DO TECHNOLOGY SPECIFIC CO_2-ALLOCATIONS DISTORT INVESTMENTS?

by

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Abstract:

This paper analyses the effects of allocating CO_2 permits to new power plants free of charge within a tradable permit system. We demonstrate that these free allocations distort investments. Furthermore, we distinguish the effects of a sector benchmark from a fuel benchmark, as both are common elements in EU member states' national allocation plans. An empirical model for the European market is used to quantify the effects in a realistic framework.

Keywords: Electricity Markets; Energy Modelling; CO_2 Emission; Permit Trading Design

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I. Introduction

The European Union has agreed to reduce CO_2 emissions using a cap-and-trade mechanism. Total reduction targets are defined by countries' commitments in the Kyoto protocol, which also determine the burden sharing between member states. Inside the European Union's trading scheme, member states have to allocate emission rights between different interest groups. It is well known that auctioning of emission rights is superior to any other allocation method with respect to efficiency (e.g. Cramton and Kerr, 2002). However, in order to promote the acceptance of emission trading among participants[1], a cost free permit allocation was finally chosen in the European Union.

It is well understood that grandfathering does not distort short-term production decisions as long as it is based on historic emissions. However, this paper demonstrates for the first time that inefficiencies can arise if new power plants also benefit from a grandfathering scheme as this may distort investments. We start by showing this effect in a general context. In the next step, we demonstrate with an empirical model that these inefficiencies indeed appear under the rules of the EU trading scheme. We quantify the inefficiencies both in the context of a sector benchmark and a fuel specific benchmark for the allocation of emission rights to new plants.

Inefficiencies can arise because of the free allocation of emission rights to new investments which gives incentives for overinvestment – compared to auctioning off all emission rights. In addition, when the benchmark distinguishes between fuels (usually implemented to protect coal fired generation), there are further investment distortions. When hard coal capacity receives more emission rights compared to gas-fired capacity, the incentive to invest in hard coal plants increases relative to gas. However, the effect is restricted by the overall emission cap: As hard coal emits more CO_2 than gas fired capacity, total potential for replacement is limited, regardless of the difference in the fuel benchmark. However, we know that new power plants are more efficient than old ones. Hence, an earlier replacement of capacity as the result of CO_2 emission rights passed on to new capacity reduces emissions. This effect in turn breaks ground for a shift from less to more emission intensive power plants.

The paper starts with a brief description of the basic concepts for permit allocations in section II. The following section III briefly presents the European Union's emission trading system as this is the foundation for the following empirical modelling. Section IV demonstrates the possible inefficiencies due to the endowment of new installations with certificates. Section V quantifies these inefficiencies in the context of an empirical partial equilibrium model of the European power market. Section VI concludes.

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[1] Incumbent emitters are clearly better off with a grandfathering scheme than they would be under permit auctioning (see Burtraw et. al. (2001) for an example from the US).

II. Basic Concepts of Permit Allocation

Different types of permit allocation and their consequences have been frequently addressed in the literature. Basic concepts are often categorised into auctioning, grandfathering and different forms of performance standards.[2]

Auctioning is a revenue-raising instrument. Permits will be traded such that emission reduction is achieved at least cost. Using revenues to reduce distorting taxes would create an additional benefit that is often referred to as double dividend. Even though some cost free allocation methods lead to exactly the same reduction measures as auctioning, they do not allow for tax reductions. Thus, they are only second-best approaches from a societal perspective.

Grandfathering is one option of allocating permits free of charge. It uses some kind of historic measure, for instance historic emissions or historic generation. Thus, it is argued that grandfathering does not affect future decisions.

When cost free permit allocation is conducted repeatedly, updated reference periods can be used. For instance, an installation's share of total permits can be set according to its share in total generation last year. In the literature this is referred to as generation performance standard. A similar approach is to use last year's share in total emissions. But updating has an essential drawback compared to grandfathering. Producers would be aware of the fact that today's generation or emission level influences permit allocation in the next period. Hence, there is an incentive to alter one's own behaviour to increase one's future permit allocation. Fischer (2001) and others already demonstrated the inefficiency of an output-based allocation. In contrast to updating, grandfathering uses a historic reference period such that there is no behavioural effect from permit allocation. Main impacts of auctioning, grandfathering and performance standards have been sufficiently examined.

