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Emissions trading and the European electricity market

Consequences of emissions trading on prices of electricity and competitiveness of basic industries

1 Introduction

Last year, the European Commission proposed the introduction of a European system of trading in greenhouse gases.[2] This proposal is currently subject to fierce debates. Opponents to the proposal of the Commission do not question the efficiency effects of emissions trading in general. The economic benefits of trading in emission permits compared to other instruments for climate policy are broadly recognized. Likely distributional effects of emissions trading, however, are the origin of fierce controversies. One of the issues under debate is the method of allocation: how should the permits be distributed upon take-off?

The European Commission has proposed a method of direct allocation while others, like representatives of large industries, plead for an indirect method. In the former approach, permits are distributed directly to the group of firms that emit the gases. End-users of energy receive their permits in the latter method. Emitters and end-users of energy are the same group of firms only when use of energy coincides directly with emissions. This is valid for the burning of natural gas for instance, but not for the generation and consumption of electricity. Emissions

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[2] European Commission, 'Proposal for a directive of the European Parliament and of the Council establishing a framework for greenhouse gas emissions trading with the European Community and amending Council Directive 96/61/EC', Brussels, COM(2001)581

of carbon dioxide result from electricity production when power is generated by means of coal, oil, or gas fired plants. Consumption of electricity does not generate any emissions. Consequently, the direct allocation of permits implies that power plants receive the permits while electricity users obtain them when the indirect approach is followed.

The debate on the method of allocation concerns its effects on the price of electricity and the competitiveness of large users of electricity. Questions that have to be answered are: 'will power producers raise their prices if they obtain their permits free of charge?', and 'to which extent does a rise in electricity price affect industries such as Steel, and Aluminium?'. The Netherlands' Committee 'Allocating emission permits" has asked the CPB to answer these questions.

In this memorandum, we describe the results of our analysis. The assessment starts with a concise description of the system of emissions trading the Commission of the European Union has proposed, paying special attention to the issue of the allocation of permits (section 2). Afterwards, the main characteristics of the electricity market in Europe will be discussed (section 3). Section 4 analyses how the direct approach of allocation affects prices of electricity, while section 5 does the same for the indirect approach. A numerical analysis is given in section 6. If the prices of electricity rise, firms using electricity will face higher costs. Section 7 analyses whether sectors with a relatively high use of electricity, like the Steel and the Aluminium industry, might face a deterioration in their competitiveness resulting from the introduction of a system of emissions trading. The paper ends with the general conclusions.

2 Emissions trading in the European Union

The European Commission has proposed the introduction of a European system of trading in permits for the emissions of greenhouse gases. The permits can be seen as allowances to emit a certain amount of greenhouse gases during a certain period. The proposed system is a 'cap-and-trade'-system, meaning that participants are allowed to trade permits which are capped through an absolute ceiling. The European Commission is going to determine this ceiling on the basis of its commitments within the Kyoto-protocol.

The value of the permits depends on their scarcity on the market. This scarcity is, in its turn, a function of the ceiling on the one hand and the demand for the permits on the other.

Expectations are that a permit price between 5 and 20 euro per ton carbon dioxide should be sufficient to clear the permit market during the Kyoto-years.[3]

The proposal of the European Commission has been subject to intensive debates since its publication. The approach of allocation is one of the issues. In theory, several methods exist for the allocation of the permits upon the take off of an emissions trading scheme. In general, one distinguishes auctioning, grandfathering, and updating.

In the case of auctions, participants in the trade system have to buy the permits initially while they receive them free of charge when grandfathering is the method of allocation. The returns of the auction are usually recycled back into the economy, for instance by means of reducing income tax rates. In its original form, the distribution of permits in the case of 'grandfathering' is based on the level of emissions in the past. Nowadays, the term 'grandfathering' refers also to distributions using external benchmarks, for instance regarding emissions per unit of output.

