Univerzita Karlova v Praze
Fakulta sociálních věd

Institut ekonomických studií

Diplomová práce

2008 **Markéta Řízková**

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Fakulta sociálních věd

Institut ekonomických studií

DIPLOMOVÁ PRÁCE

Emission Trading: Evaluation of the European Experience

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Akademický rok: **2007 - 2008**

Prohlášení

Prohlašuji, že jsem diplomovou práci vypracovala samostatně a použila pouze uvedené prameny a literaturu

V Praze, dne 20.května 2008

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ABSTRAKT

Cílem práce je podat komplexní pohled na mechanismus emisního obchodování a zaměřit se na diskutované oblasti fungování zvláště evropského systému emisního obchodování (EU ETS) jako příkladu největšího fungující zavedeného systému emisního obchodování. Základní přístupy analýzy jsou jak teoretické tak praktické. V teoretické části se zaměříme na porovnání aplikace emisního obchodování versus environmentálních daní a budeme diskutovat, kdy je lepší regulovat pomocí nástrojů zaměřených na cenu a kdy na regulaci množství. Dále se teoreticky zaměříme na metody alokace používané v emisním obchodování se zvláštním důrazem na alokaci pomocí aukcí, která je teoreticky nejvíce preferovaná. V praktické části provedeme analýzu alokačních metod v rámci Fáze 1 a Fáze 2 systému EU ETS a shrneme jaké jsou očekávané změny v systému EU ETS po roce 2012. Na závěr zhodnotíme výsledky alokace versus emise ve Fázi 1 (2005-2007) a na základě predikcí ekonomického růstu a emisní intenzity odhadneme další vývoj ve Fázi 2 (2008-2012) a v následující fázi po roce 2012.

ABSTRACT

Our aim is to show complex picture and highlight the most discussed features of the emission trading and especially the functioning of the European System of Emission Trading (EU ETS) as a representative of the biggest functioning emission trading system. The key approaches involved in our analysis are both theoretical and practical. In the theoretical section we compare emission trading and environmental taxes and we discuss when it is better to regulate by price and when by quantity instruments. We will discuss the possible allocation methods and especially method of auctioning as the most theoretically preferred allocation method. The practical approach will tackle following two aspects: how the emission allowances have been allocated within the EU ETS in Phase 1 and Phase 2 and what the planned changes are in post 2012. Finally, we will look at the results of allocation versus emission during the first trading period in years 2005-2007 and how it might look in the future in Phase 2 and beyond.

Poděkování...

Chtěla bych velice poděkovat svému školiteli Mgr. Milanu Ščasnému, PhD. za jeho cenné připomínky, komentáře a trpělivost. Velké díky patří mé mamince, celé rodině a přátelům pro neustávající oporu a dodání kuráže. Muchas gracias también a tí, Irene, por estar y ser siempre aquí...

TABLE OF CONTENTES:

List of Figures and Tables and Annexes

Figures:

Tables:

Annex Tables:

Annex Figures:

Name: Emission trading: Allocation strategies and the role of auctioning
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Specialization: European Economic Integration and Economic Policy

Methodology

Economic instruments of environmental regulation are recently becoming more widely used in the environmental policy mix in developed countries. One of such economic instruments is trade of emission allowances/permits among economic actors or whole states. Such emission trading is becoming widely used especially in case of regulation of air pollution combating the growth of CO_2 or SO_2 emission. The initial allocation of the emission permits can significantly influence the effectiveness of the system and have different implication for the system participants. In my thesis I would like to deal with the question of what would be the efficient allocation strategy that would create efficient regulatory environment with minimal adverse effects on the system participants.

Short outline of the thesis

1. **Introduction to the topic**

- Short description of the economic instruments of environmental regulation. Brief Introduction to the current situation of global policy of GHG emission reduction (e.g. UNCFF, Kyoto protocol) and its local implication (EU ETS). Literature review.

2. **Experiences with allocation strategies**

- Grandfathering, benchmarking and auctioning - basic description, experiences of their realization and assessment of the possible effects of alternative allocation approaches

The choices of initial allocation can affect the overall workings of the cap-and-trade program. The attention will be given to methods such as grandfathering based upon historical emissions and benchmarks based upon emission rates – both of which involve allowances for free to program participants. Special attention will be given to the third method: Auctioning of allowances based on the paid allocation of allowances.

3. **Methods for using and distributing auction revenues**

- funding, recycling, changing tax structure – their possible positive/negative impacts on different market participants

Theoretical evaluations of auction alternatives often assume that these revenues would be used to reduce other distorting taxes leading to possible "double dividend". However, the attention will be paid also to other possibilities for use of revenues: e.g. funding specific activities (e.g. use of renewable resources, energy efficiency) or returning the revenues to program participants

4. **Possible (efficient) portfolio of allocation options and the role of auctioning in the EU emission trading program after 2012**

- Possible hybrid portfolio options (allowances for free and auctioning) that may imply efficient environmental regulation. Possible scenario of further development of ETS after the end of Phase II. in 2012

The EC will be probably considering the expanded use of auctioning in the period after 2012. The attention will be paid to possible option that are available and their judgment on light of their possible regulatory effectiveness

Literature:

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In Prague, March 2nd, 2007

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PhD

Introduction

Environmental protection and regulation have been gaining the attention both of the academics and politicians over the last half of century. We have witnessed a slow but steady move from pure theoretical Pigouvian concept of *internalization of externalities* to well developed system of real-life regulatory sophisticated instruments. There is noticeable a general progress towards more market-based instruments of environmental regulation – especially environmental taxes or system of emission trading. Finally, in the last decade the environmental regulation has become a spotlighted issue on all levels of political debate in relation to the phenomenon of climate changes and the greenhouse gas emissions.

As we said before, there is a variety of policy instruments that can be implemented; however, there is no single one that would score the best in all the evaluation criteria (Goulder and Parry, 2008). We have chosen one example of market-based environmental regulation: emission trading. We try to evaluate it, both theoretically and practically on the example of the European emission trading system (EU ETS). The reason of choice is triggered by the author's appetite for deep understanding of policy instrument that currently become a real global policy in the field of combating climate change and has established completely new and rapidly growing world-wide carbon emission market that in 2007 already reached the financial value trades of nearly €50 billion (Capoor, 2008).

To briefly summarize our purpose: it is to look on emission trading from different key perspective and to provide a reader not a overwhelming analysis of a single aspect of the chose regulatory instrument but rather to provide a spectrum of different views on emission trading. Our aim is to show complex picture and highlight the most discussed features of the emission trading and especially the EU ETS as a representative of the biggest functioning emission trading system.

The key approaches involved in our analysis are both theoretical and practical. In the theoretical section we will provide a reader with a comparison of emission trading and environmental taxes – and a discussion when it is better to regulate by price and when by quantity instruments (*Chapter 2*). Later on, we will discuss the possible allocation methods with special attention paid to auctioning as the most theoretically preferred allocation method (*Chapter 3*). The reason why we have chosen an allocation method for detailed analysis is that the initial allocation of the trading allowances is very crucial for the functioning of the system. Apart from that, as we will see in the practical part, allocation method is highly discussed issue in debate concerning the future design of the emission trading system in the EU.

Then, the practical approach will tackle following two aspects: how the emission allowances have been allocated within the EU ETS in Phase 1 and Phase 2 and what the planned changes in the future are (*Chapter 3*). And finally we will look at the results of this allocation during the first trading period in years 2005-2007 (*Chapter 4*) and how it might look in the future with the planned changes mentioned before (*Chapter 4*).

1. Corner Stones of Emission Trading and Environmental Taxes

The first chapter is meant as a brief introduction to the topic of economic instruments of environmental regulation with the main focus directed to the description of emission trading, its theoretical rationale and practical usage accompanied with the similar introduction to the topic of environmental taxes with special focus on carbon taxes. The goal of this chapter is to answer basic questions as: *What are the economic instruments of environmental regulation? What are their advantages and disadvantages and how theoretically and where practically does system of tradable permit or carbon taxes work*?

There are several types of instruments used by environmental policy nowadays: traditional pollution standards following the command-and-control measures, economic incentives such as environmental taxes and charges or tradable emission rights and quotas, subsidies or voluntary instruments (e.g. environmental management system and auditing or covenants – voluntary agreement between industry and government). There is not a single optimal instrument that would be efficient and sufficient in all situations, in the real world there exist combination both of traditional direct regulation via limits, environmental standards or emission concentration and more indirect regulation via economic instruments based on internalization of external cost – *externalities*, that used to be omitted in the economic calculation.

While the tools of direct **command-and–control regulation** can be applicable in most of the cases, their efficiency may be limited. Their biggest advantage is a certain outcome as the polluter's compliance is mandatory and often accompanied with sanctions for breach of the standards/limits. On the other hand, the biggest drawback is their inflexibility and static approach. They do not take into account that each polluter faces different abatement cost instead of this they treat each polluter with the same measure. They focus only on the present state-of-art but they lack the dynamic incentive effect. Once the polluter reaches the required limit or standard there is not any encouragement for further improvement. Moreover, in the most cases command-and-control regulation is technology dictating so that it does not leave any space for new innovative approach.

On the other hand, the **market-based instruments** such as environmental taxes, charges, subsidies or tradable permits represent a decentralized indirect incentive system of regulation. The majority of economists favor them for their cost-efficiency. In the presence of the bounded rationality the regulator does not know the real abatement costs of the individual firm, therefore the intentions of the regulator are transmitted via changes into the price system, i.e. via modification of relative prices.

Figure 1 : Environmental Policy Options

Market-based instruments represent the efficient solution in case when the individual abatement costs differ significantly among the polluters. The environmental benefits are assumed to achieve the abatement at the lowest level of costs – polluters will pollute up to the point where the marginal abatement costs (MAC) are equal the price of *taxes/charges/pollution permits* levied on them. If the MAC of abatement activity is less than the regulation instrument polluter can abate another unit of pollution. On the other hand, if the MAC is higher than the regulation instrument, it is cheaper to pay the tax. Finally, those firms with lowest abatement costs will undertake the most pollution abatement and firms that reduce emissions in more costly way will choose paying tax or buying more emission permits.

In general we can divide the economic instruments into two basic groups according to their main target of regulation. *Instruments regulating the price of pollution* (as taxes, charges or subsidies) and *instruments focusing on regulation of quantity of pollution* (tradable pollution permits/allowances). The incentives of the market-based instruments are transmitted via price system; they change the relative prices via making the polluting activities more costly. This can be beneficial and dangerous in the same time. It is effective to use them in case of heterogeneous polluters with differing marginal abatement costs that respond to the price signals – especially for recycling and material and energy saving. However, in the same time there is a danger that they may provide too weak stimulus so that the industry response is uncertain.

The great advantage of the market-based instruments is that they differ from the direct regulation in their inherent orientation at the dynamic incentives – they create a continual incentive for firms to further reduce polluting emissions beyond the set limits. Accordingly, there is a constant stimulus for the better polluter's performance.

1.1. Transferable rights - Theoretical view

The problem of missing property rights and its impact on the level of pollution is usually known as "tragedy of commons" introduced to the economic literature by Garret Hardin in late 1960ties[1]. Usually it represents the situation of markets failure where the emission rights produce the over-exploitation of the natural resources or and over-emission of the local/global environment.

The theoretical issue of transferable permits of property rights as a solution for external cost of usage of collective resource was greatly tackled by Coase (1960) and later Demsetz (1964). Both authors were dealing with the idea of direct bargaining among the involved agents as a way of solution, i.e. bargaining without the presence of regulator on the market. The theory of transferring of tradable property rights in the presence of some regulator was introduced by Dales (1968) (water use regulation) and later followed by Croker (1966) and mainly Tietenberg (1985) focusing on the theory of pollution markets and emission permits.

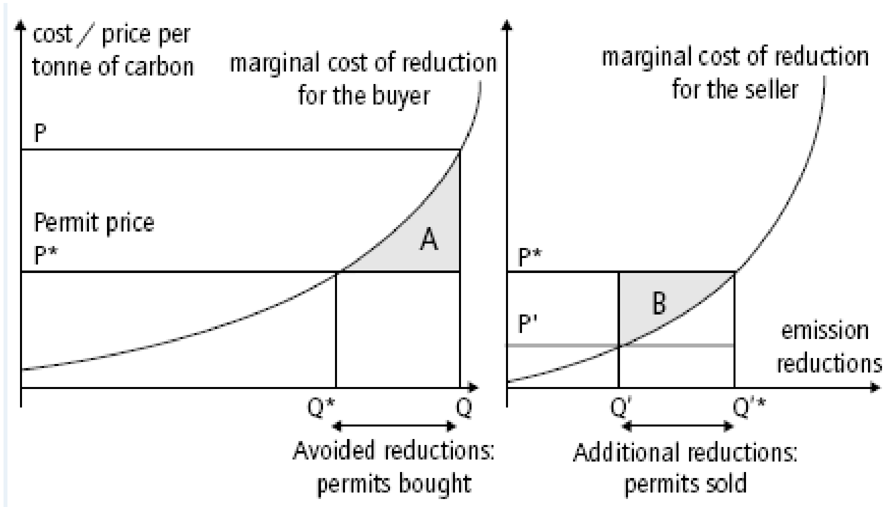
In general, the transferable rights can be useful either in case of usage/exploitation of some natural resources or in case of emitting pollution into the environment. To better understand the effect of introduction of tradable rights into the system we can show it on the example of tradable rights with pollution, that are more common in the current environmental regulation. The general well pronounced advantage of

[1] Hardin, Garret. (1968) The Tragedy of the Commons, Science 162, 1243-1248. However, the idea of price of common goods goes far back in the history to Aristotle...

tradable pollution permit mentioned by the economists is that the usage of such economic instrument will lower the total pollution abatement costs.

We can show graphically in **Figure 2** how permits affect the polluters with different marginal abatement costs. For both polluters it holds that the curve of marginal abatement costs is increasing which means that every additional unit of abated emission is more expensive (represented by greater Q on horizontal axis) than the previous one. However, each polluter has differently shaped marginal cost of reduction, i.e. the same amount of abated pollution will cost differently each producer.

Figure 2 : Economic logic of tradable pollution permits
(Application on CO_2 permits)



Source: OECD/IEA (2001)

In the **Figure 2** the Polluter 1 on the left-hand side has higher marginal abatement cost expressed by the shape of the curve, Q* is the amount of abated pollution whose marginal costs of abatement are equal to the permit price P*, to reach the higher level of abatement Q (the objective of the environmental regulation) would cost more than to buy additional units of pollution permits, therefore economically thinking polluter will abate just till the level of abatement Q* and will buy additional units of pollution permits to cover the difference QQ*. Area A represents the cost savings reached by buying permits.

On the other hand, the Polluter 2 on the right-hand side will reach at price of pollution permit P* level Q´* of abatement even though his/her objective of level of abatement was only Q´ and he/she will sell the difference Q´Q* to Polluter 1. Shaded area B expresses the profits from selling the permits. Both polluters have chosen the level of abatement where the marginal costs are equal to the price of permit, the overall level of abatement was reached but with lower costs for producers.