Actual allocation rules in EU member states' allocation plans go beyond these pure concepts. The next section will emphasise on a special characteristic of EU allocation plans: allocation rules concerning new entrants.

III. EU Allocation Designs and the Treatment of New Entrants

Directive 2003/87/EC constitutes the main framework on emission trading within the EU. But it also leaves much competence with member states, such as defining sector targets as well as emission allocation on installation level. Member states have developed national allocation plans to set up binding rules on a very detailed level. Actually, national allocation plans and their supplementary legislations comprise important rules that can influence the behaviour of participants.

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[2] Compare for instance Burtraw et. al. (2002) or Bode (2006).

First and foremost, almost all allocation plans grant permits free of charge for the period 2005 to 2007. Although the Directive allows for some auctioning, only four out of twenty five member states used this option. In general, cost free allocation distinguishes between existing installations and new installations. For existing installations the number of permits is determined by their historical emissions according to some base year. As argued above, this may lead to inefficiencies if the base year is updated. However, these inefficiencies are not in the centre of this article.

Apart from this problem, EU allocation plans constitute a blend of different allocation methods. This includes a broad variety of special allocation rules at sector and installation level, e.g. on early action, on combined heat and power, on allowance transfers to new installations, modernization incentives and rules on benchmark allocations for new entrants. Many of these rules additionally influence emission abatement behaviour. But apparently, it was not yet possible to fully assess allocation rules laid down in allocation plans of all member states. This is due to the number and complexity of allocation plans.

Schwarz (2005) attempts to quantify the possible outcome of the German allocation plan. A drawback of his analysis is that total permit allocation seems to exceed the envisaged emission cap in some cases. Earlier, authors like Vesterdahl and Svendsen (2004) and Varming (2000) explored possible designs of EU emission trading. Nevertheless, they put little attention on behavioural effects of allocation rules. To improve on that, this paper analyses allocation rules with regard to new entrants. The efficient solution would be not to give any certificates to new installations. However, this would hinder competition and greatly benefit incumbents who received free emission rights. However, if new entrants should receive certificates, the question is how many. The basic allocation concepts such as benchmarking based on historic emissions do not apply due to the lack of historical information.

Therefore, national allocation plans implemented other concepts. Several combine benchmarks with forecasted production. The endowment of a new installation often depends on whether it replaces another installation (transfer of permits) or, in the case of a new entrant, what type of plant is commissioned (benchmark allocation). Transfer rules are not subject of this paper. But the basic consequences, which will be derived for benchmark allocations, apply here as well.

In most national allocation plans a ‘best available technology’ serves as yardstick for new entrants. Nevertheless, important details, such as specific emissions and assumed plant utilisation, which are crucial for calculating permit endowment, are often not given by allocation plans itself. Most of these plans only determine whether the benchmark depends on the technology deployed or rather it refers to some sector specific best technology.

Of course, when different types of plants are endowed differently while producing exactly the same output (electricity), this will influence investment and dispatch decisions. A plant owner surely would try to optimise output production and permit endowment. It is worthwhile to the owner to accept higher production costs as long as this is compensated by the value of additional permit endowment. The next section discusses this in a more formal way. Since electricity from different power plants can be regarded as an identical product, the special case of the electricity industry was chosen. Furthermore, only permit allocation to new installations will be analysed, since this affects not only dispatch but also long-run investment decisions. To simplify the analysis further, it is abstracted from the various design concepts in actual allocation plans by considering a pure *fuel benchmark* as well as a *sector benchmark.*

IV. Inefficiencies Resulting from Distorted Investments

We will demonstrate the key effects leading to possible inefficiencies in the investment decisions in a simple way. We analyse four different cases:

Case 1: Inefficiency due to Early Capacity Replacement – One Technology

We start with an extremely simple example where we have one generation technology a. To show investment effects, the model comprises two periods (shown in the subscripts). We have an original capacity endowment of x_1^a. This capacity represents the capacity endowment before CO_2 certificate trade starts. Investment costs for this capacity are sunk; they do not enter dispatch decisions. We assume that all capacity can produce for two periods. Hence, demand in the second period (d_2) can be served with capacity built in period one (x_1^a) or new investments in period 2 (x_2^a): $d_2 = x_1^a + x_2^a$. Assume that production costs in period two are lower for old capacity in comparison to new capacity because the latter also comprise investment costs: $c_{2,2}^a > c_{2,1}^a$ [3]. Assume furthermore that demand is constant over both periods $d_1 = d_2$ and the original capacity was sufficient to cover load in the first period: $d_1 = x_{1,1}^a$. In this case, the optimal solution is not to build any new capacity in period 2 and $d_2 = x_{2,1}^a$. Total costs in the second period are then $C = d_2 c_{2,1}^a x_1^a$.

How does the situation change if both old and new capacity receive a free bonus for CO_2 emissions? Old capacity still bids into the market at $c_{2,1}^a$ as the opportunity costs of the emission rights become part the bid. The situation is different for new capacity. New capacity receives the emission rights only if it is built. Hence, emission rights worth s per unit of capacity reduce the investment costs of new capacity; they are similar to a subsidy. This can easily lead to a situation where $c_{2,2}^a > c_{2,1}^a > c_{2,2}^a - s$. In this simple model, this would lead to the case that all production in period 2 is done with new capacity; old capacity is in the market for just one period. However, this is an inefficient allocation as only the subsidy lead to the early replacement.

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[3] The first subscript denotes the period of production, the second subscript the period of the investment.

Case 2: Inefficiency due to Early Capacity Replacement – Two Technologies

Now assume that we have two competing generation technologies a and b.[4] Assume further, that permit allocation does not depend on the type of technology, which reflects the case of a sector benchmark allocation described earlier. If $\min\left\{c_{2,1}^{a}, c_{2,1}^{b}, c_{2,2}^{a}-s, c_{2,2}^{b}-s\right\}=c_{2,2}^{a}-s$, we will see $d_2 = x_{2,2}^{a}$. However, if $\min\left\{c_{2,1}^{a}, c_{2,1}^{b}, c_{2,2}^{b}\right\}<c_{2,2}^{a}$, this solution again is inefficient.

Assume now, permit allocation distinguishes between technologies such that technology a's and technology b's subsidy amount to s^a and s^b, respectively. This reflects the fuel benchmark discussed earlier. As one can see, each technology's subsidy now determines which technology to build. If $\min\left\{c_{2,1}^{a}, c_{2,1}^{b}, c_{2,2}^{a}-s^{a}, c_{2,2}^{b}-s^{b}\right\}=c_{2,2}^{b}-s^{b}$, we will see $d_2 = x_{2,2}^{b}$. This is again an inefficient solution.

