Time to turn down energy demand

Energy intelligent solutions for climate, security and sustainable development

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Simulating emissions trading in Southwest Germany

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Keywords

emission trading, climate policy, carbon trading, energy efficiency, auctions, primary allocation, capacity building, banking

Abstract

According to the planned EU-Directive, large installations from energy and most other carbon-intensive industries will be part of an EU-wide CO_2-trading system starting in 2005. Since in many Member States, including Germany, environmental policy has historically been command-and-control-type regulation, companies (and decision-makers) tend to have no experience with this market-based instrument. This paper presents results of a recent CO_2-trading simulation project, launched in early 2002 in Southwest Germany with a group of 15 companies, including producers of electric power, cement, glass, steel and paper. Once companies had quantified emissions, and identified and evaluated reduction measures for the simulation period of 2005-2013, they could buy and sell allowances via an internet platform at the (endogenously determined) market price. Keeping the rules of the game as close as possible to the proposed Directive, two types of simulations were carried out, which primarily differ in the method of allocation (grandfathering / hybrid auction system). In addition, using companies' data, a student control group carried out both simulations, too. Strategies and market outcomes of both types of simulations are compared within and across both groups of participants. After discussing the implications of the simulations for energy efficiency, policy recommendations are presented, which focus on the method of allocation and on the banking of allowances.

Introduction

On December 9, 2002 the EU-Council of environmental ministers reached an agreement on the introduction of an EU-wide CO_2-emissions trading system at company level, which is scheduled to start in 2005. As an integral part of the European Climate Change Programme (European Commission 2001), the proposed trading system is expected to help the European Union achieve its Kyoto target, which requires a reduction of greenhouse gases by at least 8% up to 2008-2012 compared to 1990 levels. Prior to the Council agreement, the European Commission had issued a corresponding Green Paper in March 2000 (COM (2000) 87), and a proposal for a directive in October 2001 (COM (2001) 581). Installations to be covered by the emissions trading system are listed in Annex I of the directive proposal (COM (2001) 581) and include combustion installations with a rated thermal input exceeding 20 MW (excepting hazardous or municipal waste) in the energy sector, mineral oil refineries, coke ovens, large installations in the production and processing of ferrous metals (steel) and the mineral industry (e.g. cement, lime, ceramic products) as well as plants for the production of pulp and paper.

In Germany, since the beginning of 2001, the Working Group "Emission trading to combat the greenhouse effect" (AGE) has been holding meetings under the chairmanship of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Here, together with representatives of German industry, possibilities are being discussed as to how an emissions trading concept can be incorporated into the German climate protection policy. However, since German environmental policy is – like in most other EU-Member States – traditionally characterised as command-and-control, as yet there has been only little practical experience with this market-based instrument, such as

Table 1: Participating companies and installations.

Company	Installations	Input	Output
Acterna Eningen GmbH	2 heating systems	Natural gas	Heat
Badische Stahlwerke GmbH	Electric steel works	Natural gas, coal	Steel
DaimlerChrysler AG	Heating & power station	Natural gas, fuel oil light	Heat, power
	Heating station	Natural gas, fuel oil light	Heat
EnBW AG	CHP-coal generating unit	Coal, fuel oil light, natural gas	Heat, power
	CHP-CCGT-unit	Natural gas, fuel oil light	Heat, power
Heidelberger Druckmaschinen AG	2 burners	Natural gas	Heat
	Heating boiler	Natural gas	Heat
	Varnishing plant	Natural gas	Heat
HeidelbergCement AG	Cement works	Coal, fuel oil light, limestone	Cement
Klingele Papierwerke GmbH & Co KG	Paper machine	Natural gas	Paper
Kunz Holding GmbH & Co KG	Combustion plant	Natural gas, fuel oil light	Heat
MTU Friedrichshafen GmbH	2 test benches for diesel engines	Light fuel oil	Heat
	2 hot water systems	Natural gas, heavy fuel oil, light fuel oil	Heat
Saint-Gobain Oberland AG	Melter	Natural gas, heavy fuel oil	Glass
Schwenk Zement KG	Cement works	Heavy fuel oil, coal, limestone	Cement
Wehrle-Werk AG	Heating boiler	Natural gas, light fuel oil	Heat

the company-wide emission trading systems at BP/Amoco and at Royal Dutch/Shell.