Environmental regulation tries to target through introducing the tradable permits either absolute or relative quantitative limits of pollution, we can distinguish between two most important groups of tradable permits so-called *credits for emission reductions* (in baseline-and-credit schemes with minimum performance principles) and *quotas* for allocated amount of emissions (in currently more often used "cap-and-trade" schemes, where polluters receive allowances/permits to produce certain amount of pollution).

There are various methods of allocation of emission tradable permits that will be described more in detail in the following chapters. Just briefly mention them: emission permits can be allocated for free i.e. grandfathered according to either the historical levels of pollution or using some benchmark, or they can be sold, i.e. auctioned.

1.2. Transferable rights in practice

As was already mentioned before, we can roughly differ between to main streams of application of transferable rights: the area of usage of some natural resources and the area of pollution. Transferable rights related to air pollution have over years become the most common area of practical application even though the usage of transferable rights related to natural resources has much older experience. Such transferable rights were for example used in relation to trading rights to abstract water (e.g. to set the balance between the usage of water for farming and other purposes) in the USA, Australia, Chile (Kraemer, Banholzer, 1999). Other examples were systems of tradable rights or quotas for river or sea fishing[2] in a number of countries as Australia, Canada, Iceland, the Netherlands, New Zealand and USA since

[2] E.g. there was set up the agreement between British and Norwegian whalers to set quotas and limits on the whaling season in Antarctica already in 1932. The quotas were meant to be transferable but without any price. (OECD, 2001)

1970ties (Wallis, 1999). Other example use transferable rights related to natural resources are programs for land-use management that are most often called transferable development rights schemes. They have been used to preserve historic landmarks, agricultural land and biodiversity, to encourage development, or to limit some certain types of activities within an area. There are experiences in their application in the USA, France, Italy and New Zealand; however the only extensive use has been undergone for development (or building) rights in the USA (Renard, 1999).

Our primary focus is on the tradable pollution rights (or emission allowances) therefore we will not go into detail in description of transferable right related to natural resources. In general we can differ between three main groups of practical usage of tradable pollution rights according to the target of regulation: **pollution of water** as the first group, **air pollution** as the second one focusing mainly on the regulation of SO_2 and NO_X substances in the air and finally **climate change** issues as the last main group targeting the reduction of green house gases (GHG) in the air.

The first two mentioned groups had their origin of practical application in the USA already in the 70ties of 20th century. Whereas the last group, the "youngest one", was first put into the practice in late 90ties in the UK and later in the EU in 2005 within the introduction of the EU ETS. On the global scale this kind of environmental regulation is represented by the flexible mechanisms of Kyoto Protocol. The more detailed description of the concrete projects of tradable pollution systems can be found e.g. in OECD (2002) or EEA (2006); at this point we will present the tables and rough information summarizing the most important existing systems of tradable permits. Later, in the following chapters we will chose the most important systems of tradable emission rights and we will dedicate them more attention.

1.2.1. Pollution of water

Generally the development of waste, land and water tradable pollution rights systems have the longest experience in the USA. The comprehensive summary of recent system of water quality trading systems counting with the list of over 45 local applications on rivers (e.g. Minesota River) or bay areas (e.g. San Francisco Bay) provides Breetz et al. (2004) also on the EPA[3] summarize that there is currently

[3] See Internet Sources on EPA Water Quality trading programs

applied statewide trading water quality framework in 7 states in other two states there is watershed specific trading program. In practice the individual water quality trading systems applied in the United State are targeted at different pollutant e.g. Selenium, Mercury, Phosphorus or Nitrogen. Theoretical approaches summary can be found in Keudel (2006).

1.2.2. Air pollution

The regulation of air pollution by tradable pollution rights began in the USA in mid 1970ties via so-called *Emission Trading Program* that consisted of various initiatives (so-called bubbles, netting, offsets, and banking[4]) as part of the *Clean Air Act's program*[5]. There was introduced an obligation for new sources of air pollution and existing sources that wanted to expand their facilities, to offset additional emissions in the area by acquiring emission allowances from existing sources. This program was gradually widened by other programs.

To mention the historically most successful example of the emission trading we have to refer to the USA *Acid Rain Program*, first large-scale, long-term US emission trading program that was established by the amendments to the Clear Air Act in 1990. The practical system of trading of sulphur dioxide (SO_2) emission from utilities was then introduced in 1994. The program has been very successful, exceeding the target at a cost much lower than predicted (Ellerman et al., 2004). The program is operating till nowadays. This program also served as important example for establishing the European System of Emission Trading (EU ETS) focused on the reduction of greenhouse gases in 2005 that will by in the centre of our attention in the following chapters

[4] ***Bubbles*** :enabled various sources to reach the one reduction target jointly as they were treated as a "bubble"
Netting: similar to bubbles. Only in case of total net emissions of the group are lower than the regulatory threshold it could enable to existing sources of pollution expand
Offsets *:* to build new sources in the heavily polluted areas that are trespassing the regulatory threshold can be done only if the polluter buy credits more than equal to their emissions
Banking: allows polluters to store the credits over time

[5] *The Clean Air Act (CAA)* was passed in 1963 but it has undergone important revisions periodically since then. The present air pollution control program in the USA is based on the 1970 version of the law and on the far-reaching revisions introduced under the 1990 Amendments for improving local air quality (UNEP/UNCTAD, 2002)

Table 1 : More recent application of the Air Pollution Emission Trading Programs *(Excluding Greenhouse Gases)*

Program / Country	Period	Participants	Economic and Environmental results
		Lead in gasoline	
Lead in Gasoline / USA	1982 - 1987	Refineries	Faster reduction of lead in gasoline Annual savings up to $250 mil
		Ozone Depleting Substances	
U.S. ODS Phase-out6 / USA	1989 - 1998	28 major U.S. producers and consumers of the controlled substances	Faster fulfillment of the reduction goals
		SO_2	
Acid Rain Program / USA (21 states)	Phase 1: 1995 - 1999 Phase 2 : 2000 - now	coal-fired U.S. electric utilities Phase 1: 445 installations Phase 2 over 2000 installations	Faster fulfillment of the reduction goals Annual savings up to $250 bln
California RECLAIM / California (USA)	1994 - 2003	wide range of sectors emitting SO_2 and NOX	Faster fulfillment of the reduction goals
Clean Air Interstate Rule (CAIR)/ 29 states	2005 - now	sectors emitting SO_2 SO_2 and NOx	n.a.
Emission Quotas SO_2/ Slovakia	2004 - now	sectors emitting SO_2 200 participants	n.a.
		NOx	
Ozone Transport Commission (OTC) NOx Budget Program / USA (13 countries USA)	1999 - 2002	fossil-fuel-fired boilers and electricity generating units	n.a.
California RECLAIM / California (USA)	1994 - 2003	fossil-fuel-fired boilers and electricity generating units	n.a.
United States EPA SIP Call – Federal NO_X Budget Trading Program 7 / USA (13 states)	2003 - now	fossil-fuel-fired boilers and electricity generating units	n.a.
Clean Air Interstate Rule (CAIR)/ 26 states USA	2005 - now	sectors emitting SO_2 SO_2 and NO_x	n.a.
NO_x emission trading/ The Netherlands	2005 - now	large combustion plants	n.a.
		Mercury	
Clean Air Mercury Rule / USA (29 states)	2005 – now (2018)	Coal Power stations	n.a.

Source: Harrison, Radov (2002), EEA (2005, Stavins (1998),), EPA, (see internet sources)

[6] Trading system implemented as a fulfillment of Montreal Protocol that was signed by the USA in 1987
[7] replacement of previous Ozone Transport Commission NOx Program

Table 1 summarizes the important features of the major relevant programs targeted on the regulation of air pollution in the USA and in later period also in Europe[8]. Targets of the regulation were polluting substances as lead in gasoline, ozone-depleting substances, sulphur-dioxide emissions and nitrogen oxide emissions

1.2.3. Climate Change

The last area of practical implementation of the transferable emission rights are the issues related to climate change and growing concentration of greenhouse gases (GHG) in the atmosphere. These trading programs target the reduction of GHG emissions, i.e. focusing on the reduction of either only CO_2 (e.g. EU ETS) or of all GHG emissions[9] (e.g. under the Kyoto protocol). The trading unit is a tone of CO_2, in case of the rest of GHG – there are traded units of tones of CO_2e (i.e. equivalents of CO_2) where the units of other GHG are changed in to equivalents according to their global warming potentials.

How does differ the GHG emission impact from the impact of the air pollution gases mentioned in the previous section? It is really the global feature of their occurrence. Whereas the gases as SO_2 or NO_X do impact the local environment where they are emitted (e.g. by occurrence of acid rains or health problems of local citizens), GHG do influence the global environment and the atmosphere (according to the many scientists their higher concentration in the atmosphere may influence the growth of global temperatures[10]).

Therefore the creation of global markets would be the most efficient solution for both environmental and economic reasons. From the environmental point of view it does not matter where the unit of GHG is abated. In the same time from the economic point of view there are more possibilities in the global market to find the cheaper way how to do it.

[8] In Europe there is only a scarce evidence of emission programs focused on the air pollution (Slovakia and the Netherlands), the main development on the European scene is in the area of climate change and promoted by the functioning of European Emission Trading Scheme (EU ETS) that target the reduction of GHG.

[9] i.e. Six gases: CO_2, CH_4, N_20, HFCs, PFCs and SF_6.

[10] In this thesis we are not going to open the discussion whether this impact is true or whether the human activity do contribute to the growth of temperatures on the Earth. For more information readers may search e.g. in reports elaborated by the International Panel of Climate Change

Table 2 : Existing GHG Emission Trading Schemes

Program	Period	Target group	No. Participants	Mandatory / Voluntary
		USA		
Chicago Climate Exchange	Phase 1 : 2003 – 2006 Phase 2 : 2007 -2010	Electricity generation, manufacturing industry	120	Voluntary
		Europe		
Denmark ETS	2001 - 2003	Biggest electricity producers	8	Mandatory
UK ETS	2002 -2006	Energy intensive industries. Electricity generators excluded from cap-and-trade	34 direct participants	Voluntary (Firms could negotiate agreements with the government to achieve reduced emissions rate targets in exchange for a reduction in the Climate Change Levy CO_2 emission regulation. Targets can be achieved via trading.)
Norway ETS	2005 – 2007, from 2008 linked to EU ETS	Coverage as the EU ETS: Mainly industry (energy facilities above 20 MW, cement, refineries and some others)	51	Mandatory for plants not under CO_2 tax
EU ETS	Phase 1 : 2005 - 2007 Phase 2 : 2008 -2012	Energy Facilities above 20 MW, heating, cement, refineries. Iron/steel, pulp and paper	Around 10.800	Mandatory
Swiss ETS	Start from January 2008	Installation covered by CO_2 taxation	n.a.	Mandatory – installations can choose between CO_2 tax and ETS
		Australia		
New South Wales	2003	Electricity generators	35 (of which 24 obligatory participation)	Voluntary & Mandatory
		Japan		
Japanese Voluntary Emissions Trading Scheme	2005 - now	Food and beverages, chemicals, paper and pulp, textile, building sector	34	Voluntary Companies/facilities participate voluntarily by pledging concrete emissions reduction targets. The ministry subsidizes the installation cost of CO_2 emissions reduction equipment to help businesses that are actively attempting to reduce CO_2.
		International		
Kyoto protocol	2008 -2012	Countries that are Signatories to the Kyoto protocol	169 signatories[11]	Mandatory

Source: Harrison, Radov (2002), Ellis, Tilpark (2006), various internet sources related to individual ETS

[11] As of September 2, 2007

The carbon markets, the youngest ones in comparison of the other above mention markets for tradable pollution permits, are at the moment the most dynamically developing segment of the market of tradable pollution permits. Currently there has be operating several mandatory or voluntary emission trading programs in the USA, within the EU and Australia, **Table 2** gives the short summary of their basic characteristics.

Over the last 10 years the issues connected to climate change and global warming have become the crucial topics of global politics. The first formal response of the international politics was a declaration signed under the United Nation Framework Convention on Climate Change (UNFCCC) in 1992; however it was just a declaration without any legally binding consequences. The initial legally mandating international agreement was signed in 1998 in Kyoto – the Kyoto protocol. It came to power in 2005 and it has established the real global market for GHG emission allowances and credits. The Kyoto protocol served as an incentive to develop a global carbon market via number of different emission trading schemes and also via the development of project-based mechanisms such as the Clean Development Mechanism (CDM) and Joint Implementation (JI) that are examples of offset programs mentioned before.

There are also many emission trading schemes focused on the cutting the greenhouse gas emission that are either announced or will be already introduced in very near future. **Table 3** provides a general overview about the planned schemes. Generally, the greatest changes in the GHG emission regulation are expected in the USA. In 2009, there will be implemented a regional trading scheme among 10 states on the Eastern coast. Initiative is also apparent among the states on the western coast, even thought currently on the lower stage of development. There is also expected that in the future 8 years there will be implemented some kind of federal emission trading scheme as all the current U.S. candidates publicly support the market-based system of emission regulation.

Table 3 : Planned and announced GHG trading schemes

Name	Expected start	General information
USA		
RGGI - Regional Greenhouse Gas Initiative	2009	5-7% of EU ETS allocation, energy sector covered with participation of 200 installations. Mandatory auction: 25%(e.g. in New York 100% auction) Participating countries : Maine, New Hampshire, Vermont, Connecticut, New Jersey, New York, Delaware, Maryland, Massachusetts, Rhode Island
Western Climate Initiative	?	Announced implementation of market-based emission regulation with emission trading and cooperation among the participating countries. Participating countries : Arizona, British Columbia, California, Manitoba, New Mexico, Oregon, Utah, and Washington
Federal U.S. Cap-and-trade system	??	Several proposals in U.S. Congress of federal cap-and-trade scheme. The most important bills being discussed are: Lieberman-Warner act and Bingaman-Spacer act.
Australia		
NETTS National Emission trading Task force	2010	The Government officially promised to implement emission trading scheme for power sector.
New Zealand		
New Zealand	(?) 2012	The Governmental intention to introduce an emission trading scheme for power sector.

Source: various internet sources related to the individual trading schemes – see Internet sources, PointCarbon news

1.2.3.a. Preliminary schemes: Denmark and UK

Historically, the first small scale emission trading schemes with GHG were established in Europe - in Denmark and in the UK. In Denmark, the system was designed only for 8 firms where two biggest firms12 received 93% of all allocation (UNEP, 2002) therefore it did not create the sufficient condition to establish liquidity of market. Another thing was relatively low level of fine for non compliance due to (DKr 40 or around €5 per ton CO2)[13] that also contributed to the limited effect of the whole system.