Case 3: Considering a Binding CO2 Emission Limit

a) No Technical Progress

How does this result change in the presence of a binding CO2 emission limit? Let technology b have lower emissions per unit of output than technology a: $e_{1,1}^{a}=e_{2,1}^{a}=e_{2,2}^{a}>e_{1,1}^{b}=e_{2,1}^{b}=e_{2,2}^{b}$. A political restriction limits total emissions in period i, denoted by $e_i^{\max}$: $e^a\left(x_{i,i-1}^{a}+x_{i,i}^{a}\right)+e^b\left(x_{i,i-1}^{b}+x_{i,i}^{b}\right)<e_i^{\max}$. If this restriction is binding, it restricts the share of production from technology a. Assume again that after the subsidy is received, new capacity of technology a is the cheapest generation option and new capacity from technology b the second cheapest: $\min\left\{c_{2,1}^{a}, c_{2,1}^{b}, c_{2,2}^{a}-s, c_{2,2}^{b}-s\right\}=c_{2,2}^{a}-s$ and $\min\left\{c_{2,1}^{a}, c_{2,1}^{b}, c_{2,2}^{b}-s\right\}=c_{2,2}^{b}-s$. In this case, the outcome is given by the solution to the following simple optimization problem: ${x_{2,2}^{a}}^{*}=\max\limits_{x_{2,2}^{a}} x_{2,2}^{a}$ s.t. $e^a x_{2,2}^{a}+e^b x_{2,2}^{b}=e_i^{\max}$ and $x_{2,2}^{b}=d_2-x_{2,2}^{a}$. Hence, the optimal solution ${x_{2,2}^{a}}^{*}$ must fulfil the following equation: $e^a {x_{2,2}^{a}}^{*}+e^b\left(d_2-{x_{2,2}^{a}}^{*}\right)=e_i^{\max} \Leftrightarrow e^a {x_{2,2}^{a}}^{*}-e^b {x_{2,2}^{a}}^{*}=e_i^{\max}-e^b d_2 \Leftrightarrow {x_{2,2}^{a}}^{*}=\dfrac{e_i^{\max}-e^b d_2}{e^a-e^b}$. The optimal ${x_{2,2}^{b}}^{*}$ has to serve the remaining demand; it is then simply ${x_{2,2}^{b}}^{*}=d_2-\dfrac{e_i^{\max}-e^b d_2}{e^a-e^b}=\dfrac{d_2 e^a-d_2 e^b+d_2 e^b-e_i^{\max}}{e^a-e^b}=\dfrac{d_2 e^a-e_i^{\max}}{e^a-e^b}$. The important result here is that the subsidy in this setting can only change whether old or new capacity is used for production; it will not change the investment in the different technologies as that is fixed in the way described above. This includes that the share $x_{i,i-1}^{a}+x_{i,i}^{a}\big/x_{i,i-1}^{b}+x_{i,i}^{b}$ is constant for all periods.

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[4] We parameterise our example that technology a could represent the characteristics of hard coal capacity and technology b of gas fired capacity.

b) Technical Progress

However, in reality we observe technical progress over time. Among other things, this technical progress increases generation efficiency. This means that not only less fuel is burned but also that less CO_2 is emitted. In the case of a binding emission limit, this ‘softens’ this limitation by allowing additional replacements of new and more efficient high emission capacity. We need some further parameters to demonstrate this case: Firstly, let us assume that emissions for capacity built in the first period remain the same in the second period. Secondly, assume that the difference in emissions between technologies dominates the effect of technological progress between periods. Therefore, we have: $e_{1,1}^{a} = e_{2,1}^{a} > e_{2,2}^{a} > e_{1,1}^{b} = e_{2,1}^{b} > e_{2,2}^{b}$. This parameterisation changes the results because now the share of generation from different technologies is not constant over time. In the case of a relatively cheap technology, which is restricted by the total emission limit, a replacement of old capacity with new capacity breaks ground for an increase in generation for the cheap technology.

V. Benchmark Allocations – Simulation Results from the German Market

Section IV demonstrated the impacts on investment behaviour that can arise from different forms of permit allocation. A simple formulization of the problem was presented to demonstrate possible inefficiencies due to the allocation of emission rights to new capacity. This section demonstrates that these inefficiencies indeed appear in a far more complex empirical model. The aim is to quantify possible impacts on European electricity industries.

Model description and data set used

The partial equilibrium model CEEM was used to derive results. It solves a dynamic, linear optimisation problem, which covers the supply side of 11 European electricity markets, namely Germany, the Netherlands, Belgium, Luxembourg, France, United Kingdom, Spain, Portugal, Italy, Switzerland and Austria. The objective function consists of total discounted costs for electricity generation, which comprises investment costs, fixed and variable production costs, fuel costs, costs for interregional power transmission. It solves for the least cost solution to satisfy an exogenously defined electricity demand while environmental targets must be fulfilled. Main decision variables are plant dispatch, commissioning and decommissioning of generation capacities.[5]

Competitive electricity and permit markets are assumed. Fuel prices and technological progress are exogenously defined. Further on, all prices are given in real terms of the base year 2005. Table 1 depicts the main assumptions.

