

# Incentives for energy efficiency and innovation in the European Emission Trading System

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## Abstract

We analyse the rules provided in the National Allocation Plans of the EU Member States (MS) for the first period (2005-2007) of the EU emission trading system (EU-ETS) with respect to their impact on energy efficiency and innovation and on technology variety. The allocation rules considered are total quantity of allowances allocated, allocation methods (auction versus grandfathering), rules for banking of left-over allowances into the second period (2008-2012), allocation to newcomers and closures of installations, and information about future allocation.

Since the overall allocation appears rather generous, allowance prices are expected to be low, in particular since almost all MS prohibit banking into the second period. Thus, price-induced innovation effects will be weak. Similarly, the auction shares are too small to have any innovation effects. Closures result in a stop of further allocation, providing disincentives for innovation. In several MS these disincentives are softened because allowances may be transferred to new installations. However, new entrants typically receive allowances for free based on specific emissions and projected output. These specific values are either based on benchmarks

for homogenous product groups or depend on best available technologies. In some countries a plethora of benchmarks within the same product categories threaten to thwart the flexibility provisions of the EU-ETS. Finally, future allocation rules are vastly unknown, amplifying the uncertainty about the benefits of new investments. In conclusion, existing allocation rules provide only modest incentives for innovation.

## Introduction

In January 2005, the EU-wide trading system (EU-ETS) for CO<sub>2</sub>-emissions started, with about 11 000 installations from the energy industry and most other carbon-intensive industries scheduled to participate.<sup>1</sup> The EU ETS is considered to be the world's largest emissions trading program and is expected to help the EU and its Member States (MS) fulfil their obligations under the United Nations Framework Convention on Climate Change, the Kyoto Protocol and the Burden-Sharing Agreement in a cost-efficient way (CEC 2000). The European Emissions trading directive came into force in October 2003 and since then had to be transformed into national law by the MS.

Environmental policy in most MS has historically been command-and-control type regulation, which implies that companies usually have to implement particular technologies or strictly comply with emission standards. Thus, emission trading represents a shift in paradigms towards a

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1. The types of installations to participate in the ET-ETS are listed in Annex I of the Directive and include combustion installations with a rated thermal input capacity of at least 20 MW, refineries, coke ovens, steel plants, and installations to produce cement clinker, lime, bricks, glass, pulp and paper if they exceed certain output thresholds.

market-based instrument. So far, emission trading has primarily been applied in the US, where it has become a key policy instrument not only to regulate air quality but also to control nutrient pollution in water bodies at federal and state level. The most well-known and most intensively studied trading system is the Acid Rain Program, which mainly covers SO<sub>2</sub>-emissions from fossil-based power plants in the US. The Acid Rain program was created by the 1990 Clean Air Act amendments and started in 1995 (see Ellerman et al. 2000).

The prime objective of an emissions trading system is cost-efficiency, that is, to achieve a given environmental target at minimum costs.<sup>2</sup> Abatement costs will eventually be reflected in the market price for emission allowances and induce a demand for innovative, energy/carbon saving processes, products and services. This increased demand will in turn lead to more research and development (R&D), invention, adoption and market diffusion of such innovations. In that sense, emission trading is said to represent a demand-oriented regulation.<sup>3</sup>

The rate and direction of technological change induced by emissions trading programs crucially depends on the design of those programs. For the EU ETS the relevant design issues had to be solved by the individual Member States when developing their National Allocation Plans (NAP) for the first trading period (2005-2007). According to Article 9 of the EU Directive, a NAP shall state the total quantity of allowances in each period, and how these allowances will be allocated to individual installations. The NAPs had to be based on objective and transparent criteria and approved by the European Commission. In particular, the Commission assessed to which extent the criteria given in Annex III of the Directive had been accounted for in the NAPs:

1. Consistency of the total quantity of allowances to be allocated with the MS's EU Burden-Sharing Agreement and national climate change programmes;
2. Consistency with assessments of historic and projected emissions development towards achieving the required emission targets;
3. Consistency with the potential to reduce emissions, including the technological potential; allocation may be based on average emissions by products (e. g. t CO<sub>2</sub>/t cement clinker);
4. Consistency with other Community legislative and policy instruments;
5. Non-discrimination between companies or sectors;
6. Information on treatment of new entrants;
7. Information on whether and how early action is accounted for;
8. Information on how clean technologies are taken into account;
9. Inclusion of provisions for the involvement of the public;

10. List of installations with intended allocation;

11. Information on how competition from outside the EU is taken into account.

Since MS differ considerably in terms of their emission targets and their achievements so far, the EU Commission left it up to the individual MS how it decides to meet its emission target.

In this paper, we explore the rules provided in the NAPs of the EU-MS for the first period of the EU-ETS with respect to their impact on energy efficiency and innovation and on technology variety. Thus, rather than discussing the innovation effects of emission trading compared to other policy instruments – where a substantial body of literature has emerged in recent years<sup>4</sup> – we focus on actual design elements within the EU-ETS. In the next section, we explain the relation between emissions trading and innovation. Then we analyse the crucial allocation rules in terms of their innovation effect and show how they differ across MS. Finally, we explore the effects of the EU-ETS on technology variety. The concluding section summarizes the main results and offers policy recommendations to strengthen the innovation effects of future allocation rules.

