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Short-Run Allocation of Emissions Allowances and Long-Term Goals for Climate Policy

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Abstract We use economic analysis to evaluate grandfathering, auctioning, and benchmarking approaches for allocation of emissions allowances and then discuss practical experience from European and American schemes. In principle, auctions are superior from the viewpoints of efficiency, fairness, transparency, and simplicity. In practice, auctions have been opposed by important sectors of industry, which argue that carbon pricing without compensation would harm international competitiveness. In the European Union's Emissions Trading System, this concern led to grandfathering that is updated at various intervals. Unfortunately, updating gives industry an incentive to change behavior to influence future allocation. Furthermore, the wealth transferred to incumbent firms can be significantly larger than the extra costs incurred, leading to windfall profits. Meanwhile, potential auction revenues are not available to reduce other taxes. By circumscribing free allocation, benchmarking can target competitiveness concerns, incur less wealth transfer, and provide a strategy consistent with transitioning to auctions in the long run.

Keywords Benchmarking · Emissions trading · Allocation of allowances · EU ETS

INTRODUCTION

The European Union Emissions Trading System (EU ETS) was launched with the purpose of reaching greenhouse gas reduction goals cost-effectively. The EU climate target goal is now emissions reductions of at least 20% by 2020. The EU ETS is the first international trading system for carbon dioxide (CO_2) emissions in the world and applies to the 27 EU member states plus Norway, Iceland, and Lichtenstein. It covers some 11 500 participating installations in the energy and industrial sectors, which are collectively responsible for close to half of EU emissions of CO_2 and 40% of its total greenhouse gas emissions (European Commission 2009). The system took effect in 2005, and in phases one and two, which conclude in 2012, emissions allowances were to a large extent allocated gratis to the participating installations based on historic emissions, a practice known as *grandfathering*. Each state developed National Allocation Plans (NAPs), following a set of criteria to govern the free distribution of emissions allowances to the covered industry (European Commission 2003). Since the value of this asset is considerable (Ellerman et al. 2007), the potential distributional consequences are important (see, for instance, Burtraw and Palmer 2008), making the allocation process inherently controversial and political (Zapfel 2007).

The allocation process and development of NAPs in phases one and two have been complex and opaque, which have damaged the perceived fairness of the trading system. Frequent changes in grandfathering rules have encouraged regulated parties to engage in so-called rent-seeking behavior in order to gain more generous future allocations.

The objective of this paper is to review arguments for using alternatives to grandfathering, including auctioning and benchmarking. We examine the consequences of allocation choices, both in theory and in the context and chronology of the EU ETS experience. We also compare this with allocation methods in US allowance markets.

REVIEW OF OPTIONS FOR ALLOCATION

A central question in the design of an emissions trading program is how the emissions allowances are initially distributed among participants, and a fundamental choice is whether firms should receive allowances for free or should have to pay for them, as in an auction. Part of this question has to do with fairness, distributional effects, and political feasibility. But another part has to do with efficiency—that is, minimizing the costs of complying with the emissions target. In the textbook example, the allocation of emissions rights, once given, should not change the cost-effectiveness of the trading system (Montgomery 1972). The allowance price, the environmental effectiveness of the system, the choice of abatement method by firms, and the downstream price effects are all determined by the emissions reduction target—and, importantly, the opportunity cost of those emissions to the economy—which should be the same whether firms initially pay for allowances or not. In this case, the allocation question is purely a distributional one: who should receive the value of the emissions assets?

Unfortunately, the textbook equivalence result holds only under specific conditions, and both allocation design and market circumstances can violate these conditions. In either case, the choice of allocation mechanism can have implications for the efficiency of the climate regulation.

From a design perspective, assuming other market conditions are ideal, the main condition is that the allocation be unconditional—that is, the allocation is fixed in advance and unaffected by any changes in the firm's circumstances, including production levels, capacity expansion, or entry or exit from the industry (e.g., Ellerman et al. 2007). This idea lies behind using historical emissions for determining grandfathering; however, in practice, the strict details of this condition are often violated.

From a market perspective, several conditions can influence the relative efficiency of allocation mechanisms, even those that might otherwise be equivalent under perfect circumstances (Harrison et al. 2007; Hahn and Stavins 2010; Fischer and Fox 2010). Some of these market imperfections relate to trading conditions, such as transaction costs, illiquidity, or market power in concentrated industries. Others relate to broader distortions in the economy.