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[5] Further information regarding the CEEM model in German language can be found in Starrmann (2001) or at www.ewi.uni-koeln.de.

Table 1: Main Assumptions

	2000	**2010**	**2015**	**2020**	**2025**	**2030**
Total electricity demand, TWh	2246	2610	2790	2962	3134	3305
Generation from renewable energies, TWh	371	577	672	756	868	947
Share of renewable energies in total demand, %	16.5	22.1	24.0	25.5	27.7	28.7
Emission cap, Million tons CO_2	814*	785	775	768	746	724
Emission reduction compared to 1990-level, %	4.4	8	9	10	12	15
Prices of fossil fuels for power plants, Euro/GJ						
Coal	1.59	1.72	1.82	1.82	1.84	1.86
Oil	4.60	4.31	4.61	4.89	5.13	5.47
Natural Gas	3.52	3.61	3.88	4.05	4.22	4.46
Lignite	0.83	0.83	0.83	0.83	0.83	0.83
Efficiency of new power plants, %						
Coal plant		47.5	48.0	48.5	49.0	49.5
Oil plant		50.5	51.0	51.5	52.0	52.5
Natural gas CCGT plant		58.5	59.0	59.5	60.0	60.5
Lignite plant		44.0	44.5	45.0	45.5	46.0

* Actual emissions

Source: Eurelectric (2005), EWI (2005) and own assumptions.

Electricity demand has been taken from Eurelectric (2005) for the period until 2020. Beyond 2020, own assumptions were made. While regional demands show different trends, depending on today’s specific consumption and future prospects of economic development, the average annual growth rate of all regions is at about one percent. This causes electricity consumption to increase from 2246 TWh to 3305 TWh in 2030. Renewable energies are assumed to account for 22 % of electricity consumption in 2010, which is almost identical with the EU-15 objective. This share is to increase further to 29 % until 2030. Since electricity supply from renewable energies is mainly driven by special support schemes, it is assumed to be the same for all scenarios under consideration. Electricity consumption less renewable supply then yields remaining demand which must be met by other conventional generation, such as fossil-fuelled and nuclear power plants.

Despite a higher contribution of renewable energies, remaining demand increases in absolute terms. At the same time, a reduction of carbon dioxide emissions is to be achieved. Therefore, steps must be taken in order to fulfil the environmental requirements given in Table 1. Important measures to achieve this goal can be (i) increasing the efficiency of power plants and (ii) switching generation to low or non-emitting fuels. To what extend a fuel switch is economically feasible will strongly depend on fuel prices. These were adopted from the recent reference forecast for the German energy sector.[6] Further research should be conducted to validate the paper’s findings especially for higher oil and gas prices. The table also depicts as-

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[6] See EWI (2005) and German Federal Ministry of Economics and Labour (2005).

sumptions on efficiencies of new power plants. While average plant efficiency is a model result, efficiency of new installations is dealt with exogenously.

Scenario definition

All scenarios assume an environmental policy that reduces carbon emissions by 8 % in 2010 and by 15 % in 2030 compared to 1990. The scenarios differ in the way the permit trading system is implemented with respect to permit allocation.

In the *auction case* all permits will be sold. The design of this auction scheme is assumed to achieve the optimal reduction path to comply with defined emission objectives.[7] Within the model this is realised by imposing an emission constraint on all countries allowing for free permit trading between them. The auction case will be used to assess two other allocation schemes free of charge based on benchmark allocation to new entrants. This is provided for in most EU national allocation plans.

One scheme is the *fuel benchmark*. Here, allocation to new entrants depends on the plant's type of fuel. So, coal-fired plants receive more permits than gas-fired ones of the same size. Since gratis permit allocation can be thought of as a subsidy, there will be an incentive to build plants granted a high number of permits. To simplify the analysis, in the case of plant replacement no transfer of permits is allowed for. Thus, all new plants are treated the same way, whether they will be built by incumbents or by new entrants.

