# CO2 trade and market power in the EU electricity sector

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**Summary:**

The EU commission is planning to launch an emission trading market for greenhouse gases within near future. This to meet its obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. After a theoretical discussion on market power in such a market, we turn to the empirical evidence which suggests that a reasonable number of sources of $CO_2$ emissions in the power sector exists for boilers larger than 25MW. Overall, together with the contestable single market for electricity, the risk of significant strategic behaviour seems negligible. Thus, the electric utility sector seems a suitable testing ground for an EU-scheme of emissions trading. In the longer run, it will be important to broaden the scope of the trading scheme as the inclusion of other sectors will further limit the risk of market power.

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## 1: Introduction

The EU commission is planning to launch an emission trading market for greenhouse gases within near future. This to meet its obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. So far, two main initiatives have been taken. First, in March 2000, the Commission adopted a Green Paper on greenhouse gas emissions trading within the EU (CEU 2000). Second, the Commission has suggested a specific policy proposal concerning the actual design of this market (CEU 2001). The proposal says that emission trade should deal with $CO_2$ initially and that trade should take place among the largest $CO_2$ emitters, most notably the electric utility sector.

As the Commission argues, this is an important step in economic terms: "The case for a Community-wide scheme is supported by several studies demonstrating efficiency gains. A Community scheme would minimise distortions of competition and potential barriers to the internal market that might otherwise arise as a result of disparate numbers of trading schemes (and prices for carbon) being established in the European Union" (ibid.).

The question we raise is whether a $CO_2$ market for the electric utility sector will be competitive and work in practice. The threat of market power stems from the fact that electric utilities compete in the same product market (that of electricity) and they are, at the same time, presumably large and of a limited number even in an EU context. This question has not yet been addressed in the literature and it is our contribution to do so.

We start out by looking at the theory of market power in Section 2. Section 3 turns to the empirical evidence. Finally, Section 4 summarizes the results.

## 2: Market Power in Theory

According to traditional economic theory concerning market power, there are four possible factors why firms might fail to reap the apparent gains available from the trade of $CO_2$ permits see Tietenberg (1985), Svendsen (1998) and Varming et al. (2000). These potential market failures of an emission trading system are: 1) Market power in the permit market, 2) Strategic interaction between the output market and the permit market, 3) Grandfathering as barrier to entry and 4) Private transaction costs. Let us consider these four possibilities in turn.

### 2.1 Permit market

A dominating firm (or coalition of firms) may attempt to manipulate the price as a monopolist or a monopsonist. The dominating firm can exert monopoly power by selling too few permits and thus raise the permit price for all permits. Correspondingly, a dominant firm can exert monopsony power by buying to few permits which and reduce the permit price. In both cases, the source may achieve a net gain at the expense of cost effective outcome because permits are not allocated in a cost-effective way so that total reduction costs for all firms are minimized. This market power depends on the firm's size relative to the market in which it is operating. In contrast, if all participants are price takers the cost-effectiveness of the system does not depend on the initial allocation of permits, Tietenberg (1985) and Svendsen (1998).

When such market power is present, the ability of the monopolist/monopsonist to exercise market power depends on his initial allocation of permits. The more permits the dominant firm receives compared to the cost-effective allocation, the larger the problem. If some sort of grandfathering, i.e. free initial allocation of permits to polluters, is being used, the present value of marginal abatement costs can fail to be equalised across periods and participants as a result of market power.

To illustrate the potential problems that can be encountered with a grandfathering scheme we will consider a set-up taken from Hagem and Westskog (1996), see Varming et al. (2000). They consider a monopolist that sells permits to a group of small buyers or, alternatively, a monopsonist that buys permits from a group of small sellers. In the following, we assume that a constant price for all permits sold exists. As noted by Munro et al. (1995), price discrimination is ignored because the costs of organising price discrimination outweigh the gross profits achieved.

