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Designing Emissions Trading in Practice

General Considerations and Experiences from the EU Emissions Trading Scheme (EU ETS)

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Non-Technical Summary

This paper focuses on the design of emissions trading schemes in practice. After a short introduction to the general idea of emissions trading, practical requirements for the introduction of an emissions trading scheme are considered, including the temporal and spatial dimension as well as administrative requirements and the role of markets. Historical developments regarding emissions trading are discussed briefly.

Currently, the largest trading scheme is the EU Emissions Trading Scheme (EU ETS) that aims to reduce greenhouse gas emissions in the European industry by 21 percent until 2020 compared to 2005 levels. Because of its prominent role, the basic design features and the process of introducing the EU emissions trading scheme are reviewed in more detail.

Finally, the impact of the EU ETS on the regulated entities is analyzed based on an annual survey among German companies regulated by the EU ETS which is conducted by the Centre for European Economic Research (ZEW) in a common project with KfW Bankengruppe.

As the survey showed, carbon dioxide abatement in Germany is currently achieved by energy efficiency improvements in most cases. Larger abatement volumes through renewal of existing production facilities can be expected to occur from 2020 to 2030. Even if most regulated companies currently receive over-allocation of freely distributed permits, about 50 percent of companies in Germany are active in allowance trading. With regard to future regulation, companies suffer from considerable uncertainty, including uncertainty about allocation from 2013 onwards and general uncertainty about the stringency of greenhouse gas regulation in Europe and beyond.

Das Wichtigste in Kürze

In diesem Arbeitspapier werden praktische Fragen der Einführung und des Designs von Emissionshandelssystemen diskutiert. Nach einer kurzen Einleitung in die Theorie des Emissionshandels werden praktische Anforderungen zur Einführung eines Emissionshandelssystems näher beleuchtet, etwa räumliche sowie zeitliche oder administrative Anforderungen an ein Emissionshandelssystem.

Derzeit ist das EU Emissionshandelssystem (EU EHS) das größte nationale Handelssystem für Treibhausgasemissionen. Ziel ist es den Treibhausgasausstoß bis 2020 um 21 Prozent im Vergleich zum Niveau von 2005 zu reduzieren. Wegen der großen Bedeutung des EU EHS werden seine wichtigsten Designelemente sowie der Prozess seiner Einführung näher beleuchtet.

Abschließend wird der Einfluss des EU EHS auf regulierte Unternehmen diskutiert. Dazu wird auf Ergebnisse von Unternehmensbefragungen zurückgegriffen, die das Zentrum für Europäische Wirtschaftsforschung (ZEW) gemeinsam mit der KfW Bankengruppe durchgeführt hat.

Wie die Umfragen zeigten, werden CO_2-Minderungen derzeit vor allem über Maßnahmen zur Steigerung der Energieeffizienz erreicht. Zu größeren Emissionsminderungen dürfte es im Zuge von Ersatzinvestitionen erst im Zeitraum von 2020 bis 2030 kommen. Auch wenn die Mehrzahl der regulierten Unternehmen gegenwärtig über einen Überschuss an frei zugeteilten Emissionsrechten verfügt, nützen derzeit etwa die Hälfte der Unternehmen die Möglichkeit zum Handel mit Emissionsrechten. Im Hinblick auf zukünftige Treibhausgasregulierung besteht seitens der Unternehmen große Unsicherheit, etwa in Hinblick auf die freie Zuteilung ab 2013, aber auch in Hinblick auf das allgemeine Ausmaß und die Art der zukünftigen Regulierung in Europa und darüber hinaus.

Designing Emissions Trading in Practice
General Considerations and Experiences from the EU Emissions Trading Scheme (EU ETS)

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Abstract

This paper deals with designing emissions trading in practice. After a short introduction to the general idea of emissions trading, practical requirements for the introduction of an emissions trading scheme are considered, including the temporal and spatial dimension as well as administrative requirements and the role of markets. Historical developments regarding emissions trading are discussed. Currently, the largest trading scheme is the EU Emissions Trading Scheme (EU ETS) that aims to reduce greenhouse gas emissions in the European industry by 21 percent until 2020 compared to 2005 levels. Because of its prominent role, the basic design and the process of introducing the EU scheme are reviewed in more detail. Finally, the impact of the EU ETS on the regulated entities is analyzed based on an annual survey among German companies regulated by the EU ETS which is conducted by the Centre for European Economic Research (ZEW) in a common project with KfW Bankengruppe.

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1. Introduction

Emissions trading is a key component of climate and environmental policy in Europe. First experiences with emissions trading schemes were made in the late 1970s in the US. Various applications for regulation by tradable permits occurred afterwards, mostly in the US. While emissions trading is under certain assumptions equivalent to a tax on emissions, it offers flexibility for policy-makers when designing policies for environmental protection. The European Emissions Trading Scheme (EU ETS) is the largest GHG regulation scheme worldwide and started in 2005. As the EU ETS shows, emissions trading can be successfully employed to incentivize firms to reduce CO_2 emissions from fossil fuels. Emissions trading is also in the center of the Low Carbon Development Pilot Program (LCDPP) in five selected provinces and eight cities of China.

