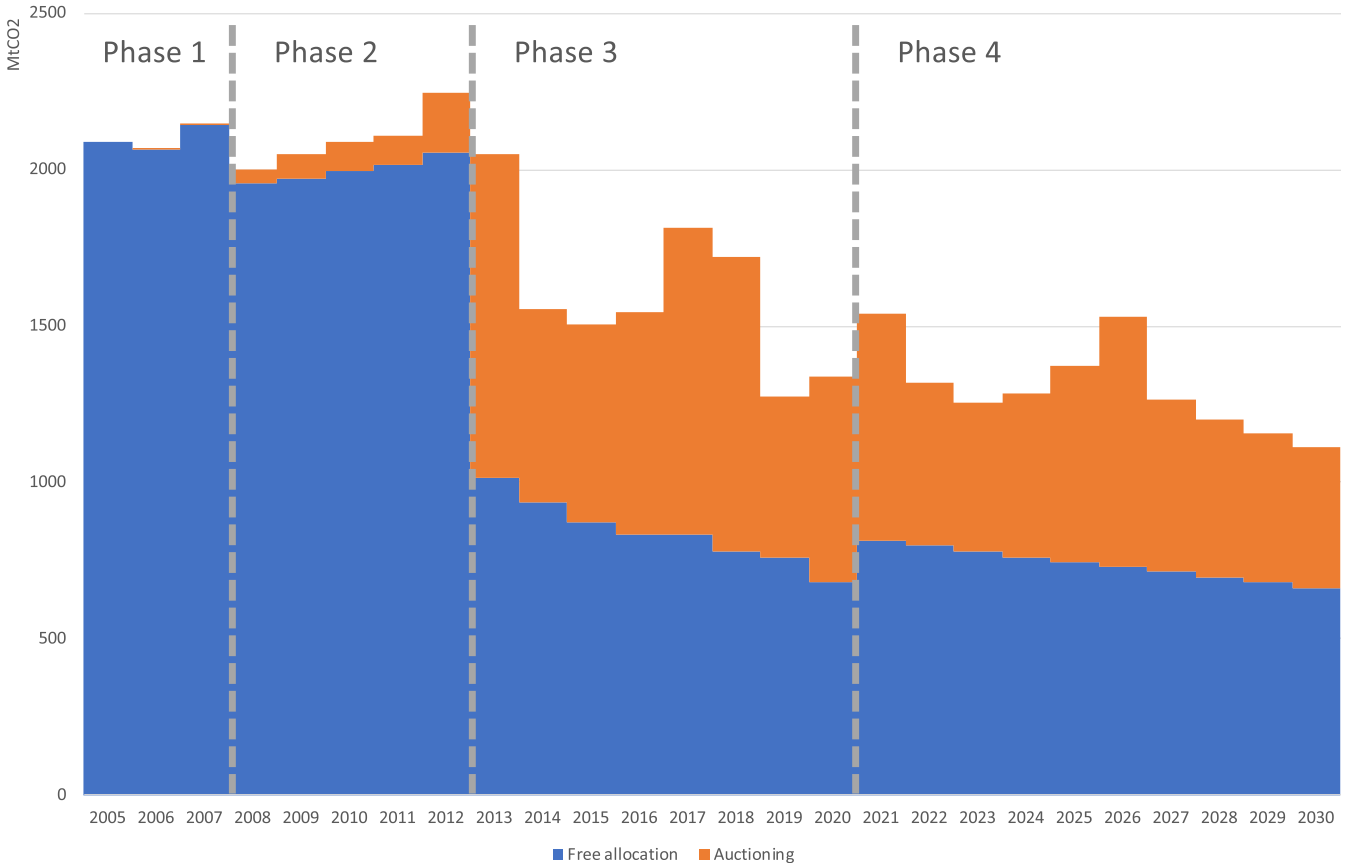

FIGURE 3 Free allocation and auction volume over Phase 1–4 (2005–2030) excluding aviation. Based on data from Sandbag analysis for Carbon Brief. Assumes the market stability reserve (MSR) will prevent some allowances entering the market, shrinking the auction pot.

450 million allowances in Phase 4 (expected to be around 2 billion euro per year) would be earmarked for a new "Innovation Fund" that supports the development of low carbon technologies, and another 2% of the revenues from allowance auctions will be sent to a new "Modernization Fund" to support energy systems upgrades in 10 low-income Member states.[24]

The reform package also put renewed emphasis on leakage protection as the main principle guiding the use of free allocations. To begin with, it was determined that free allocations to sectors with a lower leakage risk would be phased out from 2026. The question over which sectors qualified for free allocations in the interim was, of course, not entirely removed from the political arena, and many sectors continued to exert influence. It was decided that 63 sectors would still be entitled to receive up to 100% of their benchmarked allocations for free, representing 94% of Europe's industrial emissions. A mitigating factor was the decision to tighten benchmarks slightly, so that free allocations would be less generous to those that still qualified.

The reform package also moved towards using an "output-based" methodology to set levels of free allocations for industry, which reflected an important change in the thinking around leakage protection. Free allocations were previously set in reference to historical emissions of the plants themselves or of sectoral benchmarks, but now free allocations would be adjusted dynamically in response to the current output of leakage-prone facilities. This ensures that they have enough allowances to operate even if production increases, and thus removes the incentive to reduce emissions by outsourcing production (Fischer & Fox, 2007). The same number of free allowances now provide more robust leakage protection (Böhringer et al., 2017). The downside of this approach is that if the CO_2 price does not get passed through to customers, this removes the incentive for consumers to substitute towards cleaner alternatives (Böhringer & Lange, 2005). This downside was now judged to be smaller than previously believed, based on evidence that the price signal was already being muted by industry's inability to pass through the CO_2 price.