Two distortions of great concern for policy makers are (1) the incomplete reach of carbon regulation and (2) inefficiencies created by the existing tax systems. Although quite broad, the EU ETS is by no means comprehensive. Not only do most of the EU's trading partners lack comparable carbon pricing, but even within the EU, many firms and sectors are exempt from the regulation. In this case, the concern is that imposing costs on the subset of regulated firms will induce consumers to substitute toward unregulated goods—which then expand their emissions—and the resulting carbon leakage will undermine the overall environmental effectiveness of the trading program (Bernard et al. 2007; Fischer and Fox 2010). The degree of this problem depends on the nature of competition among regulated and unregulated goods, the degree to which the goods are close substitutes, and the relative emissions intensities; in other words, some industries will be more susceptible than others. Leakage also depends on how many trading partners participate in the climate regime. Again, with this distortion, allocation choices can affect the overall cost and environmental effectiveness of an emissions trading system.

The other important concern for policy makers is inefficiencies created by the existing tax systems. Governments must fund public expenditures through labor, capital, and other taxes, which unfortunately then distort decisions to supply labor, capital, or whatever is taxed. The problem for climate policy is that carbon is so pervasive in the economy that pricing it raises overall prices in the economy, which reduces the real value of wages and further discourages labor supply (see Goulder 2002). Consequently, allocation methods that mitigate this fall in the real wage or return to capital—either by lowering tax rates or by tempering price increases—can lower the overall costs of the climate regulation. These ideas lie behind the large economics literature recommending auctioning allowances and recycling those considerable revenues to lower other taxes—in other words, taxing "bads" not "goods."

Keeping in mind that trading systems implemented in the real world often (if not always) deviate from the textbook version, we consider the efficiency and other effects of the following allocation procedures.

Grandfathering

With grandfathering, an initial allocation of allowances, valid for a long time into the future, is made to existing installations. A vast majority of earlier allowance trading systems implemented to manage fisheries, air pollution, and water resources have grandfathered allowances based on historic activities. Pure grandfathering would imply that recipients retain their allocation even if they cease production, while new entrants do not receive free allowances. In the EU, as we discuss below, a slightly different version of grandfathering has been applied.

In phases one and two of the EU ETS, emissions allowances were to a large extent distributed for free based on historic emissions, or a fraction hereof. The thought was that grandfathering would offer a situation closer to the status quo, thus increasing the chances that participants would agree to the trading system in the first place. Grandfathering would also compensate firms for sunk costs of investments made prior to the regulation and relieve some financial burden going forward. Auctions were opposed by important sectors of industry, particularly the steel and cement industries, as well as by some member states. Both individual companies and their business associations argued that auctions would be economically detrimental to them, referring to the international competition that they face from firms outside the EU ETS.[1] For companies that can pass through carbon-related costs—such as power producers—this may not be a problem. But for companies competing in a global market, cost pass-through may be difficult. If these costs are not compensated, at least in part, this may lead to the relocation of economic activity and its associated emissions to outside the trading region. This "carbon leakage" could undermine the integrity of the carbon policy and, in fact, raise the cost of achieving environmental goals.

Although abatement incentives may be preserved, there are other potentially problematic effects with grandfathering. First, if all allowances are allocated gratis to incumbents as a compensation for a new climate policy, the transferred wealth can be significantly larger than the extra costs incurred by firms (Bovenberg and Goulder 2001; Burtraw and Palmer 2008; see also Fig. 1 in Åhman et al. 2007). The reason is twofold: costs for emissions are much larger than abatement costs and firms can pass on costs in the form of higher product prices. Ellerman et al. (2010) show that the annual abatement costs in the first two years of the ETS could be in the range of $0.6 billion to $1.8 billion per year, while the value of potential wealth transfer could be in the vicinity of $48 billion per year. However, as the cap is reduced in the following years, there is reason to believe that abatement costs will become significantly higher. Sijm et al. (2006) estimated that the level of pass-through of CO_2 costs in the relatively liberalized wholesale electricity markets in the Netherlands and Germany was 60–100%. Fell (2008) estimated similar pass-through in the Nordic power market. However, in the electricity sector, the regulation of retail electricity prices often limits pass-through, which has been the case in for instance Spain. There is also anecdotal evidence that at least some firms with a surplus of allowances have not passed on the opportunity rent to customers (Ellerman et al. 2010). While windfall profits are avoided, the result is a different inefficiency, in the form of a weaker price signal for the value of conservation.[2]

A second critique of allocation based on historic emissions is that it rewards large emitters rather than firms that already have already invested in carbon-efficient processes. This may undermine the credibility of and public support for the system and discourage the early action. Third, without updating, continued grandfathering would perpetuate a major asset transfer to industry, while the data and circumstances on which the allocation was based would become increasingly irrelevant. Over time, production volumes change, old installations close, new installations enter, and technologies, processes and products change, and the fairness of the allocation could be called into question.