### Emissions trading and incentives for innovation

Possible innovation effects arise from the mechanics of an emission trading system, which will briefly be outlined. To achieve an environmental objective, the regulator decides on the total quantity of allowances (in tCO<sub>2</sub>) which will be distributed to the individual operators of installations. By the end of a particular period, these operators have to surrender an amount of allowances equivalent to the number of CO<sub>2</sub>-emissions caused by their installations during that period. Otherwise sanctions have to be paid. Operators may emit more CO<sub>2</sub> than their initial allocation if they purchase the missing allowances from operators which emit less than their initial allocation. Likewise, companies with low-cost abatement measures may choose to reduce emissions in order to sell the surplus allowances to other companies. Thus, companies with high cost measures may purchase allowances while companies with low cost measures may sell allowances on a market, where demand and supply schedules can be matched and an equilibrium market price which reflects the scarcity of allowances in the system will emerge. Under ideal conditions, all measures with costs below the market price will be realized but no measures with costs above the market price. This market mechanism leads to minimum abatement costs, since marginal abatement costs of participants are equal (to the market price).

#### PRICE AND COST INCENTIVES

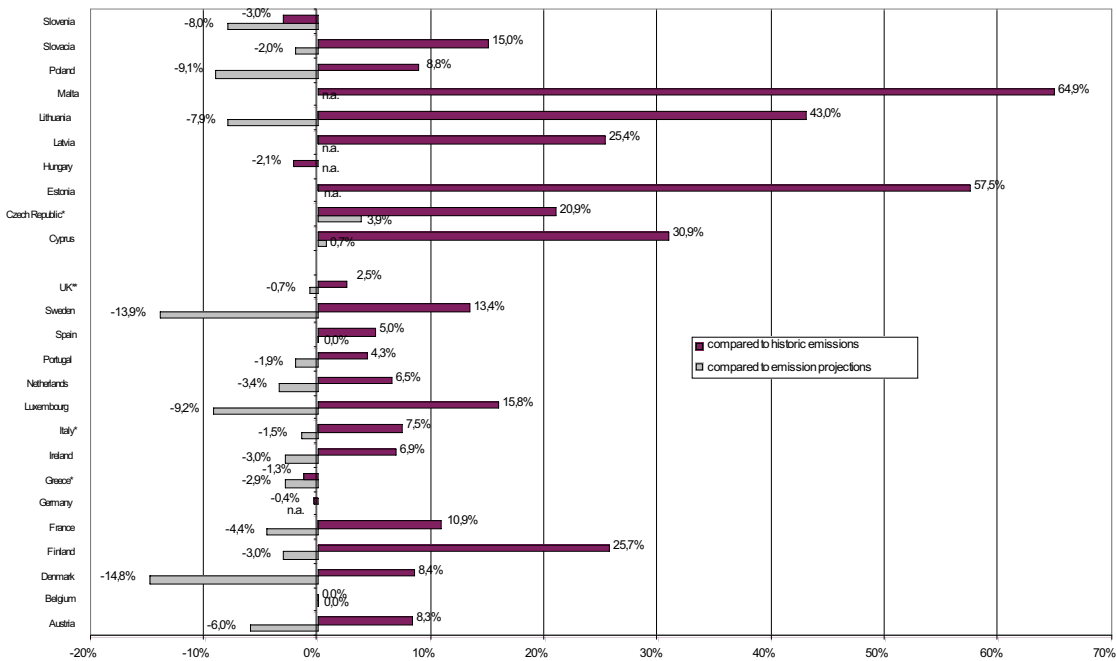
The market price not only reflects the marginal abatement costs, but also sets monetary incentives to adopt new, more energy-efficient technologies which generate lower emis-

2. For example, estimated cost savings for the Acid Rain Program range around 50% compared to command-and-control type regulation (Carlson et al. 2000).

3. By contrast, subsidies for R&D are an example for a supply-oriented regulation.

4. See Kemp (1997) or Jaffe et al. (2002) for overviews.

ALLOCATION FOR THE EMISSIONS TRADING SECTOR IN COMPARISON TO EMISSIONS PROJECTIONS (2006) AND HISTORIC EMISSIONS (BASE PERIOD) (%)



\* NAPs have not been approved by EU Commission by 15<sup>th</sup> of March 2005

\*\* UK NAP figures are taken from amended NAP, still subject on the outcome of the ongoing discussion with the EU Commission.

Sources: Different NAPs and EC Decisions on NAPs.

Figure 1. Allocation for the emissions trading sector in comparison to emissions projections (2006) and historic emissions (base period) (%)

sions. These investments either free up emission allowances which may be sold at the market price or they avoid the purchase of allowances at that price. Because of these additional revenues/cost savings, emission trading leads to *direct innovation effects* in the form of accelerated diffusion of new energy-efficient technologies (Tietenberg 1985, p. 33). At the same time, additional incentives are generated for R&D in such technologies.<sup>5</sup> As a caveat, it should be kept in mind though, that costs for emissions are only one among many determinants for innovation. Clearly, the relevance of emission trading for innovation crucially hinges on the market price for allowances. The higher the price for allowances, the higher are incentives for R&D, invention, adoption and diffusion in energy-efficient technologies.

If additional costs to cover CO<sub>2</sub>-emission are passed on and included in the product (e.g. electricity) prices, emission trading may also induce *indirect innovation effects* on the demand side where those products are used as inputs (e.g. aluminium industry, but also private households). The relevance of these indirect effects depends on the extent to which the additional costs for CO<sub>2</sub>-emissions can be passed on, as well as on the cost-share of those inputs. Thus, the in-

novation effects of emissions trading are not limited to the companies directly covered.