When permits are allocated by auctioning or grandfathering, the number of permits and hence the cap on the total emissions is fixed. In the 'updating' approach, however, the cap is not fixed during the whole period. Such a method of allocation offers the opportunity to give firms additional permits when they are needed. Such an updating system comes close to a 'relative cap-and-trade' system and is therefore not a pure cap-and-trade system. However, an updating system can be combined with a cap-and-trade system. In such a system, not all permits being available within the cap are distributed upon the start of the system. As a consequence, the initial cap is lower than the ultimate ceiling of emissions.

The European Commission has chosen to allocate the permits by means of the grandfathering approach. Member countries of the European Union can choose between different criteria for the distribution: historical emissions or external benchmarks. These countries also have the opportunity to combine this approach with a system of updating. Some countries will probably choose not to allocate all the permits when the system takes off, but distribute these permits later on, for instance to new entrants.

Although several choices regarding the allocation have been made - like grandfathering in stead of auctioning -, various aspects remain subject to debate. The current controversy on grandfathering is directed to questions like 'how many permits should the participants receive

[3] See for instance H.L.F. de Groot, T. Manders and P.J.G. Tang, 'Relocation effects of climate change policies', CPB-report 2002/4, CPB Netherlands' Bureau for Economic Policy Analysis, The Hague, 2002.

initially?', and 'which participants should receive the permits?'. In this memorandum, we do not pay attention to the first question. Regarding the latter question, one distinguishes the direct approach and the indirect approach. In the direct approach of allocation, permits are allocated directly to emitters, while end-users (consumers and other users of energy) receive the permits in an indirect approach. In the case of electricity, emitters of carbon dioxide and (most) users of electricity are different economic agents. Because end-users of electricity do not directly emit carbon dioxide, they do not need permits by themselves. They will sell the permits to firms such as power plants which actually emit.

Several criteria can be distinguished for the assessment of the alternative approaches for the initial allocation of permits. Harrison et al. (2002)[4] mention efficiency considerations, distributional considerations, feasibility, effects at sector level, and effects at plant level. In this paper, we assess the sector effects of the method of allocation. We do not analyse the other aspects of the allocation, which makes the assessment a partial one. In addition, we assess only the consequences for some specific sectors. The sectors analysed are those with a high level of electricity use and which compete on global markets. These sectors are Steel, Aluminium, Plastic, Paper and Nitrogen industry.

3 The European electricity market

The sensitiveness of the prices of electricity to emissions trading depends partly on the characteristics of the electricity market. The future development of the European electricity market is mainly characterized by three factors. These factors are:

1. gradual disappearance of the regional fragmentation;
2. continuation of large differences between the various production techniques;
3. persistence of imperfect competition between suppliers.

3.1 Disappearance of regional fragmentation

Strictly speaking, a European electricity market does not exist at present. Grid restrictions limit international trade in electricity. For instance, power generated in the South of Europe can not be supplied to end-users in the North of Europe. International trade in electricity within Europe

[4] D. Harrison and D.B. Radov, 'Evaluation of alternative initial allocation mechanisms in a European Union greenhouse gas emissions allowance trading scheme', National Economic Research Associates (NERA), March 2002.

did not take place until a few years ago. Some linkages between the national grids did exist, but they were rather limited. The rationale behind these interconnections were concerns about the security of supply. Due to those linkages, temporary shortages in supply in one country could be overcome by means of importing from neighbouring countries.

In most EU countries, the liberalisation of the electricity markets has been implemented in the past years. In countries like Austria, Finland, Germany, Sweden, and the UK, all end user groups are free to choose their electricity supplier. In other EU countries, such as Belgium, the Netherlands, Ireland, Italy and Spain, full opening of the market is expected to be realized in a few years[5]. The competition on the power market will still be hampered by remaining shortages in international transmission lines.

