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Manuel Frondel, Christoph M. Schmidt
and Colin Vance

# Emissions Trading: Impact on Electricity Prices and Energy-Intensive Industries

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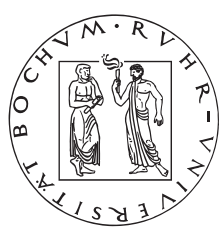

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**Manuel Frondel, Christoph M. Schmidt and Colin Vance***

# Emissions Trading: Impact on Electricity Prices and Energy-Intensive Industries

Abstract
The EU-wide Emission Trading Scheme (ETS), established in 2005, is a key pillar of Europe's strategy to attain compliance with the Kyoto Protocol. Under this scheme, CO2 allowances have thus far been allocated largely free of charge. This paper demonstrates that such cost-free allocation, commonly called grandfathering, implies an increase in electricity prices even when strong competition prevails on electricity markets. As our estimations for Germany's power sector show, these price increases result in substantial windfall profits, giving rise to public skepticism and calls for an auctioning of certificates in the future. While empirical evidence on the ETS' impacts is scant, the findings reviewed here indicate that even in the absence of certificate auctioning, energy-intensive industry sectors, such as primary aluminum production, may suffer heavily from the ETS-induced electricity price increases. We therefore argue that an abrupt transition to a complete auctioning system may endanger the competitive position of energy-intensive industries in Europe, unless all other major industrial and transition countries are integrated into a global emissions trading system.

JEL Classification: Q41, Q48

Keywords: Grandfathering, auctioning, competition.

December 2008

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## 1. Introduction

The European Union's CO2 emission target, stipulated in the Kyoto Protocol, implies an emission reduction of 8% relative to 1990 between 2008 and 2012. The establishment of the EU-wide trading scheme (ETS) for emission certificates (allowances) in 2005 is a key pillar of the European Commission's strategy to achieve the EU's Kyoto target. As documented in the environmental economics literature, the virtue of an emissions trading scheme is that it is an economically efficient means of precisely achieving an exogenously set emission reduction target (Bonus 1998:7). Although the alternative of CO2 taxation is an equally cost-effective measure, the associated emission reduction emerges endogenously as the market adjusts to higher CO2 costs, thereby making it difficult to anticipate whether any given reduction target is ultimately fulfilled.

After the introduction of the ETS, the electricity prices increased along with those of the emission allowances. This correlation instigated an intense debate concerning the distributive and welfare implications of the ETS, particularly in Germany. Confusion reigned among consumers as to why they faced an increase in prices and, ultimately, in electricity bills, despite the cost-free allocation of CO2 certificates in the majority of EU countries. Fueled by the media and political posturing, it was commonly suspected that electricity suppliers used the introduction of this climate policy instrument as a pretext for increasing electricity prices, and hence, their profits. It was further alleged that this outcome would not occur if electricity markets were more competitive.

This paper sets out to demonstrate why both of these conclusions are false. The cost-free allocation of CO2 certificates on the basis of historical emissions, commonly called grandfathering, implies an increase in electricity prices, irrespective of whether strong or weak competition prevails on electricity markets. Indeed, price increases of electricity are even desirable from an economic and environmental perspective, as this induces consumers to reduce their demand for electricity. Just such an increase in the price of electricity was predicted by economists prior to the introduction of the ETS (Burtraw et al. 2002; Reinaud 2003). In essence, the grandfathering of certificates represents a transfer of assets similar to securities. These assets can be sold at their market price or used as an input in electricity generation, thereby increasing the cost of production. To demand that electricity producers disregard this opportunity cost in price-setting would be completely ignorant of the functioning of a market economy.

If certificates are grandfathered, rather than auctioned, the ETS-induced price increases of outputs such as electricity lead to considerably higher revenues, frequently called windfall profits (see e.g. Sijm et al. 2006:49). Our estimations for Germany's power sector indicate that these windfall profits may be substantial, a conclusion that is substantiated by a Sijm et al. (2006:49) for the case of Netherlands' power sector. With a CO2 tax, by contrast, it is the government that receives the increased payments by consumers, rather than private firms. It therefore may well be justified for governments to extract some of these windfall profits via certificate auctioning, as is currently contemplated by the European Commission. It is argued here, however, that the abrupt transition to a complete auctioning may endanger the competitive position of energy-intensive industries in Europe.