**Allocation and innovation effects**

In this section we analyse the allocation rules in terms of their innovation effects and show how these rules differ across MS. The allocation rules analysed are (i) the total quantity of allowances allocated to installations (ET-Budget) in the MS; (ii) the rules on banking of allowances from the first period into the second period (2005-07) of the EU ETS; (iii) the allocation method (auction versus grandfathering); (iv) treatment of new entrants; (v) allocation rules for the closure of installations; and (vi) the information provided about future allocation.

**SIZE OF EMISSION TRADING BUDGET**

As pointed out above, the EU ETS will not cover all sources of CO<sub>2</sub>-emissions within a country. Only large installations of the energy sector and other carbon-intensive industry sectors are included and initially receive allowances. The quantity of these allowances (ET-budget) is determined in the NAPs of the MS. In terms of innovation effects, the smaller

5. See Kerr and Newell (2003) for empirical evidence from the former US trading program for lead.

the size of the ET-budget, the more scarcity will result in the market for allowances, the higher will be the market price for allowances, and the stronger will be innovation incentives.

The very first allocation criterion (1) requires that the total number of allowances to be allocated is consistent with the MS's target under the EU Burden-Sharing Agreement. For the first period (2005–2007), where no international targets exist, the Commission's published guideline on the interpretation of this criterion states that the reduction "path is intended to be a trend line, not necessarily a straight one, but one that is leading towards or goes beyond" achieving the Burden Sharing target (CEC 2004a, p.5). Thus, taking into account their national targets, MS had to decide how to "split the pie," that is, how many allowances should be allocated to the installations covered by the EU-ETS (ET-sector) and how many to installations not covered by the EU-ETS (non-ET sector). A first analysis of the ET-budgets in the NAPs shows (see Figure 1), that most MS (intend to) allocate less allowances than their projected emissions for the first period. MS used various methods to project future emissions of the ET-sector, and at least in some cases, such as for Italy, for Finland or for The Netherlands, the reference scenarios used are doubtful since they are at odds with historic emission trends. Compared to projected emissions, allocation appears to be particularly tight in Sweden and Denmark. However, compared to historic emissions, only few MS such as Slovenia, Hungary or Germany, allocate fewer allowances. Thus, allocation to the ET-sector appears to be rather generous, creating modest effects on innovation, at best.

From an economic perspective, the size of the budgets for the ET-sector and the non-ET-sector should be determined such that (before international trading starts) the total abatement costs are minimized, i.e. that the marginal costs of the abatement measures which are realized in the trading sectors and the non-trading sectors are equal. In practice, only a few MS (e.g. Ireland) used an optimization approach to determine the size of the budget. Instead, most MS based their decisions on emissions projections resulting from projected greenhouse gas emissions if proposed or potential measures to mitigate emissions are implemented (so-called "with-measures scenarios"). Furthermore, for 2008–2012 many MS plan to make extensive use of the Kyoto Protocol's Flexible Mechanisms (Joint Implementation, Clean Development Mechanism and International Emissions Trading) to reach their Kyoto/Burden-Sharing targets. Based on existing analyses of various authors<sup>6</sup> on abatement costs in the ET-sector and in the non-ET-sector and by Betz et al. (2004) on the size of the ET-budget allocation, Ehrhart et al. (2005) argue, that the budgets for the ET-sectors are too high and do not "correspond to an allocation with which the overall national emissions targets will be met at minimum cost".<sup>7</sup>

## BANKING

Theoretical and empirical analyses suggest that banking, i.e. the transfer of unused allowances into future commitment periods, and borrowing, i.e. the use of allowances that were originally designated to a later period, both reduce overall compliance costs. Banking and borrowing allow for inter-temporal flexibility because cost savings can be traded over time. Likewise, banking allows for buffering of allowances which, in turn, tends to dampen price fluctuations. In terms of innovation, banking accelerates the diffusion of new technologies: banking tends to improve the profitability of a new low-emission technology because the freed up allowances may be saved for the future rather than being sold on the market. From an economic perspective banking is profitable if the expected future market price of allowances exceeds current marginal pollution abatement costs. However, because the transferred allowances may be used to cover emissions in future trading periods, banking may result in the adoption of fewer new technologies in the future (Phaneuf and Requate 2002). Most existing emissions trading programs allow for banking (Boemare and Quirion 2002). Empirical analyses for the Acid Rain Program indicated that because of banking, companies invested earlier in new technologies, which — as a side effect — was also beneficial for the environment (Ellerman et al. 2003; Ellerman and Montero 2002).

The Directive for the EU ETS also allows for the unrestricted transfer of surplus allowances into future years — with one possible exception: according to the principle of subsidiarity, individual MS may decide whether they prefer to restrict banking from 2007 into the first commitment period under the Kyoto Protocol starting in 2008. The reason why a MS may want to do so is the following: if an individual MS permits unrestricted banking of surplus allowances from 2007 into 2008 — unless other, non-trading sectors in that MS make up for it — it may fail to meet its national Burden-Sharing emissions target for the years 2008–2012 because companies may transfer unused allowances into that period. Moreover, from a practical point of view, it would be very difficult to project the amount of banked allowances when MS draw up their national allocation plans for the second trading period 2008–2012 in early 2006. Schleich et al. (2005) argue that giving the MS the option of choosing whether to allow or ban banking from 2007 to 2008 may result in a Prisoners' Dilemma: each individual MS has an incentive to ban banking, even though each would be better off if they all allowed it. In fact, with the possible exception of France and Poland all MS (Malta's decision is still pending) have banned the banking of allowances from the first to the second period (see Table 1). France and Poland allow for limited banking where the individual limit is related to emissions reductions from actual investments. More specifically, in France, banking is restricted to the difference between primary allocation and actual emissions. Thus, it is not possible to buy allowances on the market with the sole purpose to transfer those into the second trading period.