In contrast to that, the *sector benchmark* allocates the same amount of permits to all fossil-fuelled plants. The benchmark is set to the emission level of a gas-fired plant of best available technology. Even though fossil-fuelled plants are now treated equally, the sector benchmark affects plant replacement rates. The higher the allocation, the more rapidly plants will be replaced by new ones. In addition, carbon free technologies might be worse off than fossil-fuelled plants, since they do not receive a subsidy.

Simulation results

First, an auction case was set up which will serve as a reference for comparison. In the auction case permit allocation does not explicitly privileges any technology. All plants are required to purchase permits. This scheme neither influences investment nor dispatch decisions. Thus, a tradable permit system is being implemented obtaining emission reductions at least cost. Table 2 summarises electricity generation and permit prices in the reference case.

As can be seen from the table, total generation increases until 2030 by about 36 %. This is nearly proportional to the assumed electricity demand. At the same time carbon emissions need to be reduced in absolute terms. Several options exist to achieve this. First, conventional power plants will use low carbon fuels. Also, average plant efficiency will be enhanced. On

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[7] Actually, the least cost argument was the main reason why emission trading was introduced in the EU.

the other hand, the use of renewable energies is assumed to grow, which follows directly from the EU objective to increase the share of renewable energies in electricity generation.

Table 2: Main Results, Auction Case

	2000	**2002**	**2010**	**2015**	**2020**	**2025**	**2030**
Total electricity generation, TWh	2227	2303	2523	2669	2815	2973	3136
Nuclear	*768*	*789*	*840*	*909*	*911*	*861*	*874*
Coal	*416*	*420*	*395*	*389*	*372*	*277*	*213*
Lignite	*151*	*162*	*144*	*156*	*162*	*165*	*159*
Gas	*400*	*446*	*598*	*602*	*692*	*900*	*1054*
Oil	*131*	*134*	*32*	*31*	*30*	*23*	*17*
Renewable energy	*363*	*353*	*514*	*583*	*647*	*747*	*819*
Permit price, EUR/t CO_2			8	6	8	13	20

Source: Own calculations; historical values: Eurelectric (2005).

From 2002 to 2030 electricity generation from gas and renewable energies increases considerably. Nuclear generation stays slightly above today's level. Lignite remains almost unchanged in the long run. Coal and oil suffer losses. In the medium-term the given emission cap is achieved at comparably low marginal abatement costs which results in a permit price below 10 EUR/t.[8] As carbon policy tightens further and electricity demand and gas price rise, the permit price reaches a level of 20 EUR/t.

The question at hand is now: can gratis allocation to new plants affect this outcome? And to what extend? Therefore, commissioning of capacity, electricity generation, average plant efficiency and total generation costs will be explored. Table 3 shows relevant effects on conventional plants by fuel. There are only minor changes to oil, so these numbers were dropped from the table.

Table 3: Effects of Allocation Scheme on the Electricity Industry

	Nuclear	**Coal**	**Lignite**	**Gas**
Cumulative plant commissioning until 2030, GW				
Auction	112	21	12	107
Sector benchmark	107	19	12	116
Fuel benchmark	113	26	29	100
Change in electricity generation in 2030, TWh				
Sector benchmark compared to auction	-27	-18	+1	+41
Fuel benchmark compared to auction	+2	+17	+24	-45
Average efficiency of fossil-fuelled plants in 2030, %				
Auction		47.0	43.4	59.1
Sector benchmark		46.8	43.5	59.5
Fuel benchmark		48.4	45.6	59.2

Source: Own calculations.

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[8] Note that costs for renewable energies are not included in the model. This reflects that actual renewable energy support schemes raise their budgets outside the emission trading scheme. So, the emission trading sector profits from emission reductions at the expense of non-trading sectors, which have to bear the additional costs.