Using the example of electricity production, we illustrate in the subsequent section that passing through the value of grandfathered certificates to output prices is in perfect accord with rational economic behavior and is no indication of a lack of competition. In Section 3, we appraise the magnitude of the windfall profits accruing to Germany's power sector. Section 4 shifts attention to other energy-intensive sectors. While empirical evidence on the ETS' impacts is scant, the findings reviewed here cast doubt on the efficacy of a complete auctioning of certificates as long as all other major industrial and transition countries reject the integration into a comprehensive global emissions trading system. The last section summarizes and concludes.

## 2. CO2 Certificates, Electricity Prices, and Market Power

Electricity markets follow the same economic laws as other markets, but with some important particularities. Two key properties of electricity are that, first, it cannot be stored at low cost in large quantities and, second, its demand is highly price-inelastic in the short term, but subject to substantial temporal fluctuations. These properties imply a high degree of volatility of electricity prices. In the public debate, these substantial fluctuations are frequently misinterpreted as a sign of lacking competition among electricity producers. In a similar vein, public skepticism was also aroused by the ETS-induced increase in electricity prices following the largely cost-free allocation of CO2 emission allowances.

Both phenomena, however, cannot be taken as indicators for the presence of market power.[1] Rather, the electricity-price-raising impact of certificates would also arise under

[1] Market power is defined as the ability of a producer to raise the price above the level that would prevail under full competition. In the ideal situation of full competition, all market participants are "price takers" and have no ability whatsoever to influence the price. In this theoretic ideal, prices equal the marginal costs of production.

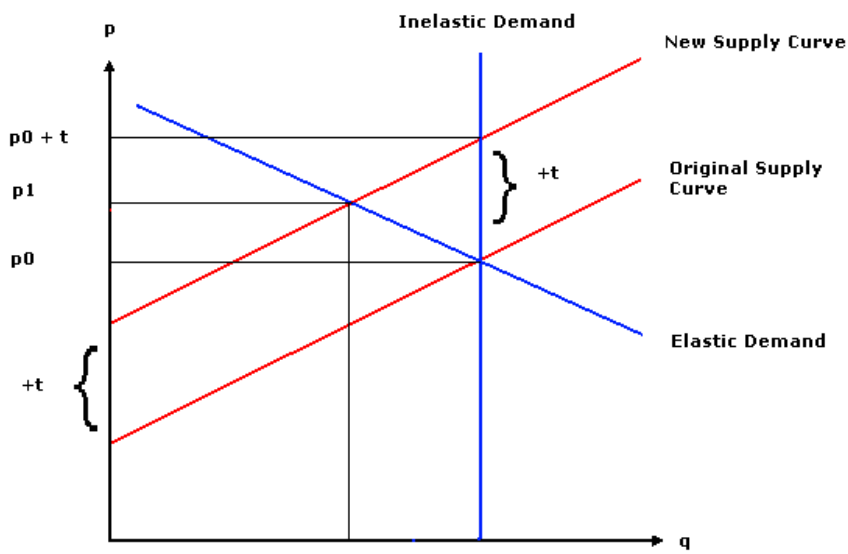
perfect and imperfect competition alike. Regardless of whether certificates are distributed at no cost or have to be purchased, they have a value that can be observed on a daily basis at exchanges such as the Leipzig Power Exchange. Because of the possibility to sell certificates and obtain a profit, a rational electricity supplier will only produce a megawatt hour (MWh) of electricity if the profit from electricity generation is at least as high as the revenue that would be garnered from selling the otherwise required certificates at the market. The electricity price that a rational supplier therefore demands should cover production- and opportunity costs, where in this case the opportunity cost originates from the certificates' value. It bears noting that taking account of opportunity cost is not specific for the analysis of electricity prices. Rather, the concept of opportunity costs is deeply rooted in economic reasoning, and is applicable in many contexts.