6. See Böhringer and Lange (2004), Böhringer et al. (2004), Criqui and Kitous (2003) or Peterson and Klepper (2005).

7. This outcome is consistent with insights from public choice theory, which suggests that organized industry groups lobby the government for additional cost-free allowances at the expense of less well organized interest groups. Other reasons for a generous allocation to the trading sectors include differences in responses to uncertain abatement costs by different sectors.

The combination of both, a generous allocation and a ban on banking implies that the price for allowances will be rather low and may approach zero towards the end of the first period (see also Schleich et al. 2005 and Ehrhart et al. 2005).

### Allocation mechanism

The innovation effects of emissions trading system also depend on the allocation mechanism, that is, whether allowances are allocated free of charge or sold at an auction. The adoption of more energy-efficient technologies reduces emissions costs for the investor since the freed-up allowances may be sold on the market, or, since less allowances need to be purchased at the auction. This effect is the same, independent of whether allowances are allocated free of charge or auctioned off. Differences between the two mechanisms exist, once the diffusion of new technologies is taken into account. Diffusion implies that the demand for allowances decreases relative to supply, so that the market price decreases. If allowances are allocated for free, this diffusion-effect implies that the freed-up allowances generate less revenue. However, if allowances are auctioned off, the investor also benefits in the longer run from the reduced allowance price (see Milliman and Prince 1989). Thus, in the literature, auctions tend to be associated with higher innovation-effects than the typical grandfathering, where allowances are allocated free of charge based on historic emissions. Whether diffusion actually leads to lower allowance prices depends on whether the regulator adjusts the target accordingly. A reduction in the ET-budget over time will counterbalance the effect of diffusion on the allowance price. In this case, the differences of grandfathering and auctions in terms of innovation vanish.<sup>8</sup> If an auction (e.g. of a small share of the emission budget) is carried out prior to the start of a trading period, the auction may generate robust early price signals for the actual scarcity in the market, since participants base their bidding behaviour on their marginal abatement costs. Hence, the auction generates an early price indicator, which may help participants develop their investment and trading strategies and improves the efficiency of the system (see also Ehrhart et al. 2005).

According to the Directive, MS were allowed to auction off up to 5% of the ET-budget in the first period (2005-2007) and up to 10% in the second period (2008-12). An analysis of the NAPs shows (see Table 1) that only few MS chose to auction off parts of their ET-budget, arguably, because allocating all allowances free of charge was politically more palatable. Since only Denmark, Hungary, Ireland and Lithuania decided to auction off parts of their ET-budget, a total of only 4,5 Million tCO<sub>2</sub> will be auctioned off annually. This amount corresponds to 0.2% of the entire ET-budget in the EU and is unlikely to lead to innovation effects beyond a 100% grandfathering mechanism, in particular, since a fairly generous allocation in combination with an (almost) EU-

wide ban on banking will allow for modest allowance prices only.

### Treatment of newcomers

In emissions trading systems new emitters may have to buy allowances on the market or via specific auctions, or they may receive allowances free of charge from a special reserve. If newcomers have to buy allowances on the market strong monetary incentives exist to implement energy-efficient technologies since these technologies require fewer allowances to be purchased. If newcomers receive allowances for free, the incentives to use cost-efficient technologies are less pronounced and depend on the actual allocation rules.<sup>9</sup> If the allocation relies on uniform product-based benchmarks (tCO<sub>2</sub> per kWh or per tonne of cement clinker) strong innovation incentives exist to invest in the most efficient measures within a given product group: Investments in technologies which require less specific emissions than the benchmark generate extra allowances which may be sold on the market. By contrast, technologies which are less efficient than the benchmark, incur additional costs for the purchase of allowances. Note that within a product group, incentives for innovations are independent of the level of the benchmark.<sup>10</sup> However, the more sub-benchmarks there are within a product group or within a technology group (e.g. fuel-specific or technology-specific benchmarks), the smaller will be innovation effects, since innovation incentives are limited to the sub-groups. If newcomers receive an amount of allowances which always equals actual emissions of the new technologies, incentives for innovation are zero, since it does not pay to use energy-efficient technologies.

The Commission would have preferred newcomers to buy allowances on the market (e.g. European Commission DG Environment 2001), as is the case, for example, in the US Acid Rain Program. Since allocation to newcomers influences the location for new investments, an implicit harmonization across MS took place in the sense, that during the process of setting up the allocation plans, all MS created newcomer reserves of which new entrants could be served free of charge. Only Sweden requires some operators of new installations – new power plants in the electricity sector (but not CHP-plants) – to purchase allowances on the market.