[12] Elsam and Energi E2,
[13] According to the description mentioned in EU ETS Danish National Allocation Plan 2005 - 2007

It the UK, the emission trading system was a part of UK Climate Change Program to reduce its GHG emissions by 12.8% bellow 1990 by 2008. The program introduced so-called *Climate Change Agreements* (CCA) with industry participant and offered the voluntary option to participate in the emission trading scheme as a parallel to CCA.

There were two types of participants — direct participants who accept an absolute cap and Climate Change Agreement participants. Direct participants were required to make absolute reductions to 1998-2000 levels of their emissions in exchange for an incentive payment paid by UK Government. The targets and value of incentive payment were set via a competitive auction 2002, where companies were bidding for the absolute level of reduction target at given incentive payment. To explain it, firms were paid by government for the reduction they had achieved when they reached the level of abatement agreed in the auction. The system finished already in 2006, it was mainly meant as a useful learning tool for UK firms and Government to understand how trading works in preparation for the European-wide emission trading system (EU ETS). It has also resulted in some environmental improvement in terms of reducing some emissions that would otherwise have occurred, but some participants may have been paid for reductions that they would have made anyway (EEA, 2005).

1.2.3.b. EU ETS –The global carbon market driver

EU ETS was established in 2005[14] as a main instrument of EU Climate Change policy for achieving the EU target of reducing greenhouse gas emissions in accordance with the Kyoto protocol commitment for the EU[15]. EU ETS has become the dominant element of the global carbon markets as it is the biggest emission trading scheme ever put into the practice in terms of countries involved (25 members of the EU in the 2005, 27 since 2007), in terms of individual installations covered (almost 10.500) and finally in terms of total amount of emission cap imposed (in the Phase 1: nearly 2.200 Mt CO_2 p.a.). In its initial phase it focused only on the reduction of single GHG – CO_2, in its second phase (2008 – 2012) the scope of regulation encompasses also other GHG via import of emission credits of Kyoto protocol (see bellow)[16]. It covers six most energy intensive industrial sectors (energy, heating, refinery, iron and steel,

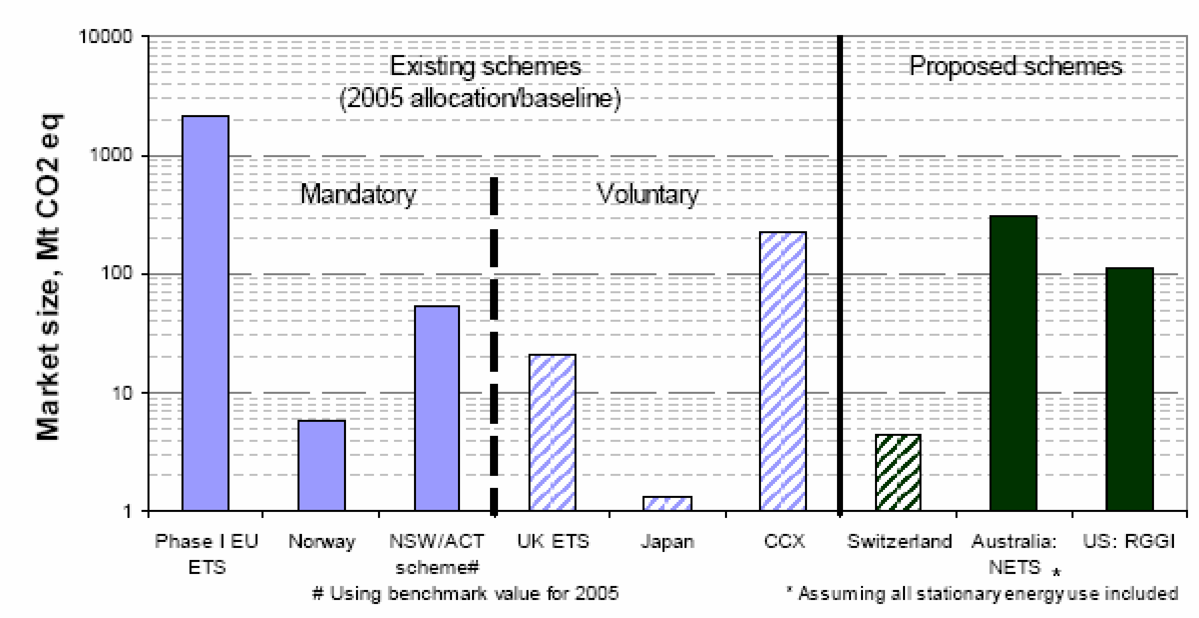
[14] According to ETS Directive (2003/87/EC)

[15] EU 15 has commitment to reduce its GHG by 8% till 2012 compared to the base year 1990; EU 12 has individual national targets in range of 6 - 8% reduction till 2012 from the same base year.

[16] The Kyoto Protocol encompasses all 6 major GHG emissions. E.g. also French NAP gives the opportunity to opt-in for chemical activities with other GHG, namely with N_2O

cement, and pulp and paper production) and it represents about 45% of the total emissions of CO_2 within the EU.

Figure 3 : Comparison of size, type and status of different emission trading schemes



Source: OECD (2006)

It was designed to run in two separate phases between year 2005 -2007 and 2008 - 2012. The second phase is in the same time the first commitment period for the Kyoto protocol. It is highly probable that these two phases will have the continuation in post-2012 development; its main features are being frequently discussed at present. In January 2008 there was released by the European Commission the first official draft of the revision of EU ETS in post-2012 scheme giving the certainty that the emission trading system will continue even without the existence of any international agreement (as was the Kyoto protocol).

Table 4 : Global Carbon Markets: Traded volume and Value

	2005		2006	
	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)
Allowances				
EU ETS	321	7,908	1,101	24,357
New South Wales	6	59	20	225
Chicago Climate Exchange	1	3	10	38
UK-ETS	0	1	na	na
Sub total	**328**	**7,971**	**1,131**	**24,620**

Source: Capoor (2007)

EU ETS with is its size (current cap more than 2,200 Mt CO_2) and number of participants (more than 10,500 installations) already offers the condition to establish the sufficient market liquidity. We can see in *Table 3* the rapidly growing number of trades that was placed in the first two years of EU ETS trading. In the year 2007 the market is also following the same growth dynamics with most of the trades focused on trading the forward emission allowances for the next compliance period 2008 – 2012.

According to the latest numbers for year 2007, the total volume and value traded on the global carbon markets represent 64% and 80% growth respectively[17] compared to the previous year. In total there was traded 2,700 Mt CO_2e reaching total value €40.4 ban. Only within the EU ETS there was traded nearly 70% of the total financial and physical volume (€ 28 bln and 1,600 Mt CO_2e) (PointCarbon, 2008). Trades were realized either on the official exchanges[18] or bilaterally between concrete two parties and via specialized brokers on so-called OTC[19] market. At the moment, the OTC markets represents the majority of current trades, e.g. within the EU ETS it counts for 70% of total trades (PointCarbon, 2008).

[17] we count together numbers form Table 3 and Table 4 to express the total volumes of the carbon markets

[18] the most important for the EU ETS are exchanges ECX, EEX, Nordpool and Bluenext, for other trading schemes we can mention for example Chicago Climate Exchange

[19] Over-the-counter market

1.2.3.c. Kyoto protocol and its Flexible market mechanisms

The aim of the Kyoto Protocol is to establish a real international co-operation in solving the climate change issues. The members of the emission trading system are the whole countries not the individual firms within the countries. Within the Kyoto protocol the signatories that represent the 39 developed economies (Annex 1 countries[20]) committed to reach within the compliance period 2008 – 2012 their individual relative targets to its GHG emission in base year (for the majority it was year 1990). The rest of the signatories (non-Annex 1 countries) are represented by developing countries without any special reduction target.

To reach their commitment Annex 1 countries have to reduce GHG emission via domestic abatement. Apart from that, they can also use so-called *Flexible Mechanism of the Kyoto protocol* that consist of international emission trading of Assigned Amount Units (AAUs) or usage of project based credits that cover the emission reductions in the developing world through so-called Clean Development Mechanism (CDM) or emission reduction from projects in more developed countries through the mechanism of so-called Joint Implementation (JI). However there must be kept a supplementary criterion that only 50% of the needed reduction can be reached by flexible mechanisms of Kyoto protocol.

What can we imagine behind the project based credits? Let's imagine a wind farm CDM project in China. The electricity generated from the wind farm would substitute electricity delivered to the grid from other coal-based power plants in China, this coal power plant would reduce its production and so it would produce less GHG emissions. There exist specialized methodologies approved by Kyoto Protocol Authority: UNFCCC[21] to count how much GHG emission would be saved by doing so, these saved GHG emissions represents the volume of project based credits from CDM projects that can be used either by governments of Annex 1 countries within the Kyoto Protocol compliance or to some limit[22] also by the companies within the EU ETS compliance.

[20] Annex I of the UNFCCC signed in 1992 and Annex B of the Kyoto Protocol are often used interchangeably.
[21] United Nation Framework Convention on Climate Change
[22] for EU ETS 2nd Phase trading period (2008 -2012) there is on average 13% limit of usage credits from JI or CDM counted as a percentage of installation allocation. More information in Annexes of this thesis

Table 5 summarizes the reached traded volume of theses credits that were traded. Again we can see the growing dynamic of the market.

Table 5 : Trades with the project based transactions

	2005		2006	
	Volume ($MtCO_2e$)	Value (MUS$)	Volume ($MtCO_2e$)	Value (MUS$)
Project-based transactions				
Primary CDM	341	2,417	450	4,813
Secondary CDM	10	221	25	444
JI	11	68	16	141
Other compliance	20	187	17	79
Sub total	**382**	**2,894**	**508**	**5,477**

Source: Capoor (2007)

1.3. Environmental taxes in application to Climate Change in theoretical perspective

The theory of environmental taxes goes back to the Pigouvian concept of environmental taxes that intends to internalize the external social cost imposed on the society by polluting activities. In this sense the optimal environmental tax should be equal to the total marginal social costs.[23]

The second stage of the development of environmental taxation is its incorporation into the broader concept of environmental tax reform that shifts taxation from taxation of labor toward environmental taxation. The early theoretical concepts of environmental tax reform were apparent in the beginning of 80ties of last century, e.g. Binswanger (1983) mentioned an implementation of energy tax whose revenues could be used for reduction of taxation of labor. This is exactly the principle of practical implementation of environmental reform that happened more than one decade later in several European countries. The concept of environmental tax reform was later broadly theoretically discussed mainly due to the issues of possible double dividend hypothesis – i.e. that change of the architecture taxation system would contribute both to the environmental benefits and to the distortion of tax system leading even to the boosting of employment. We tackle the topic environmental regulation with other taxes and regulatory instrument in section dedicated to the *second-best analysis* in Chapter 2.

When we move towards the environmental taxes related to the climate change and the greenhouse gases we usually refer to taxes imposed on fuels and energy. In theoretical perspective we can differ between directions of energy taxes. Carbon taxes can be either based directly on the verified emissions or there can be used other less direct way of computing of their tax base. The taxes imposed on the motor fuels and taxes levied on other energy sources.

In the first case the taxes on motor fuels are historically levied tax rate is supposed to be related either directly or less directly to the carbon dioxide content. Their aim is to reduce the energy consumption of the heavy carbon-intensive fuels.

[23] more e.g. in OECD (2001)

1.4. Carbon taxes in practice

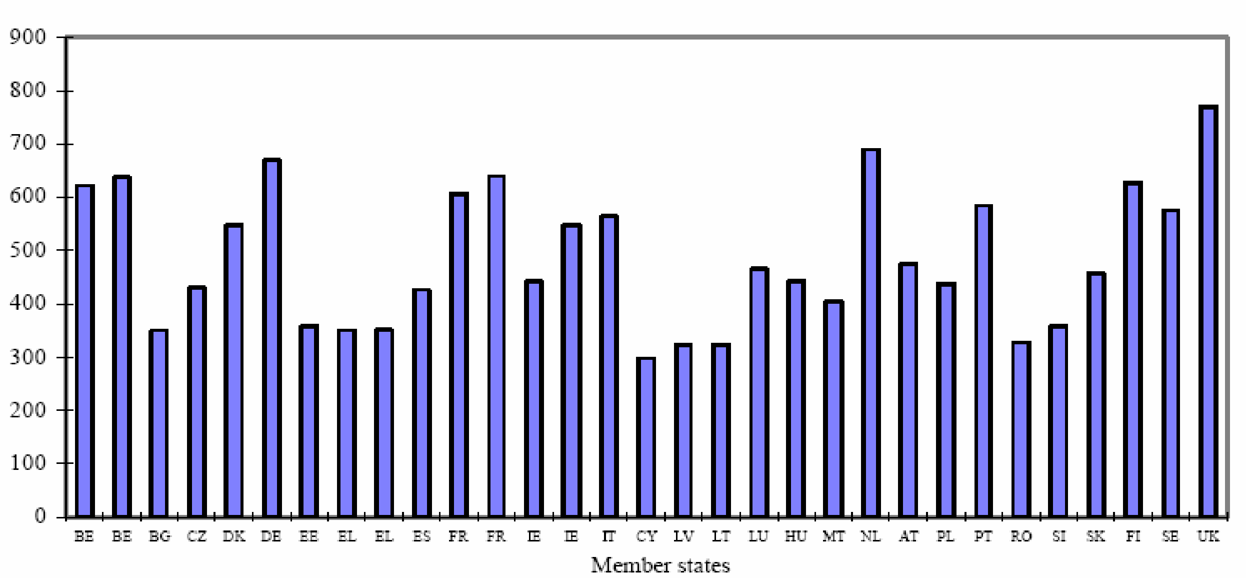
In practice we can see implementation of carbon taxes either as an additional tax added into the fiscal system or as a part of the broader environmental fiscal reform. In total, during the last 20 years there have been implemented specialized carbon taxes in Scandinavia (Sweden, Denmark, Finland, and Norway), the Great Britain, Ireland, the Netherlands, Germany, Italy, Estonia and in 2005 also by Slovenia. In all of these countries this implementation was to certain level accompanied by the reduction in other distortion taxes. For example in Germany, the complex environmental tax reform introduced tax rates for electricity and fossil fuels that were accompanied by the cuts in total social security contributions by almost 2%.

Broadly speaking, we can mention at this place all taxes related to the energy products in general that implicitly in the same time also focus on taxation of the carbon-intensive fuels. The current situation of the energy tax harmonization within the EU member states sets the minimal energy tax rates for various energy fuels[24], namely on motor fuels, all heating fuels and electricity with differentiated rates for business use and households.