A smaller, but nonetheless significant innovation in Phase 4 was the creation of a formal process and schedule for periodic review, meant to facilitate long-term planning and investment.[25] The reviews are aligned to the five-yearly timetable of global stocktakes under the Paris Agreement, with the first global stocktake taking place in 2023.

The announcement of this package of reforms resuscitated the EU ETS. By late 2018 the CO_2 price had climbed above €20/tCO_2 for the first time in a decade (Figure 1). But ETS reform was back on the agenda almost immediately. The Greens won more seats in the EU elections, and Ursula von der Leyen was elected as the new European Commission President in 2019. She pushed for a "Green Deal for Europe", pledging to deliver a European Climate law, and a new target of at least 50% emissions reduction by 2030, all within her first 100 days. The Phase 4 reforms had taken several important incremental steps, but more ambitious reforms would be required to reach these new targets. Several significant changes were now being considered, including:

- extending the EU ETS to cover the maritime, road transport, and buildings sectors;
- overhauling the carbon leakage regime, including the proposal for a Carbon Border Adjustment Mechanism (CBAM);
- and making a major adjustment to the emissions cap through a one-off downward adjustment ("re-basing") or by further increasing the linear reduction factor (Zaklan et al., 2021).

As negotiations on the new EU ETS and CBAM legislation advanced, the price of EUAs first passed €30/tCO_2 as Phase 4 began, and later reached €80/tCO_2 (Figure 1).

Europe's revamped commitment on climate brings new challenges for the EU ETS. Expanding the EU ETS will require buy-in from new sectors. Getting industrial sectors that would be protected by the CBAM to accept zero free allowances is already proving to be a key hurdle. The European Parliament has already rejected a proposal to phase out free allocation. The Commission's proposal phases in CBAM proportionately as free allocation is phased out by 2028 (European Parliament, 2021). The reopening of negotiations on emissions caps will also certainly re-energize the tug-of-war between different sets of interest group (Paterson, 2012).

The history of the EU ETS may appear, at first, a sequence of political compromise followed by unwelcome surprises. But looking at each compromise in isolation misses the larger arc of the reforms. Every concession to energy-intensive industry has been part of a larger negotiation about the future of EU ETS. Each reform gives rise to new coalitions, and also alters the incoming stream of evidence, changing the scope and direction of future negotiations. The EU ETS experience has taught us a great deal about the real design trade-offs, which in many cases

turned out to be different from what had been expected going in (e.g., static vs. dynamic effects of allocation rules, demand vs. supply uncertainty from longer trading periods, and leakage protection vs. demand substitution). Over the longer term, the EU ETS has evolved towards a design that manages these trade-offs in a more sophisticated way.

4 | REMAINING CHALLENGES

Several critical design-challenges still remain. How the renewed reform efforts address these challenges will likely determine the long-term effect of the EU ETS, will help to set the tone for carbon pricing reforms worldwide, and may help to decide whether the goals of the Paris Agreement will be within or beyond our reach. In this section, we review the major design challenges.

4.1 | Addressing carbon leakage

Carbon leakage—the climate policy driven displacement of production activity and thus emissions beyond the borders of the EU—is a potential threat to the environmental integrity of the EU ETS and to the economies of EU Member States. In practice, given the generous free allocation levels historically, it is not surprising that the EU ETS has not caused substantial leakage so far (Naegele & Zaklan, 2019; Verde, 2020).

The idea of companies moving production abroad largely turns out to be caricature, though. Far more important is the fear of foreign competitors that can sell at lower prices in domestic markets. At a longer time scale, fluctuating CO_2 prices create uncertainty at home, making it comparatively safer to invest new capital abroad. The salience of these considerations varies a lot according to particular market conditions, as well as the geographical scope of a firm's operations. Multinationals, for example may not care as much where they locate their next big investment.

The ones who struggle most with carbon leakage are the politicians, and this is what makes this argument a powerful weapon in the hands of industry (Anger et al., 2016). Companies will almost always fight efforts by government to extract revenue from their sector, and they are much more vociferous and effective if they can claim a policy treats them unfairly relative to their competitors, whether at home or abroad. At a local level, politician can rarely refuse a company, threatening to cut jobs and relocate unless they are granted exemptions from, or compensated for, climate policy.

One of the most significant lessons to have emerged from the EU's debate over free allocations, therefore, is the importance of disentangling revenue transfer (which drives lobbying) from the fear of carbon leakage (the formal argument and rationale for free allocation). The two motives were entwined at the start, with free allowances being the primary political tool that enabled the creation of the EU ETS. But subsequent reforms have gradually begun to drive a wedge between them. Calibrating free allocations to industry benchmarks has ended the built-in advantages that historically polluting firms had with "grandfathering," and instead rewards early action (Zetterberg, 2014). Also, by transitioning from fixed lump-sum allocations based on historical emissions towards output-based allocations, more robust leakage protection is achieved with the same number of allowances (Böhringer et al., 2017), the downside as noted before being the muting of the carbon price signal down the value chain.

To what extent do the current reform proposals advance this separation of revenue transfers and carbon leakage? A carbon border adjustment mechanism, proposed as part of the EU Green Deal, should in theory enable CO_2 costs to be internalized throughout the value chain and address leakage completely (Cosbey et al., 2019). This would open up space for free allocations to be phased out entirely. However, some important political and administrative constraints may limit both the effectiveness and acceptability of this solution. The fact that rebates for EU exporters would be contrary to WTO principles, or that charging CBAM on imports from least developed countries conflicts with international climate change law (Pirlot, 2021), for instance, means that there are still downsides even with a CBAM charging importers. The Commission proposal to gradually phase in a CBAM before completely phasing out free allocations may raise protectionist concerns that could trigger retaliation by the EU's trading partners (Leal-Arcas et al., 2022).