Against this background, the federal State of Baden-Württemberg in Southwest Germany initiated a management simulation game on company-based emissions trading (Schleich et al. 2002a, 2002b). Starting from the current status of the discussion at a national and European level, the companies participating could gain experience with this new instrument which is as realistic as possible, in particular develop strategies for emission reduction and allowance trading. At the same time, conclusions could be drawn for the design of an emissions trading system.

The remainder of the paper is organised as follows. In the following Section, we describe the general structure of the game, including participants and the "rules" of the game. Then, the main results are presented. Implications of the simulations for energy efficiency are discussed in the fourth Section. The final section includes policy implications based on the simulation results.

Structure

In this section, the general structure of the simulation game is presented, including participating companies, the "rules" of the simulation game, and the method of primary allocation.

TWO PARTICIPANT GROUPS

The simulation game ran between February and September 2002. Twelve real companies took part in the entire simulation game. The main criterion when selecting participants was that they operate installations which are liable to participate in emission trading under Appendix I of the Directive proposal (COM (2001) 581). In addition, several companies were included with installations which are not directly included in Appendix I, which may reflect that for the EU trading system, member states are – under certain conditions – explicitly granted the possibility to include installations and gases which are not contained in Appendix I (*opt-in*). Participating companies and installations are presented in Table 1. In total these installations caused approx. 4% of the energy-based CO_2 emissions of the state of Baden-Württemberg or approx. 10% of the industrial CO_2 emissions. In order to avoid possible distortions which could have arisen from the market power of the larger company participants and to increase the liquidity of the market, three additional virtual companies were introduced into the simulation game. This was done by three student groups conducting the entire simulation game for two electricity producers and an integrated steel works. So, in total the company group contained 15 companies.

Parallel to the simulation game with the company group, the same design variants were played through with students at Karlsruhe University. Each company was assigned a student in an identical but anonymous way. The procedure was exactly the same as the simulation game with the companies at every point in time, but the *student control group* was not informed at any time about the progression or the results of the companies' design variants already played. The reverse was also true of information from the control group to the companies.

TWO DESIGN VARIANTS

Setting the frame conditions and the development of two design variants was based to the greatest extent possible on the Directive Proposal of October 2001 (COM (2001) 581) and the current status of the discussions in AGE. In any case of doubt, assumptions were made by the project team based on plausibility, practicability with regard to conducting the simulation game and subjective estimations. Simplifying as-

Table 2: Overview of the frame conditions and design variants of the simulation game.

Frame condition	Design variant I	Design variant II
Emissions	Direct energy- and process-based CO_2 emissions	
Game horizon	9 trading periods (TP) distributed over three commitment periods (CP) CP I: 2005-07; CP II: 2008-10; CP III: 2011-13	
Overall target	For 2005: 98% of the base emissions of 1990; 2% points reduction in each subsequent year	
Primary allocation		
Method	100% free allocation	free allocation with revenue-neutral auction; auction share in CP I: 20% CP II: 30% CP III: 40%
Allowance allocation	Baden-Württemberg formula for free allocation*	
New installations	Purchasing of allowances on the market	
Phased-out installations	Immediate withdrawal of the allowances (no bonus for shutdown)	
Transferability over time		
Banking	Within commitment periods: no restriction CP I to CP II: not permitted CP II to CP III: no restriction	
Borrowing	Not permissible	
Sanctions for allowance deficits	Max {doubled weighted market price; 100 Euro} plus obligation to surrender missing allowances in subsequent period	
Trade transaction		
Intermediary	Internet platform	
Bidding form	Limit price-quantity bids	
Allocation	Market clearing price, which maximises the quantity traded	
Products	No forwards, i.e. only current allowances tradable	Forwards, unrestricted throughout all periods, also between CPs

* See "Emission target and initial allocation"

sumptions were also necessary to reduce the complexity to a minimum. The time and cost frame for the project also had to be considered. The actual simulation of the emissions trading was done in the form of two design variants (I and II), carried out consecutively, which were characterised by different "rules". The most important frame conditions of the simulation game as well as the two design variants are summarised in Table 2. A complete and more detailed description of the frame conditions can be found in Schleich et al. (2002a). In this paper, only a few design issues can be examined more closely, such as the transferability of unused allowances over time, and the formula for the primary allocation of grandfathered allowances.