For comparison we can look at current tax rates for electricity and motor fuels to see the vast differences among countries depicted in following **Figure 5** and **Figure 6.**

[24] Council Directive 2003/96/EC – Energy taxation Directive

Figure 4 : Unleaded Petrol - Excise Duty rate
(Rate applicable from January 2008)

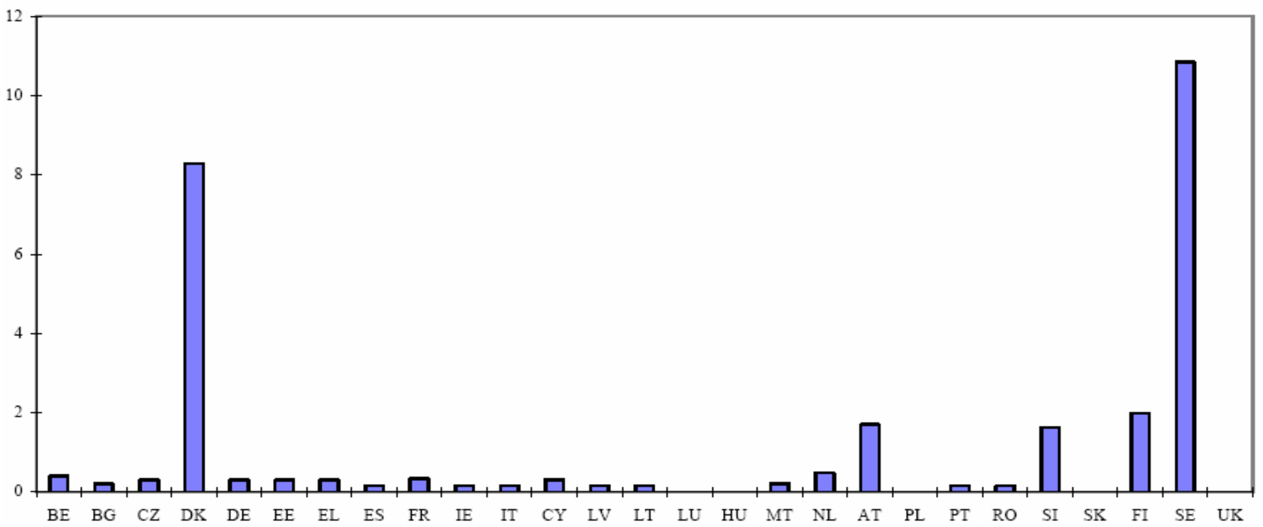


Source: DG TAXUD (2008)
Note: Minimum Excise Duty: 359 EUR per 1000 liter according to Directive 2003/96/EC. Values in EUR at 1/10/2007

In practice, these energy rates still differ significantly as some member states keep the energy taxation on minimal prescribed levels[25] and others have already imposed the tax rate many times higher than the mandatory minimum (especially Scandinavian countries). Different situation is also among the new member states, there most of the new EU10 still have the grace period for application of the minimal energy tax rates. The longest transition period have negotiated Poland, there the minimal tax rates will be applied in 2012, on the other hand the Czech Republic has already introduced the minimal energy tax rates in January 2008.

[25] Council Directive 2004/74/EC – amends the energy Directive as regards the possibility for the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia and Slovakia to apply temporary exemptions or reductions in the levels of taxation.

Figure 5 : Coal and Coke (heating "business use“) - Excise Duty
(Rate applicable from January 2008)



Source: DG TAXUD (2008)
Note: Minimum Excise Duty: Minimum excise duty: 0.15 EUR per gigajoule according to Directive 2003/96/EC. Values in EUR at 1/10/2007

Notably in **Figure 6** showing the tax rates for coke for business use there is evident the stringency in environmental regulation in Scandinavian countries – namely in Denmark (€ 8.29) and Sweden (€10.85) where there is in the final tax rate also included the CO_2 tax.

2. The Choice of Tradable Pollution Rights and Environmental Taxes

Tradable pollution rights/quotas and environmental taxes are nowadays common economical instruments of environmental regulation. The environmental regulation via taxes is a price based instrument. By imposing the tax we fix the marginal cost of compliance, however, we leave the final level of pollution uncertain. On the other hand, the quantity based instruments represented by tradable rights/quotas ensure the final level of pollution but leave the marginal compliance cost uncertain.

In this chapter we will examine in detail the differences between their usages. The choice of a proper policy instruments is an important part of successful regulation. We can divide the chapter into two parts: an analysis in the so-called *first-best setting* where we will compare the instruments per se and secondly an analysis in the *second-best setting* where the comparison will be placed into the interaction with other existing taxes (i.e. income or sales taxes). We will examine the possible negative welfare impact of such interaction named *tax-interaction effect* as well.

We will try to answer questions as: *when is it preferable to use taxes and when are quotas more efficient? Would it be more efficient to use them both? Is there any difference in their impact on effectiveness of the system, competitiveness issues or dynamics of the technological change?*

2.1. First-best setting analysis

2.1.1. Price or quantity regulation?

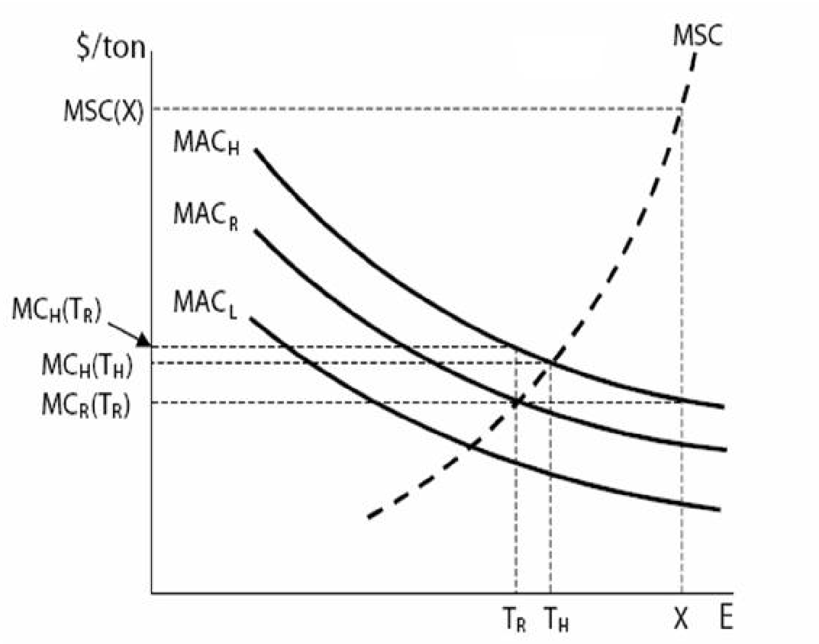
As was already mentioned in the introductory chapter, economic instruments of environmental regulation can be suitable and efficient in case where the abatement costs vary among the different polluting firms and in case of asymmetric information, when the regulator does not have the sufficient information about the abatement costs of regulated firms. The pioneer work that compared the different efficiency outcomes of taxes and quotas in field of environmental regulation under the conditions of information uncertainty was elaborated by Weitzman (1974).

In centre of Weitzman's attention there were different relative sensitivities of costs of abatement and benefits from the abatement (i.e. social costs from higher pollution) on the change of regulated emission reduction level. In the presence of incomplete information regulator simply does not know how much the costs of abatement are sensitive on the level of emission reduction. Generally it is perceived that the cost abatement curves are rising with level of abatement. The regulator makes his or her best prediction *ex ante* how such a marginal abatement cost curve may look like; however, this marginal abatement cost curve generally differs from the real shape of the curve known *ex post*. According to his or her prediction the regulator chooses the level of abatement. The regulator can choose to regulate the level of abatement either by price of quantity-based policy instrument. In a nutshell, Weitzman's point was that the better instrument is the one that is more probable to lead to the smaller mistakes in the stringency of control imposed.

Say it in the words of the economic theory: the different shapes of the marginal abatement curves and the curves of marginal social costs from the pollution are what matter here. Generally, Weitzman's outcome was that regulation via prices under the conditions of uncertainty is more efficient if the shape of the marginal benefit curve (or marginal social cost curve) is relatively flatter compared with the curve of marginal costs (i.e. is less sensitive to the not proper choice of level of abatement). And vice versa the quantity-based instruments are more efficient in case of relatively flatter marginal compliance cost curve compared to the marginal benefit curve of compliance or marginal social benefit curve. We can show it graphically at following figures.

Figure 7 depicts the situation where the marginal abatement costs are relatively flatter to the marginal social costs from the increasing level of pollution. On the horizontal axis there is the level of the abatement (starting from 100% level of abatement and decreasing along the axis towards 0% of abatement). Marginal abatement costs fall slowly with the decreasing level of abatement, on the other hand marginal social cost (MSC curve) growths rapidly with the increased pollution. Regulator assumes that polluters have their marginal abatement cost curve at MAC_R level. Therefore the optimal level of abatement is according to his or her assumptions the intersection of MAC_R with MSC. However, in the reality the real marginal abatement curve can have shape also either MAC_L or $MAC_{H.}$ The regulatory issue is to choose the instrument that would even with the changed MAC_L and MAC_H lead to smaller departure from the desired level of pollution abatement.

Figure 6 : When the Quantity instrument is better choice



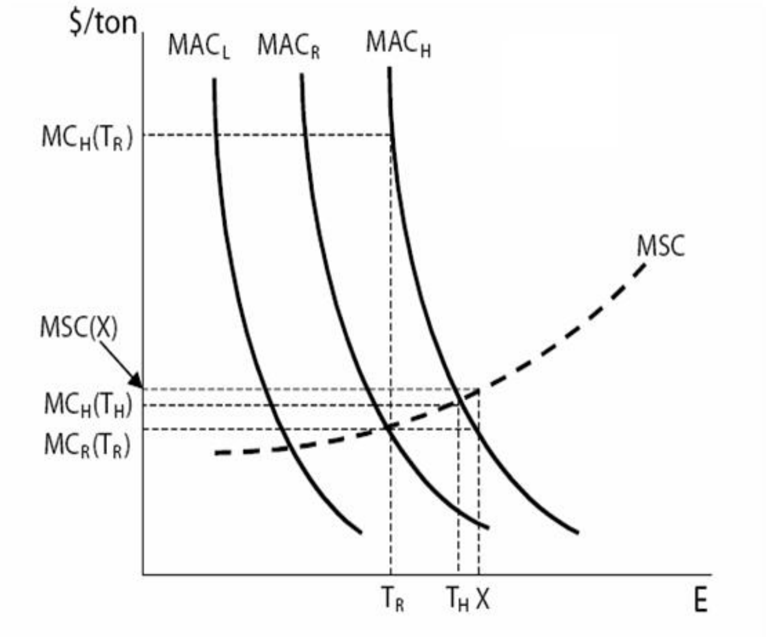
Source: Jacoby and Ellerman (2003)

If the regulator chooses price as the target of regulation, he or she sets the level of environmental tax at MC_R (T_R) where the assumed marginal abatement curve meets MSC. Later it shows that the real abatement costs are related to the higher marginal abatement curve $MAC_{H.}$ A new intersection of the chosen level of environmental tax with MAC_H leads to much lower level of abatement (X) and much higher lever of social costs.

On the other hand, if the regulator has chosen the quantity of abatement as a target policy instrument, he or she would have set the regulation at T_R level of abatement. In case of real higher abatement costs represented MAC_H, the chosen level of abatement would have led to slightly higher abatement costs (MC_H (T_R), however the final departure from the desired level would have been much lower. To sum up the outcome of **Figure 7**, the marginal abatement costs are less sensitive to the change of level of abatement that the social cost. Therefore it is more efficient to target quantity by the policy instruments.

Similarly, **Figure 8** shows the situation where it is more beneficial to choose the price as the policy target followed the same logic as before.

Figure 7 : When the price is better choice



Source: Jacoby and Ellerman (2003)

The marginal social cost are less sensitive to the changes of level of pollution (i.e. level of abatement), whereas marginal abatement costs of polluters are much more sensitive to the chosen level of abatement. If the regulator chooses $T_{R\ as}$ a target then with actual marginal abatement costs MAC_H polluters will bear much higher costs of abatement MC_H (T_R). In the same time these costs of abatement are much higher than the social costs at same level of abatement. Therefore, the choice of price-based regulatory instrument would be more efficient in this case.

2.1.2.Combination of price and quantity

Both in theory and in practice we can see that the price and quantity-based instruments are used in combination at the same time. From the environmental benefits point of view there is not a clear advocacy for it. If the total demand for the emission allowances is greater that the allocation, i.e. the supply, the taxes will only have influence on the distribution of the emission reduction within the system, however, will not lead to higher level of emission reduction.

Though, from the point of view of political economy of the environmental regulation we can mention several reasons why such a combination can be beneficial. The use of tax as a complementary instrument to the emission trading can support the stringency of the regulation and function as a penalty for non-compliance or they can be used to reduce uncertainty of the compliance costs (to serve as so-called safety valves). Another reason can be that the additional taxes might serve to capture windfall rents in case of free allocation.

Table 6 : Penalties and permit prices of selected tradable permit systems

Program	Permit price	Penalty
USA – Acid Rain Program	125-225 per ton in 2000 – 2004	2,000 USD per ton[26] (inflation adjustment)
USA - Ozone Depleting Substances system	n.a.	25,000 USD per kg
USA - NO_X	2-3,000 USD per tonne in 2004	Three allowances for each excess ton
EU ETS	Phase 1 : €0 - 30 Phase 2: €20* – 40* (*price prediction)	Phase 1: €40 + allowance price Phase 2: €100+ allowance price

Source: EPA (see Internet sources), OECD (2006), based on OECD (2003), PointCarbon (see Internet Sources)

First point is referring to the deterrent function on excessive polluting activity. In this case the tax rate would be designed to be very high to insure that the polluters will not dare to emit more emission than what is their actual endowment of emission allowances. The cost of monitoring can also influence the height of penalty tax. In the emission trading systems where there can be installed a real-time monitoring of compliance (e.g. the case of EU ETS and SO_2 and NO_X trading in the USA), the penalty price does not need to be as high because it is highly probable that the non-compliance will be detected. On the other hand, in case of less efficient monitoring, the penalty must be significantly higher to deter from the polluting activity. There is a negative correlation between the probability of being caught for the non-compliance and the optimal level of penalty (OECD, 2006).

[26] http://www.epa.gov/fedrgstr/EPA-AIR/1997/October/Day-07/a26531.htm (6.3.2008)

Second point, taxes can server as price caps for the system in case the non-compliant pays only the value of the penalty as a final price. In this sense taxes reduce the uncertainty for the emitters about the possible maximal cost of compliance. In other words, paying penalty instead of reducing the emission can be legitimate compliance strategy if the penalty is set sufficiently low.

Another reason why can be used taxes with emission trading combination is the possibility of capture the windfall profits in case of free allocation of the emission allowances. The example of such windfall profit tax can be the US tax on ozone-depleting substances that was applied together with the ODS permit trading program. This tax is applied to all sold ODS and on any stocks of ODS. According to the OECD Tax Database[27] the current values ranges between €1.33 and €133 per kg depending on their ozone depleting potential. OECD (2006) points out that the windfall profit tax is more proper to use in the case when permit relates to commercial products such as ODS products and not pollutants per se that are only part of the production process, however, not final products as ODS.