Emissions trading offers the option to achieve a given emissions reduction target at least costs. Pigou (1920) introduced the idea of a tax to reduce negative side-effects of economic activities on humans, such as environmental pollution. The tax can be designed, so that the negative impact of pollution can be reduced in a way that harms consumers and industry as little as possible while maximizing social welfare. In the case of a Pigouvian tax, the actual amount of achieved emissions reduction is a priori unknown due to unknown marginal abatement costs of polluters. Emissions trading can be regarded as the counterpart of a Pigouvian tax on emissions. In an emissions trading scheme, policy makers exogenously set an overall limit for a pollutant and assign permits to each unit of the pollutant. Emissions permits can be traded freely between regulated firms. As a consequence, a price for each unit of emissions occurs on the market. Crocker (1966) and Dales (1968) discussed tradable permits for the cases of air and water pollution. Baumol and Oates (1971) and Montgomery (1972) proved theoretically that regulation under tradable permits can yield an efficient allocation of resources, i.e. it is able to cut back effluents or emissions from various sources under an exogenously given overall quantityrestriction at least costs. The basic difference between a tax and an emissions trading scheme is that in the case of a tax a price per unit emissions is announced by policy-makers, while in the case of an emissions trading scheme, an overall amount of allowed emissions is set by policy-makers. As shown by Downing and White (1986), both schemes can offer adequate incentives for emitters for green innovations and to reduce emissions efficiently.

In this article we look at the designing of emissions trading in practice. We briefly describe the elements for the use of emissions trading and the European experiences with its emissions trading scheme. Chapter 2 describes the general aspects of emissions trading and summarizes the requirements for a successful introduction in practice. In Chapter 3, we briefly discuss the evolution of different emissions trading schemes, e.g. in the USA or Chile. In Chapter 4 we describe the evolution of the EU emissions trading scheme and its most important aspects. Chapter 5 presents an overview of firms responses to the EU emissions trading scheme, based on the experiences made in Germany in the past years. Finally, in Chapter 6, a brief conclusion is drawn.

2. Designing Emissions Trading in Practice

A central feature of quantity regulation is that the regulator defines a fixed amount of allowed emissions for the whole economy (or the regulated area) for a certain period of time. The quantity restriction is often referred to as "cap". The period in which emissions are restricted is often called "compliance period" or "commitment period". To assure that the overall quantity restriction is not exceeded, the regulator assigns permits to each unit of emissions. These permits are distributed to regulated entities and must be surrendered (handed in to the regulator) for each emitted unit.

2.1. Allocation of Permits

Permits can be sold or auctioned by the regulator or can be partly or fully distributed for free (known as "grandfathering"). In the case of selling or auctioning, the regulator generates revenues which can be "recycled" or "redistributed", for example, to reduce other taxes. It was shown that revenue recycling can lead to an increase in social welfare compared to non-recycling (Goulder et al. 1997). Free allocation of permits (grandfathering), in contrast, is an implicit subsidy for regulated entities. The allocation of permits distributes the cost burden of the required emission reduction among firms, sectors and households, which are affected through prices on emission in the emissions trading system. With auctioned permits, the scarcity rents go to the government and the distributional consequences are largely the same as with an emission tax. With grandfathered permits, the scarcity rents are given to the firms. This offers an incentive for companies to accept an enforceable constraint on emissions. The allocation of permits, however, has no direct impact on the permit price on the market under general assumptions, i.e. if firms that receive free allocation are aware of the opportunity costs that would arise from not valuing the free allocation at the market price.

2.2. Emissions Trading in Time

While compliance is organized within a certain period (e.g. one year), meaning that regulated entities must surrender permits for verified emissions at the end of the period, banking or borrowing of permits between the compliance periods can increase flexibility in the trading scheme. Banking of permits occurs when regulated entities are allowed to hold back permits for compliance in the future. Intermediaries in the permit market can generate special products like futures or options when banking is allowed. Banking can not only occur at the level of regulated entities or intermediaries but also at the level of the regulating authority. The regulating authority can bank permits over time and build a permit reserve. If permits are freely allocated, a reserve might be necessary to provide free allocation to entities that newly enter into regulation. If permits are auctioned or sold to regulated entities, the regulator can build a permit reserve and sell additional permits to the market in times of high demand to avoid large upward price volatility. Borrowing is the counterpart to banking. In that case permits from future compliance periods are borrowed for current compliance. Borrowing incurs the risk of excessive borrowing which could lead to non-compliance in the future. Because of the perverse incentives that can stem from borrowing, it is often starkly restricted in practice. While, for example, banking is allowed within the EU ETS over the whole period 2008 to 2020, borrowing is restricted from year to year. Regulated entities receive free allocation in February each year, while permits must be surrendered in April. Hence, implicit borrowing from next year's free allocation for current year's compliance is possible. The modest borrowing provision in the EU ETS increases flexibility while preventing excessive borrowing.