Although opportunity costs are not incurred in the same sense as the actual costs associated with inputs to electricity production, such as natural gas, this kind of cost is nevertheless equally price-relevant: Irrespective of whether an emission allowance has been obtained via grandfathering or through an auction, the electricity producer always has the option of selling it at the exchange, rather than actually using it in the production process. That electricity prices need to reflect this option is independent of whether individual suppliers can exercise market power and of the allocation mechanism in place, be this grandfathering, auctioning, or some mixture of the two. Thus, the suggestions by politicians, consumers, and also cartel offices that electricity producers not include the value of grandfathered certificates in electricity prices is fundamentally at odds with free-market principles. Were the electricity sector forced to do so, rational electricity producers would certainly reduce production, thereby driving up electricity prices to the point that the sale of certificates would become the unattractive alternative relative to production. As a result, market laws ensure the inclusion of the certificates' value in the electricity price even in the presence of command and control measures.

In short, the view that the inclusion of allowance values in electricity prices can be regarded as an indication of the striking absence of competition among utilities (Ecologic 2005:31) is misplaced. As Figure 1 illustrates, the degree to which firms' higher production costs are passed onto consumers depends on the relative price elasticities of supply and demand. If supply is elastic, but demand is perfectly inelastic, suppliers will pass increased costs, e.g. from taxation, entirely onto consumers even when perfect competition reigns. In this case, the tax $t$ in Figure 1 accounts for the full amount of the resulting market price increase from $p_0$ to $p_0 + t$.

The more elastic is the demand, though, the smaller is the corresponding price increase. This is illustrated in the figure by the equilibrium price $p_1$ that results from the tax when demand is elastic. It is lower than the equilibrium price $p_o + t$ that results from an inelastic demand curve. Consequently, the burden of the cost increase is shared by consumers and producers. This stylized example demonstrates the fallacy of attributing the pass-through of allowance prices to market power, as the extent of this pass-through is a function of the supply and demand elasticities even in the case of perfect competition. Given the notoriously price-inelastic demand for electricity,[2] it is reasonable to surmise that CO2 prices would largely be passed onto consumers, even if perfect competition prevailed in the electricity production sector.

**Figure 1: Cost Pass-Through to Consumers**




It is equally erroneous to seek evidence for the electricity sector's lack of competition in the fact that the price increases in other industry branches affected by emissions trading are less pronounced: "An additional indicator for the argument of weak competition in the electricity sector is the differential development of producer prices in branches that participate in the ETS. […] Even in the booming steel industry, where international demand in recent years has increased substantially, price increases were minor" (Heyman 2007:3). While the cartel office interprets such observations as evidence for the exercise of market power in the

[2] Branch (1993:111), for example, estimates the electricity price elasticity in the USA to be -0.2. Accordingly, a price increase of 10% would be accompanied by a decrease in electricity consumption of 2%. In a review of the literature from Branch (1993: 118), the electricity price elasticity in the USA ranges from -0.11 to -0.55.

electricity generation sector, this conclusion is not compelling because there are a range of equally plausible explanations. One reason is that in contrast to the electricity market, the demand in many other markets is relatively elastic, thereby impeding the pass-through of CO2 prices to consumers.

That the intensity of competition plays a secondary role in the pass-through of CO2 prices is demonstrated by a simulation exercise for Belgium, France, Germany, and the Netherlands (Sijm et al. 2006:61). The decisive factor is instead seen in the distinct mix of fuels used for electricity production, which differs substantially across these countries. According to the simulation results, a CO2 price of the plausible magnitude of 20 € would have a particularly strong effect in raising electricity prices only in Germany, where the price increase of electricity would lie between 13 and 19 €/MWh. The corresponding price increase in France is considerably lower, ranging between 1 and 5 €/MWh, while it lies in an intermediate range between 9 and 11 €/MWh for the Netherlands, depending on whether the market structure is assumed to be oligopolistic, monopolistic, or fully competitive and on whether the calculation specifies a completely inelastic demand or a moderately elastic demand.

Given that the various generation technologies imply different CO2 emissions per MWh, and therefore distinct opportunity cost, these results are not surprising in light of the fuel mix in the electricity production of these countries. While France relies on CO2-free nuclear power for roughly 80% of its electricity generation (IEA 2006), gas-fired plants with comparably low CO2 emissions are dominant in the Netherlands, owing to the country's gas deposits. In Germany, by contrast, electricity prices are largely determined by coal-fired plants. Accordingly, the EU-wide prices for CO2 allowances have a stronger impact in increasing electricity prices in Germany than in countries with less carbon-intensive electricity production. Only when there is a sufficiently integrated electricity market in Europe will the EU-wide uniform CO2 prices have no differential effects on the electricity prices in the individual countries. This state of affairs, however, is unlikely to be achieved in the foreseeable future given the inadequate cross-country network capacities.