Using this set-up, Hagem and Westskog (1996) then compare how this affects the working of the two following permit systems:

1) A system where the permits entitle the holder to emit a certain amount of $CO_2$ over the whole length of the compliance period with no restrictions on the allocation of emissions between the different sub-periods within the compliance period. Trade is arranged at the beginning of the period. This system is referred to as a *flexible permit system.*

2) A system where there are restrictions on emissions in each sub-period. The permits entitle the holder to emit a certain amount of $CO_2$ in each sub-period, and trade is arranged at the beginning of each sub-period. A permit bought in the first period has a value for the holder in each of the following sub-periods. This is referred to as a *durable permit system.*

Intuitively, under the flexible permit system each participant will be able to distribute abatement costs effectively across periods. When market power is present in the permit market, however, this relative advantage of the flexible permit system can be lost due to larger differences in marginal abatement costs across participants. In other words, the durable permit system has a relative advantage in terms of avoiding the abuse of market power and thus equalising abatement costs across participants. The reason is that if the monopolist holds back permits in the initial sub-periods to drive up the permit price he will have incentives to lower the price in the later sub-periods to sell more units. Assuming that the buyers will be able to foresee this, they will be willing to pay less for the permit today. In this way, a durable permit system will limit the inefficiencies stemming from the use of market power. Hence, there is a trade-off between reducing the exercise of market power and allowing for flexibility over time.

If the monopolist is a seller of permits, then, in a flexible permit system, the inefficiencies stemming from the use of monopoly power will increase the more the initial allocation favours the monopolist, i.e. the more permits he is given compared to the rest. Likewise, if the monopolist is a buyer of permits (monopsonist) decreasing the initial allocation of permits to the monopsonist will also increase inefficiencies due to the use of market power. In conclusion, the more the initial allocation of permits deviates from a cost-effective distribution of abatement across participants, the lower is the cost of the durable permit system compared to the flexible permit system[1]. However, the inclusion of private parties in any trading scheme will drastically increase the number of participants and as such limit the scope for exercising market power in this way.

### 2.2 Output market and permit market.

The strategic incentive to exclude competitors in the product market by keeping them out of the permit market must be considered too. A source – or a group of sources – may refuse to sell permits to new entrants and thereby create a barrier to entry. Such a 'predatory' source may in this way increase its opportunities for manipulating the price in the product market. This behaviour occurs if the two engaging sources are direct competitors in the same product market and emit the same pollutant in the same regulated area. This set of conditions is fulfilled in the case of the electric utility sector, Svendsen (1998).

When strategic interplay between the permit market and the output market is possible, grandfathering will not result in the minimisation of marginal abatement costs. In such a case, a firm that receives a favourable allocation of permits can, by holding on to these permits, expand its own production at the expense of other firms. The other

[1] For example, with a small number of potential buyers, each purchasing a sizeable fraction of units sold organisational costs are greatly diminished. It is a well-known result from industrial economics that perfect price discrimination achieves a socially optimal allocation of resources. However, all the benefits from trading will accrue to the monopolist. Monopoly or monopsony is only a potential source of inefficiency when the numbers of agents on the other side of the market makes price discrimination impracticable

firms will now find it harder to underbid the first firm since their production is constrained by the amount of permits. They would now have to lower their emissions to output ratio presumably at a very low cost in order to expand their market share. Clearly, this will not result in an equalisation of marginal abatement costs and thus permit prices between participants, and as a result the cost-effective reduction in emissions will be realised.

Especially relevant to the electricity sector is the presence of a contestable product market. The presence of a single market for electricity may in itself force agents to produce at lowest costs including cost-effective permit trading. If a firm can enter and exit a product market easily, the market is contestable even if the conditions for pure competition are not met. For example, the threat of entry and potential underbidding is sufficient to force a local electricity company to act in a competitive way, even if it is the only local supplier of electricity, see Tietenberg (1985) and Svendsen (1998).

### 2.3 Grandfathering

On a related note, if the industry structure is not competitive, grandfathering can also be a barrier to entry. This can be seen from the following reasoning. Assume that the industry structure is not competitive due to the presence of economies of scale. Economies of scale mean that there is a minimum efficient scale of production necessary to generate rents to cover the fixed costs. If in addition this minimum efficient scale is a significant proportion of the total industry demand, the market can sustain only a small number of firms. In this way, the presence of fixed costs has the potential to generate an imperfectly competitive market structure by limiting entry (Tirole, 1990). Of course, the threat of entry by other firms may still serve to discipline the established firms so the degree of imperfect competition will depend on the concrete case at hand.