2.3. Emissions Trading in Space

Spatial aspects of environmental regulation depend on the nature of the regulated emissions. For example, the concentration of effluents in a river or the concentration of SO_2 in the air is perceived locally (downstream of the river or in the periphery of a coal fired power plant). When local pollutants (like SO_2) are addresses, emissions stay in a certain area, and hence, must not exceed a specified amount in a certain period. In such a case, a trading scheme has to be designed in a way that assures that the concentration of a pollutant or emissions from regulated sources in a regulated area (e.g. county) stay below a targeted level which can imply restrictions on purchasing additional permits from outside the regulated area as well as banking or borrowing within the region. Emissions trading systems may otherwise violate local air quality goals and may lead to the concentration of emissions in certain areas (hot spots). Examples are the US Offset-Policy, starting in 1976, and the US Acid Rain Program, starting in 1980. In the former, achieved reduction of pollutants were tradable. In the latter, emission permits were allocated to sources and banking was allowed (see Chapter 3). In contrast, the emissions of greenhouse gases, like CO_2, are expected to have an impact on global climatic conditions. When global pollutants like greenhouse gases are addressed, the spatial and timely occurrence of emissions is of less importance. Greenhouse gases, for example, stay in the atmosphere for a long time and are widely diffused (fully mixing). They are harmless on the local level and at the time they are emitted, at least if the concentration is not extremely high. However, the global stock of greenhouse gases in the atmosphere is expected to have an impact on overall climatic conditions in the long run.

2.4. Administrative Requirements

For an emissions trading scheme to be maintained, a regulating authority is required that allocates permits or verifies emission offsets, assures that emissions are properly monitored and reported, manages a permit registry to assure that each permit is surrendered only once so that the overall "cap" is not exceeded, traces transactions in the registry to document property rights, and enforces compliance, e.g. imposes a fine on regulated entities in the case of non-compliance. Compared to a regulation by prices (unit tax), a quantity approach (tradable permits) is more complex in terms of administration. The most important difference is the permit registry which is needed for regulation by quantities. Within the registry each market transaction of permits must be recorded. In the case of emissions offsets (reducing emissions compared to a baseline) the authority must verify the offset and allocate the offset permits.

2.5. The Role of Markets

Quantity regulation by emissions trading is often referred to as a market based approach. The price that incentivizes emitters to reduce economy-wide emissions is generated by supply and demand on markets. Reduction efforts by companies are not defined by the regulating authority as under a command and control regime. Hence, liquid and transparent markets are of great importance. Transparency in markets (about prices and traded volumes) is beneficial as it provides information to all market participants. In the US SO_2 trading program, prices for private transactions were unknown to others and hence assessing a "fair" price was accomplished with relatively high informational costs. The market was not very liquid meaning that finding a potential seller/buyer was accomplished with search costs. These factors lead to relatively high transaction costs in general and hampered the efficient exchange of permits and the efficiency of the emissions trading system as such. Since the price is generated at primary auctions or sells (initial permit allocation by authority) and at secondary markets (exchanges over the counter trade), liquidity and transparency within the market is crucial for minimizing transaction costs and facilitating efficient exchange of permits. Allowing intermediaries to be active in permit trading can play a crucial role here. Also markets for machinery and equipment to achieve emissions reductions can be of importance. While in the case of SO_2 trading, retrofitting of existing plants to reduce emissions was relatively easy, technical solutions for the reduction of CO_2 are more complex because of the non-existence of end-of-pipe technologies for CO_2 emissions. If markets for energy efficient machinery and equipment are sticky, transaction costs can hamper the effective transformation of the economy (Heindl, 2011).

2.6. Regulation under Uncertainty

If there is full information, i.e. no uncertainty about the benefits and costs that are related to the regulation of a harmful substance, there is no difference between price (tax) and quantity (emissions trading) regulation. In practice, this would imply that it is perfectly known what price (unit tax) yields which quantity (emissions reduction) and vice versa. Since there is usually uncertainty about the exact costs and benefits of regulation, the decision is usually made under uncertainty. Weitzman (1974) presented a model that accounts for uncertainty in the choice of the regulation scheme. Basically he finds that prices (unit tax) should be preferred over quantities (tradable permits) if the slope of marginal costs for providing environmental quality is steeper than the slope of marginal benefits and vice versa. The steepness of marginal costs and benefits defines the relative importance of one variable over the other. Newell and Pizer (2003) showed that regulation by prices (unit tax) would be preferable in the case of greenhouse gas regulation. Roberts and Spence (1975) were the first who considered mixed regulation by prices and quantities for the case of effluents. They conclude that a mixed system of permits and prices is more efficient than a scheme with either permits or prices alone. They also point out that the additional fee motivates polluters to approximate the expected damage function more closely. Pizer (2002) argues that a mixed system of price and quantity controls is preferable to a system with pure quantity controls in the case of greenhouse gas mitigation. In a first-best setup, a price approach should be chosen. However, recognizing the importance of quantity targets for the political feasibility of international agreements (Nordhaus, 2006), a quantity targets with a certain "trigger price" for the issuance of additional permits (to restrict prices) would improve welfare compared to a pure quantity approach.