Time-frame and transferability of allowances

The simulation game was played for nine years (2005 till 2013). Three trading periods (TP) made up one commitment period (CP). There were two trading windows (TW) in each trading period when the participants could sell and buy emission allowances on the market. There was thus a total of 18 trading windows over the entire game.[1] At the end of each trading period, the participants had to relinquish the number of emission allowances corresponding to the emissions from their installations in this period. Transferring surplus allowances to subsequent periods, so-called *banking*, was not limited between trading periods within all the commitment periods. In the same way, from the second commitment period, all surplus allowances could be transferred to subsequent commitment periods. Banking was, in contrast, forbidden from the first to the second commitment period, i.e. from 2007 to 2008. Whether banking should be allowed into the Kyoto-Commitment Period has been subject to change between the directive proposal from October 2001 and the political agreement passed by the EU-Council in December 2002. According to the directive proposal Member States may decide individually on whether they allow banking from 2007 to 2008. The working paper of the Danish Presidency (ENV/02/8), which was crafted in August 2002 as a compromise paper did not allow banking from 2007 to 2008. Finally, according to the EU-Council agreement from December 2002, Member States may decide individually, but they may limit banking into the Kyoto-Period to emission reductions made on their national territory between 2005 and 2007. Figure 1 illustrates the banking rules applied in the simulation game. Participants still in possession of allowances at the end of 2013 received a credit. This was supposed to prevent a price collapse at the contrived scheduled end of the simulation game.

Emission target and initial allocation

The total upper limit of CO_2 emissions was selected in the simulation game such that (i) the targets could be met with the measures participants had to identify and report in advance[2] and (ii) a sufficiently large amount of supplied and

1. The first commitment period is supposed to mirror the three year period of the planned EU emission trading system prior to the first five-year commitment period of the Kyoto-Protocol. In the simulation game subsequent time intervals of three years were chosen for practical reasons: within one afternoon session, there was only time to open the trading window six times, that is play three trading periods.
2. See Section "Starting-point".

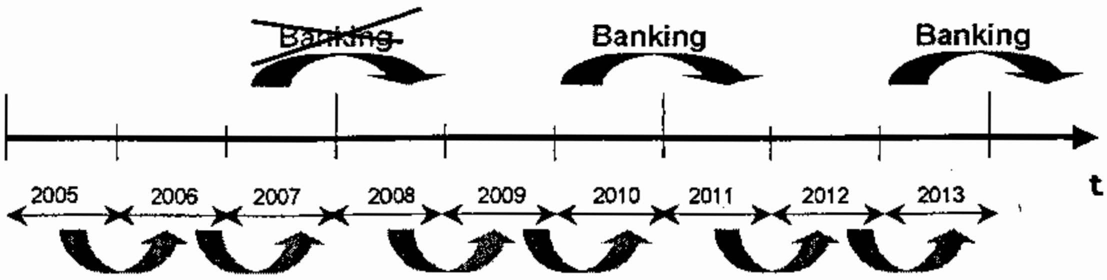

Figure 1: *Transferability of allowances over time.*

demanded allowances could be expected at each trading window for a market equilibrium to appear. In the final year of the simulation game (2013), – apart from transferred allowances – 18% less CO_2 had to be emitted as in the reference year 1990. In design variant I of the simulation game, the installation-based allocation of emission allowances occurred *free of charge*. A *hybrid approach* was chosen for design variant II, i.e. some of the available emission allowances were auctioned off. The number of emission allowances allocated free of charge (GF) for the relevant installations was calculated using the *Baden-Württemberg formula*, which was developed within the project, in both design variants:[3]

$$GF = \left(\frac{E^{1990}}{Y^{1990}} \right) * Y^{2000} * \beta$$

The allocation according to the BaWü-formula is determined by three components: (i) the specific emission factor (emissions E per unit of production Y) in the base year (here 1990); (ii) the production level in the reference year (here 2000); and (iii) a fulfilment factor (β), which guarantees compliance with the given overall target.[4] Electricity or heat (in kWh) is the valid production variable for installations of the energy sector, for others, to the extent that this is reasonable, the physical production in unit amounts (e.g. t paper, t cement, t steel, etc.). By choosing an early base year, here 1990, the BaWü-formula can explicitly account for *early action*. In contrast to pure grandfathering based on historical emissions, *changes in the production level* between the base year and the present are also entered into the BaWü-formula.[5] In the simulation game, new market participants, i.e. new installations of participating companies, had to meet their demand for emission allowances on the market. Emission allowances from installations which were no longer in operation were immediately withdrawn (no credits for shutdowns!).