In case of EU ETS or Acid Rain program there are no great examples of such wind fall tax. Some tendencies can be seen from the media news for example in Spain were government intents to push Spain's utilities to write off €1.2 billion from their balance sheets after the government published calculations on how it will hold power companies liable for booking windfall profits from emissions trading[28]. The future development of the windfall profit capturing within the EU ETS mainly in the power sector will probably follow the way of introduction of greater portion auction of allowances in the allocation process rather than introduction of windfall profit tax. For example the current version of draft of post 2012 revision of the EU ETS proposes 100% auction for power sector. We will discuss the post-2012 development of regulation in Chapter 3.

2.1.3. Price or quantity – The case of Climate Change

In general, we can label the pollutants as a stock pollutant or a flow pollutant. In case of the environmental damage, what matters is the total concentration of the pollution – i.e. the existing stock, rather then the flow of pollutants. The current flow

[27] http://www2.oecd.org/ecoinst/queries/index.htm (10.3.2008)
[28] PointCarbon News 20.11.2007 at www.pointcarbon.com (8.2.2008)

contributes to the changes and affects stocks in the future, but in many cases the current flow does not contribute directly to current damages. This may be also the case of climatic changes and the concentration of greenhouse gases in the atmosphere. The changes caused by concentration of greenhouse gases today are effectively almost the same as tomorrow, therefore the marginal benefit of abatement (or marginal cost from pollution) is rather flat as it is shown in **Figure 8** before. In this sense it seemed to be more suitable to regulate it via taxes rather than tradable quotas.

For this argument we also find several supporting findings in academic literature. For example Hoel and Karp (2001) summarize the recent developments in the academic literature by stating (p.92, ibid) that in almost all the previous literature (i) *a steeper marginal environmental damage curve, or a flatter marginal abatement cost curve favor the use of quotas and (ii) a higher discount factor or a lower decay rate – factors which make stocks more important – favor the use of quotas.* They compare the taxes and quotas in case of application to global warming and the concentration of greenhouse gases. They support the finding that also in the case of global warming the taxes dominate quotas. They stressed out that the question of uncertainty and its modeling makes the right choice of regulation policy very important. Pizer (1999, p. 29) tries to quantify the benefits of both policy instruments in case of global warming and sums up that the expected net gains of a harmonized tax are fives times higher[29] than even the most favorably designed quantity target. Also Nordhaus (2005) summarizes the possible approaches towards climate change issues concluding that price-type approaches are likely to be more effective and more efficient solution.

In theory we can see that the choice of some kind of harmonized carbon tax that would regulate the greenhouse gases would be probably more efficient solution for global warming issues. However, in the real world we see that the global politics prefers to regulate it via (tradable) quotas such as in case of EU ETS or Kyoto Protocol under UNFCCC. Why it is so?

[29] $337 bn versus $69 at a global level incase of tax. The simulations are based on a global quantity target of 8.5 GtC and a carbon tax of $80/ tonne CO_2.

The evaluation of the choice of either price or quantity instrument but not lays only on the comparison of the objective efficiency costs and benefits. In the real unperfected world we should at least briefly mention the obstacles hidden in the policy decision making process where the different interest groups try to influence the policy outcome.

The implementation of new environmental regulation instrument will trigger opposition of the polluters that should be regulated. From the polluters point of view the choice of grandfathered emission permits the cost for polluters are not so explicit therefore it will be preferred by this interest group. On the other hand the implementation of taxes or auctioned permit system will create a possible new income for the regulator and politicians in general in case of both taxes and auctioned permits that will motivate the regulator to choose this way. These are two opposite influences that are present in the decision making process. The final outcome has to always be based on agreement among the interest groups – therefore it will depend on the relative exertive power of the different groups.

In case of regulation of business sector we may expect much higher influence on the final regulation than in case of regulation of households. This may also be partly a reason why the emission trading (mostly grandfathered, i.e. allocated for free at the moment) is favored to carbon taxes in practice. This regulation is more supported by the industry that is quite well organized in expressing its opinions in comparison with the household sector.

When we are speaking of the implementation of the internationally-based policy there is again the same problem with diverse interest and opinions that impede the international agreement. The negotiation on the EU-level and the negotiations on a global world level may serve as examples.

Within the EU to introduce a new EU-harmonized tax there is a unanimous agreement in the EU Council of Ministers needed. There, however, a proposal for EU-wide CO_2 taxation was defeated. The strict rules for unanimity however do not hold for implementation of other regulation that is not a tax. Therefore there was no legal constrain on the EU to agree on emission trading with qualified majority without unanimous consent.

What we can see on the functioning of EU ETS is a gradual tendency to tighten the allocation rules and to implement higher share of auctioning into the existing emission trading system once the industry participants have learned the core mechanism of the system. By these gradual changes there are definitively lower transaction costs of policy implementation compared to the case of carbon taxes where there are explicit costs for the participant imposed from the beginning of the regulation and in the same time the system moves slowly to the almost tax-based system by growing share of auctioning. According to the current proposal of EU ETS revision directive[30] there is assumed in the 2012 it should be already more than half of the allocation auctioned and by 2020 the whole 100% amount of allocation should be auctioned.

2.2. Second-best setting analysis

The final impact of market based environmental regulation can be significantly different from the principal intentions of the regulator. The existence of pre-existing taxes and tax exemptions heavily influence the final effect of imposition of carbon taxes and/or tradable emission permits. By introduction of taxes or tradable emission permits we add a new element into the complex regulatory system. The increase in costs of emission intensive production factors will have repercussions speeding up the growth of costs in other sectors.

The second best setting analysis examines the final effects in the general equilibrium setting. In the academic literature the core contributors appeared in the mid 1990ties represented mainly by several works of Ian W.H. Parry, Wallace E. Oats, A.L. Bovenberg and Lawrence H. Goulder.

Generally, we can divide the concerns of second-best setting analysis into three main topics of adverse effects mentioned in the literature:

- Primary welfare gains and costs
- Revenue recycling effect
- Tax-interaction effect

[30] See Internet sources for link to current version of EU ETS Revision Proposal

The first effect was in the centre of attention also in the first best (partial equilibrium) setting analysis. It compares the welfare gains and costs from the internalization of the external costs (so-called externalities) of pollution in the sense of traditional Pigouvian approach. The optimal level of the regulation from the point of view of its efficiency should be where the marginal social costs equal the marginal social benefits. In this situation implementing the environmental tax in the value of the marginal social cost of pollution will drive the economy to the Parreto-optimal level. In such partial-equilibrium analysis the revenues are normally considered to be returned in the lump-sum fashion to the participants. However to compute the total efficiency impact we have to compare it with the additional two effects: revenue recycling and tax-interaction effect.

2.2.1. Revenue-recycling and tax-interaction effect

The revenue recycling effect can occurs only in case of revenue-raising regulation instruments (taxes or auctioned tradable permits). With the non-revenue raising instruments as grandfathered emission permits we can speak only about the indirect recycling effect stemming from the higher corporate profit taxes from higher profits of firms that received the permits for free and have monetized them.

As the name suggests, the revenues yielded from the environmental taxes or auctioned emission permits are "recycled" within the existing tax system via reduction of other distortion existing taxes (mainly in the labor market). In academic literature the main authors focusing on the benefits stemming from the recycling of revenues were for example Pearce (e.g. 1991) or Nordhaus (e.g. 1993). They were speaking of the effect of a "double dividend" via curbing emissions and the pre-existing tax distortions at the same time. Their argument was that by reducing the taxes on labor we are decreasing the wedge between the gross wage paid by the employer and the net wage received by the employees – therefore increasing the real household income that may contribute to the increased level of labor supply and labor demand.

However here comes the third effect mentioned in the literature: the tax-interaction effect. Market-based instruments of the environmental regulation try to internalize the external costs in the sense of Pigouvian tax. They increase the cost of emission intensive production factors that may lead to the change of the composition of consumption by favoring the cleaner goods. These regulatory instruments raise the production prices and leads finally to the reduction of the real income of households and to decrease of labor supply and demand.

Typically, environmental taxes or tradable permits increase the cost of energy inputs of production (i.e. electricity, coal, oil and gas). These increased costs are further transmitted to some extend to the final consumers. The degree of passing the increased cost to the final consumer depends on the price elasticity of demand of the final consumers. Electricity markets are often quoted as environmentally regulated markets where the great majority of increased cost of production due to environmental regulation can by passed through to the end-users. The reduction of the household real wage may lead to the reduction of labor supply by decreasing the real value of one working hour compare to its substitutes represented by leisure time.

The idea of tax-interaction effect is also align with common optimal (Ramsey) theory of taxation. According to the optimal principle the more efficient are broad-based taxes compared to narrower ones. The effect of the narrowly focused tax is that it pushes people from the taxed activities or goods towards those non-taxes and by this distortion of activities or consumption pattern creates an excess burden of the tax system. This also seems to be the case of substitution of revenues of labor taxes (broader-based ones) by environmental taxes (narrower ones). In the second-best setting the optimal tax should show the balance between the social benefits from the decreased pollution and social cost that occurs with the excess burden of the tax system.

The degree of the tax-interaction effect depends mainly on several features:

- level of emission abatement required
- degree of pre-existing tax distortion

Several findings conclude that the efficiency of environmental regulation in a second-best setting with distortion taxes is usually lower than in a first-best world. For example, Goulder et al. (1998) concludes that the occurrence of pre-existing tax rates may have a significant influence that may lead to substantial cost increase (35 percent or more). They stress on that the impact of pre-existing taxes is particularly large for (non-auctioned) emissions quotas, where the cost increase can be even several hundred percent.

Bovenberg and Goulder (1994) come with concrete numerical results from running both numerical and analytical model on the U.S. data. Their finds are summarized in **Table 7**. Generally, they support the occurrence of the negative tax-interaction effect that degreases the optimal level of taxation in comparison with the first and second-best setting. In some of their scenarios the computed outcome shows that the zero rate environmental tax (i.e. no tax) would be the most efficient.

Table 7 : Difference between the Optimal tax rates in the First and Second-Best Settings

Assumed Marginal Environmental Damages ($/ton)	„Optimal" Pigouvian Tax in the First-best setting ($/ton)	Optimal Tax Implied by Analytical Model (replacement of Personal Income Tax) ($/ton)	Optimal Tax from Numerical Model		
			Realistic Benchmark		Optimized Benchmark, Personal Income Tax Replacement ($/ton)
			Lump Sum Replacement ($/ton)	Personal Income Tax Replacement ($/ton)	
25	25	22	0	7	17
50	50	45	0	27	41
75	75	67	13	48	64
100	100	89	31	68	85

Source: Bovenberg and Goulder (1994)

2.2.2. Induced innovation effect

Both empirical and theoretical findings confirm that environmental regulation may be one of the stimulating motives for the firm's decision to innovate. The regulation can act as a demand-push factor that can influence the amount and the direction of the innovation. Therefore we are speaking about the induced innovation that follows the direction of regulation. The technology response may vary from incremental changes represented by the end-of-pipe technology inventions which does not change the production process itself or more radical changes, e.g. in form of clean technologies that are able to decrease firms cost in the long-run. As far as the different regulation instruments are concerned, generally the market-based instruments are supposed to be more innovation inducing as they give the operation space to the polluter to choose according to his/her needs

At this place we can mention several studies that treat the induced innovation effect of the environmental regulation both theoretically and empirically. Requate and Unold (2003) and later Requate (2005) summarize the latest theoretical approaches in this area of research. They confirm the assumptions that market based instruments are more efficient that the command and control instruments – if there are placed in the market environment with competitive conditions. They critically review the historical approaches that tried to evaluate the innovation induced effect of environmental regulation by counting the total industry costs before the implementation of the new technology and after it. In such a setting the efficiency ranking was (Requate and Unold, 2003): 1. Auctioned permits, 2. Taxes and subsidies, 3. Grandfathered permits, 4. Emission standards.

Instead of this, Requate and Unold (2003) and later Requate (2005) focus on the individual firms and their decisions to implement a new technology at the point of the markets equilibrium. They compare two options concerning the attitude of the policymakers. In the first scenario policymakers do not anticipate the technology change, however, in the second scenario policymakers set the direction of the technological change in the intended direction. They come to the conclusion that in case the regulators do not anticipate the direction of the technological innovation (which is quite realistic view), taxes may serve as better innovation incentive in the long term than tradable permits.

On the other hand, in the second scenario, the difference in the effect of taxes and tradable permits is erased. The reason why it might be so we have already discussed in the previous subsection devoted to first-best setting analysis, if the regulator assumes properly the marginal abatement curves of the polluters he or she sets also the level of abatement or tax level properly and it does not matter which policy instrument is chosen. Interestingly, the authors also did not find the difference in the influence on the level of innovation between the auctioned permits and grandfathered permits. This sounds reasonable, because firms always count with the price of the permits in their investment decisions either as an explicit price they have to pay in the auction or an implicit price in form of opportunity costs in case the permits are allocated for free.

What are the findings of the innovation effect of the environmental regulation in the empirical works? Here the impact of environmental regulation on technological change can be measured by level of R&D expenditures, adoption of new technologies or products by firms or the easiest observable - the number of new patents. Indirectly and more tediously it can be measured by the number of firms that have exit from the market or by the change of the abatement costs. The very extensive summary of the latest empirical findings provide OECD (OECD, 2007) that encompassed over 40 individual research papers mainly based on the evidence in the USA. The major conclusion of the study is that there is an evidence of the impact of environmental policy on the technological change – or at least on the direction of the technological change and this holds both for market-based and command-and-control regulatory instruments.

The shortcomings of the empirics are a lack of the data and much shorter history of the market-based instruments compared to traditional command-and-control regulation that does not allow us to say robustly whether the market-based instruments outperform the latter one. Studies that try to compare these two different types of regulation mainly focus on the US regulation of SO_2 via Clear Air Act and its implementation of emission trading via Acid Rain Program in the mid 90ties and secondly on the lead in gasoline phase-down trading in then 80ties. In both cases, there can be found studies that are confirming better performance of the market-based instruments. For example Burtraw and Palmer (2002) in their analysis of implementation of the Clean Air Act conclude that "*there is an ample evidence that allowance trading has achieved cost saving" and that the program also triggered experimentation and innovation through changes in organizational technology and organization of markets."* (ibid., p. 25). They show that by the amended regulation of the Clean Air Act there were also influenced not only the final suppliers but also the intermediate industries (e.g. scrubber manufacturing, coal mining companies or railroad transportation) which were competing in finding the low cost compliance strategies for the electricity generating industries. This resulted in price fall of low sulphur coal by 9% (when the sale of low sulphur coal increased by 28%) and fall of the high sulphur coal by 6% (with the 18% decrease of sales) mainly for the improved efficiency of the transport and scrubbers. Also Lange and Bellas (2005) focusing on the SO_2 trading within Acid Rain Program conclude that innovation decreased scrubber costs and improved efficiency, however, they point out that the decrease in scrubber costs is more probably just once-in-time fall instead on the continual process.