The final problems relate to interactions with the aforementioned market distortions. Grandfathering means the revenue is not available to reduce other taxes, which would otherwise reduce the macroeconomic costs of the program. Furthermore, in competitive markets, the increase in product prices should reflect the opportunity costs of emissions allowances in the same way as they do under an auction. Thus, unconditional grandfathering does not actually improve international competitiveness, since firms would be free to relocate and sell their allocations.

Updating Allocations

Casual reasoning suggests that at some point the allocation needs to be updated, and this creates a dilemma for the regulator. If allocation in future trading periods is based on data that can be affected by industry, this will change the firms' incentives for action. Neuhoff et al. (2006) point out that in contrast to the US sulfur dioxide trading program, wherein allocation was done only once as a lump sum, the EU ETS adopted a sequential approach. Allocation plans are decided for one commitment period at a time, with repeated negotiations about the allocation for the following period. The authors conclude that if power generators anticipate that their current behavior will affect future allowance allocation, this can distort today's decisions. In a similar way, Sterner and Muller (2008) show that if allocation is regularly updated based on prior emissions, firms will have a financial incentive to pollute more. Harstad and Eskeland (2010) show this formally in a dynamic setting, where firms that anticipate the regulator's future desire to give more allowances to firms that appear to need them purchase allowances to signal their need. This raises the price above marginal costs and thus results in an inefficient market outcome. If the social costs are high and the government intervenes frequently in the market, the distortions could potentially be greater than the gains from trade, and nontradable permits would be better. Åhman et al. (2007) argue that if the updating uses a sufficiently long lag (such as 10 years), discounting will reduce firms' incentives to increase current emissions for the purpose of gaining allocation profits in the far future. Over 10 years, such an approach could transition to an auction.

[1] See, for example, EUROFER position paper on ETS, October 2008, www.eurofer.org/index.php/eng/content/pdf/776; and the Cembureau position paper, Climate Change: CO_2 Emissions Trading—Points of Convergence within the Cement Industry, www.cembureau.be/Cem_warehouse/POINTS%20OF%20CONVERGENCE%20WITHIN%20THE%20CEMENT%20INDUSTRY.PDF (both accessed May 2009).

[2] For a detailed analysis of this in a U.S. context, see Burtraw et al. (2001).

In one context, the fact that updating creates an incentive to change behavior does not pose a problem for efficiency. Rosendahl and Storrøsten (2011) show that in a system where the allowance price is determined endogenously (closed system), long-term incentives regarding entry and exit are actually equal under updated emissions-based allocation and pure grandfathering. This is because the quota price is higher under updated grandfathering, as firms anticipate the effect of current emissions on future allocation revenues. New firms have to pay a higher bill initially but are better off later on when they have earned the right to receive free quotas. This holds under special conditions, such as if all firms have the same expectations on discount rates and future quota prices and no banking or borrowing is allowed, conditions that would not seem appropriate in the EU ETS, where banking is allowed (in the second and third phases) and firms appear to hold diverse expectations (especially in the first phase).

In sum, there is a risk that grandfathering allocations based on historic emissions in a recent period has affected not only the distribution of costs but also the economic efficiency and environmental effectiveness of the system. Nevertheless, updating of allocations is both explicitly and implicitly part of the design of the EU ETS—explicitly through the renewed allocation for each trading period and implicitly through the treatment of new entrants and installations that close. The current (phase two) rules on new entrants and closures create distortions among member states, between new and old installations, and among technologies. The policy of withdrawing the allocations from installations that close constitutes an implicit subsidy to remain in operation, thus putting new (and potentially cleaner) installations that do not receive free allocations at a disadvantage (Åhman et al. 2007). Further, the methods differ greatly among member states and prevent a level playing field across the market.

Auctioning

The obvious way out of many problems with grandfathering is to replace free allocations with auctioning. A large literature in economics generally supports the finding that an auction with revenue recycling is the preferable approach to the initial distribution of the newly formed value created by the introduction of a price on CO_2 (Cramton and Kerr 2002; Dinan and Rogers 2002; Hepburn et al. 2006). The EU Commission has come to embrace this conclusion and has stated that auctioning of allowances should be the basic principle for allocation from the third phase onward (beginning in 2013). "This ensures efficiency, transparency and simplicity of the system and creates the greatest incentives for investments in low-carbon economy. It best complies with the Polluter Pays Principle and avoids giving windfall profits to certain sectors that pass on the notional cost of allowances to their customers despite receiving them for free" (European Commission 2008). Notably, the Regional Greenhouse Gas Initiative (discussed later) already relies on auctions to allocate about 90% of the allowances.