Industry will undoubtedly also influence the ultimate shape of a CBAM. Indeed, the EU Transparency Registry data records significant lobby activity around the planning and negotiations for a CBAM.[26] Although a CBAM in theory promises to further separate the issues of carbon leakage and revenue transfer, it remains an open question whether this can be accomplished in practice.

Neuhoff et al. (2016) proposes, as an alternative to a CBAM, to implement a "climate contribution" or excise duty on basic material production and imports, combined with continued output-based free allocations. This could simultaneously address leakage and eliminate the incentive for producers to outsource production, thus reinforcing the CO_2 price both up and down the supply chain. Economists have also advocated creating "climate clubs" of countries that adopt a common CO_2 price and impose higher VAT or other punitive measures against non-members (Nordhaus, 2015).

Leakage from the EU ETS has so far been minimal, but the way this was accomplished—free grandfathered allowances—has some very real downsides. The reforms in Phase 4 continue to move the EU ETS further in the direction of leakage prevention without free allocations. History teaches us that we should not only pay attention to the particular concessions that a deal will inevitably include, but also to think about how such a deal will change the scope and direction of future negotiations.

4.2 | Encouraging low-carbon investment and innovation

Considerable technological development is required to put nations on a path towards rapid decarbonization (Rockström et al., 2017). One of the principal objectives of the EU ETS has been to contribute to this transition by encouraging polluters to invest and innovate in low-carbon technologies (European Commission, 2005). However, unpredictable CO_2 prices and rapidly changing rules are not necessarily conducive to large private sector investments in risky technologies with long time horizons.

The EU ETS certainly has not single-handedly brought about the technological change necessary for deep decarbonization (Lilliestam et al., 2021). Nevertheless, it appears to have been moderately successful in stimulating low-carbon innovation among firms regulated under the program (Calel, 2020; Calel & Dechezleprêtre, 2016; Grubb et al., 2021). Expected future stringency of EU ETS has been an important factor motivating companies to innovate more (Martin et al., 2014).

By contrast, the EU ETS does not seem to have had much effect on near-term investments in low-carbon capital. The EU ETS does not appear to have affected total capital expenditures (Aus dem Moore et al., 2019), and most studies find little direct or indirect evidence of low-carbon investment specifically (Borghesi et al., 2015; Calel, 2020; Jaraite-Kažukauske & Di Maria, 2016; Klemetsen et al., 2020; Löfgren et al., 2014; Petrick & Wagner, 2014; Widerberg & Wrake, 2011). The only exception appears to be France, where the observed reduction in carbon-intensity appears to be best explained by small but significant low-carbon capital investments (Colmer et al., 2020).[27]

Several of the reform have been driven partly by a desire that the EU ETS provide greater incentives for investment. The Market Stability Reserve is intended to provide a more stable price signal to the private sector. Sectoral benchmarking of free allowance allocations, too, provides greater incentives for investment by rewarding the cleanest firms, instead of rewarding firms simply for having historically high emissions. The new Innovation Fund and Modernization Fund also represent an effort to pursue technological transformation more aggressively. These Funds are relatively small so far, but they signal a direction of change that could prove enormously consequential in the longer term.

The renewed Phase 4 reform discussions, especially the debate around the "Fit for 55" package, reflect a desire to kick start the industrial transition to carbon neutrality. One idea attracting growling attention is for "Carbon Contracts for Differences," whereby governments make advance commitments to pay a fixed CO_2 price to investors (Chiappinelli & Neuhoff, 2020). Several more familiar measures are also being debated, including green public procurement, sustainable finance, and a ban on sales of products from emission intensive processes. All of these measures are targeted at trying to reduce the financial risks of low carbon investment (Neuhoff et al., 2021).

5 | LEARNING FROM EUROPE'S EXPERIENCE

Some 20 years after the EU embarked seriously on creating an international CO_2 market, the inarguable fact is that designing and implementing such a program has repeatedly tested the limits of political and economic understanding. The EU ETS we have today would have been politically unimaginable in 2003, nor did economists predict which trade-offs would end up mattering most. Europe's experience with CO_2 trading is one of co-evolving political and economic ideas.

Notwithstanding the simple economic principle that for markets to work properly, external damages should be reflected in the cost of producing and consuming goods, no-one likes paying for activities that were previously free (to them at least). Free allocation may be useful in securing initial buy-in from polluters, and for creating a constituency in favor of continuing the system, but it may be possible to purchase these political advantages at a lower price. Separating electricity from trade-exposed industrial producers, and using output-based allocation rules selectively where the downsides are minimal, could avoid building in a number of structural inefficiencies, and more importantly, may avoid spawning powerful coalitions whose interest in protecting rents are at odds with the elimination of those inefficiencies. Policy makers will inevitably have to tackle innumerable technical complexities, distributional contests, governance challenges, and leakage concerns, and the initial ETS design can profoundly shape the political environment in which these questions have to be resolved. If we learn this lesson from the EU's experience, other jurisdictions may find a more direct route to efficient and effective CO_2 pricing programs.

Another critical lesson is that politicians and experts are unlikely to correctly anticipate the best way to design every detail of a CO_2 market. The clear implication is that ETS designs can benefit greatly from being open to evolution, with scope for learning-by-doing reflected in sequential stages. This sounds like a recipe for uncertainty and instability, but it need not be, especially if the legal underpinnings are secure and if there is a formal process for periodic review.