When compared to auctioning, under the sector benchmark considered here generators feel compelled to build up some more gas-fired plants while investment in nuclear energy is less attractive in the long run. Cumulative capacity commissioning turns out to be 9 GW higher for gas. At the same time, 5 GW less nuclear capacity is built until 2030. Coal is slightly below the level in the auction case. This also affects future electricity generation. Gas is up by 41 TWh, while generation from nuclear and coal decreases by 27 and 18 TWh, respectively.

As already mentioned, a sector benchmark may treat fossil-fuelled plants alike, but it can still disadvantage carbon free plants. Due to this, Table 3 shows a reduction of generation in nuclear plants compared to the auction case. Since this means an increased fossil fuel use, additional measures must be taken to comply with the emission cap. The foremost measure is a shift in electricity generation from coal to gas. More gas-fired capacity is commissioned, causing a rise in average efficiency of that technology to 59.5 %. At the same time, less coal-fired plants will be built, causing their average efficiency to be lower than under auctioning.

The fuel benchmark causes mostly opposite effects. When compared to auctioning, generators feel now compelled to build up some more coal and lignite plants while investment in gas is less attractive in the long run. Cumulative capacity commissioning turns out to be 5 GW and 17 GW higher for coal and lignite, respectively. At the same time, 7 GW less gas-fired capacity is built until 2030. As a consequence, generation from coal and lignite are up by 17 and 24 TWh, respectively, while generation from gas decreases by 45 TWh. Nuclear energy remains almost unchanged.

Due to the allocation scheme’s modernisation effect, average plant efficiency increases. Average efficiency of coal plants is 48.4 %, while it was 47.0 % in the auction case. The average lignite plant is more efficient as well, while the effect on gas-fired plants proves to be rather limited.

Of course, compared to total generation of more than 3100 TWh the effect is not dramatic at all. Gas will still play an important role in electricity generation. The same holds true for nuclear power. Nevertheless, the fuel benchmark causes generation from lignite to rise by 15 % and coal by 8 % in 2030. Since lignite and coal possess similar technological characteristics, both are rather close competitors in base load generation. Therefore, the actual design of a fuel benchmark determines which of them will profit the most. In the case considered here, it is obviously lignite.

Finally, Table 4 presents changes in total generation costs. They consist of the sum of investment, operation and maintenance, variable production and fuel costs.

Table 4: Effects of Allocation Scheme on Generation Costs Compared to Auctioning

	2010	**2015**	**2020**	**2025**	**2030**
Change in total generation costs, Million EUR annually					
Sector benchmark	-11	+17	+15	+14	+145
Fuel benchmark	+87	+190	+55	-146	+906

Source: Own calculations.

Since all allocation schemes impose the same emission cap, these cost changes indicate the cost-effectiveness of obtaining the emission cap. Compared to the auction case, additional costs are highest under the fuel benchmark. The net present value accumulates to about 1 billion Euros over a 25 years period at an assumed discount rate of 5 %.[9] Additional costs under the sector benchmark prove to be considerably lower, even though still positive in the long run.

Although cost changes are moderate, their positive sign indicates that emission reduction is not efficient. But for political reasons, the parties involved in emission trading do often not accept auctioning. From the results found here one might conclude that a sector benchmark could be a second-best approach, when auctioning is not feasible. But one also should be cautious, since only one scenario simulation was conducted here. Altering some of the main assumptions, such as gas price or emission cap, should be performed in order to prove the robustness of this outcome.

Another question regarding the design of benchmark allocation is how many permits will be given to new installations. This obviously depends on how many plants are commissioned in a certain year and on specific rules that determine the number of permits for a single plant. Of course, the more permits will be allocated to new installations, the less are left for existing ones. Table 5 depicts the number of permits given to new installations as share of overall permits available for allocation. As can be seen, this share is highest in 2030 under the fuel benchmark reaching almost one quarter of total permits. In fact, this can be a critical point in a benchmark scheme. While in this paper new plants are granted allocations only for the first five years, some EU allocation plans guarantee ten years or more.[10] Additional calculations for the fuel benchmark case would show that already ten years of cost free allocation can end up in a situation, where allocation to new plants exceeds the total amount of permits available. This result refers to all countries as a whole. Since permit allocation in the EU is a matter of member states, to a single country this kind of problem might be triggered earlier.