Auctions have several advantages. One important element already mentioned is that auction revenues can be recycled in ways that reduce the overall cost of the regulation. In particular, by reducing preexisting taxes, they can enhance the efficiency of the economy as a whole (Parry 1995; Parry et al. 1998). Auctions may also promote innovation, relative to grandfathering. If innovations are adopted widely in the economy, abatement costs and ultimately allowance prices will fall; therefore, a firm holding many allowances will have less incentive to innovate, in fear of driving those asset values down (Milliman and Prince 1989; Fischer et al. 2003). Furthermore, an auction, in comparison with grandfathering, may improve administrative transparency and the perception of fairness (Binmore and Klemperer 2002), which are crucial to the formation of a new market for an environmental commodity.

On the other hand, while auctions improve efficiency in most dimensions, they do not address the problem of competitiveness and carbon leakage concerns in vulnerable, trade-exposed sectors.

Benchmarking and Output-Based Updating

Shortly after the EU ETS was launched, a review was mandated that led to a broadened understanding of the shortcomings of grandfathering and the advantages of an auction. Consequently, the EU ETS directive has been revised (European Commission 2009), drawing on experiences from the first two phases. In the third phase, beginning in 2013, auctioning will be gradually phased in to reach 100% in the year 2027. However, an exception will be made for installations in sectors judged to be at significant risk of carbon leakage. For these sectors, the directive provides a limited amount of free allowances. The allocation of these free allowances will be based mainly on output and sector common benchmarks, referred to as *output-based allocation* or *benchmarking* (European Commission 2009, § 18).

According to the European Commission, the arguments for using benchmarking are to "reward operators that have taken early action to reduce greenhouse gases and give stronger incentives to reduce emissions, as allocations would no longer depend on historical emissions"

(European Commission 2008). This is largely in line with the views of EU industry.[3]

A number of studies have investigated how benchmarking influences abatement incentives (Fischer 2001; Burtraw et al. 2001; Fischer and Fox 2007; Sterner and Muller 2008; Zetterberg 2011). The first point is that updated output-based allocation serves as an implicit production subsidy, since additional output garners additional allowance values. However, it does not disturb a firm's incentives to undertake abatement activities. For this reason, Böhringer and Lange (2005) show that output-based allocation is distinctly less costly than emissions-based allocation as a means to preserve output and employment in energy-intensive sectors. On the other hand, output based allocation pushes up carbon prices since more effort must be put into reducing the emissions intensity of production in order to meet the cap. If benchmarking is applied only to some sectors, these carbon price pressures mean that other sectors will bear a larger burden of compliance. The implications for the efficiency of the trading system then depend on whether this distortion is outweighed in importance by other market distortions, particularly carbon leakage.

Fischer and Fox (2010) conduct simulations of alternative US climate policies in a global trade model that considers both labor tax distortions and carbon leakage. They find that, from a domestic perspective, updating output-based allocation targeted to energy-intensive, trade-exposed industries can be more efficient than auctioning alone, due to the improvements in competitiveness and reduced carbon leakage. They also consider the trade-offs in extending such allocations to the electricity sector, which is not trade-exposed. If the revenues would otherwise be recycled to lower taxes, this allocation reduces efficiency; however, if the revenues would otherwise be grandfathered, benchmarking allocations to electricity actually improves cost-effectiveness, since the change in product prices and consequently the tax interactions are smaller.

One can also make a distinction between domestic and global cost-effectiveness. Preferential allocations distort the terms of trade, so auctioning—even in a unilateral trading system—is generally preferred by the rest of the world. However, tax distortions play a role here as well: if the revenues would otherwise be grandfathered or distributed in lump-sum fashion (such as through dividends) rather than recycled, updating output-based allocation can also be preferred from a global perspective. Together, these studies indicate a potentially legitimate role for benchmarking, with the caveat that it must be carefully designed and circumscribed. We note that most climate policy models are unable to represent the full range of substitution opportunities—such as among steel, cement, and other materials in construction—so they may well underestimate the potential distorting effects of output-based updating. This calls for even greater care in designing such policies. The studies also indicate the importance of auctioning with proper revenue recycling for the remaining allowances.

ALLOCATION IN PRACTICE

In this section, we summarize how benchmarking is applied as a transitional strategy in different carbon markets.

EU ETS

The design of the initial allocation of allowances has been the single most debated feature of the EU ETS.[4] Benchmarking was identified early on as a way to mitigate some of the perverse incentives associated with grandfathering. In phases one and two, benchmarks were primarily applied when allocating allowances to new entrants. The general principle was that allocation should be based on best available technology (BAT). However, particularly in the power sector, benchmarks were often made fuel-specific and were not harmonized across countries, which significantly diminished the potential efficiency gains (Åhman and Holmgren 2006).

In phase three, from 2013 onward, a much greater part of the emissions allowances will be auctioned.[5] However, full auctioning is still applied only to the electricity sector. For other sectors, a "transitional free allocation" based on EU-wide sector-specific benchmarks will be used. The benchmarks should be product-specific and represent the average of the top 10% of installations regarding greenhouse gas efficiency in the EU in the years 2007–2008.