If emissions permits are grandfathered to an existing industry with large fixed costs, the permits can serve as an extra barrier to entry. First of all, entrance into the industry may be restrained because potential entrants need a large share of permits to meet the minimum efficient scale of production. Knowing this, the existing firms may be reluctant to sell excess permits to newcomers. Secondly, as we saw before, the existing firms may be reluctant to sell permits to each other, because by doing so, they can force competitors to close down some or all of their plants if they are not able to create the necessary rents. On the other hand, given a reasonable auction design, auctioning emissions permits guarantees immediate access to the market for any new firm, see for example Cramton and Kerr (1998), Daugbjerg and Svendsen (2001), Svendsen and Christensen (1998). In other words, the auctioning of permits will not tend to further the already present market failures to the same degree.

In conclusion, grandfathering can be an extra barrier to entry if other market failures are present. However, it is clear that the larger the actual number of participants in the permit market and the more evenly distributed the permits are, the less will be the possible problems of market abuse related to grandfathering.

## 2.4 Transaction costs

Munro et. al (1995) make two assumptions about the nature of transaction costs in a permit market. First, transaction costs increae with the number of firms that have to engage in any trade. Second, transaction costs increasing for a firm, the larger the number of potential partners it has to contact to set up a deal.

In a frictionless world it is clear that the more firms participating in a permit market the better. At first sight it seems, however, that the presence of transaction costs will put an upper limit to the number of participants that is it practical to include. However, it is necessary to make a distinction between whether or not a formal marketplace for trading $CO_2$ permits has been set up. There are fixed costs of setting up a formal market, which create an externality across permit market participants. With a few possible traders the fixed costs of setting up a formal market place may be too large. If, however, the number of possible market participants is large then these set-up costs can be overcome.

### 2.4.1 No formal marketplace

In a market with few participants each individual firm can consider all possible trades quite easily. Also, each firm may have better knowledge of the marginal abatement costs of the other firms, which would suggest that a market with few participants is superior to a market with many participants. So, the problems with transaction costs are most pertinent when there are many traders but not so many that a formal market can be set up.

In the absence of a formal market the sequential nature of individual trades can be a big problem, since there is no way of knowing that the "right" parties will make a deal. As noted by (Munro et al., 1995), the sellers with the lowest reservation prices and the buyers with the highest willingness to pay are likely to be the most active searchers for deals and as such are likely to make deals with each other. This could mean that other buyers and sellers, i.e. parties with higher reservation prices and parties with lower willingness to pay, would not be able to make deals.

Asymmetric information would also pose a problem in the case where no formal market is established. When the same firms have to deal directly with each other several times, they may be reluctant to let their bids and offers reflect their true costs in the beginning, since by doing so they could earn more money. In contrast, in a formal and impersonal permit trading system with many participants there are no incentives for firms not to let their bids and offers reflect their true private information.

### 2.4.2 With formal marketplace

The presence of a formal market or broker can drastically reduce the transaction costs of the individual firm. However, even with a formal market there can still be positive transaction costs. One cost is the commission fee paid to the market maker or broker for rendering their services. A second type a transactions costs is the search costs incurred from deciding which broker to use and the search costs incurred if the firm decides instead to act as its own broker. A third transaction cost is the cost of having to negotiate a contract and the accompanying terms of sale. Search costs could be noticeable in the beginning but may decline over time as firms become more experienced with executing transactions in the permit market (Bailey, 1998).

## 3: Market power in practice

Now, let us turn to the empirical evidence to find out whether a grandfathered permit system, as suggested by the Commission (CEU 2000) will cause market power problems.