Typically, MS use information on best available technologies (BAT) or benchmarks for relatively homogenous product groups for the allocation of new entrants (see Table 1). To calculate the actual allocation, the specific values from BAT or benchmarks are multiplied by projected output. Most MS indicated the use of BAT, but the BAT-values are usually not (yet) published in the NAPs or in other laws. Alternatively, up-to-date information provided by manufacturers may be used. As of January 2005 only eight MS have published benchmarks for particular products, primarily for electricity generation. A comparison of these values shows

8. In fact, a clear ranking of environmental policies (emissions trading, environmental taxes, standards, emission rates) in terms of innovation is not possible, once the regulator's response to diffusion or technology-spillovers, which affect the costs of innovations, or the market structure, is taken into account (see Requate and Unold 2003, or Fischer et al. 2003).

9. In addition, from the perspective of economic efficiency, too many companies may enter the market (see Graichen and Requate 2005 or Spulber 1985).

10. The profits, however, do depend on the level of a benchmark: the more stringent the benchmark, the lower the profits. Thus, the quantity of allowances allocated for free may well have an impact on the decision of whether to invest in a particular technology in a particular MS or not.

**Table 1. Overview of selected allocation rules in EU Member States /continued on next page/.**

Member State	Banking	Auction	Newcomers	Closures	Transfer option
Austria	No	No	BAT	Allocation will stop the year following closure	From existing installation to new installation of same operator
Belgium	No	No		Flanders: If emissions < 20% of emissions in base period, no further allocation Brussels/ Wallonie: no information	No
Czech Republic	No	No	BAT	Allocation will stop the year following closure	No
Denmark	No	5% of ET-budget	Benchmarks based on capacity, fixed throughput and fixed emission factors	Allocation will stop the year following closure	No
Estonia	No	No	Benchmark of technologies installed during last 5 years	No information available	
Finland	No	No	BAT	Allocation will stop the year following closure	
France	Yes, but restricted	No	Benchmarks (same as for existing installations)	If emissions < 50 % of allocation, no allocation for the years following closure	Transfer of allocation to new installation optional; process not specified yet
Germany	No	No	-Energy sector: essentially BAT with upper and lower bounds -Industry sector: benchmarks for single "homogenous" product groups or sub-groups; otherwise BAT	No allocation for the years following closure	From existing to new installation with similar production (also to other operator) for 4 years; adjustment of capacity
Greece	No	No	Not available	Not available	Not available
Hungary	No	2,5 % of ET-budget	Allocation based on general BAT or BAT in Hungary; a law for benchmarks for specific product groups is under preparation.	If emissions < 10% of emissions in the base period, allocation will stop the year following closure; exception: temporary closure of electricity production	Transfer of allocation for 4 years to new installation in the same sector within 6 months after closure; adjustment of capacity
Ireland	No	0,75% of ET-budget	BAT plus reduction factor of 2 %	No allocation for the years following closure	No details provided in NAP.
Italy	No	No	Benchmark for electricity sector, differentiated by fuels and technology;	Three different definitions of closure: a) Permanent suspension of services (permit is revoked) b) Temporary suspension of services (the plant discontinues its activity on a temporary basis for more than 1 year)	Feasible from existing installation to new installation for allocation in first period

quite some variation across countries, which may be explained by the underlying reference technologies, assumed load hours, fuel inputs etc. Except for Italy and Germany, MS did not choose fuel-specific benchmarks.<sup>11</sup> In Italy benchmarks differ by technology as well as by fuel (com-

bined cycled gas turbines, steam power plants and condensation power plants). In the UK, benchmarks also differ by a multitude of technologies, but they are all based on gas. For electricity and heat generation in Germany upper and lower bounds exist (e.g. 365g CO<sub>2</sub> per kWh and 750g CO<sub>2</sub> per

11. France: 900 g CO<sub>2</sub> per kWh, Germany: 365-750 g CO<sub>2</sub> per kWh, Lithuania: 551 g CO<sub>2</sub> per kWh, Belgium/Flanders: 500 g CO<sub>2</sub> per kWh, Italy: 396-1.531 g CO<sub>2</sub> per kWh and 555 g CO<sub>2</sub> per kWh, Denmark: 342 g CO<sub>2</sub> per kWh, Sweden: 265 g CO<sub>2</sub> per kWh, UK: gas-based benchmark for 5 distinctive technologies.

Table 1. Continued from previous page.

Member State	Banking	Auction	Newcomers	Closures	Transfer option
				c) Significant change requiring a permit update Must surrender 50% of excess allowances for year of closure, or use transfer rule	
Latvia	No	No	Based on projected emissions	No final decision yet	
Lithuania	No	1,5% of ET-budget	Benchmark	No information available	
Luxembourg	No	No	BAT	If emissions < 10 % of allocation, allocation will stop the year following closure	From existing installation to new installation with similar production of the same operator, case by case decision.
Malta	Not decided yet	No	BAT	No information available	No
Netherlands	No	No	BAT with reduction factor based on benchmarks for energy use from existing voluntary agreements	Allocation will stop the year following closure	No
Poland	Yes, but restricted	No	BAT	No information available.	From existing to new installation with similar production.
Portugal	No	No	BAT	Allocation will stop the year following closure Correction of allocation if emissions < 30% of allocation	From existing to new installation within the same commitment period
Slovakia	No	No	BAT	No information available	No information available
Slovenia	No	No	BAT	Allocation will stop the year following closure	From existing to new installation
Spain	No	No	BAT plus reduction factor	Allocation will stop the year following closure	
Sweden	No	No	Power industry must buy allowances on the market; industry: allocation based on BAT, but benchmarks for combustion plants; all CHP: benchmarks	No final decision yet	No final decision yet
United Kingdom	No	No	Multitude of bench-marks, typically with gas as standard fuel	No final decision yet	No