[3] Based on a series of seminars with representatives from EU industry, business associations, and nongovernmental organizations, Egenhofer and Georgiev (2010) summarize stakeholder views on the advantages of benchmarking over grandfathering. These arguments include "incentivizing emissions reductions; allow[ing] for updating without introducing perverse incentives; ensuring a non-distorted carbon price."

[4] For a more extensive discussion of this and other contentious issues, see Wråke et al. (2012 [this issue]).

[5] At least 60% auctioning in 2012, with a target of reaching 70% auctioning in 2020.

This results in a large number of benchmarks,[6] but in some cases the EU has not developed product-specific benchmarks. In those cases, allocation will be based instead on heat-, fuel-, or process-related benchmarks. The basic principle is that, in 2013, firms eligible for free allocation will receive an allocation equal to 80% of their projected emissions, calculated by multiplying historic production activity level by the benchmark emissions rate. Allocations will decrease to reach 30% of the benchmark level in 2020. However, firms that are deemed as "exposed to significant risk of carbon leakage" will receive 100% of the benchmark level for free through the entire period up to 2020.

Determining which firms are exposed to significant risk of carbon leakage and what the benchmarks should be has been a lengthy and complicated process. The end result is a set of technical documents that specify what rules and benchmarks should apply to different products and installation types. A list of what sectors and subsectors are at risk of carbon leakage has been published. In many cases, installations have to be split into sub-installations, with different rules applied to different parts of the production process. For instance, one part of the production process may be determined to be at risk for carbon leakage, while another part may not. A revised list of sectors at risk will be applied from 2015 onward.

Policies in North America

Policies are unfolding in four settings in North America, each with quite different features. One regional program involves a cap and auction, one Canadian province involves a tax, one US state program involves a cap with benchmarking allocation, and probably the most important policy—national regulation in the United States under the Clean Air Act—has benchmarking without a cap. These features likely span the future of climate policy in North America and perhaps on the international stage. They also seemingly span the manner in which the value created by putting a price on CO_2 can be distributed through the economy.

Beginning in 2009, 10 northeastern US states launched the Regional Greenhouse Gas Initiative (RGGI).[7] This policy sets a modest but binding emissions cap on power plants in the region. During the first compliance period (2009–2011), the program was expected to result in prices per metric ton of CO_2 of $3–$5, yielding a 10% (17-million ton) annual reduction in emissions by 2018 from emissions levels in 2006. Many felt the program was intended primarily to help initiate federal policy, but the states in the program took it seriously. The modest emissions target took shape in a region that is part of an open electricity transmission network, where leakage was estimated to amount to 17–40% of emissions reductions (Burtraw et al. 2005). By the time the program took effect, changes in fuel prices and the economic downturn led to a low allowance price and a situation of overallocation similar to what was experienced in the first phase of the EU ETS. However, one feature of RGGI distinguishes it from the EU ETS: in RGGI, about 90% of the allowances are auctioned, and importantly, the auction includes a reserve price. Although that price, initially $2.07 per ton and growing with inflation, is quite low by the standard of the EU ETS, it has prevented the price of allowances from falling to zero and consequently has generated about $1 billion in the first compliance period. The vast majority of these funds have been directed toward strategic energy investments, primarily energy efficiency. The RGGI program leapfrogged over benchmarking as a transition path and began by giving a primary role for allocation to a well-designed auction. Consequently, it has met with important success even while climate policy has faltered at the national level in the United States.

At the other end of possible policy outcomes is the CO_2 emissions fee in the Canadian province of British Columbia. The fee is assessed on fossil fuel combustion, including personal transportation, by industry and individuals. In July 2011, the tax rate rose to $25 (Canadian) per ton of CO_2-equivalent ($24.16 USD), and it will increase to $30 ($28.99 USD) per ton in 2012. The tax is anticipated to reduce CO_2 emissions by up to 3 million tons annually by 2020. Revenues are directed toward reducing personal and corporate income taxes, thereby accomplishing important efficiency goals, as well as providing some tax credits for low-income individuals.

California plans to launch its cap-and-trade program in 2013. This policy is a consequence of 2006 legislation that adopted binding economywide targets to reduce the state's emissions to 1990 levels (about 432 million metric tons) by 2020, roughly 29% below forecast 2020 business-as-usual emissions. At the center of the policy are a number of regulatory standards and measures that are expected to achieve the lion's share of necessary emissions reductions, including the state's motor vehicle standards, which have subsequently been adopted as federal policy, and an ambitious renewable portfolio standard that sets a goal for renewable sources to provide 33% of total electricity consumption in the state by 2020. These measures are expected to achieve most, but not all, of the 2020 target, and the residual is left to the cap-and-trade program. Although the policies might

[6] This includes 52 products in 21 sectors, representing some 80% of free allocations.