3. Past Experiences with Emissions Trading

The first practical experience with quantity based regulation schemes for pollutants were made in the USA. In the early 1970s the US Environmental Protection Agency (EPA) evaluated the feasibility of market based approaches for environmental regulation. In 1976 the EPA started the "Offset Policy", an early approach with tradable offset permits amongst regulated sources in regions that did not meet ambient air quality standards, so called nonattainment areas. Firms were allowed to create emissions reduction credits (ERCs) by reducing its emissions below a baseline level. ERCs were tradable between firms and within the firm, meaning that emission permits are transferable from one installation to another. Because targeted emissions were local pollutants, the USA was divided in 247 air quality control regions. States had to develop State Implementation Plans (SIP), which must be approved by EPA. The SIPs defined how the state intended to meet EPAs ambient air quality standard, whose sources were regulated and defined the amount of a given pollutant that a regulated source was allowed to emit (Hahn and Hester, 1989).

In addition to the Offset Policy, the Bubble Policy allowed firms to include various sources of emissions under one regulatory scheme. The Bubble Policy hence helped to reduce overall regulatory costs. Firms were also allowed to bank permits, which increased flexibility. Netting allowed firms to increase emissions at one source within a plant while avoiding the classification of the source as a "major emitting source" when emissions were decreased at another source and the net increase in emissions did not equal to a major source. The EPA also applied a scheme of tradable permits to phase out lead of gasoline (Hahn and Hester, 1989; Nussbaum, 1992). As a consequence of the Montreal Protocol that targeted the phase-out of Chlorofluorocarbons (CFCs) and Hydrochlorofluorocarbons (HCFCs), the USA implemented a trading scheme in 1988.

Beginning in 1990 the sulfur trading scheme under Title IV of the "Clean Air Act", an US law specifying environmental policies, entered into force. The sulfur trading program extended existing command and control policies and delivered sizeable increases in regulatory efficiency (Hanemann, 2009). The Nox Nudget Programm aimed to reduce seasonal Nox emissions in the Northeastern USA and started in 2003. Also regional trading schemes were implemented like the "Regional Clean Air Incentives Market" (RECLAIM) in California or the "Chicago Emissions Reduction Market System" (Tietenberg, 2006). Howe (1994) reviewed environmental regulation in the USA and Europe. The USA tended to use market based approaches to environmental regulation and mainly quantity based approaches rather than taxes since the mid-1970s. The European Countries, on the other hand, implemented mainly command and control policies and showed little interest in the use of tradeable permits. In 1992 an emissions trading scheme for particulate matter (PM10) was installed in Santiago de Chile (Montero et al, 2002). In 1997 the parties of the United Nations Framework Convention on Climate Change (UNFCCC) agreed on the Kyoto Protocol that mandates a reduction of greenhouse gas (GHG) emissions of about five percent on average until 2012 compared to 1990. GHGs are global pollutants that are expected to contribute to global climate change. With the Kyoto Protocol, two trading schemes were established: First, an international emission trading scheme that allows countries with GHG emission targets (Annex B countries) to trade "Assigned Amount Units" (AAUs) in compliance with the Kyoto Protocol. Second, two project-based offset schemes, Joint Implementation (JI) and the Clean Development Mechanism (CDM). JI allows for crediting of achieved emissions reductions in Annex B countries and the CDM allows for crediting of achieved emissions reductions in Non-Annex B countries (developing and least developed countries). International emissions trading was expected to significantly reduce the costs of compliance under the Kyoto Protocol (Böhringer and Löschel, 2002). In 2011 New Zealand started a domestic GHG treading scheme. In Japan there are local GHG trading schemes in Tokyo and the province of Saitima. In the USA and Canada there are several local GHG trading schemes, like the Regional Greenhouse Gas Initiative (RGGI) which is active since 2008. Other schemes like the Western Climate Initiative (WCI) and the Midwest GHG Reduction Accord (MGGRA) are scheduled and expected to start in 2012.

4. The EU Emissions Trading Scheme

The European Emissions Trading Scheme (EU ETS) currently is the largest GHG regulation scheme worldwide (Kossoy and Ambrosi, 2010). About 11,000 industrial installations located in 30 countries are covered by the scheme (the EU27, Liechtenstein, Norway and Iceland). The first trading phase, scheduled for 2005 to 2007, was intended as a test phase and was characterized by generous free allocation of permits. In the second phase, scheduled for 2008 to 2012, free allocation was reduced, but free allocation of at least 90 percent of permits is obligatory for EU Member States. With the start of the third trading phase from 2013 to 2020, allocation rules will be changed. Free allocation will be completely phased out for electricity producing facilities. The remaining facilities will receive free allocation based on product benchmarks. Free allocation shall be phased out entirely until 2027. The overall aim of the EU ETS is to achieve a reduction of GHG of 21 percent versus 2005 until 2020. To achieve the targeted emissions reduction, the overall cap on emissions will be decreased by 1.74 percent each year, starting in 2013.