Design concept

The simulation game fulfils the prerequisite of a *closed model* for each design variant conducted: none of the main variables observed or those influencing the participants (offers, demand, certificate prices) were artificially created or integrated in the form of virtual markets or built-in uncertainties.[6] To allow for control and repetition of the experiment, emission projections, abatement measures and costs had to be fixed before the start of the game and could not be altered afterwards. Likewise, individual accounts kept track of changes in costs, which resulted from participants' abatement and trading activities, so that the outcomes of the various variants could be compared. Further, all data on installations, emissions, abatement and trading activities, as well as the trading itself was handled through an internet platform.

STARTING-POINT

15 companies with a total of 32 installations participated in the simulation game (of which three were virtual companies). As can be seen from Figure 2 for the period before the ban on banking 2007/2008, no reduction was necessary for the majority of participants (surplus allocation), but there was a need for continuous abatement after this period.

To comply with the reduction targets, participating companies had, on average, five abatement measures available (Table 3). Abatement costs of these theoretically available measures lay between –124 and 1 418 per t CO_2. Prior to the actual simulation, participating companies group had to quantify and project emissions, as well as identify and evaluate reduction measures for the simulation period of 2005–2013. All data on abatement measures were also gathered on the internet platform and could not be altered afterwards. Participants only had access to their own data. Since abatement measures and the associated costs were fixed in advance, no new abatement measures could enter the system in response to market outcomes. In particular, price-induced technological change (Hicks 1932) resulting from increased research and

3. An installation, here, can also mean a chain of installations in which a new one replaces the previous one. If operators lost the allowances for old installations when they replaced an inefficient old installation by a new more efficient one, this would diminish the economic incentives to invest in low CO_2 technologies.
4. The fulfilment factor is calculated as the ratio of two measures: (i) emission target for all participants; and (ii) sum of grandfathered allowances in the absence of the fulfilment factor.
5. In order to reduce the influence of temporary fluctuations on the initial allocation, several base or reference periods could be used instead of the base and reference years.
6. Other pilot projects on emissions trading, which have been, or are currently being carried out in Germany such as the "Hessen-Planspiel" (Meyer et al. 2001) or "Emissionshandel Nord" (Energiestiftung Schleswig-Holstein, 2003) do not employ a closed-model approach. The focus of these projects is rather on calculating and projecting emissions, and identifying abatement measures rather than on strategic aspects.

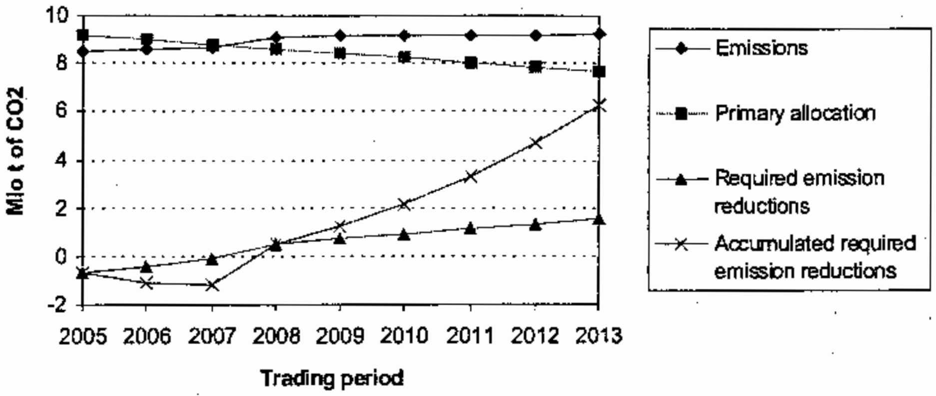

Figure 2: Emissions, allocation and required emission reductions.

Table 3: Selection of available abatement measures in the simulation game.

Input measures	Technology measures
- Co-firing CO_2 free or CO_2 neutral fuels (secondary fuels, bio gas, sewage sludge)	- Heat recovery measures
- Fossil fuel substitution for processes	- Efficiency increases
- Fossil fuel substitution for electricity generation	- Optimised burner control
- Increasing the share of recyclable materials	- Conversion of drying process to microwave drying
	- Preheating combustion air
	- Thermal insulation

development in energy efficiency/less carbon-intensive technologies is not captured in the simulation game.