3. Design of emission trading system – allocation matters

While designing the emission trading system there can be considered several determinants of the efficient functioning of the system, as there are choices of proper industrial sectors to be covered by the regulation, allocation method to distribute the emission allowances and finally setting the proper emission reduction target to create enough incentives for the emission reduction. We have chosen only one determinant for the deeper both theoretical and practical analysis thanks to the limited scope. Another for analysis of the allocation method is the future revision of the biggest emission reduction trading scheme: the EU ETS that will be based mainly on the revision of the allocation method.

In this chapter we will pay the attention to possible methods that can be used for distributing the emission rights among participants of the system. Emission permits can either be given away freely according certain rules (e.g. according to the historical levels of emissions or various technical benchmarks) or auctioned off – sold to the participants. Both those options have benefits and drawbacks. The volume of allocated allowances determines the scarcity of the allowance – their price on the market and therefore the total effectiveness of the system. To design the effectively working system the basic rule should hold: there have to be allocated less emission permits than is the actual level of pollution to create the demand for abatement and effective price of the allowances.

We will first theoretically discuss all those possible options. Special attention will be given to the auctioning option of allocation as it is allocation method that is being preferred both by the theory and more and more also by the practical usage. Later on, we will move towards the analysis of the practical usage of the allocation methods in the most important existing system of emission trading: EU ETS. Finally we will tackle the topic of future development if EU ETS by summing up the most important features of the current version of the EU ETS revision Directive that was introduced in January 2008.

The objective of this chapter is to offer the answers to following questions: *What are the possible methods how to distribute emission permits among the system participants? How they are used in the existing emission trading systems?*

3.1. Allocation strategies in theory

3.1.1. Grandfathering – allocation for free

Grandfathering represents the allocation method where the allowances are allocated for fee. Compared to the second allocation option where participants have to buy their emission permits at the auctions, here participants do not have to pay the direct costs of permits. The value of permits represents the opportunity costs for them (because if they do not use the permits for their compliance, they can sell them on the market, the opportunity costs are therefore equal to the price the polluters would received on the market). For that reason they incorporate them into the list of their variable costs of production. Participants are paying just for the additional permits above their level of individual allocation; they buy them on the market.

The grandfathering creates much more responsibilities for the regulator to design transparent and effective rules how to allocate. This seems as a big disadvantage of this method: the sensitivity to the political decision of the regulator (and obviously related political and lobbing pressure of the participants on the market). In case of not well designed rules of allocation via grandfathering, the regulator can create distortions to the markets and offer a hidden state aid to the most powerful lobbying groups. Grandfathering methods of allocation are always reflecting somehow the historical behavior of the participants. Therefore other disadvantage is the necessity of transparent reliable data about the historical emissions or production output/ input (depending on the concrete allocation method). This creates another burden that the regulator has to take on his back. Free allocation accumulates not negligible administrative costs that the regulator pays and it is not generating any financial revenues that would repay at least part of the cost. Despite, up to present in nearly every case of implemented cap-and-trade programs, allowances have been allocated without charge to participants. The reason why may by the higher acceptability of such a system for the participants

There exist various ways how to allocate the permits gratis. Generally, there are two basic metrics for such allocations:

a) Allocation according to the historical emissions of installation

The regulator chooses the base year of emission and sets the target of emission reduction compared to the base year that should be achieved. According to this target the regulator later redistributes the emission allowances (each facility would get for example allowances amounting the 90% of its emission in the base year). For the emission-based allocations, one could consider whether to use "direct" emissions (i.e., emissions directly from each installation) or the sum of direct and "indirect" emissions, which would include estimated emissions from the electricity and heat used at the facility as well. (In reality in the existing programs, we can see the usage only of the direct emission as it is practically more feasible)

b) Allocation according to the benchmarks

Generally, there are many alternatives for allocation methods that are based on benchmarking. We can differ between: Input, output or capacity benchmarks. The benchmark can be defined as emissions per unit of input (Typically these inputs of energy, but they may refer to other raw materials. e.g. units of coal, lignite, gas) or emission per unit of output (e.g. electricity produced). It is also possible to define a benchmark related to capacity, often in conjunction with assumed utilization rates. The activity (e.g., output, input) used in the benchmark for each installation can be determined in various ways either including historical, projected, or continuously updated during different allocation periods

There can be also set various criteria related to the benchmark rate including the "best" available technology, the industry average, or some projected level. Benchmark rate can be also differentiated for multiple subsectors or other categories within a sector. The goal of benchmark in allocation is to increase the transparency and distributional fairness of the system because comparable and equal measures are implemented to all participants. This seems to be the biggest advantage compared to the allocation based simply on the historical emissions of individual installations which is favoring those installations with higher historical emissions.

In general, benchmarking approaches are combining the site-specific information together with standardized measures, The most direct approaches are input- and output-based ones that multiply a site' s process or energy input or its output by an emission factor. **Annex Table 1** summarizes the 4 types that are based always of different combination of site-specific and standardized information.

The main disadvantage is however the hard task for the regulator how to define such benchmarks, how to set the benchmarking rates and how to set the categories where the same benchmarking rates would be applied. This again can be a difficult issue for the regulator to face the political and lobbying pressure during the process of preparing the design of the benchmarks.

3.1.2. Auctioning – polluters pay

Within the allocation by auctioning, participants have to buy the emission permits by bidding on an auction. There are several advantages related to choice of auction as an allocation method. The main advantage of using auctioning as an allocation method is that there is simply no allocation method needed during the process. The regulator only sets the overall allocated volume he/she wants to put into the auction and the concrete allocation is done via the market competition during the bidding at the auction itself. Therefore it lowers the information burden for regulator and overcome the inherent information asymmetry that is rooted within the relationship of regulator – polluter. Another advantage is that since there is not needed any time-consuming negotiation and everything is settled within an act of auction, it is the fastest allocation mechanisms. Apart from that there is another not negligible advantage for the regulator: the new source of revenues from the auction of permits.

While speaking about the design of auction suitable for emission permits we should focus on various important features of possible auctioning: the format of auctioning (one round or multi round) that is also connected with the frequency of auctions (once in the allocation period or every year/month), harmonization in case of multi-country model (one multi national auction or national auctions) and last but not least the way of auction revenue recycling (R&D into renewable sources of energy or giving back to industries involved in the emission trading). It is also interesting to consider how these different options of concrete design of auction affect different participants of the scheme – for example we can look whether the smaller participants have the same conditions as the bigger ones under this allocation scheme. We should also consider whether there is a secondary functioning market for the auctioned permits and how much is the market for allowances concentrated.

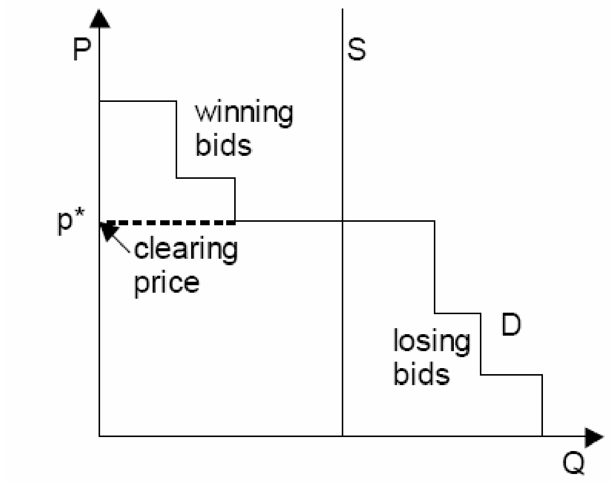
3.1.2.a. Auctioning format

The auction of emission permits is a type of auction where there are sold amounts of units of identical and homogenous commodity. Generally, we can speak about two kinds of auction: static one-round (sealed-bid) auctions and dynamic two-(or multi-) round (open) auction. The main difference between them is that in the multi-round auction participants can adjust their bids between the individual rounds of auctioning process – they accurate their bids according to new information about the overall market and prices received during the previous rounds of the auction. This is the biggest advantage of multi-round auctions, that they reveal more information about the emission allowance prices to the system participants during the process of auctioning. On the other hand the main advantage of static auction may be its simplicity both for the organizer and participants. **Annex Table 2** gives the summary of various auctioning formats mentioned in the text and/or relevant in the field of emission permit auctioning.

a) Static auction

There are many different auction forms possible. We can divide them into two basic forms: uniform price auction and discriminatory price auction (pay-your-bid auctions). In static auctions, the simplest setting is a situation where a seller - regulator is offering a fixed supply of identical items and the buyers express their willingness to buy various quantities at various price levels by submitting bids at the auction. The regulator adds these demand schedules to form an aggregate demand curve and to find the market clearing price where the demanded volume of allowances is equal to the volume of allowances that the regulator wants to distribute. All bids below the clearing price are rejected. All bids equal or greater to the clearing price are winning; those at the clearing price have to be rationed. All winning bids pay the market clearing price – the price of the last marginal bid. The situation of the uniform price auction is shown graphically in **Figure 8**. This format of auction is also common for the electricity markets[31].

Figure 8 : Aggregated Demand Curve for Uniform Price Sealed Bid Auctions



Source: Crampton and Kerr (2002)

This pricing mechanism is efficient in case where no individual bidder is able to influence the market price. Because when there are only few participants on the market they can strategically influence the prices by bidding artificially low price and therefore lowering the final marginal clearing price. This is called *shading* of bids. To use this strategy, a bidder would need to estimate the quantity of all bids of other participants of the trading scheme to estimate their chance of influencing the market price effectively.

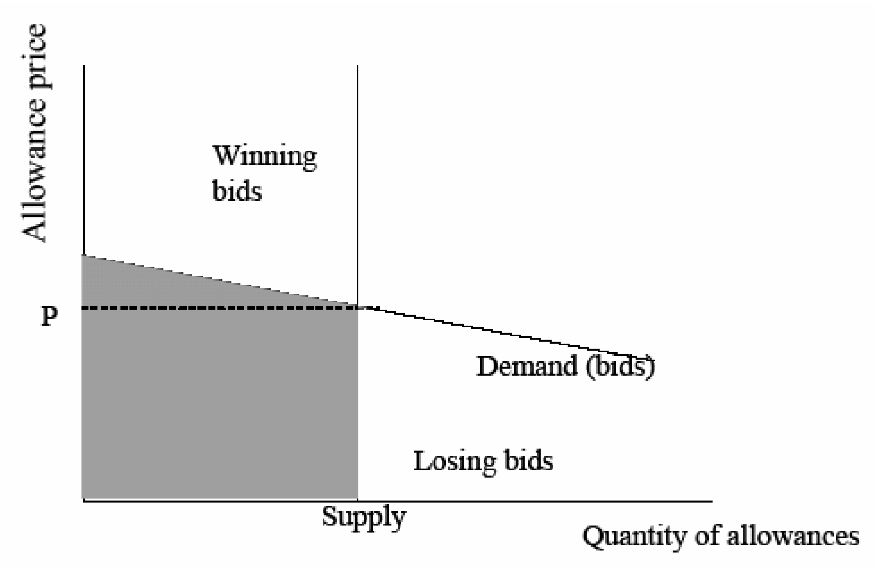
Regulator can reduce the possibility of artificially low clearing price due to strategic behavior of the market participants by introduction of minimal reservation price into the auction. In such a situation permits cannot be auctioned bellow the reservation price.

With Discriminatory Price Auction, each winner pays the price of his/ her own bids as it is depicted in **Figure 9**. Each bidder attempts to guess what the clearing price will be and then bids slightly above it. Under pay-your-bid format of one round auction,

[31] However at power auctions, the price is formed by the marginal bid that is the highest not the lowest one

optimal bids are created more according to the best guess of the market clearing price, rather than according to the marginal values of individual bidders.

Figure 9 : Pay-your-bid Auction



Source: Entec and NERA (2005)

This kind of auction is also sometimes called pay-your-bid pricing. The disadvantage of this kind of auction is that it may raise the potential for an economically inefficient allocation where the allowances are not allocated to the bidders who would pay the higher price for the allowances but rather to those bidders who most precisely estimate the clearing price, i.e. those with the best information about the market. In this sense such auctioning format may favor the large participants on the market because small or inexperienced bidders may perceive it too difficult to predict the market clearing price and might be deterred from bidding for fear of making costly mistakes.

While it might at first sight be thought that the pay-your-bid auction would result in higher revenues to the seller than the uniform-price auction, bidders will tend to bid lower prices in a pay-your-bid auction than in a uniform-price auction so there may not be much difference in the total revenue (DTI, 2005). For example Archibald and Malvey (1998) even mention that there are some evidence of higher revenues from uniform price auctioning e.g. in securities auction markets.

It should be stressed that the market participants behave with different pricing strategy under each mentioned auctioning format. The incentive to shade the bids will be much stronger under the discriminatory pricing. All bidders have the opportunity to re-sell the permits on the secondary market for the same re-sale price for all the bidders. Therefore the bidders estimate what this price will be and set their bids according to it. On the other hand the incentive to shade the price under the uniform pricing mode will be only in case the participants think he/she can influence the final clearing price.

Another problem related to the possible concentration of power on the market and the possibility to exercise the power is possibility to "*short squeeze*" the market. This term refers to the case where one bidder attempts to corner other players buy buying large amount of allowances and later re-sell it at higher prices to those that are short. In case the aggregated demand bidding curve is very flat near the clearing price, one can win a large share of the market at little additional expense (i.e. by just overbidding the last highest price by a small amount). Cook (2005) pointed out that this was a significant problem in US Treasury auctions in the early 1990s, and as a result the US Treasury switched from pay-as-bid to uniform pricing in 1998.

b) Dynamic auction

Within the dynamic auction market participants have more time to adjust their bids according to the information discovered in the earlier auction rounds. Among other options there are two basic ways of conducting the dynamic multi-round auctions: either as an ascending so-called English auction or a descending (Dutch) auction.

In an ascending-clock auction price is gradually raised until there is no excess demand. The demand schedule approach can be seen as a multiple-round version of the sealed-bid auctions. In each round, bidders submit a demand schedule. The schedules are aggregated to form the demand curve. The clearing price, where demand meets supply, defines the split between winning and losing bids. If this were the final round, those bids above the clearing price would be winning, those at the clearing price would be rationed, and those below the clearing price would be rejected. The process repeats until no bidder is willing to improve (raise) its bids. The descending-clock format is reverse process similar to English auction, however, starting with the highest prices and repeatedly decreasing the price.

For efficient working of the multi-round auction it is important to set the rules to minimize strategic behavior. Two things might be considered: First issue is setting the proper rules for bidding. For example with English-type auction each bidder's activity in one round predetermines the bidding amount of the subsequent round, i.e. the number of units requested in a one round and cannot be raised in subsequent rounds. The activity has therefore so-called "lose-it-or-use-it" feature that prevents bidders from shading their interest in early rounds.