4.1. Origin and Design of the EU ETS

Convery (2009) and Ellerman et al. (2010) discuss the origin of the EU ETS. We focus on the most important milestones here to illustrate the political process of establishing the EU ETS. Initially the EU was in opposition to a market based approach in the Kyoto Protocol and planned to install a community wide carbon and energy tax. First efforts to install a community wide carbon and energy tax were made in 1992, but the proposal was finally withdrawn in 1997. One reason for this was the resistance of EU countries to shift tax competencies to the European level. Rather, the EU defined internal country specific emissions reduction targets in the Burden Sharing Agreement in 1998 to meet the Kyoto obligations and welcomed a quantity based approach. In 2000 the Green Paper on Emissions Trading was released, summarizing options to implement an emissions trading scheme in Europe. The ETS Directive was drafted in 2001 and finally adopted in 2003. Since the Emissions Trading Directive focused on the Europe-wide trading scheme, the European Commission drafted a separate Directive to link the EU ETS to the project based offset mechanisms of the Kyoto Protocol, defining the options for using permits from the CDM and JI in the EU ETS in addition to domestic permits, called European Emissions Allowances (EUAs). The Linking Directive was agreed in 2004. Because there were different positions on how to include CDM and JI in the EU ETS, the ultimate decision to define quantity restrictions for the use of offset permits from the CDM or JI was left to the member states.

The ETS Directive (Directive 2003/87) defines the regulated activities and the type of regulated emissions in Annex I. From 2005 onwards the Directive stipulated only the regulation of carbon dioxide (CO_2) from combustion installations, mineral oil refineries, coke ovens, metal ore roasting and sintering, pig iron and steel production, cement and clinker production, glass manufacturing, ceramic and bricks manufacturing as well as pulp and paper production. By doing so, many branches of the European economy remain outside the regulation of the trading scheme, like the transportation sector or the agricultural sector. Those sectors are often referred to as "non-traded sectors". In general, the EU ETS covers roughly 50 percent of CO_2 emissions in Europe and approximately 40 percent of GHG emissions, respectively. A downstream approach was chosen since pure upstream regulation in the European Emissions Trading Scheme would have effectively lead to double taxation of many products and would have partly removed the fiscal autonomy of the member states. EU member states have autonomy with regard to fiscal policy and many countries already had taxes, e.g. on fuel, in place. The regulatory framework set out in the ETS Directive is hence motivated by practical concerns and the requirements of the political architecture of the European Union, rather than concerns of economic efficiency and environmental effectiveness of the scheme. However, the ETS directive explicitly considers an extension of the EU ETS to the transport sector for the future, recognizing its importance in contributing to greenhouse gas reductions.

The ETS Directive states that each member state shall develop a "National Allocation Plan" (NAP) for each trading period based on "objective and transparent criteria", listed in Annex III of the Directive. The NAPs define the amount of freely allocated EUAs to each installation in the respective member state. The EU Commission has the right to reject a NAP. The allocation of permits in the EU ETS is characterized by free allocation (grandfathering) in its first two trading periods. In the first period from 2005-2007, at least 95 percent of permits had to be allocated for free, according to the Directive. For the period 2008-2012, at least 90 percent of permits must be allocated for free. Permits have to be handed out to installations by the national authorities by 28 February each year. Firms have to surrender permits for compliance by 30 April each year. While the Directive does not allow for borrowing of permits in general, the allocation rule actually enables firms to borrow permits from their next year's free allocation for current compliance. This one-year ahead implicit borrowing increases flexibility of firms and help to reduce potential distortions on the markets for permits due to excess demand around the compliance date. To ensure compliance with the EU ETS, the Directive defines a fine, posed to regulated firms that do not surrender a sufficient amount of permits. For each emitted ton of carbon dioxide for which a firm has not surrendered a permit, it is liable to a financial penalty of EUR 40 for the period 2005 to 2007 and EUR 100 from 2008 onwards. Paying the fine does not release firms from the obligation to surrender the respective permits.

Information about the freely allocated EUAs, the verified emissions and surrendered permits of regulated installations are available to the public. The Community Independent Transaction Log (CITL) database provides the information online. In addition, each national authority in the member states runs a registry, where regulated installations and their emissions data can be viewed online by the public. Each person or firm is allowed to hold permits under the premise that it has an account at a national authority's registry. Within the registries, exchange of permits is documented so that the person or firm holding a permit can be identified. Member states have to report to the EU Commission each year, first to collect emissions data and second to control the general implementation of the trading scheme in the member states. Annex IV and V of the ETS Directive defines principles for monitoring, reporting and verification (MRV) of emissions. Detailed MRV rules were developed for each technology since 2003. In Germany the competencies are shared between the federal states (*Länder*) and the German Emissions Trading Authority (DEHSt). The *Länder* are responsible for the permission of installations and the validation and approval of the monitoring plans which describe the methods used for calculating CO_2 emissions. They also randomly check installation-specific issues in the emission reports. A verifier validates and verifies the emission reports by installations and reports the amount of emissions to the DEHSt. The DEHSt checks the emission reports more closely to ensure compliance and is responsible for enforcement and sanctioning.