Results

The simulation game was examined using a *two-dimensional analysis*: first of all, the four runs of the two variants were examined in separate *individual analyses* (two variants with the companies and two with the control group). The results of the company and student control groups were compared within and across design variants. All outcomes were compared with the calculated *cost-efficient optimum*.[7]

DESIGN VARIANT I

The first design variant was the one with the least information for the participants. The companies made individually rational decisions about abatement measures here, which means a company carried out abatement measures in the ascending order of their costs. When regarded generally, however, i.e. over all the companies, the choice of measures over time was not those with minimum cost: some cost-effective measures were not realised, whereas more expensive measures were. The market price development is shown in Figure 3. In the first three trading periods, market prices were generally low and a complete price collapse could be observed in 2007. The low market prices are primarily a result of the surplus allocation of allowances in commitment period I. That is, more allowances were allocated than demand required (see Figure 2). In addition, most participants decided to realise their no-regret measures[8] which added to the excess supply in the market. Since any left over emission allowances could not have been transferred from 2007 to 2008, the economic value of those allowances at the end of 2007 was zero and trading volumes were low, because demand plummeted. So the price path for allowances from 2005 till 2007 appears to be fairly consistent with participants acting rationally. Companies, which based their investment decisions on actual market prices for allowances, initially only realised low-cost measures. The most prominent development in commitment period II was a dramatic increase in the price for allowances. Because emission targets were continuously tightened (see Table 2) and excess allowances could not be transferred from commitment period I, demand for allowances increased and supply dropped. Likely reasons for this development include incomplete information about the scarcity of allowances in the future and risk-aversion on the side of the participants. Companies with surplus allowances and low-cost measures still available, decided to bank allowances rather than selling them on the market, and failed to activate measures. Likewise, under the given sanction mechanism companies with excess demand were willing to buy allowances at any price. Thus, allowance prices started to soar in commitment period II and lay far beyond the actual costs for still available abatement measures. Once prices started to rise in 2008, some participants decided to implement new measures. However, due to implementation lags of up to three years, these measures were not immediately effective, and, on average, they were too expensive. In commitment period III

7. To calculate the cost efficient optimum all abatement measures and emissions were considered. When making their decisions on abatement and trading, individual participants only knew the costs of their own measures and emissions.

8. These are understood as measures which are profitable under the given economic frame conditions in the simulation game even without an emissions trading system.

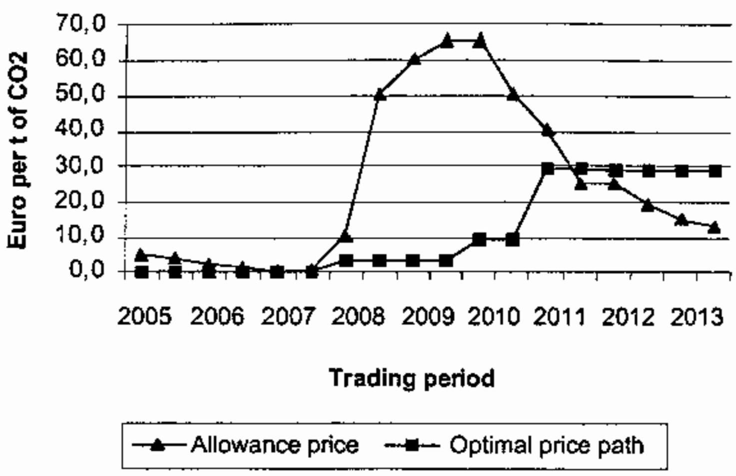

Figure 3: Allowance trading: price path in design variant I and optimal price path.

market prices came back down to expected levels. In Figure 3, the gap between observed and optimal prices reflects the economic inefficiency observed in the company group. The results of the first design variant of the student control group were astonishingly similar to those of the companies: activated measures, market use and market price development were almost identical.

DESIGN VARIANT II

In the second design variant a relatively small amount of allowances was traded on the spot-market. This was partly due to the auctions held beforehand, which resulted in an allocation of allowances that is much closer to the actual needs than with the pure grandfathering method in design variant I. So, some of the trading opportunities that existed under variant I, were already captured through the auction. The lower trading activity was also partly due to a shortage of allowances in the third commitment period caused by a participant *trying to exert market power* – the results of which were not worthwhile to him. Unlike the company group, the control group managed to significantly reduce overall reduction costs due to a more efficient choice of abatement measures, and the price development on the allowance market was *without a price bubble*, balanced and smooth.