[7] After a significant change in political leadership, the state of New Jersey has decided to withdraw from the group in 2012.

seem redundant because they both might target the same emissions reductions, the regulatory policies are viewed as necessary to drive technological changes in transportation and electricity, and allowance prices without these policies already in place. Such a high allowance price might exacerbate the leakage of economic activity and emissions out of state. This outcome is mitigated by the mixed policy approach, although total economic costs are likely higher than might result from a cap-and-trade program alone.

The California trading program in 2012 will affect stationary sources, including out-of-state generation of electricity that is delivered to consumers in the state. The program will expand in 2015 to include transportation and will cover 85% of total emissions in the state.[8] An advisory committee has advised that an auction is the preferred approach to distribute allowances (EAAC 2010), similar to the path being taken by the EU ETS. However, for practical reasons, an auction plays a limited role initially. An important fraction of allowances will be distributed for free to local electricity distribution companies. These entities are regulated and for the most part do not have a compliance obligation, so they are expected to sell the allowances (through an auction), use the allowance value to offset changes in the wholesale power price, and deliver these price reductions to their retail customers. Industrial sources also start with free allocation, at about 90% of average emissions, based on an efficiency benchmark for each industry, to be updated annually. In both cases, the free allocation is expected to protect California industry from increases in product prices that would create a competitive disadvantage relative to facilities located outside the state. Eventually, free allocation is expected to be phased out in favor of auctioning.

When California's full program ultimately takes effect, it will provide an economywide emissions cap in what constitutes the eighth-largest economy in the world. However, the most important policy development is the enforcement of greenhouse gas rules by the US Environmental Protection Agency under the Clean Air Act. Sources of emissions will be affected in three waves (Richardson et al. 2011). As of January 2011, new model-year 2012 vehicles now must comply with fuel-efficiency standards that mirror those adopted in California and other states. These standards will largely offset changes in emissions over the next decade that would otherwise occur from a growing population and greater vehicle miles traveled. Later this decade, actual emissions reductions will begin, especially if the next round of vehicle standards is developed as expected. The second wave affects construction permitting for new and modified stationary sources. Standards are still being developed, but the permitting requirement for these sources also took effect in January 2011. The third and most important wave will affect the operation of existing stationary sources. Early in 2012, the first standards governing emissions from steam electricity boilers and refineries will be implemented.

The actual form of the regulations affecting existing sources is expected to be an emissions rate performance standard, which resembles output-based allocation except with no emissions cap. However, the emissions reductions under a tradable performance standard can be just as great and depend on the stringency of the performance standard (Burtraw et al. 2011). The benchmark is likely to be justified technically based on a narrow source category definition, but it may be implemented on a broader basis to allow compliance flexibility, meaning that sources can overcomply and sell credits to other sources. Hence, there is no allocation decision under a performance standard, but the design questions under the standard reflect most of the issues affecting the design of benchmarks: how should facilities be grouped, what measure will be used, how will that measure evolve over time, and will the groups evolve over time?

Another aspect of the US regulations may fully illustrate the role of benchmarks as a transition. An idiosyncrasy of US environmental law places the states, not the federal government, in the primary role of planning and enforcement of the Clean Air Act. The role of federal agencies is to approve and oversee, and occasionally intervene in, the process. In developing their implementation plans, states have a great deal of discretion. A major question on the horizon is how regional cap-and-trade programs will be assimilated into the federal requirements. Moreover, potentially with federal encouragement, states might explore the recombining of source categories (for example, to enable fuel switching from coal to natural gas for electricity generation) to allow greater compliance flexibility and greater emissions reductions at less cost. States may also propose to allow trading across states, and indeed, most legal scholars believe they have the legal authority to implement new cap-and-trade programs as one way to comply with the federal standards (Wannier et al. 2011).

In summary, four policies in North America span the main options for allocation (Fig. 1). Two avoid benchmarking entirely, seemingly hatched as fully formed systems intended to place a price on CO_2 through an auction or its analog, an emissions tax. But the other two embody benchmarks on what may be a transitional path to some other design.

[8] Sources outside the trading program are included in the 2020 target.