In the Scandinavian countries, an integrated power market has existed for about 10 year. These countries established the Nordic Power Exchange, also known as Nord Pool, in 1993. The power markets in Norway, Sweden, Finland and Denmark are closely linked now. As a consequence, for instance, the hydro generators in Norway compete with nuclear power plants in Finland. The interconnections of the Scandinavian market to the other countries are, however, still very limited: not more than 1% is imported from other European countries.

Other regional markets within Europe are the UK-market, the Iberian market, the Italian market and the Central European market with France, the Benelux, Germany and Austria (Morgan Stanley, 2002)[6]. Within each of these markets, end-users face approximately the same electricity prices, while prices are rather different between these regions. Prices of electricity are relatively low in the Nord Pool, the UK-market, and the Central European market. The Iberian and especially the Italian markets show high electricity prices.

It is expected that the regional dimension of the European electricity market will disappear in the near future. New investments in interconnection between national and regional transmission grids will improve the competition between suppliers from different parts of Europe. The ongoing process of the liberalisation of European electricity markets will ultimately result in one European market.

[5] Commission of the European Communities, 'Second benchmarking report on the implementation of the internal electricity and gas market', Commission Staff Working Paper, Brussels, 1 October 2002.

[6] Morgan Stanley, 'Utilities: industry overview', 16 May 2002.

3.2 Large differences between techniques

The various techniques for generating electricity show large differences in costs. These differences will remain when the European market is fully liberalized. Some techniques face high capital costs and low marginal costs, while others have low capital costs and high marginal costs. Nuclear, coal fired, and hydro power plants belong to the former group, while the latter consists of oil and gas fired power plants. The techniques with high fixed costs and low marginal costs have an economic advantage at the market for base load demand, while the peak load demand is served by the low fixed costs and high marginal costs techniques. This phenomenon stems from the fact that during off peak moments demand and hence prices are relatively low. Only generators with relatively low marginal costs are able to deliver electricity in that circumstances. On the contrary, demand is high during peak moments with high prices as result, making the production of high marginal costs techniques profitable. As a consequence, the number of techniques actually competing with each other is less than the total number of generation techniques that exist.

The various generation techniques differ also in the level of emissions per unit product. Nuclear and hydro generations do not emit any greenhouse gases, while coal fired power plants emit most out of all techniques. The introduction of scarcity in the allowances to emit affects the competitiveness of all generation techniques accordingly. Coal fired power plants will face an increase in their costs compared to all other generation techniques, while nuclear and hydro generators will get comparative advantages.

3.3 Imperfect competition

Although the regional fragmentation of the market is going to disappear and different techniques exist to serve demand, competition on the electricity market will be imperfect. One expects that the concentration on the supply side will remain high due to international mergers and consolidations of producers.[7] This concentration offers suppliers of electricity the opportunity to set prices above marginal costs. Suppliers take into account, however, the price elasticity of demand in order to maximize their profits.

[7] Commission of the European Communities, 'Second benchmarking report on the implementation of the internal electricity and gas market', Commission Staff Working Paper, Brussels, SEC(2002) 1038

4 Effects of direct allocation on electricity prices

The allocation of permits by means of grandfathering is a kind of wealth transfer. The emitters receive valuable assets without payment. In order to answer the question whether a transfer of wealth affect prices, in this case the electricity prices, one has to analyse its effects on marginal costs, and the mark-up.

4.1 Use of permits implies opportunity costs

The introduction of a system of emissions trading affects the marginal production costs, since a positive relation exists between the scale of the production and the costs of using the permits. An increase of the production implies, ceteris paribus, an increase in the emissions. The latter implies that some allowances to emit are actually used. The cost of using a permit is the opportunity cost of not selling the permit on the permit market. This opportunity cost exists no matter whether the emitter has received the permits by grandfathering or by auctioning. It can be concluded, therefore, that the production of electricity always coincides with the sacrifice of the opportunity to sell the permits on the permit market.