The EU ETS today bears little resemblance to its starting point of National Allocation Plans, a legal minimum of 95% free allocation, almost all grandfathered, no mechanisms to ensure an adequate and stable price, and premised on the fantasy that international agreements would solve the leakage problem. Confronted with the realpolitik of pricing CO_2, the EU ETS still has important challenges to overcome, but with every step, has become a system that shows ever greater evidence of delivering on its founding promises—to efficiently reduce emissions in pursuit of increasingly urgent and ambitious climate targets.

AUTHOR CONTRIBUTIONS

Misato Sato: Conceptualization (lead); formal analysis (supporting); project administration (lead); supervision (lead); writing – original draft (supporting); writing – review and editing (lead). **Ryan Rafaty:** Conceptualization (supporting); data curation (supporting); formal analysis (supporting); writing – original draft (lead); writing – review and editing (supporting). **Raphael Calel:** Formal analysis (supporting); writing – review and editing (supporting). **Michael Grubb:** Writing – original draft (lead); writing – review and editing (supporting).

ACKNOWLEDGMENTS

We have received helpful comments from Matthew Paterson and two anonymous referees. Misato Sato gratefully acknowledges financial support from the Economic and Social Research Council Future Research Leaders grant ES/N016971/1, the ESRC Centre for Climate Change Economics and Policy (CCCEP) (ref. ES/R009708/1) and the Grantham Research Institute on Climate Change and the Environment, at the London School of Economics.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ORCID

Misato Sato https://orcid.org/0000-0002-9978-9595
Raphael Calel https://orcid.org/0000-0002-0759-0395
Michael Grubb https://orcid.org/0000-0003-2393-3041

RELATED WIREs ARTICLES

The EU emissions trading scheme
Carbon markets: A historical overview
The effects and side-effects of the EU emissions trading scheme
The European Union Emissions Trading Scheme: Should we throw the flagship out with the bathwater?

ENDNOTES

[1] Our definition of the political economy of the EU ETS is thus in line with public choice theory (see chapter 5 of van Zeben (2014) for a conceptual overview of public choice theory and its relation to EU ETS discourse). Our analysis refrains from exploring broader questions around how the ETS development interacts with the overall structure of the global political economy (see Paterson & P-Laberge, 2018).

[2] Standard academic search engines including Web of Science and Google Scholar were used to identify the relevant peer-reviewed articles for our analysis.

[3] The international diffusion of CO_2 trading happened largely outside of the climate governance process and focused on the transnational network of ETS advocates (Paterson et al., 2014).

[4] Pezzey (2003) points out that in theory one could get the same effect with a tax that is paid only above a set emissions threshold.

[5] The costs of regulation using economic incentives are consistently overestimated *ex ante* (Harrington et al., 2000).

[6] The idea of applying ideas of emissions trading for CO_2 was proposed earlier, including by the Project 88 team led by Stavins, and international level trading by Grubb (1990) and Paterson et al. (2014).

[7] Although the point on efficiency of emissions trading and inefficiency of command and control regulation is frequently credited to Coase (1960), it was in fact a series of historical developments in pollution regulation in the United States in the 1970s and 1980s that translated into this "law" (Lane, 2012).

[8] In practice, EUAs can not only be traded with other plants, but also with financial intermediaries, and even with private individuals. An active market in derivatives has also emerged. See Betz and Schmidt (2016), Cludius and Betz (2020) and Abrell et al. (2021) for analysis on trading behavior and intermediaries.

[9] Ironically, while the Kyoto Protocol's first period defined the timeframe of the EU ETS Phase II, if anything it was the other way round subsequently: the demand from industry for greater certainty and foresight drove the EU decision to extend Phase 3 to and eight-year period, which then became the EU's (successful) position in lobbying for the Kyoto Protocol's Second Commitment Period to match that.

[10] United Kingdom left the EU on February 1, 2020, and separated from the EU ETS at the end of the transition period (December 31, 2020), replacing it domestically with the UK ETS.

[11] Private, non-commercial jets are exempt if their annual emissions fall below a minimum threshold of 1000 tons CO_2.

[12] In practice the rules of the EU ETS did make it possible for Member States to bank allowances forward through technicalities, and France and Poland sought to do so, but this loophole was closed once the Commission announced that any banked allowances would be removed from the Phase 2 emissions cap.

[13] In the end, only Ireland, Hungary, Denmark and Lithuania actually conducted auctions, but each for an even smaller percentage (Betz et al., 2004).

[14] M. Grubb (personal communication), drawing upon research consultations at the UK Carbon Trust, cites the example of UK-based refineries, who expressed major concern about the differentials in allocations of the Dutch government to their refineries as being far more important than concerns about competition from refineries outside Europe.

[15] The first leaks came from the Netherlands and the Czech Republic, which both announced significantly lower emission levels than their allocations. This was followed by announcements and leaks from a number of other countries, including a technical fault that leaked the data for 20 countries on May 12, 2006.

[16] Spain without its proposed NAP, and few months later in February 2007, its revised plan was also approved, with conditions.

[17] Emissions from these countries had mostly declined so much since 1990 that compliance with Kyoto Protocol targets was not the issue; instead, the Commission used anti-subsidy provisions to oppose NAPs which offered implausibly inflated allocations.

[18] Phase 3 reforms were largely agreed on by 2009.

[19] These included fuel-specific benchmarks which enabled them to give more free allowances to coal plants than to gas, for example.

[20] Calls from the European Commission and Germany to move unilaterally to a 30% emissions reductions target failed to garner support, for example.

[21] M. Grubb (personal communication). Not only was analysis of implications of auctioning in the steel sector more limited and complex than in cement, and the industry more directly exposed to international competition: the economic

stakes were also much higher and more concentrated, and lobbying correspondingly more brutal: the CEO of Arcelor Mittal threatened to close key plants if he did not get what the industry demanded in terms of free allowances, risking huge political fallout in major Member States.