Fig. 1 While the EU emission trading scheme is closing in on its third phase, the policies in North America is unfolding in four settings and with quite different features. Photo by Lize Rixt (Stock.xchng)

SUMMARY AND CONCLUSIONS

In this paper, we have reviewed the main arguments for using auctioning and benchmarking for allocating emissions allowances instead of grandfathering, and we summarized related policy developments in the EU and North America. In the long term, auctioning is the most efficient way to distribute allowances. It conforms to the "Polluter Pays Principle," increasing the perception of fairness in the system, and ensures transparency and simplicity of the trading system. Moreover, the substantial revenues from CO_2 auctions can be recycled in ways that improve the health of the economy and reduce the overall cost of the regulation. But in spite of the theoretical advantages of auctioning, practical political barriers to implementation remain. Auctions have been opposed by important sectors of industry, as well as by some member states. Industry argues that auctions would be economically detrimental to them, pointing to the international competition they face from firms outside the carbon markets in the EU ETS and North America. If these costs are not compensated, at least in part, this may lead to the relocation of economic activity and its associated emissions to outside the trading region. This "carbon leakage" could undermine the integrity of the carbon policy and raise the cost of achieving environmental goals.

Grandfathering does not provide a remedy to the leakage problem if it is implemented based on truly historic criteria. Moreover, experience from the EU ETS shows that Member States wish to update the allocation in order to adjust for closures, new entrants, and production changes. Unfortunately, this raises a new set of problems. If allocation in future periods is based on factors that can be affected by industry, this will change the firms' incentives for action. Moreover, with grandfathering, the transferred wealth to incumbent firms can be significantly larger than the extra costs incurred on them, leading to windfall profits. Further, potential auction revenues are not available to reduce other taxes, which would reduce the overall costs of the program.

Updating output-based allocation with benchmarks preserves abatement incentives but involves an output subsidy that introduces inefficiency in the economy. However, output-based allocation provides a mechanism to address leakage. In an economy with imperfections, including preexisting distortionary taxes and leakage, this approach may offer a remedy.

Hence, in a transitional period, benchmarking may offer a way to move from grandfathering in phases one and two of the EU ETS toward the long-term goal of auctioning. Of the four regional programs in North America, one uses auctioning, one employs an emissions tax, and two use benchmarking. Benchmarking provides compensation to firms for increased costs and allows for updating without reducing abatement incentives. This allocation rule rewards operators that have taken early action to reduce greenhouse gas emissions. Moreover, this type of allocation is more cost-effective than grandfathering when taking into account such issues as leakage and interactions with pre-existing taxes in the domestic economy. Finally, benchmarking ends the incumbent's entitlement to emissions allowances, which is a precondition for the ultimate move to an auction.

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REFERENCES

Åhman, M., and K. Holmgren. 2006. New entrant allocation in the Nordic energy sectors: Incentives and options in the EU ETS. *Climate Policy* 6: 423–440.

Åhman, M., D. Burtraw, J. Kruger, and L. Zetterberg. 2007. A ten-year rule to guide the allocation of EU emission allowances. *Energy Policy* 35: 1718–1730.

Bernard, A.L., C. Fischer, and A.K. Fox. 2007. Is there a rationale for output-based rebating of environmental levies? *Resource and Energy Economics* 29: 83–101.

Binmore, K., and P. Klemperer. 2002. The biggest auction ever: The sale of the British 3 g telecom licenses. *Economic Journal* 112: C74–C96.

Böhringer, C., and A. Lange. 2005. Economic implications of alternative allocation schemes for emission allowances. *Scandinavian Journal of Economics* 107: 563–581.

Bovenberg, A.L., and L.H. Goulder. 2001. Neutralizing the adverse industry impacts of CO_2 abatement policies: What does it cost? In *Behavioral and distributional effects of environmental policy*, ed. C. Carraro, and G. Metcalf, 45–89. Chicago: University of Chicago Press.

Burtraw, D., and K. Palmer. 2008. Compensation rules for climate policy in the electric sector. *Journal of Policy Analysis and Management* 27: 819–847.

Burtraw, D., K. Palmer, and D. Kahn. 2005. *Allocation of CO_2 emissions allowances in the regional greenhouse gas cap-and-trade program*. Discussion paper 05–25. Washington, DC: Resources for the Future.

Burtraw, D., K. Palmer, R. Bharvikar, and A. Paul. 2001. *The effect of allowance allocation on the cost of carbon emission trading*. RFF discussion paper 01–30. Washington, DC: Resources for the Future.

Burtraw, D., A. Fraas, and N. Richardson. 2011. Greenhouse gas regulation under the clean air act: A guide for economists. *Review of Environmental Economics and Policy* 5: 293–313.

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

Dinan, T.M., and D.L. Rogers. 2002. Distributional effects of carbon allowance trading: How Government decisions determine winners and losers. *National Tax Journal* 55: 199–221.

EAAC. 2010. Allocating emissions allowances under a California cap-and-trade program (March), Economic and Allocation Advisory Committee, State of California Air Resources Board. http://www.climatechange.ca.gov/eaac/documents/eaac_reports/2010-03-22_EAAC_Allocation_Report_Final.pdf. Accessed 9 Jan 2012.