Implications for energy efficiency

In emissions trading systems, rational participants apply the following decision rule, independent of whether they have excess allowances or not: invest in abatement measures if the additional costs associated with the investment are lower than the expected costs for buying the same amount of greenhouse gases on the allowance market, that is saved through the abatement measure. Thus, the higher expected market prices are, the more energy/carbon-saving measures will be implemented. In contrast to an emissions tax, where companies may just choose to pay the tax bill, an emissions trading system forces companies to actively search for and economically assess measures to improve energy efficiency. Through this process, companies may become aware of low cost or even no-regret measures.[9] This has also been the case for some of the participating companies, when they had to identify abatement measures within their organisation as part of the preparation for participating in the simulation game.[10] In this sense, an emissions trading system may help overcome transaction costs, which may otherwise have prevented the realisation of these measures.[11]

As illustrated above, in the simulation game surplus allocation of allowances resulted in low market prices in commitment period I, so that only low-cost measures, in particular no-regret measures, were realised. The extend to which there will be surplus allocation in the European emissions trading system, depends crucially on the total number of allowances allocated to participants in the EU-Member States. According to the directive proposal (COM 2001), Member States have to set up national allocation plans, which determine the initial allocation of allowances for each installation covered by the Directive.[12] Criteria for the allocation of allowances include the Member States' compliance with the Kyoto/Burden-Sharing agreement, savings potential, non-discrimination and early action. Since projections for the greenhouse gas emissions for the European Union suggest, that meeting the EU-Kyoto-target will be very challenging, it is unlikely that there will be surplus allocation of allowances in the European emissions trading system, at least not for the first Kyoto-period.[13] Thus, if

9. IPCC (2001) estimates the no-regret potential to range between 10 and 20% of global emissions in the year 2020.
10. See Section "Design concept".
11. See, for example, Ostertag (2002) for the role of transaction costs on the implemenatation of energy efficient measures.
12. According to the proposed directive, on which the EU-council agreement was based on, allowances will be allocated for free in the three year period 2005-2007. For the five-year commitment period starting in 2008, at least 90 % of the allowances have to be allocated free of charge.
13. Greenhouse gas emissions in the EU have only been reduced by about 3.5% since 1990, the majority of which resulted from special circumstances in two Member States in the early 1990ies: the so-called "wallfall profits" - the restructuring of the East German industry and energy system after reunification - and the "dash for gas" in the UK after the liberalisation of the energy markets (Schleich et al. 2001, Eichhammer et al. 2002).

Member States do not impose strict emissions targets for the period 2005-2007, only low cost measures to improve energy efficiency are expected to be realised, in particular, if banking of excess allowances into the first Kyoto-period will be prohibited. For the period 2008-2012 more expensive measures will be realised, unless Member States allow emission credits from national or international project-based mechanisms, i.e. CDM and JI, to be included in the European trading system to a large extend. Since these projects are expected to be relatively cheap, they would set an upper bound for the market price of emission allowances, and on the costs of energy/carbon-saving measures to be realised.

Results from the simulation game further suggest, that if Member States do not allow for banking of excess allowances from 2007 to 2008, a price bubble may emerge in the European emissions trading market. In this case, companies may invest in more expensive energy/carbon saving measures than would be optimal from an economic point of view. If companies, as in the simulation game, act risk-averse or base their investment decision primarily on current market prices, investments in energy/carbon saving measures will be too expensive. A similar result will emerge, if participants have little faith in the market and decide to reduce emissions internally, rather than buy missing allowances on the market.

Finally, the experiences made in design variant II with the company group point to the potential problem of market power in he market for emission allowances.[14] If a large proportion of allowances was, as in design variant II, allocated through an auction, a company might try to buy a large share of total allowances in order to sell them later at a high price at the spot market. Similarly, depending on the formula for the allocation of allowances used, few companies might end up with a large share of allowances, even when they are allocated free of charge.[15] When a company/few companies exert market power, allowance prices will be higher, trading volumes will lower, and the total cost for complying with the emission target will be higher than for the cost-efficient optimum. So companies have to realise energy/carbon saving measures which are too expensive. In addition, since the monopolistic/oligopolistic behaviour leads to a reduction in the supply of allowances, companies realise more energy/emission-saving measures than optimal.

Policy implications

In this section we will briefly summarise the main implications with respect to the objectives of the simulation game. Participating companies should have been able to gain experience with the environmental policy instrument of emission allowance trading. The emphasis was on the development of trade and avoidance strategies. Another objective was to draw policy conclusions for the design of an emissions trading system.