[22] Having started from a position of principle that Phase 3 volumes and prices could not be adjusted, the Commission gradually changed its position as prices sank, recognizing that single-digit prices out to 2020 would fundamentally undermine its claim for the ETS to be a key driver of emission reductions, let alone low carbon investment. However it remained adamantly opposed to a formal price floor, which many economists recommended. Again this was related to the legal and political context including the political difficulty of negotiating a specific price and the fear of opening a legal door to claims that the ETS was turning into a tax requiring unanimity.

[23] Article 10a(5) and 10a(5a) of Directive 2003/87/EC set the maximum volume of total annual free allowances. If this is exceeded, an annual uniform cross-sectoral correction factor is applied to adjust the free allocation volumes.

[24] One of the main sticking points in the talks over the reform was whether to keep coal blacklisted from the new funding mechanisms. Under the Estonian Presidency, The EU ultimately did allow one exception to coal-fueled district heating systems in Romania and Bulgaria.

[25] The Article 30 text says: "This Directive shall be kept under review in the light of international developments and efforts undertaken to achieve the long-term objectives of the Paris Agreement" (European Parliament and Council of the European Union, 2018).

[26] Interest groups stating explicitly in their lobbying reports that all or part of the discussion topics in meetings with EC officials in 2020 pertained to the CBAM include: the European Cement Association (CEMBUREAU), The European Steel Association (EUROFER), the Confederation of European Business (which includes 40 national industry and employers' organizations), Repsol (energy and petrochemical producer), ArcelorMittal (steel producer and mining), and Norsk Hydro (aluminum producer).

[27] It should be noted, also, that despite little evidence of carbon leakage, there is some evidence that the EU ETS has encouraged investment in non-EU countries, in the form of FDI (Borghesi et al., 2018).

FURTHER READING

Grubb, M., Jordan, N. D., Hertwich, E., Neuhoff, K., Das, K., Bandyopadhyay, K. R., van Asselt, H., Sato, M., Wang, R., Pizer, B., & Oh, H. (2022). Carbon leakage, consumption and trade. *Annual Review of Resource Economics*, Vol 47.

IPCC. (2022). Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

REFERENCES

Abrell, J., Cludius, J., Lehmann, S., Schleich J., & Betz R. (2021). "Corporate emissions-Trading behaviour during the first decade of the EU ETS." *Environmental and Resource Economics*, 1–37.

Anderson, B., & Di Maria, C. (2010). Abatement and allocation in the pilot phase of the EU ETS. *Environmental and Resource Economics*, *48*, 83–103.

Anger, N., Asane-Otoo, E., Böhringer, C., & Oberndorfer, U. (2016). Public interest versus interest groups: A political economy analysis of allowance allocation under the EU emissions trading scheme. *International Environmental Agreements: Politics, Law and Economics*, *16*(5), 621–638.

Aus dem Moore, N., Großkurth, P., & Themann, M. (2019). Multinational corporations and the EU emissions trading system: The specter of asset erosion and creeping deindustrialization. *Journal of Environmental Economics and Management*, *94*, 1–26. https://doi.org/10.1016/j.jeem.2018.11.003

Bayer, P., & Aklin, M. (2020). The European Union Emissions Trading System reduced CO_2 emissions despite low prices. *Proceedings of the National Academy of Sciences*, *117*(16), 8804–8812.

Bel, G., & Joseph, S. (2015). Emission abatement: Untangling the impacts of the EU ETS and the economic crisis. *Energy Economics*, *49*, 531–539. https://doi.org/10.1016/j.eneco.2015.03.014

Betz, R., Eichhammer, W., & Schleich, J. (2004). Designing national allocation plans for EU emissions trading—A first analysis of the outcome. *Energy and Environment*, *15*(3), 375–425.

Betz, R., Rogge, K., & Schleich, J. (2006). EU emission trading: An early analysis of national allocation plans for 2008–2012. *Climate Policy*, *6*(4), 361–394.

Betz, R., & Schmidt, T. S. (2016). Transfer patterns in Phase I of the EU emissions trading system: A first reality check based on cluster analysis. *Climate Policy*, *16*(4), 474–495. https://doi.org/10.1080/14693062.2015.1028319

Böhringer, C. (2014). Two decades of European climate policy: A critical appraisal. *Review of Environmental Economics and Policy*, *8*(1), 1–17.

Böhringer, C., & Lange, A. (2005). On the design of optimal grandfathering schemes for emission allowances. *European Economic Review*, *49*(8), 2041–2055.

Böhringer, C., Rosendahl, K. E., & Storrøsten, H. B. (2017). Robust policies to mitigate carbon leakage. *Journal of Public Economics*, *149*, 35–46.

Borghesi, S., Cainelli, G., & Mazzanti, M. (2015). Linking emission trading to environmental innovation: Evidence from the Italian manufacturing industry. *Research Policy*, *44*(3), 669–683.

Borghesi, S., Franco, C., & Marin, G. (2018). Outward foreign direct investment patterns of Italian firms in the European Union's emission trading scheme. *The Scandinavian Journal of Economics*, *122*(1), 219–256.

Branger, F., & Sato, M. (2017). Solving the clinker dilemma with hybrid output-based allocation. *Climatic Change*, *140*, 483–501.

Braun, M. (2009). The evolution of emissions trading in the European Union—The role of policy networks, knowledge and policy entrepreneurs. *Accounting, Organizations and Society*, *34*(3), 469–487.

Calel, R. (2020). Adopt or innovate: Understanding technological responses to cap-and-trade. *American Economic Journal: Economic Policy*, *12*(3), 170–201.