## 3. The Magnitude of Windfall Profits

With the observed electricity price increases in the aftermath of the ETS introduction, it is of interest to estimate the magnitude of associated windfall profits. Although the data required for more precise calculations is largely proprietary, an approximation can be undertaken using

publically available figures for German electricity production. The following estimation for 2006 assumes that 80% of the certificate price is passed on to electricity consumers, which is in the middle of the interval of 60% to 100% Sijm et al. (2006:67) identify for the CO2 cost pass-through rates for Germany's whole sale markets. In 2006, CO2 prices averaged 17.4 €/ton on the Leipzig Power Exchange, so that an 80% pass-through would imply a CO2 cost of 13.9 €/ton. For the electricity production from brown coal, for instance, the 80% pass-through would increase the electricity price by 13.9 €/MWh, given a CO2 emission factor for brown coal of around 1 ton CO2/MWh.

While nuclear-, hydro-, and brown coal power plants are typically employed to satisfy base-load demand, brown coal power plants usually determine the electricity price in base-load times (IEA 2005:xiv). Hence, it is the additional CO2 cost of electricity production from brown coal that increases base-load prices, irrespective of whether it is produced from brown coal, nuclear or hydro power. Multiplying 167.5 million MWh of nuclear power by the price increase of 13.9 €/MWh suggests that the associated windfall profits attributed to nuclear-based electricity production in 2006 were on the order of 2.3 billion €.

In short, it is reasonable to surmise that a large share of windfall profits can be ascribed to CO2-free nuclear power generation, as this kind of electricity production incurs no additional costs from the CO2 penalty, but benefits from the ETS-induced price increases. This is in line with Sijm et al. 2006:63), who conclude that, given their high share of nuclear power in total generation, Germany's E.ON and the Electricite de France (EdF) may benefit most from emissions trading even if electricity producers would have to buy all their allowances.

Additional revenues accruing to electricity production come from hydro power, which does not imply any CO2 costs either. In 2006, 27.9 million MWh of electricity were produced from hydro power (Table 1). If it is again assumed that 80% of the certificate price is passed on, then another 0.4 billion € in revenues would theoretically accrue (Figure 2). The CO2-free electricty production of nuclear and hydro power alone would thereby account for some 2.7 billion € in windfall profits, illustrating the enormous economic significance of the ETS.

Besides nuclear and hydro power plants, the CO2-free electricity production by wind power and other renewable energy technologies also allows for windfall profits. Not least, even the CO2-intensive electricity production from brown and hard coal will have profited from the cost-free allocation of certificates in the first trading period, despite the costs resulting from the potential need to purchase additional allowances: According to Germany's National Allocation Plan (NAP1), existing plants were forced to a CO2 reduction of only

2.91% relative to the historical emission level in the first trading period (2005-2007). Given such light reduction requirements, the CO2 costs of those German utilities basing their electricity production on coal should have been moderate relative to the windfall profits. Yet, the simulation results of Sijm et al. (2006:63) indicate that utilities with an unbalanced production portfolio mix, such as Germany's purely coal-based STEAG, would experience profit losses under a regime of complete auctioning.