4.2 Grandfathering of permits is lump-sum transfer of wealth

Besides its effect on the marginal costs, the grandfathering can also affect the mark up above the marginal costs. The transfer of wealth to the emitters can be seen as fixed subsidy, independent of future production. Firms use such a subsidy as a compensation for fixed costs. As a consequence, firms could reduce the mark up above the marginal costs. Whether the firms will actually reduce their mark up depends on the treatment of new entrants in the trading scheme.

The mark ups will not be decreased by the incumbents when new entrants have to buy the permits, as is the case in the standard cap-and-trade scheme. The incumbents do not have any incentive to pass on the 'subsidy' in the prices. In other words, new entrants are marginal suppliers determining the price of the products. The costs of these marginal suppliers partly consists of the price of the permits. Therefore, these suppliers are not able to supply against a price which does not pay for the permits. Consequently, the incumbents, having received the permits free of charge, take the 'rent' of the scarcity on the permit market.

When new entrants receive, just as the incumbents do, the permits free of charge - for instance, by means of updating the total ceiling -, competition within the product market can result in a decline of the mark ups. In this case, new entrants are able to supply against the unchanged

product price. Such an allocation method doesn't fit well, however, within the standard cap-and-trade case, in which the level of total permits is fixed during the whole period. A system in which the number of available permits increases with demand, for instance by means of 'updating', resembles a performance standard trading system(see chapter 2).

4.3 Pricing behaviour of electricity producers

The characteristics of the product market determine whether firms pass on the total increase of the marginal costs in the product prices. At a market with perfect competition, the price increase is equal to the rise of the marginal costs. At markets with imperfect competition however, prices are higher than the marginal production costs. Suppliers are able to set prices above the marginal costs due to their market power.

In their decision whether to pass on an increase in marginal costs in product prices, firms operating on markets with imperfect competition do take into account the consequences on the demand. Firms facing linear demand curves will probably slightly decrease their mark ups in order to mitigate negative effects of rising costs on electricity demand. When, however, consumer demand has a constant elasticity, mark ups of firms are also constant.

5 Effects of indirect allocation on electricity prices

In the case of indirect allocation, electricity users instead of electricity producers receive the permits when the emissions trading scheme takes off. As the use of electricity doesn't coincide with emissions of carbondioxide, the electricity users do not need the permits for themselves. The only reasonable opportunity for using the permits is selling. Electricity producers, on the other hand, actually emit carbon dioxide and hence need the allowances. In order to produce electricity, they have to buy permits. The electricity producers face, therefore, additional costs for their inputs. To them, this effect is equal to a rise in the price of inputs like coal or natural gas, for instance due to the introduction of a tax on these energy carriers.

Just as in the case of direct allocation to the electricity producers, allocation to the electricity users affects the marginal costs of electricity generation. The main difference between these two approaches is that the indirect allocation doesn't transfer wealth to the electricity producers. As a result, the electricity producers raise their prices, although they account for the effect of price increases on the demand. The electricity users get a higher electricity bill, but the sale of the grandfathered permits compensates these costs to a large extent.

6 Simulation of the electricity market

In order to understand the significance of the above mentioned effects, we did a numerical analysis with ELMAR, CPB's model of the European electricity market[8] and STREAM, CPB's model of the National and European basic industries within the global economy[9]. ELMAR describes the European electricity market as Cournot competition. Key elements in this model are the differences between various generation techniques and the distinction between the base load, and the peak load market.

As both the direct and the indirect allocation approach lead to higher marginal costs, the numerical analysis is valid for both approaches. We assume that new entrants do not receive the permits for free. The price of permits is implemented by means of a levy on fossil fuels, differentiated to contents of carbon per unit of fuel. Because of the Cournot description of the supply, producers automatically take into account likely effects of price changes on demand.