Calel, R., & Dechezleprêtre, A. (2016). Environmental policy and directed technological change: Evidence from the European carbon market. *Review of Economics and Statistics*, *98*(1), 173–191. https://doi.org/10.1162/rest_a_00470

Carbon Trust. (2008). *Cutting carbon in Europe—The 2020 plans and the future of the EU ETS*. Carbon Trust.

CE Delft and Oeko Institute. (2015). *Ex-post investigation of cost pass-through in the eu ets: An analysis for six sectors*. EU DG Climate Action.

Chiappinelli, O., & Neuhoff, K. (2020). *Time-consistent carbon pricing: The role of carbon contracts for differences*. Discussion Paper 1859, DIW Berlin.

Cludius, J. (2018). Winners and losers of EU emissions trading: Insights from the eutl transfer dataset. *Economics of Energy & Environmental Policy*, *7*(2), 93–110.

Cludius, J., & Betz, R. (2020). The role of bank in EU emission trading. *The Energy Journal*, *41*(2), 275–299.

Coase, R. H. (1960). The problem of social cost. *Journal of Law and Economics*. http://dx.doi.or/10.1086/466560

Colmer, J., Martin, R., Muûls, M., & Wagner, U. J. 2020. *Does pricing carbon mitigate climate change? Firm-level evidence from the European union emissions trading scheme*. Centre for Economic Performance Discussion Paper (1728).

Convery, F. J. (2009). Origins and development of the EU ETS. *Environmental and Resource Economics*, *43*(3), 391–412.

Cosbey, A., Droege, S., Fischer, C., & Munnings, C. (2019). Developing guidance for implementing border carbon adjustments: Lessons, cautions, and research needs from the literature. *Review of Environmental Economics and Policy*, *13*(1), 3–22. https://doi.org/10.1093/reep/rey020

Cramton, P., & Kerr, S. (2002). Tradeable carbon permit auctions: How and why to auction not grandfather. *Energy Policy*, *30*(4), 333–345.

Dechezlepretre, A., Nachtigall, D., & Venmans, F. (2018). *The joint impact of the European Union Emissions Trading System on carbon emissions and economic performance*. OECD Economics Department Working Papers (1515).

Ellerman, A. D., & Buchner, B. K. (2008). Over-allocation or abatement? A preliminary analysis of the EU ETS based on the 2005–06 emissions data. *Environmental and Resource Economics*, *41*(2), 267–287. https://doi.org/10.1007/s10640-008-9191-2

Ellerman, A. D., Buchner, B. K., & Carraro, C. (2007). *Allocation in the European emissions trading scheme: Rights, rents, and fairness*. Cambridge University Press.

Ellerman, A. D., Joskow, P. L., Schmalensee, R., Montero, J. P., & Bailey, E. M. (2005). *Markets for clean air: The U.S. acid rain program*. Cambridge University Press.

Ellerman, A. D., Marcantonini, C., & Zaklan, A. (2016). The European Union emissions trading system: Ten years and counting. *Review of Environmental Economics and Policy*, *10*(1), 89–107. https://doi.org/10.1093/reep/rev014

European Commission. (2005). *EU action against climate change: EU emissions trading—An open scheme promoting global innovation*. http://ec.europa.eu/environment/pdfs/2007/pub-2007-015-en.pdf

European Parliament. (2021). Draft report on the proposal for a regulation of the European parliament and of the council establishing a carbon border adjustment mechanism (COM(2021)0564—C9-0328/2021—2021/0214(COD)).

European Parliament and Council of the European Union. (2003). EU directive 87/EC of the European Parliament and of the council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61. *Official Journal of the European Union*, *275*, 25.

European Parliament and Council of the European Union. (2018). Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814. *Official Journal of the European Union*, *L76/3*, 76/3–76/27. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0410

Fischer, C., & Fox, A. K. (2007). Output-based allocation of emissions permits for mitigating tax and trade interactions. *Land Economics*, *83*(4), 575–599.

Fitch-Roy, O., Fairbrass, J., & Benson, D. (2020). Ideas, coalitions and compromise: Reinterpreting EU-ETS lobbying through discursive institutionalism. *Journal of European Public Policy*, *27*(1), 82–101.

Fuchs, D., & Feldhoff, B. (2016). Passing the scepter, not the buck: Long arms in EU climate politics. *Journal of Sustainable Development*, *9*(6), 58.

Grosjean, G., Acworth, W., Flachsland, C., & Marschinski, R. (2016). After mon-etary policy, climate policy: is delegation the key to EU ETS reform? *Climate Policy*, *16*(1), 1–25.

Grubb, M. (1990). The greenhouse effect: Negotiating targets. *International Affairs (Royal Institute of International Affairs 1944)*, *66*(1), 67–89. https://doi.org/10.2307/2622190

Grubb, M. (2014). *Planetary economics: Energy, climate change and the three domains of sustainable development*. Routledge.

Grubb, M., Drummond, P., Poncia, A., McDowall, W., Popp, D., Samadi, S., Penasco, C., Gillingham, K., Smulders, S., Glachant, M., Hassall, G., Mizuno, E., Rubin, E. S., Dechezlepretre, A., & Pavan, G. (2021). Induced innovation in energy technologies and systems: A review of evidence and potential implications for CO_2 mitigation. *Environmental Research Letters*, *16*(4), 043007.

Grubb, M., Laing, T., Counsell, T., & Willan, C. (2011). Global carbon mechanisms: Lessons and implications. *Climatic Change*, *104*(3–4), 539–573.

Grubb, M., & Neuhoff, K. (2006). Allocation and competitiveness in the EU emissions trading scheme: Policy overview. *Climate Policy*, *6*(1), 7–30.