An internal trading system for greenhouse gases would have the dual benefits of limiting the cost of meeting the Kyoto targets and giving the EU early experience in emissions trading before a global trading scheme gets off the ground in 2008–12. Thus, the Commission proposes that the EU trading system should initially focus on $CO_2$ emissions and involve only a relatively small number of economic sectors and sources that contribute significantly to emissions (Svendsen, 2003). More specifically, the proposed target group covers $CO_2$ emitters from the five industrial sectors (electricity producers, iron and steel, oil and gas, building materials, paper and pulp) where power and heat generation installations exceed 20 MW. The inclusion of these 'core activities' in the market will comprise some 4,000 to 5,000 installations. However, only this rough estimate of market participants is available. No exact data exist for these five industrial sectors, except for the electricity producers larger than 25 MW. This sector is by far the largest sector, with almost one-third of total $CO_2$ emissions and it also contains the largest single actors in the market. So, if this market is competitive, then the full market for firms above 20 MW in all five sectors will be even more competitive (ibid.).

Table 1 shows the total number of boilers in the EU with different primary fuels. Firstly, the total number of fossil-fuelled boilers in the EU amounted to 7038 in 1999, while the number of boilers larger than 25 MW amounted to 1690. Secondly, the total number of *legal entities* is reduced from 2959 to 375 while most of the installed capacity of fossil-fuelled boilers is still included in the market. As you can see, coal drops from 162 to 160, oil from 83 to 72 and gas from 75 to 66 GW. In other words, most of the emissions are still kept within the system despite the 25 MW limit imposed (Varming et al., 2000).

*Table 1: Potential trading partners in the EU power sector, 1999.*

| | Coal | Oil | Gas | Fossil fuelled boilers (total) | Legal entities (total) |
|---|---|---|---|---|---|
| Number of fossil fuelled boilers | 916 | 2713 | 4280 | 7038 | 2959 |
| Installed capacity by primary fuel, $GW_e$ | 162 | 83 | 75 | - | - |
| Number of fossil fuelled boilers > 25 $MW_e$ | 695 | 492 | 579 | 1690 | 375 |
| Installed capacity by primary fuel, $GW_e$ | 160 | 72 | 66 | - | - |

Source: UDI database, 2001 and Varming et al. (2000, 119).

The crucial question is whether a $CO_2$ market for these 375 companies will be competitive. Here, we need to consider the risk of price manipulation both in the permit market itself and from using the permit market to exclude competition in the product market of electricity (see Tietenberg, 1985 and Svendsen, 1998a). Let us look at both possibilities in turn.

### 3.1 Permit market

Firstly, concerning price manipulation in the permit market, a dominating source (or a coalition of sources) may attempt to manipulate the price as a monopolist or a monopsonist. This market power depends on the firm's size relative to the market in which it is operating. If the dominating source offers too few permits, it can exert monopoly power by withholding permits which cause the market price to rise. If the dominating source buys too few permits, it can exert monopsony power and cause a lower market price. In both cases, the source may achieve a net gain at the expense of the cost-effective outcome.

The likelihood of market power being present can also be illustrated by a concentration index for the EU power sector. Here, the risk of price manipulation in the permit market and the strategic interaction can be assessed by using an *m-firm concentration ratio*. This index simply adds up the *m* highest market shares in the industry and the risk of price manipulation is simply expected to increase with higher market shares, see Tirole (1990) and Varming et al. (2000).

Table 2 shows that the five largest electricity producers (legal entities) have an electricity market share of 38 per cent and are responsible for 25 per cent of the $CO_2$ emissions. Furthermore, the five largest *$CO_2$ emitters* (which are different from the five largest electricity producers) have a $CO_2$ market share of 34 per cent. Are these numbers high or low? An answer can be found in the EU Treaty. Here, the legal basis concerning competition policy is defined in Articles 3, 10, 81–86 and 87–89). In this setting of monopolistic behaviour, the monopoly rule in Article 86 is relevant. It defines a dominant market position in the following way. If the market share for the largest firm is below 25 per cent, it will not dominate. If it is between 25 per cent and 40 per cent, the firm may be investigated. If it is between 40 per cent and 50 per cent, the regulator may suppose that the firm has a dominant market position. If higher than 50 per cent, the firm has a dominant position. Adding together the market shares from the five largest firms ($R_5$) gives a total percentage ranging from 25 per cent to 38 per cent, thus indicating that both the electricity market and $CO_2$ market are competitive.