The second issue is related to information to be revealed within the single auctioning rounds. What exactly should be revealed to the participants? Bidders will see the price development during the each stage; however should the regulator also unveil something more about the bidding amounts? Burtraw (2007) while summering the current real-life experience with this question assumes that the best option is not to reveal the total number of allowances requested in each round so that bidders will not be able to determine whether unilateral demand reductions on their part will stop the clock. Providing less information will discourage collusion among bidders.

3.1.2.b. Auctioning frequency and multinational harmonization

There are various options how frequent the auctions can be. We can consider the extreme case where the allowances are auctioned only once per the allocation period or continuous auctioning on yearly/monthly or even daily basis. All the options have their pros and cons.

The election of the frequency format is driven by three main criteria. First, high frequency allows most participants to find their bidding volumes close to their actual demand. With less frequent auction this balancing of needs is offered more by financial intermediaries as they are prepare to bear financial exposure to price risk on the open position and via secondary market. Second, with higher frequency auctions only a lower volume of allowances enters to the market. Thus, such volume does not destabilize the market and offer lower possibility to exercise the market power of the large player on the market (even if a market participant could purchase all auctioned allowances, he/she could not short-squeeze the secondary market). Third, transaction and administrative costs of auction. With higher frequencies of the auction these costs are increasing and reduce the total revenues of the regulator.

The auctioning frequency influences the liquidity of the whole system. There is a natural trade off between the transaction cost on one side related to more frequent auctions and the influences on the liquidity of market on the other side related to less frequent auctions. To auction all the allowances in one auction could hamper the functioning of the system as the huge influx of allowances destabilizes the price stability. On the other hand too frequent auctions would generate excessive administrative and transaction costs both for the regulator and participants. The key features related to this matter are presence of the functioning secondary market (e.g. stock exchanges) and the volume of allowances to be auctioned because it makes difference whether the allocation method via auctioning is only auxiliary allocation instrument (e.g. only a share of total volume is allocated via auction) [32] or it is the only means of allocation.

a) More frequent auction

As was already mentioned to auction less amount but more frequently has several advantages. First, it brings advantages for the regulator. It lowers the uncertainty of revenues for the regulator and reduces the possibility that the whole allocation amount would be auctioned in the period of low allowance prices. With more frequent auctions the relative significance of any auction is reduced, consequently, it reduces market and political risks from mistakes during the initial learning phase.

Second, it offers better conditions also for the smaller emitters to participate on the auction of the system. With single one-off auction at the start of a trading period it would be required large initial investments from companies. Therefore, smaller companies would be in a less advantageous position. Another thing is that to ascertain that auction participants will pay for their bids; there are common requirements for credit or collateral to be posted before the auction. The collateral may be either equal to some share of the value of the bid the participant want to submit or as a unified fee. The greater the amount of allowances to be auctioned the

[32] e.g. as in current EU ETS, there is allowed to auction only certain amount of allowances (5% in Phase 1, 10% in Phase 2) and the rest of allowances has to be allocated for free

greater the collateral requirements are needed. This may again limit the smaller players as their financial position is not so strong.

Third, more frequent auctions can reduce the negative effect on the price stability. If there are frequent auctions, producers can purchase allowances at the time when they are selling the product and they hedge themselves against the uncertainties created by an open position. In case of longer periods between the auctions financial intermediaries substitute the role auction and offer the sales of allocation within the periods between individual auctions however they charge the risk premium for carrying the risk of an open position. The longer are the periods between the auctions, the higher is the risk premium. E.g. Neuhoff (2007) is discussing an impact on the frequency on the value of risk premium pointing out that by higher frequency the charges for risk premium significantly drop.

b) Multinational organization of auctions

While speaking about the international emission trading schemes (such as EU ETS) and the possibility of auctioning we should focus on the issues related to framework of multinational organization of individual auction: whether to choose either a harmonized format of national auctions, single auction for all participating states or leave the organization of auction on the national authorities without any harmonization.

In first general question whether to harmonize the national approaches or not there is a broad consensus in the academic literature that some kind of harmonization of national auction reduces the transaction costs and stabilize the system and avoid distortion (most recently e.g. Ahman et al (2005), Hofmann (2006) Hepburn et al (2006) or Neuhoff (2007)). Among the advantages of such harmonization there are mentioned the reduction of set-up costs for the national regulators (economies of scale), reduction of cost for the players (by avoiding the multiple registration in various auctions and acquiring information about them) and last but not least harmonized auction would reduce the need for arbitrageurs.

In case of no harmonization of national auctioning schemes there would be higher pressure on the national regulators to favor and protect the domestic industries that could result in conflict with the strict state aid legislation (e.g. in the case of EU).

There would also occur the problem how to treat the foreign and/or international firms –whether to restrict them from some national auctions that would again conflict with the state aid rules or to open the auction to all participants.

In case of harmonization there would be needed co-coordinated action in setting harmonizes timetable and setting common reservation price. Without unified price floor there would be a competition among the auctioneers to set lower reservation price in order to attract more bidders.

There is not a wide consensus about how often the harmonized auctions should be organized. For example Hepburn et al (2006) consider two different possible ways how to set up the auction either to follow the format based on the experiences with electricity markets (e.g. weekly auctions) or follow the different format based on experienced with Treasury bill auctions (less frequent 1 – 3 times a year).

In case of single auctioning platform common for all participating players there can be chosen an independent hosting institution that would run the auction. The member states would later share the revenues according the relative size of their national allowance allocation. There can be also used already existing exchanges of secondary market and sell the allowances directly within their trading schemes.

3.2. Allocation strategies in practice

In general, all the emission trading schemes that we have mentioned in this thesis are mainly based on the grandfathering method of allocation with limited amount of allowances being auctioned. The explanation for that lays probably in the political economy issues mentioned earlier in the text. To implement a completely new regulation it is more feasible to start with less stringent way of the regulation – that is represented by the allocation for free in case of implementation of emission trading schemes – to gain the larger political acceptance of the regulated participants. This political acceptance later creates space for introduction of stricter rules in form of large share of auctioning within the scheme. This is apparent for example in the EU ETS scheme, which will be in centre of our attention in following sub-chapter.

Table 8 : Allocation Approaches in existing and proposed emission trading schemes

Program	Emission Covered	G	B	A	Uses of Revenues
			Existing		
U.S. Acid Rain Program	SO_2	yes	-	2.8%	Recycled to participants in proportion to grandfathered allowance allocation (a share of which is withheld for auction)
California RECLAIM	SO_2, NO_X	yes	yes	-	-
U.S: OTC/SIP Call	NO_X	yes	yes	partly	n.a.
EU ETS Phase 1	CO_2	yes	yes	Max 5%	JI/CDM credits; administration costs
EU ETS Phase 2	CO_2	yes	yes	Max 10%	JI/CDM credits; administration costs; renewable energy; energy efficiency; national fund for environmental protection
Swiss ETS	CO_2	yes	-	-	-
Danish ETS	CO_2	yes	-	partly	-
			Proposed		
EU ETS Phase 3 -	CO_2 and N_2O	partly	yes	Up to 100% in 2020	Renewable energy; energy efficiency; CCS
RGGI (USA)	CO_2	yes		Min 25%, some states up to 100% (e.g. New York)	Energy efficiency and clean energy technology
USA Federal trading schemes proposals	CO_2, GHG	yes		partly	Various

Source: Harrison (2007), internet source of Swiss ETS
Note: G = Grandfathering, B = Benchmarking, A = Auctioning

However, contrary to what was said above, what we can see on the new emission trading schemes that will be introduced in the near future is the general movement towards allocation via auctioning, and the movement towards compulsory minimal level of auctioning. The reason why may lay in the advances of the practical implementation of emission trading in the USA (regulation of SO_X and NO_X) and in the EU (regulation of GHG) that show the inefficiencies of the 100% allocation for free. The example of the trading scheme being introduced with mandated minimal level of auctioning of 25% is the RGGI - regional trading scheme among the 10 U.S. states that will start in 2009.

Table 8 gives a summary of allocation method in existing and proposed ETS. In the following subchapter we will look closely on the EU ETS scheme and the difference of allocation among the member's states.

3.2.1. EU ETS

The initial allocation of the trading allowances is very crucial for the functioning of the system; therefore before we move to the evaluation of the outcomes of the first phase of EU ETS we will discuss the allocation strategies within the EU ETS both for the Phase 1 (2005-2007) and partly also for the Phase 2 (2008-2012) and later we briefly comment the direction of the prepared changes of the EU ETS revision in Phase 3 starting in 2013.

As was already mentioned before, the implementation of emission trading instead of harmonized CO_2 tax on the EU level was kind of compromise that allowed to move further in the joint EU climate change policy. Nevertheless, the price for reaching this compromise was quite high in leaving the multinational scheme highly decentralized in the field of national allocation rules. The general rules of allocation design were set by EU ETS Directive[31], however, when we try to evaluate and compare the individual national allocation plans for the first trading period, we encounter almost 27 different approaches of allocation. As an extreme example we can mention the National Allocation plan of Belgium, where there are in practice three individual sub-allocation plans: allocation for the Flemish region, allocation for the Walloon region and allocation for the Brussels Capital region.

The unifying feature is the general method of allocation – allocation for free (via either grandfathering or some kind of benchmarking). This way of allocation was prescribed by the EU ETS Directive[33] allowing only 5% and 10% share of allocation to be auctioned in Phase 1 and Phase 2, respectively[34]. Setting those benchmarks and allocation among the individual sectors in individual states are both in Phase 1 and Phase 2 on the decision of national regulators and their coordination is limited.

[33] Council Directive 2003/87/ES
[34] .In practice, both in Phase 1 and Phase 2 this maximal limit has not been reached

Detailed description of the design of National allocation plans in Phase 1 is given in the **Annex Table 3**. To provide the same level of details also for the Phase 2 was impossible as many of the allocation plans are still known only in the national languages without English translation or they have not been officially published yet. Now, we highlight the main differences among those national allocation plans in Phase 1 and in some cases we compare them with the development in Phase 2. The differences lay mainly in:

a) Definition of the sub-sectors

The participants of the EU ETS system are installation from the energy intensive industries as heat and power generation, refineries, production of cement, paper, coke, ceramics and steel. However on the national level we find vast variety of national definition of the sub-sectors of these industries that makes the international comparison more difficult. The same pattern of decentralization of the national allocation was followed also in the preparation of the national allocation plans for the Phase 2 that was just finished in the end of 2007[35].

We can mention the revised final version of the Czech National allocation plan for the Phase 2 that meant a movement towards the simplicity and transparency of the allocation. Compared to the Phase 1 where there are 9 sector industries, in the Phase 2 there is no division between the sectors according to their field of activity, but according to their volume of CO_2 emissions they emit every year: small installation with annual emission less then 50,000 t CO_2 and large installation emitting more than 50,000t CO_2 p.a. These two sectors are treated differently – to set their final allocation their historic average emissions from 2005 and 2006 are multiplied by certain growth factor. This growth factor is more favorable to the smaller installation[36] than to the larger installation.

b) Allocation among the years

National Allocation plans are defined for the whole period, either 3 years (Phase 1) or 5 years (Phase 2). Then, there is set the annual allocation among the years. The

[35] Off course there are delays in the implementation of the National allocation plan. Till the April 2008 there are still several states that do not published their installation allocation tables so that we cannot compare all the National Allocation Plans for the Phase 2

[36] Growth factor 7% for smaller installation and growth factor1.279% for larger one

majority of the states allocate the same volume every year (e.g. Czech Republic, Spain, Germany) or they chose to allocate more in the beginning of the phase and than less in following years to introduce more stringency into the system (e.g. Italy, Denmark, Slovenia)

c) Usage of auctioning

The EU ETS Directive[37] enables to allocate some share of emission permits via auction. In the Phase 1 it was 5%, in the Phase 2 it is 10% of the national allocation. In the Phase 1 there was auctioned almost negligible amount of allowances with total amount less than 10 Mt CO_2 p.a. whose revenues were in majority earmarked to cover the administration of the national trading scheme (e.g. in Ireland) except Denmark where the revenues were used for JI CDM governmental acquisition. In the Phase 2 the auctioned amount of allowances will be significantly higher reaching almost 70Mt CO_2 p.a.

The way of the auctioning is not harmonized at the moment. There are states that organized the auction via private trading platform (e.g. Hungary in two rounds in December 2006 and 2007[38]). Other states organized the auction on their on (e.g. Ireland via its Environmental Protection Agency). For the Phase 2, many states still have not clarified the way of auctioning; the exception is Germany that has already started to regularly auction small volumes on the emission trading exchange already in January 2008. **Table 9** summarize the individual volumes

[37] Council Directive 2003/87/ES
[38] via a company Vertis Environmental Finance (PointCarbon News 5.12.2006)

Table 9 : Auctioning in the EU ETS

	volume (Mt CO_2)	% allocation	Note
Phase 1			
Denmark	5.025	5%	Revenues to purchase emission credits for JI and CDM programs.
Hungary	2.4	2.5%	The Hungarian Ministry of Finance offered the allowance for uniform price auction in two rounds: 1st in December 2006 with clearing price €7.42 per EUA, and 2nd in March 2007 with clearing price €0.88 per EUA per EUA via private trading platform.
Lithuania	0.5	1.5%	Auction organized by private trading platform in September 2007.
Ireland	0.5	0.75%	Sealed Bid Auction Format: Uniform Price Method. 1st round held in January 2006 with clearing price of €26.30 EUA, 2nd round in December 2006 with clearing price €6.87. Auctions organized by Irish Environmental Protection Agency
TOTAL	8.13	0,12%	
Phase 2			
Austria	0.4	1.2%	Format of the sale remains unclear.
Belgium	0.99	0.3%	Auction in the Flemish region either in one-run auction or in several times during the Phase 2.
Germany	40	8.8%	2008-2009 Monthly regular sales of allowances via KfW (German bank). From 2010 different type of auction planned.
Hungary	1.32	5%	Format of the sale remains unclear.
Ireland	0.1	0.5%	Format of the sale remains unclear.
Lithuania	0.5	2.7%	Format of the sale remains unclear.
Netherlands	3.2	4%	Format of the sale remains unclear.
Poland	2	1%	Format of the sale remains unclear.
United Kingdom	17.2	7%	First auction should be in September 2008. Auction solely in the sector of Large Electricity Producers
Total	50*	3%	

Source: European Commission, National Allocation Plans of individual states, Point Carbon News
Note: *estimation, at the time of writing some of the Member states have not officially published the final revised version of National Allocation Plans for Phase 2

d) "Old" EU-15 member states versus "New" EU-12 ones

The main difference between the group of EU-15 and EU-12 is in setting the reduction targets to achieve by the EU ETS. Generally these targets are determined by meeting the reduction obligation set by the Kyoto protocol. As almost all the states of EU are Annex 1 countries that have set the reduction targets[39] the EU ETS us the principal instrument to achieve it. The difference is that the reduction targets set by the Kyoto protocol are real only to the EU-15, whereas in majority of the EU-12 the compulsorily reduction set by the Kyoto protocol individually for each state

[39] Except Malta and Cyprus

was mainly done by restructuring of the whole industrial sector during the transition period[40].