Gulbrandsen, L. H., Wettestad, J., Victor, D. G., & Underdal, A. (2019). The political roots of divergence in carbon market design: Implications for linking. *Climate Policy*, *19*(4), 427–438.

Hahn, R. W., & Stavins, R. N. (2011). The effect of allowance allocations on cap-and-trade system performance. *Journal of Law and Economics*, *54*, S267–S294. https://doi.org/10.1086/661942

Hanoteau, J. (2014). Lobbying for carbon permits in Europe. *Recherches économiques de Louvain*, *80*(1), 61–87. https://doi.org/10.3917/rel.801.0061

Harrington, W., Morgenstern, R. D., & Nelson, P. (2000). On the accuracy of regulatory cost estimates. *Journal of Policy Analysis and Management*, *19*(2), 297–322.

Hintermann, B., Zarkovic, M., Di Maria, C., & Wagner, U. J. (2020). *The effect of climate policy on productivity and cost pass-through in the German manufacturing sector*. Discussion Paper Series 249, CRCTR.

Ikwue, T., & Skea, J. (1994). Business and the genesis of the european community carbon tax proposal. *Business Strategy and the Environment*, *3*(2), 1–10.

Jaraite-Kažukauske, J., & Di Maria, C. (2016). Did the EU ETS make a difference? An empirical assessment using Lithuanian firm-level data. *The Energy Journal*, *37*(1), 1–24. https://doi.org/10.5547/01956574.37.2.jjar

Jevnaker, T., & Wettestad, J. (2017). Ratcheting up carbon trade: The politics of reforming EU emissions trading. *Global Environmental Politics*, *17*(2), 105–124.

Klemetsen, M., Rosendahl, K. E., & Jakobsen, A. L. (2020). The impacts of the EU ETS on Norwegian plants' environmental and economic performance. *Climate Change Economics*, *11*(1), 2050006.

Koch, N., Fuss, S., Grosjean, G., & Edenhofer, O. (2014). Causes of the EU ETS price drop: Recession, CDM, renewable policies or a bit of everything?—New evidence. *Energy Policy*, *73*, 676–685. https://doi.org/10.1016/j.enpol.2014.06.024

Koch, N., Grosjean, G., Fuss, S., & Edenhofer, O. (2016). Politics matters: Regulatory events as catalysts for price formation under cap-and-trade. *Journal of Environmental Economics and Management*, *78*, 121–139. https://doi.org/10.1016/j.jeem.2016.03.004

Laing, T., Sato, M., Grubb, M., & Comberti, C. (2014). The effects and side-effects of the EU emissions trading scheme. *WIREs Climate Change*, *5*(4), 509–519. https://doi.org/10.1002/wcc.283

Lane, R. (2012). The promiscuous history of market efficiency: The development of early emissions trading systems. *Environmental Politics*, *21*(4), 583–603.

Leal-Arcas, R., Faktaufon, M., & Kyprianou, A. (2022). A legal exploration of the European Union's carbon border adjustment mechanism. *Indian Journal of International Economic Law*, *XIV*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3999019

Lilliestam, J., Patt, A., & Bersalli, G. (2021). The effect of carbon pricing on technological change for full energy decarbonization: A review of empirical ex-post evidence. *WIREs Climate Change*, *12*(1), e681.

Löfgren, Å., Wråke, M., Hagberg, T., & Roth, S. (2014). Why the EU ETS needs reforming: An empirical analysis of the impact on company investments. *Climate Policy*, *14*(5), 537–558.

Martin, R., Muûls, M., De Preux, L. B., & Wagner, U. J. (2014). Industry compensation under relocation risk: A firm-level analysis of the EU emissions trading scheme. *American Economic Review*, *104*(8), 2482–2508. https://doi.org/10.1257/aer.104.8.2482

Martin, R., Muûls, M., & Wagner, U. J. (2016). The impact of the European Union emissions trading scheme on regulated firms: What is the evidence after ten years? *Review of Environmental Economics and Policy*, *10*(1), 129–148.

Michaelowa, A. (2013). The politics of climate change in Germany: Ambition versus lobby power. *WIREs Climate Change*, *4*(4), 315–320.

Montgomery, D. (1972). Markets in licenses and efficient pollution control programs. *Journal of Economic Theory*, *5*(3), 395–418.

Naegele, H., & Zaklan, A. (2019). Does the EU ETS cause carbon leakage in European manufacturing? *Journal of Environmental Economics and Management*, *93*, 125–147.

Narassimhan, E., Gallagher, K. S., Koester, S., & Alejo, J. R. (2018). Carbon pricing in practice: A review of existing emissions trading systems. *Climate Policy*, *18*(8), 967–991.

Neuhoff, K. (2008). Learning by doing with constrained growth rates: An application to energy technology policy. *The Energy Journal*, *29*(1). https://doi.org/10.5547/issn0195-6574-ej-vol29-nosi2-9

Neuhoff, K., Ahman, M., Betz, R., Cludius, J., Ferrario, F., Holmgren, K., Pal, G., Grubb, M., Matthes, F., Rogge, K., Sato, M., Schleich, J., Sijm, J., Tuerk, A., Kettner, C., & Walker, N. (2006). Implications of announced phase II national allocation plans for the EU ETS. *Climate Policy*, *6*(4), 411–422.

Neuhoff, K., Chiappinelli, O., Kröger, M., Lettow, F., Richstein, J., Schütze, F., Stede, J., & Xi, S. (2021). Green Deal for industry: A clear policy framework is more important than funding. *DIW Weekly Report*, *11*(10), 73–82.