4.2. First and Second Trading Phase (2005 to 2012)

Ellerman et al. (2010) provide a detailed analysis of the first trading phase of the EU ETS (2005 to 2007). In general, the first trading phase was characterized by generous free allocation of permits. It is important to note that European Emissions Allowances (EUAs) from the first trading period could not be transferred to the subsequent periods. This underlines the test-character of the first trading period. While firms had to fully comply with the scheme's rules like specified in ETS Directive, EUAs from the first period were only valid for compliance in the first trading period. The EU ETS was scheduled as a decentralized trading scheme, combining the schemes of the EU member states. Ellerman et al. (2010) points out that the EU ETS shows a much higher degree of decentralization as any previous trading scheme, like the US SOx trading scheme or the Nox budget trading program. Each member state had to develop its own National Allocation Plan (NAP). The overall cap, consisting of the sum of capped emissions from the member states, was ex ante unknown. In addition, when the NAPs were developed, countries could possibly treat installations differently, meaning that installations could receive a different amount of free allocation in different countries which might raise fairness issues. Since the first trading period did not seek to reduce emissions in the first place, but rather phase-in the trading scheme, the cap was planned to be set close to business-as-usual (BAU) emissions (Ellerman et al., 2010). However, exact data on BAU emissions were not available, e.g. in Germany (Matthes and Schafhausen, 2007), or were not reliable, as in the case of Sweden (Zetterberg, 2007). Hence, authorities in charge for developing the NAPs partly relied on voluntary submitted emissions data from industry, which set incentives for the industry to over-report.

As a consequence, there was a net surplus of allowances in the first trading period which was ex-ante unknown to regulated firms. When allowance trading started in 2005 prices were between EUR 20 and EUR 30 per ton of CO_2, showing relatively high volatility. When the first year of trading ended and the first verified emissions data in the EU ETS were published, prices dropped sharply from EUR 29.43 on 24 April 2006 to EUR 10.90 on 2 May 2006. Regulated companies became aware of the allowance surplus in the scheme, when verified emissions where published for the first time. This event is known as "compliance break". It outlines the importance of the test phase of the EU ETS when the scheme was introduced. Towards the end of the trading phase, prices for emissions allowances eligible for the first phase converged to zero. The reason for that is simply that permits from the first trading period were not eligible for compliance in the second trading period and the scheme was oversupplied with emissions permits.

With the start of the second trading phase in 2008, also the commitment period to the Kyoto Protocol started. The overall cap was decreased in the EU from 2,299 $MtCO_2e$ per annum in the years 2005 to 2007 to an annual maximum of 2,083 $MtCO_2e$ in the years 2008 to 2012. Free allocation was slightly decreased compared to the first trading period. The EU member states were asked to allocate a minimum of 90 percent of emissions permits for free to regulated installations. From 2008 onwards, permits from the Clean Development Mechanism (CDM) and Joint Implementation (JI) were also eligible for compliance for installations regulated under the EU ETS. While permits from CDM (Certified Emission Reductions – CERs) and JI (Emission Reduction Units – ERUs) were only moderately used in the start of the second trading phase, usage speeded up gradually in the years 2009 and 2010. However, the usage of permits from CDM and JI is limited in the EU ETS. Each EU member state individually decides how much permits can be used for compliance. In Germany, for example, installations can surrender permits from CDM and JI up to 22 percent of received free allocation. Table 1 summarizes overall usage of permits from CDM and JI in Europe and Germany.

Table 1: CERs und ERUs Usage for Compliance in the EU ETS (Million Permits)

	2008	2009	2010	Total (2008-2010)
EU-wide				
CERs (from CDM)	82.5	77.9	116.9	277.3
ERUs (from JI)	0.05	3.2	20.1	23.35
Germany				
CERs (from (CDM)	23.7	26.0	33.4	83.1
ERUs (from JI)	0	0.67	4.2	4.87

Source: CITL (2011), CDC (2011)

4.3. Perspectives on Emissions Trading in Europe from 2013 onwards

With the start of the third trading phase of the EU ETS in 2013, several changes will apply to the EU ETS. New sectors will be regulated. The biggest one is the aviation sector, which will already be added to the scheme in 2012. In 2013 new stationary installations from sectors producing bulk organic chemicals, hydrogen, ammonia, and aluminium will be opted in to the EU ETS. While only CO_2 emissions were covered by the scheme until 2012, N_2O emissions from the production of nitric, adipic, and glyocalic acid production as well as perfluorocarbons from the aluminium sector will be covered by the scheme (EU, 2010b). The Netherlands and Austria included some N_2O emissions from specific installations already in the second trading period of the EU ETS. The most relevant change for existing installations from 2013 onwards will be the revised free allocation rules. Auctioning will be the principle of allocation from 2013 onwards. In practice, auctioning will progressively replace free allocation from 2013 onwards and grandfathering shall be completely phased out until 2027 (see Table 2). Over the third trading period from 2013 to 2020, about half of the issued European Emissions Allowances shall be auctioned (EU, 2010). Also the way how free allocation is organized will change. From 2013 onwards, free allocation will be based on product specific performance measures. To do so, the EU Commission developed product benchmarks. In practice, free allocation will be orientated on the performance of the ten percent most energy efficient installations in a certain product group (see Table 3). This implies that less efficient installations will receive far less free allocation from 2013 onwards.