**Figure 2: Electricity Price and Variable Cost of Production in 2003 (IEA 2005).**

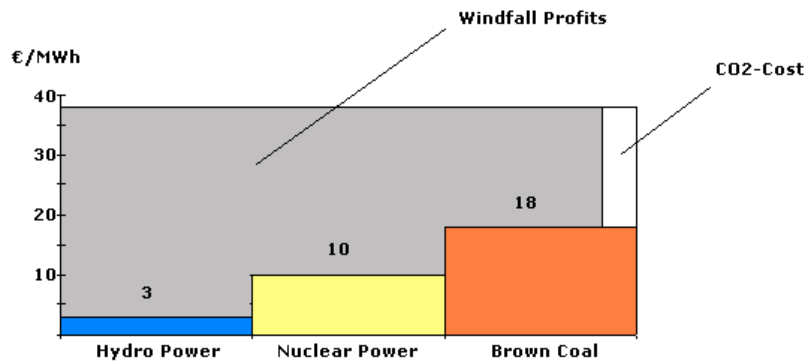



**Table 1: Gross Electricity Production in 2006 in Germany (Schiffer 2007:38)**

| | Mio. MWh | Shares | t CO2/MWh |
|---|---|---|---|
| **Nuclear Power** | 167,4 | 26,3 % | 0,000 |
| **Brown Coal** | 152,0 | 23,9 % | 1,003 |
| **Hard Coal** | 136,0 | 21,4 % | 0,924 |
| **Natural Gas** | 73,5 | 11,6 % | 0,470 |
| **Oil** | 10,5 | 1,7 % | n. a. |
| **Hydro Power** | 27,9 | 4,4 % | 0,000 |
| **Wind Power** | 30,5 | 4,8 % | 0,000 |
| **Biomass, etc.** | 38,0 | 6,0 % | 0,000 |
| **Total** | 635,8 | 100,0 % | |

## 4. Impacts on Energy-Intensive Industries

Rational economic calculus dictates that electricity producers include the value of CO2 certificates in the electricity price, thereby increasing profits if certificates are allocated entirely cost-free. By auctioning the certificates, these windfall profits could be diminished or

even completely eliminated. This possibility is one of the primary reasons why in the second trading period (2008-2012) German electricity producers must purchase almost 9% of the certificates that are allocated to the sectors participating in the ETS. This is close to the auctioning limit of 10 % that is stipulated by the European Commission for the second trading period. For the third trading period, starting in 2013, the Commission is currently considering expanding the extent of the auction to cover up to 100% of all certificates required. This would not only adversely affect the electricity-producing sector, but any industry participating in the ETS, if certificate costs have not yet been entirely passed on to electricity prices.

Despite the substantial economic repercussions of this climate policy instrument, however, there are few empirical analyses that explore the effects of the higher electricity prices from emissions trading on the energy-intensive industries in Europe. A particularly conspicuous research lacuna concerns the effects of a complete auctioning, one reason being that to date no complete auctioning system has been in practice. In the US, for example, the motherland of emissions trading systems, certificates have been almost exclusively grandfathered on the basis of historical emissions (Graichen and Requate 2005:52).

One of the few relevant studies is the "Report on International Competitiveness" (Ecofys and McKinsey 2006), which was commissioned by the General Directorate for Environment of the European Commission. Because the study does not consider future developments of Europe's power sector, the results reflect the ETS' short-term effects. With a complete auctioning of certificates, however, it is most likely that the fuel mix of European power generation would change significantly.

Without a doubt, emission-intensive plants, such as those producing electricity from brown and hard coal, incur higher CO2 costs from complete auctioning, thereby triggering the environmentally desirable change from high- to low-emission technologies. In the short run, this would result in an increased utilization of existing gas power plants and the reduced employment of coal power plants. Over the long term, a complete auction is most likely to be associated with the accelerated retirement of coal power plants, instead fostering the installation of new gas-fired power plants. Consequently, a substantially higher demand for natural gas is to be expected among EU countries. This demand shift will lead to increasing prices for natural gas, thereby further pushing up electricity prices.

These long-term effects of a complete auction on the competitive position of European industry have received scant attention in empirical studies, with the report from Ecofys and McKinsey (2006) being no exception. Nevertheless, this study shows that even under the assumption of small-scale auctioning accompanied by a grandfathering of 95% of allowances,

and a CO2 price of 20 €, the impact of CO2 penalizing on electricity prices could be substantial for energy-intensive industry sectors.

Among the most strongly affected would be the highly electricity-intensive production of primary aluminum. Its migration to countries with low electricity prices, such as the Gulf States of the Middle East, would be clearly accelerated by an auctioning system. Small et al. (2006:40), for instance, reach such conclusions for Great Britain. Their study shows that primary aluminum production on the island would already be completely abandoned at a CO2 price of 15 €/ton even when all allowances are grandfathered. Similar consequences could be expected for other electricity-intensive industries, such as copper production.