Neuhoff, K., Ismer, R., Acworth, W., Ancygier, A., Fischer, C., Haussner, M., Kangas, H. L., Kim, Y. G., Munnings, C., Owen, A., Pauliuk, S., Sartor, O., Sato, M., Stede, J., Sterner, T., Tervooren, M., Tusveld, R., Wood, R., Zhang, X., ... Zipperer, V. (2016). Inclusion of consumption of carbon intensive materials in emissions trading—An option for carbon pricing post-2020. *Climate Strategies*.

Neuhoff, K., Martinez, K. K., & Sato, M. (2006). Allocation, incentives and distortions: The impact of EU ETS emissions allowance allocations to the electricity sector. *Climate Policy*, *6*(1), 73–91.

Neuhoff, K., & Ritz, R. (2019). *Carbon cost pass-through in industrial sectors*. Cambridge Working Papers in Economics: 198.

Nordhaus, W. (2015). Climate clubs: Overcoming free-riding in international climate policy. *American Economic Review*, *105*(4), 1339–1370.

Ovodenko, A., & Keohane, R. O. (2012). Institutional diffusion in international environmental affairs. *International Affairs (London)*, *88*(3), 523–541.

Paterson, M. (2012). Who and what are carbon markets for? Politics and the development of climate policy. *Climate Policy*, *12*(1), 82–97.

Paterson, M. (2013). A climate of crisis: The impacts of the economic crisis on eu climate change policy. In J. DeBardeleben & C. Viju (Eds.), *The economic crisis in Europe* (pp. 133–153). Palgrave Macmillan UK.

Paterson, M., Hoffmann, M., Betsill, M., & Bernstein, S. (2014). The micro foundations of policy diffusion toward complex global governance: An analysis of the transnational carbon emission trading network. *Comparative Political Studies*, *47*(3), 420–449.

Paterson, M., & P-Laberge, X. (2018). Political economies of climate change. *WIREs Climate Change*, *9*(2), e506.

Petrick, S., & Wagner, U. J. (2014). *The impact of carbon trading on industry: Evidence from German manufacturing firms*. Available at SSRN: https://ssrn.com/abstract=2389800

Pezzey, J. C. V. (2003). Emission taxes and tradeable permits a comparison of views on long-run efficiency. *Environmental and Resource Economics*, *26*(2), 329–342.

Pirlot, A. (2021). Carbon border adjustment measures: A straightforward multi-purpose climate change instrument? *Journal of Environmental Law*, *34*(1), 25–52.

Quirion, P. (2021). Tradable instruments to fight climate change: A disappointing outcome. *WIREs Climate Change*, *12*(3), e705.

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., & Schellnhuber, H. J. (2017). A roadmap for rapid decarbonization. *Science*, *355*(6331), 1269–1271.

Rosendahl, K. E. (2008). Incentives and prices in an emissions trading scheme with updating. *Journal of Environmental Economics and Management*, *56*(1), 69–82.

Sijm, J. P. M., Neuhoff, K., & Chen, Y. (2006). CO_2 cost pass-through and windfall profits in the power sector. *Climate Policy*, *6*(1), 49–72.

Skjærseth, J. B., & Wettestad, J. (2008). *EU emissions trading: Initiation, decision-making and implementation*. Ashgate.

Skjærseth, J. B., & Wettestad, J. (2010). Fixing the EU Emissions Trading System? Understanding the post-2012 changes. *Global Environmental Politics*, *10*(4), 101–123.

Stavins, R. N. (1998). What can we learn from the grand policy experiment? Lessons from SO_2 allowance trading. *Journal of Economic Perspectives*, *12*(3), 69–88. https://doi.org/10.1257/jep.12.3.69

Thomas, A. (2021). 'Heart of steel': How trade unions lobby the European Union over emissions trading. *Environmental Politics*, *30*(7), 1217–1236.

Tuerk, A., Mehling, M., Flachsland, C., & Sterk, W. (2009). Linking carbon markets: Concepts, case studies and pathways. *Climate Policy*, *9*(4), 341–357.

van Zeben, J. (2014). *The allocation of regulatory competence in the EU emissions trading scheme*. Cambridge University Press.

Verde, S. F. (2020). The impact of the EU Emissions Trading System on competitiveness and carbon leakage: The econometric evidence. *Journal of Economic Surveys*, *34*(2), 320–343.

Wettestad, J. (2005). The making of the 2003 EU emissions trading directive: An ultra-quick process due to entrepreneurial proficiency? *Global Environmental Politics*, *5*(1), 1–23. https://doi.org/10.1162/1526380053243477

Wettestad, J. (2009). EU energy-intensive industries and emission trading: Losers becoming winners? *Environmental Policy and Governance*, *19*(5), 309–320.

Wettestad, J. (2014). Rescuing EU emissions trading: Mission impossible? *Global Environmental Politics*, *14*(2), 64–81.

Wettestad, J., & Jevnaker, T. (2016). *Rescuing EU emissions trading: The climate policy flagship*. Palgrave Macmillan.

Widerberg, A., & Wrake, M. (2011). The impact of the EU emissions trading system on CO_2 intensity in electricity generation. *Energy Studies Review*, *18*(2), 64–83. https://doi.org/10.15173/esr.v18i2.533

Zaklan, A., Wachsmuth, J., & Duscha, V. (2021). The EU ETS to 2030 and beyond: Adjusting the cap in light of the 1.5°C target and current energy policies. *Climate Policy*, *21*, 1–14.

Zetterberg, L. (2014). Benchmarking in the european union emissions trading system: Abatement incentives. *Energy Economics*, *43*, 218–224.

How to cite this article: Sato, M., Rafaty, R., Calel, R., & Grubb, M. (2022). Allocation, allocation, allocation! The political economy of the development of the European Union Emissions Trading System. *WIREs Climate Change*, e796. https://doi.org/10.1002/wcc.796