\* Information was taken from approved and submitted NAPs and other laws, if available by December 2004.

kWh for electricity). Investors may apply for higher specific values than the given lower bound if they can prove that the new technology is BAT. But this provision essentially implies that between the upper and lower bound the allocation is based on a multitude of BATs, rather than on a benchmark. Given those figures, the only innovation effects exist for gas-fired power plants (to stay below the 365 g CO<sub>2</sub>/kWh) and for lignite power plants (to approach the 750g CO<sub>2</sub>/kWh from above). Only few countries, like Germany and the UK, not only apply benchmarks to the energy sectors, but also to some industrial products. The chosen product groups are

usually cement clinker, lime, brick works, or glass. In some cases there exist sub-categories by product (roof tiles versus bricks) or by technologies (size of rotary kilns for cement clinker), but not by fuel. In Denmark, there are 28 benchmarks for the industry sector in addition to the benchmarks for the energy sector. Notably, allocation to individual installations in Denmark will be based on capacity (not expected production!), a fixed throughput and a given emission factor.

To avoid excess-allocation, some MS, like Germany, Italy, Portugal and Luxembourg had originally planned to use an ex-post adjustment of the allocation, in case actual output

turns out lower than projected. From a purely economic perspective, this ex-post adjustment introduces inefficiencies into the system, since it provides little incentive to reduce output which may – under some circumstances – be cost-efficient. Also, the Commission did not approve ex-post adjustments (for violation of criterion (10) and (5)) and most MS (e. g. Portugal and Luxembourg) have eliminated these adjustments in the meantime (e.g. European Commission 2004a). Only in case of Germany, the European Courts will have to settle this conflict. However, if the ex-post adjustment gets approved, this may have serious consequences for product prices and thus indirect innovation effects. With ex-post adjustments, emissions for new installations would be associated with zero costs.<sup>12</sup> If these new installations turn out to be the marginal suppliers in the output market, emissions trading will not increase marginal production costs, and no additional indirect effects on innovation will exist.

### Treatment of closures

In general, the closure of an installation may be treated in two polar ways: allocation may be terminated or continued. In the US Acid Rain Program closed installations are allowed to keep their allocation (for up to 30 years). Taking away allowances for closures results in (economic) inefficiencies and disincentives for new investments.<sup>13</sup> If a closure leads to a stop in allocation, old plants may be operated too long and new investments postponed, since the opportunity costs of the closures are not accounted for properly. In fact, such a procedure subsidises output, since there are too many companies in the market (Graichen and Requate 2005, Spulber 1985). Allowing a transfer of allowances from closed installations to new installations may partially alleviate those negative effects. As for the treatment of closures, the Directive did not foresee an innovation-friendly solution. The Directive requires that allowances can only be allocated to installations which operate under a permit to emit greenhouse gases (Article 11 in combination with Article 4, European Parliament and Council, 2004). By the very nature, closed installations cease to have a permit. However, if incumbents received allowances permanently even after the closure of an installation, they would constrain future allocation to other installations. Thus, failing to stop allocation for closures may have negative distributive effects, since other sectors or activities would have had to reduce more emissions.

While countries differ in the definition of a “closure” (see Table 1), a closure of an installation during the first period generally means that allocation will be terminated in the year following the closure. In about half the MS, the transfer of allowances to a new installation is permitted (see Table 1), but – if MS provide any details at all – the transfer is typical-

ly restricted to the same type of installation or product group, to the same operator, and to a few years only.<sup>14</sup>

### Future allocation

Planning reliability and thus incentives for innovation are higher, if future allocation rules are known in advance. Future allocation may be based on emissions prior to the start of the system, or on emissions within the first trading period (updating), or on benchmarks. In addition, the auction share may be extended up to 10%.

The Directive only required rules for the first trading period (2005-2007) to be included in the NAPs. Likewise, in its review of the NAPS, the Commission only approved the rules for the first trading period. Consequently, most NAPs do not include any information about allocation for the next period (2008-2012) or beyond.<sup>15</sup> Planning reliability is particularly relevant for investments in new technologies, but NAPs typically provide only the allocation rules for the first period. By contrast, according to the German NAP new installations may receive their allocation under the benchmark rule for 14 years. At this point, however, this rule can only be a declaration of intent. Whether it becomes effective, depends on the Commission’s approval of the German NAPs for the subsequent trading periods.

### Technology variety

So far, the arguments and concepts used to analyse the innovation-effects of the EU ETS in this paper have primarily been based on neoclassical-economics. As an alternative, the systems-oriented perspective of evolutionary economics stresses the importance of technology variety and selection (e.g. Metcalfe, 1994; Nelson, 1995). From this perspective, an emission trading system affects the selection process determining the range of innovations introduced in the system. Compared to regulation via technology standards, emissions trading allows for a much higher degree of flexibility: companies may decide by themselves on their preferred technological solutions. Emission trading is expected to lead less to radical technological change, but rather to incremental technological change, reflecting a more efficient use of resources in existing installations. For example, Fri (2003) and Arentsen et al. (2002) argue that technological change in the energy sector is realized over long periods because of the large number of actors and corresponding actions, decisions and experiences involved. These are affected by several dimensions including social, institutional, political, managerial, technological or financial dimensions. As a result of this complex set of relations, technological change emerges as an incremental process. In general, innovations to reduce environmental damage (such as CO<sub>2</sub>-emissions) may be distinguished in end-of-pipe innovations

12. In the case of Germany, it is reasonable to assume, that actual output will not exceed projected output. When companies applied for allocation they were aware of the Commission’s position and thus had every incentive to be on the safe side and “overstate” rather than “underestimate” future output. Thus, depending on the European Court’s decision, allocation for these companies may be adjusted downward. In this case, since cutting output would not result in additional allowances, the opportunity costs of output reduction in terms of emissions would be zero.