Table 2: Sectors and Allocation Principles in the EU ETS form 2013 onwards

Activity / Sector	Allocation Rule
Electricity Generation	No more free allocation
Heat	Free allocation
Industrial Sectors and Subsectors which are deemed to be exposed to a significant risk of carbon leakage (EU, 2010b)	100% free allocation based on benchmarks from 2013 to 2020
Industrial Sectors (remaining)	80% free allocation based on benchmarks in 2013, falling to 30% in 2020

Source: EU, 2011

Table 3: Benchmarks and their Estimated Coverage of Emissions

Activity / Sector	Benchmark
Electricity Generation	None
Heat Generation	Heat-benchmarks (approx. 20% of emissions)
Industry	Product benchmarks (approx. 75% of emissions)
	Fuel benchmarks (approx. 5% if emissions)
	Process emissions (approx. less than 1% of emissions)

Source: EU, 2011

Apart of the reduced amount of freely allocated permits, the EU-wide amount of issued permits ("cap") will be decreased annually by a linear factor of 1.74 percent. In practice, this will result in an annual reduction of the overall EU-cap of 37.4 $MtCO_2$ for stationary sources. The cap for the year 2013 is determined at 2,039 $MtCO_2$. An amount of 107 $MtCO_2$ for newly opted sources in 2013 is included in the 2013 cap (EU, 2010b). The EU, however, will determine the exact cap finally in 2013. Until 30 September 2011, the national authorities of the EU member states shall work-out the plans for revised free allocation from 2013 onwards and submit their "national implementation measures" (NIM) to the EU Commission. The commission is expected to review the NIMs in the course of 2012. Hence, it is likely that the concrete figures for free allocation will be available at best a few months before the start of the third trading period in March 2013. This practice leaves firms with a relatively high degree of uncertainty.

5. The German Experience – Evidence from the KfW/ZEW CO_2 Barometer

The Centre for European Economic Research is annually surveying all German companies regulated by the EU ETS on their behavior under the trading scheme in a common project with KfW Bankengruppe. In the survey, topics like abatement efforts, trading activities and issues related to carbon management and organizational responds of firms to the EU ETS are addressed. The firm-level survey data are merged with emissions data from the Community Independent Transaction Log (CITL), allowing an identification of larger and smaller emitters based on verified official data from the EU. The data are aggregated from the installation to the firm-level. In the CITL there are 1,668 regulated installations identified for Germany. After aggregation, 816 firms can be identified. From the survey additional information on the firms are available, e.g. the number of employees and the main activity based on the NACE classification. The firm-level data gathered at ZEW in the years 2009 to 2011 describes the firm-behavior of German firms in the EU ETS and gives empirical evidence on the transformation towards the third trading period of the EU ETS.

5.1. Abatement

For the years 2009 and 2010, 63 percent of surveyed German firms said that they already had implemented CO_2 abatement activities since the start of the EU ETS in 2005. Small and medium sized companies (< 250 employees) and small emitters (< 25,000 tCO_2 emissions p.a.) are less active in abatement than larger companies or larger emitters. In March 2010 57 percent of emitters planned to implement abatement activities until the end of 2012. In March 2011 65 percent of companies stated that they plan abatement from 2013 onwards, implying slightly increasing overall abatement activities in the third trading period. Abatement activities carried out between 2005 and 2010 were in most cases not scheduled to achieve CO_2 reductions in the first place. Abatement mostly occurred as a side-effect of other measures, including general restructuring and optimization of production processes. 25 percent of companies state that from 2013 onwards activities with the primary reason of CO_2 abatement will be scheduled, implying an increasing impact of the EU ETS on economic activities in Germany, caused by the stricter rules in the EU ETS and higher carbon price from 2013 onwards.

One important determinant of CO_2 abatement is the technical lifecycle of existing installations under regulation. While existing installations might be optimized to reduce emissions, the achievable reductions are limited. One reason is the non-existence of end-of-pipe technologies for carbon dioxide abatement. Under existing regulation firms might take carbon emissions into account when it comes to new investment in machinery, replacing existing installations. As a consequence, considerable emissions reductions might be achieved by replacing existing installations by more energy efficient ones. Based on that, German firms were asked about the remaining average life-cycle of existing installations in their machinery portfolio. 82% of emissions stem from installations with an average remaining technical life-cycle of 15 to 20 years. Accordingly, carbon dioxide abatement through investment in energy efficient new machinery might only occur to a relatively large extent in the long run (see table 4).