For this reason, Ecofys and McKinsey (2006:37) conclude that for energy-intensive industry sectors – and only these sectors are involved in the ETS – the "possibility of production shifts and CO2 leakage is real". In other words, the ETS-induced burden placed on energy-intensive European industries leads to a transfer of emissions to other countries that have no such climate protection costs. The emissions reduction within the EU would then be offset by emissions increases outside the EU, a phenomenon commonly to as *carbon leakage* (Oliveira-Martins et al. 1992).

Three drivers account for carbon leakage. First, high-polluting industries may relocate outside the EU. Second, imports of pollution-intensive goods may diminish production within Europe. Third, a substantial reduction in the energy demand in countries with strongly curbed emissions could lead to lower energy prices worldwide, which would in turn increase demand for fossil fuels in the remaining countries. While skeptics argue against overestimating the leakage effect given that environmental regulations are only one of many factors determining firm location, the possibility of resettlement is nevertheless acknowledged (Hentrich and Matschoss, 2006:51).

Yet, the possibility that importing pollution-intensive goods could curb European production, but do not decrease global emissions accordingly, appears to be often overlooked. For the case of the cement industry, for example, a sector that accounts for around 5% of global anthropogenic CO2 emissions, Demailly and Quirion (2006:109) find leakage effects of 50% under the assumption of a 90% grandfathering of allowances and a CO2 price of 20€/ton, using a trade model for homogeneous goods with high transportation costs. In other words, roughly half of the emission-savings would be offset by cement imports from non-EU countries, with a corresponding decrease in cement production within the EU as a result[3]. This decreased production would not imply a reduction in profits, however, because the EU cement

[3] According to Grubb and Neuhoff (2006:12), this high leakage rate can be explained by t …

industry could sell its unused allowances, 90% of which were obtained for free. But if these certificates were auctioned at a rate of 50% or higher, the study finds that the cement industry would have to contend with substantial cuts in profits.

## 5. Abrupt Transition to Complete Auctioning?

Given such economic repercussions, the number of empirical studies addressing the ETS' impact on energy-intensive industries in the EU is surprisingly low. This empirical void should be reason enough for the European Commission to abandon plans of an abrupt transition from the current 10% to a 100% auctioning of certificates as of 2013. With a complete auctioning, after all, the competitive position of energy-intensive EU industries would suffer relative to their counterparts in countries without comparable environmental cost, with detrimental effects on economic growth, income, and employment (Sijm 2006:291).

In addition to ETS-induced electricity price increases, the production cost increases resulting from auctioning may imply a heavy burden for energy-intensive industry sectors such as the cement industry or the copper and aluminum producers. Hence, although the grandfathering of allowances does not create additional incentives to reduce emissions beyond those already reflected in the ETS-induced higher electricity prices, non-electricity sectors should be exempted from the auctioning of certificates as long as all other major industrial and transition countries abstain from serious climate protection measures and reject the integration into a comprehensive global emissions trading system.

With particular respect to the electricity sector, the obligation to purchase all certificates would trigger a substantial increase in the EU's demand for natural gas: A February 2008 paper of UBS, a Swiss bank, predicts that 43% of Europe's coal-fired power generation will switch to gas (Economist 2008). In the long run, this will ultimately lead to higher electricity prices via increasing gas prices as well as a stronger reliance on gas imports, in particular from Russia.[4] Not only would a complete auctioning thus undermine the EU's endeavor of improving its energy security situation; it could also imply dramatic changes in countries such as Poland, whose electricity production largely rests on coal-fired plants. Coal-based production currently contributes 93.1 % to total Polish electricity generation (IEA 2008: III 465).

[4] On top of this, Germany's phase-out of nuclear power would further exacerbate the effects of a full auctioning on energy security and the cost-effectiveness of electricity provision, with negative consequences for the international competitive position of domestic industries.

In the medium term, the electricity generation in such EU countries would be much more expensive, making electricity price increases likely if certificate costs have not been entirely passed on to electricity prices. In the long term, higher price levels will be indispensable for the deployment of expensive clean-coal technologies, including carbon capture and storage. This is all the more relevant as it bears noting that after 2012, a substantial reduction in emissions will be required if compliance with the ambitious European climate protection goals set for 2020 is to be achieved. The most likely consequences would be higher certificate prices and further increasing electricity prices. These perspectives cast doubt on the Commission's plan of an abrupt switch to complete auctioning for European electricity producers after 2012.

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