SKILL ACQUISITION AND LEARNING EFFECTS

Learning effects among the participants could already be inferred from the market results during the execution of the first design variant. One indication of this was that the abatement costs (in both the company and the control groups) gradually approached the theoretical optimum solution. In the second design variant, through a better selection of abatement measures, the student control group was able to strongly reduce the total abatement costs compared with design variant I. Also, an internal ex-post evaluation of the project was carried out. According to responses from a questionnaire, 75% of the simulation game companies were of the opinion that they had experienced learning effects in strategy formation over the course of time. The biggest knowledge gain from the simulation game for half the participants was in the field of *strategy development*. Almost as significant, however, was *experience in the collection and recording of emission data*. In some companies, structures were created which can be used in a future trading system. New insights when identifying cost-favourable abatement measures were also classed as important. In addition, an external evaluation confirmed that companies, through participating in the simulation game, acquired important skills for a future EU-emissions trading scheme (Baumann 2002).

SUGGESTIONS FOR THE DESIGN OF AN EMISSIONS TRADING SYSTEM

The simulation game also made it clear that a system for trading allowances does not automatically entail the expected cost savings.[16] Certainties among the participants about future price development on the certificate market resulted in abatement options being realised in three of the four runs for which the costs were clearly above the optimum. But design variant II conducted with the control group also showed that through increased planning security a much better result can be achieved. In the design of a real emissions trading system therefore, those features should be emphasised which provide for and promote the planning security among companies. In this regard, the following suggestions are made:

Early allocation and long-term price signals

Alongside the earliest possible allocation of allowances, long-term price signals are the very important.[17] An auction, in which – as in design variant II – a certain share of the available allowances is auctioned, could transmit such early price signals and increase the efficiency of the system. Results for the student control group suggest that the auction

14. See also Hahn (1984) or Westskog (1996).
15. For example, if emission allowances were allocated according to historic CO_2-emissions, a few electricity producers would get a substantial share of the market. According to a recent report by PricewaterhouseCoopers (2002), cumulated emissions of the five largest emitters account for 60% of total emissions from European prower producers.
16. According to Calson et al. (2000) and Swinton (2002), inefficient choices of abatement measures was also observed within the US-EPA trading program for SO_2-emissions from utilities.
17. Early price signals are even more significant when trading CO_2 allowances than when trading with SO_2, which has already been practised for many years within the scope of the Acid Rain Programme in the USA. Unlike the SO_2 trading system, where massive savings were able to be achieved by using low-sulphur coal, the substitution of fossil energy sources is usually linked with investment measures and correspondingly longer lead times.

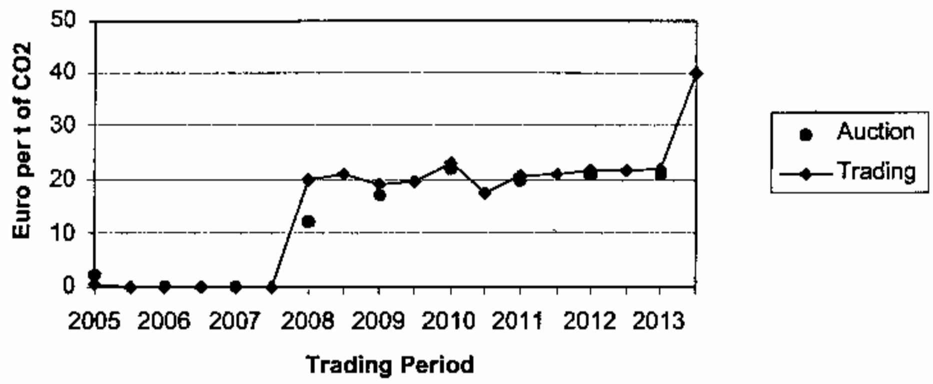

Figure 4: Auctions - comparison with trading prices for control group.

prices were a very good early indicator for the prices on the spot market (see Figure 4).

In order to make the planning security as long-term as possible, allowances should be offered at such an auction not just for the immediately subsequent period but also for following future periods. Early price signals can additionally be given from ***forward trading***. It is true that this was a negligible amount in the simulation game, but it will probably have a much higher significance in reality due to the much larger market, especially for risk coverage.[18]

Correct price signals

Price signals should not only be recognisable at an early stage, but also correct, i.e. mirror the actual abatement costs. In the simulation game, incorrect price signals were partly the result of the manipulation attempts already mentioned in connection with the auction. When designing the auction, therefore, attention must be paid explicitly to elements which restrict market power. In three of the four runs a price bubble developed from 2008 due to uncertainty about overall abatement costs and the awareness of future scarcity developments, which gave incorrect price signals for the abatement selection. The prices observed on the market sometimes exceeded the actual abatement costs many times. As explained above, the cause of this price development is mainly the ban on banking for surplus allowances from 2007. The price bubble was reinforced by the very low market prices in the first phase resulting from ***excess allocation***. Companies which orient their investment decisions mainly on current market prices, took only low-priced measures to start with. Due to the dramatic price increase from 2008, measures were then realised which were too expensive compared with the actual abatement costs.