Table 4: Average remaining technical life-cycle of existing installations in Germany

Average remaining life-cycle (evaluated in 2011)	% of companies	% of current emissions
Up to 5 years	8 %	0,6 %
5 to 10 years	20 %	4,8 %
10 to 15 years	19 %	3,3 %
15 to 20 years	28 %	81,9 %
20 to 30 years	14 %	7,3 %
30 to 40 years	1 %	< 0,02 %
More than 40 years	10 %	2,1 %

Source: Löschel et al. 2011

Current abatement activities are mostly based on process optimization. In March 2011, 63 percent of surveyed firms said that emissions reductions were achieved in this way. 59 percent also invested in energy efficient technology. Fuels-switch was used by 26 percent of respondents and renewable energy sources by 25 percent. One option to reduce emissions is, of course, the reduction of output by firms. For the year 2009, during the financial and economic crisis, 20 percent of firms stated that they had achieved emissions reductions by reducing output. The statement corresponded to the overall figures for CO_2 emissions in Europe, which dropped in 2009 compared to previous years. After the German economy recovered in 2010, emissions rose again. As a consequence, only 9 percent of firms reported the reduction of output as a reason for declined emissions for the trading year 2010.

5.2. Allowance Trading

Trading of allowances was carried out in a similar frequency by regulated companies in Germany in the tradingyears 2009 and 2010. 51 percent of surveyed firms traded allowances in 2009 and 54 percent in 2010 respectively. About two-thirds of the companies only trade once per year, the remaining firms trade more than once per year. Very large emitters also choose to trade daily or weekly. In contrast, small emitters (< 25.000 tCO_2) usually trade once per year or, in rare cases, quarterly or biannual. Surprisingly, there is no significant difference in trading activities of firms with an overall surplus or net short position of freely allocated allowances. This gives evidence for intra-firm or intra-trust exchange of permits and borrowing. In fact, 77 percent of firms with more than one regulated installation prefer to exchange permits internal, rather than using markets or exchanges in the first place. Only 23 percent of firms usually clear internal short/long positions generally via the market. Most companies prefer to trade allowances via intermediaries, like carbon funds or banks. The second most frequent way of trading are over the counter (OTC) transactions. Only a relatively small number of firms trade directly at exchanges. The preferred way of trading is dependent on the annual emissions levels. Smaller emitters tend to trade via intermediaries or OTC. Only relatively large emitters directly trade at exchanges.

5.3. Companies Response to Changes in the EU ETS from 2013 Onwards

Some of the regulated companies are particularly struggling with the uncertainty of planning that stems from the lengthy drafting process of the actual reforms. 72% of the interviewed companies in Germany have tried to estimate the volume of the new allocation from 2013 by March 2011.

However, the information base for such estimations remains rather limited. It seems that approximately 63% of all interviewed companies expect an insufficient allocation of certificates from 2013. By comparison, only 27% of all respondents suffered from insufficient allocation in 2010. As a consequence, many companies will have to expect substantial additional expenditures from 2013 due to emissions trading. While the additional expenditures for smaller emitters will be limited, bigger emitters will face additional expenditures of several hundreds of thousands of euros. Very large emitters even have to expect additional costs amounting to millions of euros, especially in the energy sector where the most reductions to the free allocation will be made.

Indeed, for a transformation towards a low greenhouse gas European economy, it is necessary to set clear incentives for CO_2 reductions by means of a price signal. This fact is widely accepted within the German economy. However, given the extensive reforms, the companies must be sufficiently informed and need enough time for an adequate preparation for the changes to come. This is clearly a weak point of the European climate policy. The interviewed companies stated that they would need an average of 20 months between the announcement of the actual free allocation from 2013 and the enactment of the regulations in order to be perfectly prepared for the changes. This seems reasonable, since many companies will have to plan for substantial additional costs. In reality, the preparation phase for the companies is likely to be way shorter. It depends on the assessment procedure that the EU commission will apply to the propositions for free allocation made by the German Emissions Trading Authority, but most likely the allocation will be known only a few months ahead.

6. Conclusion

Emissions trading offers the chance for Europe to achieve its emissions reduction commitments in an economically efficient way, meaning at least costs. In addition to that, regulated companies are provided with a great amount of flexibility. Firms with high costs of carbon dioxide abatement are allowed to buy additional emissions allowances, while companies with relatively low costs of carbon dioxide abatement have incentives to reduce emissions. In the course of that, the overall emissions reduction target can be achieved with certainty because of the Europe-wide fixed amount of allowed emissions. Based on the German experience, firms in general respond very well to the regulatory scheme. Most firms already have started to implement CO_2 abatement measures and abatement activities are expected to increase in the future. The EU emissions trading scheme was introduced gradually, starting with a "test phase" from 2005 to 2007, a period of moderate regulation from 2008 to 2012 and increasing regulatory pressure from 2013 onwards. This way to introduce the trading scheme actually turned out to be of great use for regulated firms as well as for policy makers. Firms were able to adapt to the new regulation and policy makers were able to adjust the scheme based on gathered experience and data. Despite the fact that emissions trading plays a key role for Europe to efficiently reduce its CO_2 emissions, some criticism remains. Most importantly, firms are confronted with ongoing reforms in the EU ETS and climate policy in Europe. Uncertainty about future regulation can actually hamper investment in new technology and has a negative impact on the overall efficiency of the emissions trading scheme.

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