Table 5: Permit Allocation to New Plants as Share of Overall Permit Allocation

	2010	**2015**	**2020**	**2025**	**2030**
Sector benchmark	6 %	11 %	16 %	11 %	13 %
Fuel benchmark	4 %	14 %	6 %	5 %	24 %

Source: Own calculations.

In other words, allocation to new plants must somehow be limited. Most EU allocation plans do so by defining a fixed permit reserve. The reserve is then allocated either proportionally to

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[9] Temporary cost savings in 2025 appear to be a dynamic effect of a net cost transfer to 2030. The commissioning of some lignite plants is being postponed from 2025 to 2030. At the same time gas-fired plants are advanced. Although overall capacity remains unchanged in each period, lignite-fired plants, being more expensive than gas-fired plants, additionally increase total costs in 2030, while the cost change in 2025 turns temporarily negative.

[10] For instance, the German plan applies no compliance factor to new entrants for fourteen years from commissioning.

all applicants or using a first-come-first-serve rule. An exception, for instance, constitutes Germany’s allocation plan. It requires the administration to increase the reserve if necessary. Additional permits would need to be purchased, imposing a financial burden to the national budget.

VI. Conclusions

This paper analysed the potential inefficiencies from permit allocations. We briefly discussed the inefficiencies resulting from an updating of reference periods. However, additional inefficiencies can result from the treatment of new power plants. New power plants often receive emission rights for free. This is done to compensate disadvantages compared to incumbents receiving free rights. However, these rights are similar to a subsidy for new capacity. It is well known that subsidies tend to distort investments. We demonstrated this effect in the framework of a dynamic model.

Furthermore, we quantified the effects for the European market. We compared the results of auctioning with a sector and a fuel benchmark. We simplified the actual allocation rules to isolate the effects on new entrants and assumed a non-distorting allocation to incumbents, e.g. grandfathering or auctioning.

Results were calculated for the electricity industry of ten EU countries and Switzerland using a technology-based bottom-up approach. It was found that both a sector and a fuel benchmark incur higher costs compared to auctioning. The reason for this is increased plant replacement as a cost free allocation subsidises new power plants. Hence, benchmark allocation in the EU hampers the efficiency of the tradable permit system.

In the sector benchmark case, we assumed that all fossil-fuelled plants receive the same amount of permits. In this case, future electricity generation uses slightly more gas and less coal than under auctioning. The results for the fuel benchmark are different. When we assumed that coal-fired plants receive considerably more permits than gas-fired ones, we find that more coal and less gas will be used in production compared to the auctioning scenario.

Even though the effect of benchmark allocation turns out to be moderate, the negative effect can amplify if permits were granted to new installations for more than five years. Some EU allocation plans guarantee ten years or more. That duration could lead to a situation were the overall permit budget is already exhausted by new installations. This further accelerates early plant replacement, reducing the efforts in other abatement measures.

Mentioned investment distortions could be avoided if new entrants would have to buy emission rights. But as long as incumbent firms receive permits free of charge, this would hinder competition. Our results suggest that a sector benchmark could be a second-best approach because it incurs lower abatement costs than a fuel benchmark.

Emission abatement will continue to pose an ambitious challenge to all industrialised countries. Without a doubt necessary changes will lead to significant costs. It is important that environmental targets are realised in an efficient way. As our results suggest, this might not be the case for the EU trading scheme. Further research is necessary to analyse the full range of allocation rules in all national allocation plans. Many aspects have not been surveyed so far. For example, country-specific compliance factors, which could give rise to a generation shift to countries with extensive permit allocation. This may raise the question whether there is even a need for harmonisation of crucial aspects of permit allocation.

VII. References

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