To start with, we made assumptions regarding the future permit price. We analysed a variant in which the permit price will be 5 euro per ton CO2 in each year during the simulation period 2005 till 2010. In the other variant, the permit price is assumed to be 20 euro per ton. In both variants, we assumed that the firms pass on all their additional costs in the product prices.

Table 6.1 shows the effects of these permit prices on the electricity market. When the permit price is 5 euro per ton CO2, the electricity wholesale price in 2010 is on average 6.5% higher than in the base line scenario. Since the costs of coal fired generation increase most, this generation technique shows a large decline in production. The supply from the coal fired generators is partly replaced by supply from generators emitting less or none CO2. Due to this substitution process within the power sector and the decline in overall electricity demand, the CO2-emissions in 2010 are 3% below the base line level. When the permit price is 24 euro per ton CO2, the effects are about 4 times larger. The electricity wholesale price rises with 24%, while the production of the coal fired generators declines with about the same percentage. The emissions by the power sector declines with more than 10%.

[8] See for a description and application of ELMAR: Mark Lijesen, Hein Mannaerts and Machiel Mulder, 'Will California come to Europe? A numerical simulation', Journal of Industry, Competition and Trade, 2:1/2, 173-188, 2002

[9] H.J.B.M.Mannaerts, 'STREAM: Substance Throughput Related to Economic Activity Model, a partial equilibrium model for material flows in the economy', Research Memorandum 165, CPB, May 2000

Table 6.1 Consequences of emissions trading on electricity market (percentage deviation from base line in 2010)

Electricity market	Permit price is 5 euro/ton CO2	Permit price is 20 euro/ton CO2
commodity price	6.5	24
production by fuel/technique		
- coal	-6	-22
- natural gas	2	8
- nuclear	1	4
- hydro	1	4
- renewable	8	32
CO2 emissions	-3	-11

Source: ELMAR

7 Consequences for large electricity users

7.1 Direct allocation

Industries in Europe that compete on global markets can not pass on an increase in the electricity prices to their customers. As a result, the supply of these industries declines when the electricity price is raised. Hence, the market share of the European industries on the global markets decreases. The production of the European steel, aluminium, plastic and nitrogen industries reduces by about 2% when the price of permits is 5 Euro/ton carbon dioxide (see Table 2). This effects follows mainly from the increase in the electricity price. Within these industries, a shift towards the secondary production, i.e. the production based on recycled materials, takes place. The growth of secondary production partly compensates the decline of the primary production. This substitution effect stems from the differences in the use of electricity per unit of output.

The decline in value added is not as big as the decline in the production value. Firms partly replace energy by capital and labour due to the changes in the relative factor prices. The decrease of the value added of these industries is about 1%.

The use of energy by these sectors in 2010 is about 5% below the base line level. This decline results partly from the decrease in the production and partly from an improved energy

efficiency. The production of plastic and nitrogen shows a rather low decline in energy use, since the energy carriers oil and natural gas are mainly used here as non-energetic inputs.

Although, the effects on sector level could be significant, macroeconomic effects of emissions trading are rather small. Realising the Kyoto commitment by means of emissions trading will result in a loss of approximately 0.2% GDP in 2010.[10]

Table 7.1 Consequences of a permit price of 5 Euro/ton carbon dioxide on raw material processing industry (percentage deviation from base line in 2010)

Sector	Total production	Primary production	Secondary production	Energy use
Steel	-2.5	-5	0.5	-5
Aluminium	-2	-4	0.5	-6
Plastic	-2	-2	n.a.	-4
Paper	-0.25	-0.5	0.25	-5
Nitrogen	-2	-4	n.a.	-4

Source: STREAM

7.2 Indirect allocation

As is shown before, both direct and indirect allocation (without updating) result in higher electricity prices. In the case of indirect allocation however, electricity users receive compensation for the higher prices. The higher costs stemming from the higher electricity prices equalize the benefits of the sale of the permits. These two opposite effects cause that firms will not use the transferred wealth to pay higher dividends; after all, the value of the firm has not changed.[11]

As a result, the marginal costs of these sectors increase with the increase of the electricity prices, but the average costs do not change. Indirect allocation, therefore, affects the use of energy and hence the energy efficiency without having large effects on competitiveness of these sectors. Some effect will emerge, however, due to costs associated with investments in energy efficiency.