Abolishing the ban on banking?

The price development observed and the resulting inefficient selection of abatement measures suggest that the ban on banking at the end of the first phase should be abolished. If allowances were allowed to be transferred from 2007 to 2008, the price collapse towards the end of 2007 could be averted and uncertainties about the future price development reduced. This would increase the incentives to invest early in abatement options. The price development on the certificate market would then be "flattened", even with ratcheted emission targets and, over time, it would be more likely that (marginal) avoidance costs and market prices converge quickly. However, it should be noted that, with unrestricted banking and, in particular, with less stringent targets in the first phase, there is always the danger that the Kyoto targets of individual Member States or of the EU would not be met from 2008. As pointed out earlier, according to the EU-Council (environment) agreement from December 2002, Member States may decide individually on whether they allow banking from 2007 to 2008. However, while Member States' assigned amounts will be adjusted for cross-national trading from 2008 on, the proposed directive does not provide for any kind of adjustment for international trades between 2005 and 2007. Suppose France does not allow for banking between 2007 and 2008 but the Netherlands do. If in 2007 a French company sells allowances for 100 t of CO_2 to a Dutch company, the Dutch company may either use these allowances to fulfil its obligations for 2007, it may sell those allowances, or it may transfer them into 2008. If they are banked, the Dutch company (but not the Netherlands!) will be allowed to emit an extra 100 t of CO_2 in 2008 or later. However, to meet their burden sharing target, the Netherlands may have to cut emissions elsewhere to make up for the transferred allowances. Eventually, in 2007 all excess allowances in the EU will flow into Member States without banking restrictions.[19] Hence, companies in Member States without banking restrictions will benefit at the expense of other sectors in those States. These companies will also be in a competitive advantage compared to their foreign counterparts, who may have to buy allowances at a high price in future periods, when overall emission targets will be tighter. Similarly, multinational companies are in a better

18. Uncertainty about future emission developments did not play a role in the simulation game because the participants' emissions were already fixed at the beginning for the entire duration of the game.

19. Restricting the transfers into 2008 to actual emission reductions between 2005 and 2007, as considered in the EU-Council agreement, does not appear to address this problem adequately, since the Dutch company could use the French allowances to cover its obligations in 2007 and transfer emission reductions into 2008 (or sell them to another Dutch company with actual reductions).

position to circumvent banking restriction if they own subsidiaries in States with and without banking restrictions. These dangers could be defused by a harmonised partial banking restriction (e.g. only 5 percent of primary allocation per installation can be banked) or by setting tight emission targets so that not too many allowances would be transferred from 2007 into the Kyoto commitment periods.[20]

Allocating too many allowances in the first phase is also critical because, with lack of demand, hardly any market transactions would result and the expected gains in experience between 2005 and 2007 would be small.[21] Such excess allocation would challenge the early development of forward markets which make long-term risk coverage and price signals possible, and also, if they are accounted for, destroy the value of *early actions*.

Concluding remarks

With regard to design issues which have to be decided on a political-administrative level, the experience gained from the simulation game makes it clear that rules which are selected for an emissions trading system in the real world, have to be examined and tested in detail beforehand. Overall, the system planned should be subjected to a multifaceted stress test, before it is launched. Linked with this, the simulation game also showed how important it is to familiarise the affected players with the rules and the range of possible strategies. Comprehensive training and information campaigns are thus not just facilitative concomitant phenomena, but necessary prerequisites for a functioning allowance trading. Otherwise, the efficiency gains, which economists and policy makers expect from the proposed EU-emission trading system for greenhouse gases, may not materialise.

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20. Challenging targets and crediting early action are compatible since when allocating (free) emission allowances on an installation level, early action can be taken into account on an installation basis even with a demanding overall target. From an economic viewpoint, it is decisive that crediting early action influences the relative positions of companies within a sector or between competing sectors.

21. A lack of demand for allowances can also be the result of a temporary but conditioned *opt-out* of sectors or installations as is allowed under the EU-council agreement from December 2002.