Egenhofer, C., and A. Georgiev (rapporteurs). 2010. *Benchmarking in the EU—Lessons from the EU emissions trading system for the global climate change agenda*. Centre for European Policy Studies, Place du Congrès 1, B-1000 Brussels: ISBN:978-92-9079-959-7.

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

Ellerman, D., F. Convery, and C. de Perthuis. 2010. *Pricing carbon: The European union emissions trading scheme*. Cambridge: Cambridge University Press.

European Commission. 2003. Directive 2003/87/EC of the European Union and of the Council of 13 October 2009 establishing a scheme for greenhouse gas emission allowance trading within the community and amending council directive 96/61/EC.

European Commission. 2008. MEMO/08/35, Brussels, 23 January 2008. Questions and answers on the commission's proposal to revise the EU emissions trading system.

European Commission. 2009. Directive 2009/29/EC of the European Union and of the council of 23 April 2009 amending directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the community.

Fell, H. 2008. *EU-ETS and Nordic electricity: A CVAR analysis*. Elforsk report 08:57. Stockholm, Sweden.

Fischer, C. 2001. *Rebating environmental policy revenues: Output based allocations and tradable performance standards*. Discussion paper 01–22. Washington, DC: Resources for the Future.

Fischer, C., and A.K. Fox. 2007. Output based allocation of emissions permits for mitigation tax and trade interactions. *Land Economics* 83: 575–599.

Fischer, C., and A. K. Fox. 2010. *On the scope for output-based rebating in climate policy: When revenue recycling isn't enough (or Isn't Possible)*. Discussion paper 10–69. Washington, DC: Resources for the Future.

Fischer, C., I.W. Parry, and W.A. Pizer. 2003. Instrument choice for environmental protection when technological innovation is endogenous. *Journal of Environmental Economics and Management* 45: 523–545.

Goulder, L.H. (ed.). 2002. *Environmental policy making in economies with prior tax distortions*. Cheltenham: Edward Elgar.

Hahn, R.W., and Robert N. Stavins. 2010. *The effect of allowance allocations on cap-and-trade system performance*. Working papers 2010.80. Milan: Fondazione Eni Enrico Mattei.

Harstad, B., and G. Eskeland. 2010. Trading for the future: Signalling in permit markets. *Journal of Public Economics* 94: 749–760.

Harrison, D., P. Klevnas, D. Radov, and A. Foss. 2007. *Complexities of allocation choices in a greenhouse gas emissions trading program*. Boston: NERA Economic Consulting.

Hepburn, C., M. Grubb, K. Neuhoff, F. Matthes, and M. Tse. 2006. Auctioning of EU ETS phase II allowances: How and why? *Climate Policy* 6: 137–160.

Milliman, S.R., and R. Prince. 1989. Firm incentives to promote technological change in pollution control. *Journal of Environmental Economics and Management* 17: 247–265.

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

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

Parry, I.W. 1995. Pollution taxes and revenue recycling. *Journal of Environmental Economics and Management* 29: 64–77.

Parry, I.W., R.C. Williams, and L.H. Goulder. 1998. When can carbon abatement policies increase welfare? The fundamental role of distorted factor markets. *Journal of Environmental Economics and Management* 37: 52–84.

Richardson, N., A.T. Fraas, and D. Burtraw. 2011. Greenhouse gas regulation under the clean air act: Structure, effects and implications of a knowable pathway. *Environmental Law Reporter* 41: 10098–10120.

Rosendahl, K.E., and H.B. Storrøsten. 2011. Emissions trading with updated allocation: Effects on entry/exit and distribution. *Environment Resource Economics* 49: 243–261.

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

Sterner, T., and A. Muller. 2008. Output and abatement effects of allocation readjustment in permit trade. *Climatic Change* 86: 33–49.

Wannier, G.E., J.A. Schwartz, N. Richardson, M.A. Livermore, M.B. Gerrard, and D. Burtraw. 2011. *Prevailing academic view on compliance flexibility under section 111 of the clean air act*. Discussion paper 11–29. Washington, DC: Resources for the Future.

Wråke, M., Burtraw, D, Löfgren, Å., and L. Zetterberg. 2012. What have we learnt from the European Union's Emissions Trading System? *Ambio* 41. doi:10.1007/s13280-011-0237-2.

Zapfel, P. 2007. A brief but lively chapter in EU climate policy: The commission's perspective. In *Allocation in the European Emissions Trading Scheme: Rights rents and fairness*, ed. D. Ellerman, B. Buchner, and C. Carraro. Cambridge, UK: Cambridge University Press, Chapter 2.

Zetterberg, L, 2011. *Instruments for reaching climate objectives—focusing on the time aspects of bioenergy and allocation rules in the European Union's Emissions Trading System*. PhD thesis. University of Gothenburg, Sweden.

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