13. From an environmental perspective, closure of an installation in an EU MS may result in carbon leakage if the output if the closed installation will now be produced in a country without emission restrictions.

14. Since combustion installations based on RES (biomass) are typically excluded from the EU ETS, they cannot benefit from a transfer rule either.

15. From this perspective, the French NAP 2007 should be commended for stating that allocation in the second trading period will not be based on emissions in the first period.



(such as carbon storage), process-integrated innovations (such as controls, fuel switch, substitution of old installations by new installations, heat recovery) and product-integrated innovations (production of glass or paper with a higher share of recycled material). Over time, the EU-ETS may trigger all three kinds of innovations, although end-of-pipe type innovations such as carbon capture and sequestration may only become economically attractive for relatively high allowance prices and once learning-effects have resulted in lower abatement costs for these technologies (e. g. MacGill and Outhred 2003).

Newell and Stavins (2003, p. 44) point out that “abatement-cost heterogeneity is a fundamental determinant of the potential cost-savings associated with market-based policy instruments”. Technological variety and abatement-cost heterogeneity depend on the type of installations covered under the EU-ETS. For the EU-ETS the types of installations to be included are listed in Annex I of the Directive and include combustion installations with a rated thermal input capacity of at least 20 MW, refineries, coke ovens, steel plants, and installations to produce cement clinker, lime, bricks, glass, pulp and paper if they exceed the output thresholds given in Annex I of the Directive.<sup>16</sup> Thus, the impact on technology variety and cost-heterogeneity should be comparatively higher in the EU-ETS than in the Acid Rain Program, which only covered electricity generating plants. Across countries installations covered differ significantly due to the different industry structure and type power generation mix. Additional differences stem from different interpretation of Annex I of the EU ETS Directive by MS (see Betz et al. 2004). Most MS base the interpretation on their national implementation of the EU-Directive on Integrated Pollution Prevention and Control (IPPC) and include installations as requested by the Commission (European Commission DG Environment 2003). However, since MS differ in their implementation of the IPPC Directive and thus Annex I of the EU ETS Directive (CEC 2003a) not the same installation are included in the EU ETS across the entire EU. For example, in Germany, Poland and Luxembourg, steam crackers and melting furnaces are not (or would not be) covered, since the definition of combustion installation covers only activities which transform energy carriers into secondary or primary energy carriers such as electricity, heat or steam.<sup>17</sup> Furthermore there are differences in the interpretation of the “accumulation rule”. This rule sets the criteria governing which of the installation capacities below the 20 MW<sub>th</sub> threshold or other production thresholds have to be accumulated and to be included in the EU ETS. In Germany, for example, the accumulation rule is less stringent than expressed by the Directive. According to the Directive, capacities have to be accumulated if they are run by the same operator, or if they fall under the same sub-heading in the same installation or on the same site (CEC 2003a, Annex I). In Germany all criteria had to be fulfilled at the same time. The coverage also depends on the use of opt-

in and opt-out. While almost all MS – except the Netherlands, Poland and the UK – do not allow for opt-out, opt-in was used more frequently. For example Finland, Sweden and Slovenia have used the opt-in provision for heat and power installations smaller than 20 MW<sub>th</sub>. These installations are included if they are part of a district heating system and if one installation has a capacity of more than 20 MW<sub>th</sub>. In case of Sweden the opt-in provision has already been approved by the EU Commission (European Commission 2004b).

Since renewable energy sources (RES) like wind power, hydro or photovoltaic installations are not covered by the EU-ETS, no direct innovation effects can be expected for these technologies. At best, these types of renewable energy sources may benefit indirectly, if the EU-ETS results in a sufficient increase in the costs of conventional power (and heat generation), making RES more competitive. In general innovation effects for RES are rather driven by direct national support mechanisms such as feed-in tariffs, (tradable) quota systems or direct R&D subsidies for RES. According to a non-paper by the European Commission (2003), installations fuelled exclusively or predominantly by biomass have to be included in the EU-ETS if their rated thermal input exceeds 20 MW. In these cases there may be double regulation and double subsidization I response, some countries (e.g. Germany) did not include renewable combustion installations in the EU-ETS, if they qualify for the feed in law. In sum, the EU-ETS is not expected to directly enhance the diffusion of RES-technologies.

By construction, the market mechanism of CO<sub>2</sub>-emissions trading systems does not directly favour a particular technology. Instead, the price and cost incentives favour variety of energy/carbon-saving technologies in general. However, allocation rules for newcomers could be used to support particular technologies. In fact, based on allocation criterion (9), some countries decided to include special provisions for clean technologies, notably for new combined heat and power (CHP) plant. In Germany, for example, new CHP-plants receive an allocation based on a “double benchmark” for heat and electricity. Allocation rules for new entrants based on a plethora of benchmarks or on BAT, inhibit the feedback relationship between variety creation and selection. In these cases, it is less the market which provides the incentives for selection, but rather decisions by policy makers setting the benchmark values or standard.