[10] CPB, 'Klimaatbeleid en Europese concurrentieposities', CPB-document 24, November 2002.

[11] See also A.L. Bovenberg and L.H. Goulder, 'Neutralizing the Adverse Industry Impacts of CO2-Abatement Policies: What Does It Cost?', NBER Working Paper No. W7654.

If, however, permits are allocated for a long period of time, economic effects could be completely different. In that case, industries receive a large amount of money when the emissions trading system takes off while their production costs will be higher during the whole period of trading. If the transfer of wealth is larger than the costs of changing the location of production, firms operation on global markets have an incentive to relocate to a country outside the European Union. Allocation of permits for a short period of time, for instance a year, would prevent such relocation effects.

8 Conclusions

The ultimate price effect of the *direct* allocation approach, which distributes the permits directly to the emitters, depends on three components, i.e. the rise in the marginal costs, the incentives to pass on subsidies to end-users and the expectations producers have regarding demand responses on price changes:

- No matter whether permits are allocated initially by auctioning or grandfathering and with or without updating, a positive permit price always implies an increase in the marginal production costs (for generators emitting the green house gas of course).
- The subsidy on fixed costs emerges only in the case of grandfathering. In the pure 'cap-and-trade' system, without updating the ceiling, the incumbents do not have any incentive to pass on the subsidy to their customers. That incentive occurs only when new entrants get the permits for free as well. In that case, the mark up on the marginal costs will be decreased, compensating the rise of the marginal costs, resulting in rather stable product prices.
- Electricity producers, operating on a market with imperfect competition and hence having set the prices above the marginal costs level, will take into account demand response to price increases. We expect that an increase in marginal costs will not fully be passed on to product prices as producers, facing a linear demand curve, will partly reduce their mark ups.

If permits are allocated *indirectly*, electricity users obtain the permits for free while electricity producers have to buy the permits. As a result, the latter marginal production costs are affected, just as happens in the case of the direct allocation. Electricity producers will raise their prices, although they account for likely effects of price increases on electricity demand.

A numerical assessment of the proposal for the introduction of emissions trading within the European Union shows that electricity prices increases by approximately 6.5% when permit price is 5 euro per ton CO_2. Electricity price could raise with nearly 24% when permit price is four times as high. The effect on the electricity price could be lowered by updating the ceiling, for example by giving permits free of charge to new entrants.

The power sector will show significant changes if the emissions trading system is introduced. Production by coal fired power plants will decrease, while other techniques, especially renewable, will increase. The size of these effects depends, of course, on the permit price.
An increase in the electricity price affects the competitiveness of the sectors using much electricity and competing at global markets. If permit price is 5 euro per ton carbon dioxide in 2010, total production of these industries will be about 2.5% less than in the base line scenario. The macroeconomic effects of a permit price of that size are, however, rather limited

The overall conclusions are as follows:

- In the direct approach without any updating of the ceiling, electricity producers, operating on a regional (i.e. European) market, receive the rents of the introduction of emissions trading. Due to the regional character of their market, they do not need the rent as compensation for higher costs since all firms face the same cost increase. Energy users operating on global markets, however, get higher production costs without receiving any compensation. This deterioration of competitiveness will result in loss of market shares on the global markets. Macroeconomic effects of such developments are rather small.
- Energy users do receive compensation in the case of indirect allocation. Consequently, the economic effects for these firms are relatively small. When the compensation is given for a long period of time, however, firms operating on global markets could use the transferred wealth for relocation instead of paying the higher electricity bill. In that, hypothetical, case, macroeconomic effects would be rather large.