*Table 2 Electricity and $CO_2$ market shares in EU, 1996/1997*

| | Electricity market shares | $CO_2$ market shares (electricity producers) | $CO_2$ market shares (emitters) |
|---|---|---|---|
| $R_5$ | **38 %** | **25 %** | **34 %** |
| $R_{10}$ | 51 % | 40 % | 44 % |
| $R_{15}$ | 58 % | 43 % | 49 % |

Source: Reproduced from Varming et al. (2000, p. 120).

## 3.2 Output market and permit market

Concerning possible strategic interaction between the output market and permit market, must be considered. The incentive to exclude competitors in the product market by keeping them out of the permit market may cause monopolistic behaviour as a source of these – or a group of such sources – may refuse to sell permits to new entrants and thereby create a barrier to entry, i.e. a cost of production. This extra cost 'must be borne by a firm which seeks to enter an industry, but is not borne by firms already in the industry' (Stigler, 1968, p. 67). Such a 'predatory' source may in this way increase its opportunities for manipulating the price in the product market (Tietenberg, 1985, p. 138). This behaviour must be considered here, as the two engaging sources are direct competitors in the same product market (electricity), emitting the same pollutant ($CO_2$) in the same regulated area (the EU).

Varming et al. (2000) show that the largest companies are not among the highest emitters of $CO_2$. For example, EDF (Electricité de France) is the largest electricity producer, but one of the smallest $CO_2$ emitters because it is based on nuclear power. Thus, the fact that the electricity producers holding the largest production shares are different from those holding the largest $CO_2$ shares also suggests that the electricity sector can form the basis of a competitive $CO_2$ market in the EU (ibid.). In other words, EDF cannot, as a small $CO_2$ emitter, influence the entry to the electricity market by refusing to sell $CO_2$ permits to a potential competitor; it is easy for the competitor to buy the needed $CO_2$ permits from other emitters that are small in the electricity market. However, the electricity sector should not be seen in a static perspective: 'The changing frame conditions following the liberalisation directive for the electricity and gas sectors have started to provoke a response from the industry itself. It seems clear that the size of a company is a shaping factor with regard to the type and dimension of risks that can be accepted and the ability to expand into new markets and businesses clearly depends hereon. So far, we have seen a tendency towards horizontal integration between power companies as well as power companies buying up distribution companies. Within the last few years, several of the larger companies in have merged (or have announced plans to do so). This is true for EDF/EnBW, PreussenElektra/Bayernwerke and RWE/VEW. This process is expected to proceed and the result will probably be only a handful of large companies within a relatively short period of time' (ibid).

In comparison to the EU $CO_2$ market, the American 'Acid Rain Program' comprises roughly the thousand largest electricity producers in the United States. These electricity producers are owned by roughly 200 companies, so there are actually 200 legal units in the market. This market structure has proved to be functioning well in practice (Ellerman et al., 2000, Schmalensee et al., 1998, Stavins, 1998, Hansjürgens, 1998, Svendsen, 1998, Brandt and Svendsen, 2000, Burtraw 1996, Klaassen, 1996, Klaassen and Nentjes, 1997, see Tietenberg, 2002 for a comprehensive review of the tradable permit literature).

Table 3 shows the market shares in United States from 1985 (which was the starting year for allocation of historical emission permits) in the successful Acid Rain Program. In comparison, the five largest American companies (legal entities) have an electricity market share of 17 per cent, a 17 per cent share of the $SO_2$ emissions and that the five largest *$SO_2$ emitters* also have a $SO_2$ market share of 17 per cent. These percentages are roughly half of those for the EU $CO_2$ market, so the Acid Rain Program is even more competitive. Though market power presumably will not be present in the EU $CO_2$ market, the Commission must be aware of the fact that both the American electricity market and the Acid Rain Program are more competitive. For example, further liberalisation in the single market for electricity will help to increase competition further in the EU.

*Table 3 Electricity and $SO_2$ market shares in United States, 1985.*

| | Electricity market shares | $SO_2$ market shares (electricity producers) | $SO_2$ market shares (emitters) |
|---|---|---|---|
| $R_5$ | **17 %** | **17 %** | **17 %** |
| $R_{10}$ | 27 % | 30 % | 22 % |
| $R_{15}$ | 48 % | 35 % | 28 % |

Source: Calculated on basis of data from EPA (1998).