The number of direct participants in the EU ETS affects liquidity in the allowance market and price volatility, which in turn also have innovation effects<sup>18</sup>. On the one hand, volatile prices increase uncertainty about returns on investments in energy efficiency and may slow down innovation. On the other hand, such investments reduce companies’ “risk exposure”, since less emissions need to be covered once energy-efficient technologies are implemented. The relative magnitude of both effects is company-specific and generally ambiguous. Whether market price volatility in-

16. The emissions trading sector (ET-sector) typically covers 30 - 50 % of the national greenhouse gas emissions in the Member States.

17. France, Italy and Spain originally only included combustion installations in the energy sectors, and not in the industry sector (e.g. large boilers in the sugar industry). However, the Commission forced France and Spain to change its interpretation of Annex I, which resulted in a doubling of the number of installations in France. Spain is currently completing the list and for Italy the Commission's judgement is still missing.

18. See, for example, Gagelmann and Frondel (2005).

creases or decreases innovation depends – among other things – on a company's attitude towards risk, the expected net position on the market (seller or buyer) and on the irreversibility of the investments (see Ben-David et al. 2000).

The more installations participate and the more diverse these installations are, the more likely it is that a liquid market for emission allowances can be established. In liquid markets, the variance of allowance prices tends to be low creating a more stable environment for new investments in energy efficiency. Also, a liquid market is usually a precondition for futures markets and derivatives markets to develop. These markets allow investors to reduce uncertainty and hedge their investments, for example, via long-term futures contracts.

Finally, to lower compliance costs for companies the so-called Linking Directive (2004/101/EG) allows operators of installations which are covered by the EU-ETS to use the project-based mechanisms of the Kyoto-Protocol, Clean Development Mechanism (CDM) and Joint Implementation (JI). Thus, companies can also benefit from emission reductions achieved outside the EU-ETS. In that sense, the Linking Directive extends the scope of technologies which may be directly fostered by the EU-ETS, in particular RES-technologies. But this increased flexibility will also boost the supply of compliance measures available to the companies resulting in lower allowance prices and reduced price and cost incentives for innovation within the EU-ETS.

## Summary and conclusion

This paper analyses the impact of existing allocation rules for the European emission trading system (EU-ETS) on energy efficiency and innovation and on technology variety. To do so, we first identify and relate crucial allocation rules for the first trading period of the EU ETS (2005-2007) to their impact on energy efficiency and innovation. These rules include the total quantity of allowances allocated in the individual Member States (MS) and in the EU, the allocation method (auction versus grandfathering), the rules for banking of left-over allowances from the first period into the second period (2008-2012), for newcomers and for closures, as well as information available about future allocation rules. Existing National Allocation Plans of the EU MS for the first trading period are analysed and assessed according to these allocation rules. Since, the overall allocation appears rather generous allowance prices in the first period are expected to be low, in particular since almost all MS prohibit banking into the second period. Thus, only small price- and cost-induced incentives for an early diffusion of energy-efficient technologies can be expected. Similarly, the marginal share of allowances that will be auctioned off is insufficient to have any effects on innovation. In most MS, installation closures result in the suspension of further allowances, providing disincentives for innovation. In several MS, like Slovenia, Germany or Hungary, such disincentives are softened because allowances from closures may be transferred to new entrants. Usually, new entrants receive allowances for free based on specific emissions and projected output. These specific values are either based on benchmarks for homogenous product groups or depend on best available technologies. In some countries, including Germany and the

UK, a plethora of benchmarks within the same product categories threaten to thwart the flexibility provisions of the EU-ETS. Finally, future allocation rules are vastly unknown, amplifying the uncertainty about the benefits of new investments and potentially creating the perverse incentive not to decrease emission in order to get more allowances in subsequent periods.

In terms of technology variety, emission trading allows for a much higher degree of flexibility compared to technology regulation and does not directly favour a particular technology. Some MS utilized the allocation rules for newcomers to directly provide particular support for new CHP-plants. By contrast, since RES-technologies are usually not included in the EU-ETS, only indirect effects on the diffusion of RES can be expected.

Based on the findings presented in this paper, policy recommendations in terms of innovation for the subsequent phases will be briefly summarized. First, the share of allowances to be auctioned off should grow continuously to eventually 100%. A high auction share for incumbent installations would also be consistent with the second recommendation: newcomers should purchase allowances on the market or via auctions. In this case, incumbents and newcomers would be treated equally. For the transition time, new installations could be allocated based on EU-wide benchmarks for "homogenous" product groups, where the number of sub-groups should be kept at a minimum. Third, closed installations should be allowed to keep their allocation. Such a rule would spur the closures of old plants, leaving space for new, more efficient technologies. Finally, future allocation rules and emission targets should be known long time in advance to be more in line with the length of innovation cycles. This request is supported by results of a recent empirical study by Cames (2004). He finds that significant investments in new power plants in the EU will be postponed because of uncertainty about future allocation rules.

In conclusion, existing allocation rules provide only modest incentives for technological innovations. Instead, as in the US Acid Rain Program, where most of the reductions have been achieved by switching from high sulphur to lower sulphur coal or – to a lesser extent – also by installing new scrubbers (see Burtraw 2000), the first phase of the EU-ETS may rather lead to low-risk and low-cost strategies like fuel switch and to institutional and organisational changes within companies.

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