Note, that the Acid Rain Program only includes electric utilities larger than 25 MW initially. Therefore it is, based on the overall experiences from the United States, crucial to start with a single sector to make the system as simple as possible. This argument is valid in the EU system too for three main reasons. Firstly, the electricity sector is responsible for one-third of total $CO_2$ emissions in the EU. In comparison, the industrial sector emits one-sixth and households one-fifth (EU, 1999). Secondly, many low-cost $CO_2$ emission reduction opportunities exist within the electricity sector. Thirdly, the electric utilities are a manageable number and are already tightly regulated in administrative terms (Svendsen, 2003).

If the EU $CO_2$ market works for the 375 electricity producers, then other sectors can, as is the case in the Acid Rain Program, be allowed to join the programme. Starting with five sectors, as suggested in the directive proposal, is a heavy administrative task, particularly when the implementation is decentralised to fifteen different member states (and possibly more following enlargements in the near future). It would be better to start with one sector; the electricity producers, as was successfully done in the United States.

Some special features concerning the electricity sector must be considered as they may threaten the workability of the suggested EU permit market. Here, the fact that electricity has to be supplied via a grid makes the competitive situation quite unique for three reasons. Firstly, as there are no economically viable storage opportunities for electricity, supply has to equal demand at all times. Secondly, the flow of electricity in a grid is governed by the law of physics and cannot be allocated in a certain direction. Thirdly, the power loss in a grid rises quadratically with the current and linearly with the distance. What all this means is that the competitive situation of a specific power plant can change dramatically during the day, week or year. At some hours the power plant may be exposed to competition by a range of other suppliers while at another time of day the competitive situation may be more like a local monopoly. The transmission capacities and the way the usage of this transmission capacity is priced determine the extent to which a Danish power plant will compete with a Dutch power plant. Even though a system with free third-party access to the transmission grid is established, securing that future investments in the transmission grid will actually reflect the scarcity in the grid can also be a potentially contentious issue, especially with regard to the building of international transmission capacity. However, as long as primary energy is by large cheaper to move around than electricity, there will be no need for moving around a substantial volume of base load electricity from the southernmost part of the EU to the northernmost part (see Varming et al., 2000).

Moreover, the experience with the market liberalisation for the electricity sector so far clearly indicates that the lack of third party access to the grid in some cases have resulted in abuse of market power (ibid.). The point is, however, that the market for $CO_2$ permits will extend Community-wide and not be regional in character like the electricity market itself. Furthermore, the establishment of a formal marketplace for the buying and selling of $CO_2$ permits means that the buyers and sellers of permits will not know the identity of each other.

## 4: Conclusion

In conclusion, strategic interplay between the permit market and the output market can be a real problem for grandfathering. However, we have to distinguish between whether or not a formal marketplace for trading emissions permits has been set up or not. If there are only very few participants and setting up a formal market is not deemed feasible, then the buyers and sellers will all know each other and consequently be able to use this knowledge strategically. If, on the other hand, there are enough participants to set up a formal marketplace for permits, buyers and sellers will not know the identity of each other. Then the problem disappears.

The empirical evidence suggested that a reasonable number of sources of $CO_2$ emissions in the power sector exists for boilers larger than 25MW so that, together with the contestable single market for electricity, the risk of significant strategic behavior seems negligible. Thus, the electric utility sector seems a suitable testing ground for an EU-scheme of emissions trading. In the longer run, it will be important to broaden the scope of the trading scheme as the inclusion of other sectors will further limit the risk of market power.

**References**


CEU (2000): Green Paper on greenhouse gas emissions trading within the European Union. Commission of the European Communities, Brussels, 8.3.2000, COM (2000) 87 final.

CEU (2001): Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework for greenhouse gas emissions trading within the European Community. Brussels, 31.5.2001 COM(2001)xxx. VERSION FOR INTERSERVICE CONSULTATION

Bailey, E. M. (1998), *Intertemporal pricing of Sulphur Dioxide Allowances*, MIT-CEEPR 98-006.

Brandt, U.S. and G.T. Svendsen (2000), 'A European Acid Rain Program based on the US experience?' *European Environment,* **10**, (5), 220-29.

Burtraw, D. (1996), 'The $SO_2$ Emissions Trading Program: Cost Savings Without Allowance Trading', *Contemporary Economic Policy,* **14**, 79-94.

Cramton, P.; Kerr, S. (1998), *Tradable Carbon Permit Auctions. How and why to auction not grandfather*, University of Maryland.

Daugbjerg, C. and Svendsen, G.T. (2001): *Green Taxation in Question.* Palgrave (MacMillan), UK.

Ellerman, A. D., P.L. Joskow, R. Schmalensee, J.P. Montero and E.M. Bailey (2000*), Markets for Clean Air: The U.S. Acid Rain Program,* Cambridge, UK: Cambridge University Press.

EPA (1998), THE NATIONAL ALLOWANCE DATA BASE, VERSION 2.2, TECHNICAL SUPPORT DOCUMENT, 1998 Revision. US Environmental Protection Agency, Washington D.C.

EU (1999), *EU's Annual Energy Review,* Brussels.

EU (2001), http://europa.eu.int/comm/budget/pdf/infos/vademecum2000/en.pdf, key figures (access date 20 December 2001).

Hagem, C.; Westskog, H. (1996), *The design of a Tradable $CO_2$-quota System under Market imperfections*.

Hansjürgens, B. (1998), 'The Sulfur Dioxide ($SO_2$) Allowance Trading Program: Recent Developments and Lessons to be Learned', *Environment and Planning C: Government and Policy*, 16, 341–361.

Klaassen, G. (1996), *Acid Rain and Environmental Degradation,* New Horizons in Environmental Economics, Cheltenham, UK and Brookfield, US: Edward Elgar and IIASA.

Klaassen, G. and A. Nentjes (1997), ‘Sulfur Trading Under the 1990 CAAA in the US: An Assessment of First Experiences’, *Journal of Institutional and Theoretical Economics*, 2, 384–410.

Munro, A.; Hanley, N.; Faichney, R.; Shortle, J. S. (1995), *Impediments to trade in markets for pollution permits*, Paper presented to the European Association of Environmental and Resource Economists Conference, UMEA, 1995.

Schmalensee, R. et al (1998), ‘An Interim Evaluation of Sulfur Dioxide Emissions Trading’, *Journal of Economic Perspectives*, **12**, 53–68.

Stavins, R. (1998), ‘What Can We Learn from the Grand Policy Experiment? Positive and Normative Lessons from SO2 Allowance Trading’, *Journal of Economic Perspectives*, **12** (3), 69–88.

Stigler, G.J. (1968), *The Organisation of Industry*, Homewood: Richard D. Irwin.

Svendsen, G.T. 2003. *Political Economy of the European Union: Institutions, Policy and Economic Growth.* Edward Elgar, Cheltenham, UK. In press.

Svendsen, G.T. (1998): *Public Choice and Environmental Regulation: Tradable Permit Systems in United States and $CO_2$ Taxation in Europe.* New Horizons in Environmental Economics, Edward Elgar, Cheltenham, UK.

Svendsen, G. T., Christensen, J. L. (1999). *The US $SO_2$ auction: analysis and generalisation*. Energy Economics Vol. 21(5), 403-416.

Tietenberg, T.H. (1985): *Emissions Trading: An Exercise in Reforming Pollution Policy*. Washington, D.C.: Resources for the Future.

Tietenberg, T.H. (2002), *Tradable Permits Bibliography,* http://www.-colby.edu/personal/thtieten, (access date: 20 June 2002).

Tirole, J. (1990), *The Theory of Industrial Organisation*, The MIT Press.

UDI database (2001): "World Electric Power plants Data Base", Platts Utility Data Institute: Update June 2001.

Varming, S.; Eriksen, P. B.; Grohnheit, P. E.; Nielsen, L.; Svendsen, G. T.; Vesterdal, M. (2000), *$CO_2$ permits in Danish and European energy policy.* Risø. R-1184(EN). Risø National Laboratory, Roskilde, www.risoe.dk/rispubl/SYS/ris-r-1184.htm.