Therefore most of EU-12 regulates the growth but does not set the target for real emissions reduction. The general advocacy for this approach is the economic growth that is expected and needed in the region of EU-12 to catch up with the living standards and economic development of EU-15. This economic growth is to the great extent positively correlated with the growth of emission as all the EU-12 countries are rather energy intensive economies.

e) Power sector

In many allocation plans the power sector is treated differently compared to the rest of the sectors involved in the emission trading. The power and heating sector is the only sector covered by the EU ETS that does not have to face the drastic international competition with overseas competitors from non-emission regulated countries. As the power sector operates in the market with very low elasticity of demand to the changes of power prices. The increased cost of the emission trading could be therefore to the great extent passed-through to the end-users by increase of electricity prices. This is the reason why we find in many national allocation plans stricter allocation rules for the power sector – mainly in case of the old EU-15 member states (e.g. Denmark and UK in Phase 2, Germany in Phase 2). The **Annex Table 3** gives a summary of individual national approaches towards the power sector.

In general, we can divide the allocation approaches for power sector in those that rely mainly on the historic emissions or emission prediction based on prediction of the energy demand that are later divided by certain reduction factors or those that choose the method of benchmarking that sets the benchmarks for individual types of fuels.

Example of a strict approach can be the allocation rules of the United Kingdom where the allocation rules for power sector are visibly different to the rest of the sectors. The UK allocation to individual sectors is set according to the BAU emission scenarios.

[40] The exception is Slovenia where there is a real gap between the real emissions and Kyoto target obligation (EEA, 2007)

Power sector has the greatest reduction of 21% between annual emissions in 2003 and total allocation prediction for 2005-2007. Also in Ireland the growth of the emissions from the power sector is strictly limited. The cuts in the Irish allocation plan compared to the BAU emission scenario that was used to build up a national Allocation are minus 26 %. In Sweden it is a reduction of 20% compared to the emission in the base historic year.

The tendency is also visible in comparison between the individual allocation approaches in Phase 1 and Phase 2. The example is again the UK, where the whole cut in allocation that was done between the Phase 1 and Phase 2[41] is totally borne by power sector and it is more than 25% of the annual allocation of the power sector in the Phase 1. Apart from that also the total amount of allocation that should be auctioned (7%) is entirely taken from the power sector allocation.

Significant changes between the Phase 1 and the Phase 2 are also noticeable in German allocation plan. In the Phase 1 there was no specific rule for the power sector, whereas, in the Phase 2 a new benchmarking system for power plants has been introduced[42]. This system is favoring the new built power plants that are in operation since 2003 or later and it allocates significantly less to the old plants[43].

3.2.2. EU ETS Revision Post 2012

The first trading period was mainly meant as a learning period the should teach the participants how such trading system could work and to prepare both states and individual EU ETS participants for active second trading period that is in the same time also the compliance period of the Kyoto protocol.

The second period is supposed to set more stringency into the system, however, not by changing general design of the system, but by defining only more stringent emission caps. On the other hand, a new trading period starting from 2013 is assumed to bring not only even more significant emission caps but also significant

41 130 mil EUA compared to almost 100 mil EUA in Phase 2 according to the comparison of the original text of UK National allocation plan for Phase 1 and Phase 2

42 According to the German National Allocation Plan there are set two best available technology (BAT) benchmarks: 750 g CO_2 /kWh for coal and 365 g CO_2 /kWh for gas

43 with thermal efficiency bellow 41% (lignite), 45% (hard coal) and 55% (gas).

changes of the overall functioning of the system introduced by the revision of the existing EU ETS Directive.

The official draft of the EU ETS Directive revision was published in the end of January 2008[44]. At the moment we do not know the final changes that will be introduced by the EU ETS revision directive as those changes are currently being discussed both on the ground of the European Parliament and the European Council under the co-decision legislative procedure. The ambition of policymakers is to approve the directive revisions in the first reading of the European Parliament, i.e. till the spring 2009 before the European Parliament elections. Nevertheless, generally, we can define following main areas that will be changed in the emission trading system in post 2012 phase:

a) *Allocation rules*

The allocation rules are the most pronounced topic in the revision process. The tendency is to centralize and harmonize the whole allocation process that should be in future and mainly to accentuate the auctioning as the general rule of the allocation. This revision of the allocation rules is a response for the general critique of the highly decentralized process of allocation. And also the response for another argumentation focused on the so-called windfall profit gains from the free allocation mainly to the power sector. According to the current proposal there should be auctioned 100% of the power sector allocation together with auction of 20% shares in the remaining sectors already in 2013. The share of auctioning should gradually grow to reach the 100% level of all EU ETS allowances in 2020.

The allocation of the share of allowances to auction will be based both on the historic emissions in 2005 and also by the level of GDP of individual states – so that countries with GDP per capita lower than the 120% of the EU average will receive relatively more allowances for auction. If we assume that currently there is less than 10% of allowances auctioned, this means a huge change to the whole system. It will also mean a huge amount of financial recourses to be managed by the regulator. It is assumed that the auction revenues will belong to the national state not to the EU itself as a main emission market regulator. According to the current legislative

[44] see in Internet sources the web page with the official EU ETS revision proposal

version at least 20% of the auction revenues should be earmarked for the combating the climate change and promotion of the renewable sources of energy.

b) Period duration

Phase 1 was established for 3 years, Phase 2 will mean an allocation for next 5 year. The revision of the post-2012 development will again enlarge the allocation period to 8 years. The longer the allocation period the more stable the system is and it creates better incentives for abatement activities in a larger scale.

In the short term, the ways of abatement and emission reduction are more constrained. In case of the EU ETS setting the short-term possibility lays mainly in the power sector – namely in the fuel switching from coal-to-gas among existing power plants, i.e. dispatching the coal-based power plants by gas-based ones. Though, the possibilities are limited by existing generation portfolio. The reduction potential is significantly larger if there are stable conditions for investment in the longer term – e.g. by building new clean sources or replacing out-of-day technologies by the BAT options.

This longer-term perspective is already given in the Phase 2 thanks to the banking of allowances between Phase 2 and Phase 3. This rule is already incorporated in the existing EU ETS Directive. As a result, we can see the Phase 2 and Phase 3 till 2020 as one continuous period. This already starts to match with the investment cycle and it may presumably help to bring the desired regulation outcome: shift towards cleaner technologies.

c) EU ETS coverage

The EU ETS coverage in post-2012 will change in three areas: (i) in the sector scope, (ii) in the definition of the minimal size of participants and finally (iii) in the greenhouse gases coverage. Since the beginning of the Phase 3, there will be added new sectors of aluminum producers and chemical industry. The EU ETS coverage will be enlarge by the inclusion of other greenhouse gases as nitrous oxide[45] and perfluorocarbons[46]. It is estimated by the EU ETS revision directive that adding these

[45] The greenhouse gas that is apparent mainly in the production of fertilizers.
[46] Aluminum production

new gases and related sectors the EU ETS coverage can grow by around 6-7% (150 Mt CO_2) compared to the level of allocation in Phase 2.

Apart from the EU ETS revision there are also discussed independently other sectors in separate legislative proposals: aviation that will probably to the EU ETS be added in 2011 or 2012 which is already in the second reading of the European Parliament and currently also maritime shipping that is however in less mature stage of political debate.

The EU ETS revision also counts with the provision of the possibility of opt-out of smallest emitters provided that there is an equivalent emission reduction measures for those small emitters. The opt-out clause tackles the frequently criticized issue of the efficient functioning of the emission trading for the very small polluters that have to bear high administrative cost for participating in the system[47]. The EU ETS Revision directive is mentioning the 10,000 t CO_2 p.a. as a threshold.

As it is summarized in **Table 10** by setting the threshold value at 10,000 we would reduce the total number of installations by more then 4,000, however, the total emission would be reduced by less than 1%. In the table we can also see the high degree of concentration of the emission among the small number of large installation. Therefore by reducing dramatically the number of installation the overall target emission under regulation would not be changed however the overall regulative burden related to the amount of participants would be reduced significantly.

Table 10 : Concentration of the allowance allocation

Verified emissions CO_2 in 2005 (Mt)	<10,000	<20,000	<25,000	>1,000,000
Number of small installations (share of total number of installation)	4164 (cca 35%)	5792 (cca 50%)	6311 (cca 60%)	431 (cca 4%)
Total emissions of small installation in 2005 (Mt) (Share no total emissions)	14.8 (<1%)	38.3 (<2%)	49.9 (<3%)	1,387.8 (cca 65%)

Source: Author's own computation according to the CITL data (see Internet Sources)

[47] due the mainly CO2 monitoring and annual verification

d) Link to international emission trading schemes

At the moment the EU ETS is indirectly linked to the global emission trading scheme established by the Kyoto Protocol via the JI and CDM emission reduction projects. The revision proposal offers the scenarios of the future development and provides the targets to be reached as well: (i) the scenario where there is no future international cooperation and (ii) the scenario where there is an international agreement reached after the 2012 Kyoto protocol scheme.

In the first case the total emission reduction to be reached by the EU ET is 21% compared to the level in 2005 that goes in line with the overall EU reduction target of 20% compared to the level in 1990. In the latter the scenario the target is adjusted to the emission reduction 30% compared to the 1990 on the whole EU level, however, the concrete reduction target for the EU ETS is not defined.

The revision of the EU ETS Directive provides with the possibilities to link the compulsory national or sub national trading schemes provided there is an agreement between the EU and the state with the compulsory trading scheme.

4. Analysis of EU ETS in Phase 1 and Phase 2

The last chapter is meant as the practical analysis of the short-term results of the policy in the EU related to the climate change where the main instrument used on the EU level is the emission trading scheme – the EU ETS. In Chapter 2. we were discussing why this instrument can be preferred. In Chapter 3. we tackled the design of the EU ETS concerning the design of allocation. In this chapter we finally look on the real results of the implementation of EU ETS in Phase 1 and what we can expects for the coming Phase 2.

We first look on the comparison of allocation and real verified emissions in Phase 1 analysis both on the country and sector level. Afterwards, we try to use these data of the past development to look into the future Phase 2.

We try to answer questions as: *Which states and sectors were short of allocation in Phase 1? What are the factors influencing the possible deficit or over allocation? Will it be the same in the Phase 2?*

4.1. Results of EU ETS Phase 1 - Learning Phase

To evaluate the Phase 1 of EU ETS we can do it from many starting points according to the main purposes of the emission trading system. The purpose of Phase 1 was to: (i) establish the emission trading market with (ii) clear CO_2 price signals and to (iii) trigger the abatement activities in the cost effective way. Therefore our indicators of evaluation can be: (i) emission market value and the liquidity of the market, (ii) price of CO_2 expressed by EUA prices and finally (iii) the comparison of the allocation versus real emission during 2005 – 2007.

Before going into the details, we can sum up the main results. The most successful was the EU ETS in establishing the real and liquid carbon emission market. However, already less successful was in fulfilling the remaining criteria thanks to the general over-allocation. Nevertheless, as we will see in the next subchapter focusing on the outlook of Phase 2, the reduced allocation for the following trading periods in Phase 2 and subsequently in Phase 3 can correct the functioning of EU ETS.

a) Market liquidity

EU ETS is covering nearly 11 thousand installation representing almost 5 thousand companies – the biggest emission market ever established. This creates sufficient condition for establishing a liquid market with multiple participants. The emission market liquidity can be measured by the volume of trade both on the specialized emission trading exchanges[48] and by the volume of bilateral OTC trades.

Generally we can see a dynamic growth on both segments of the market with majority of trades happened on the OTC market. EUA has been started bilaterally already in the end of 2004, on the emission exchanges in February 2005. Whereas, in the first year of Phase 1 the total volume reached almost 269 Mt C02 traded, in 2007 it was already more than 5 times more almost 1,500 Mt C02[49].

b) Price of CO_2

Prices of CO_2 expressed by prices of EUA have experienced large volatility during the Phase 1 reaching almost €30 in the beginning of the Phase and later gradually falling to 0. On the graph of EUA prices development in **Annex Figure 4** we can see the sensitivity of prices of the chosen level of cap. The release of the first verified emission data of 2005 in April 2006 gave a strong signal to the market participants about the balance between the allocation and emission that trigger a significant fall of prices.

The development of prices of CO_2 was reflecting the main drawback of the EU ETS in Phase 1: insufficiently binding reduction targets that created over-allocation. The reason for the over-allocation can be the combination of both limited quality of historic emission data and the influence of national and industrial interest to set the emission caps sufficiently high. However, we should have in mind that the Phase 1 was meant as a learning period to implement smoothly the regulation. This goal was reached. Thanks to the abolished banking of emission allowances between the Phase 1 and Phase 2 the over-allocation experienced in the Phase 1 that drove the EUA prices towards 0 will not influence the prices and price signals in Phase 2 and beyond. On the other for the giving more stability to the market there is already

[48] for EUAs the 3 most important European Emission Exchanges are European Climate Exchange (ECX) in the UK, Nordpool in Norway, European Energy Exchange (EEX) in Germany

[49] according to PointCarbon – see Internet sources

allowed the banking between Phase 2 and Phase 3 showing more than educational ambitions of the Phase 2 and beyond.

c) Allocation versus emissions

The end of April 2008 was the official end of trading with the allowances from Phase 1 of the EU ETS. During April 2008 there were also published in the Community Independent Transaction Log (CITL[50]) the verified data for the emission in 2007. We still do not have the 100% of all 2007 data in hand, however, we can already analyze more than 95% of all installation covered. For our analysis we can use all 25 states that were participants from 2005 comparing whole allocation for 3 years 2005 – 2007 to the emissions for the same period. Romania and Bulgaria became the EU ETS participants in 2007, however, we still do not have the verified data complete of Romania and currently we do not have any data for Bulgaria.

CITL data shows a slight growth of CO_2 emissions over the 3-year period time showing a total over allocation of around 200-250 Mt CO_2[51] (in the whole 3 year period). When we look on the country level, the only countries with the real short allocation were the UK, Italy Spain, Greece and Slovenia. On the other hand the countries with the biggest allocation surplus were Poland, France and Germany. The detailed numbers are showed in **Annex Figure 1**.

From the sector allocation point of view, we have divided the allocation into 5 sectors to compare the sector allocation (power and heat, paper production, production of metal, production of ceramics, glass and cement, production of oil in refineries) Sector of power and heat generation was the only sector with allocation deficit (around 150 Mt over 3 years). On the other hand, the sector with the most abundant allocation was metal production. Comparison of individual sector deficit and over-allocation are depicted in **Annex Figure 2**. The detailed numbers related to the deficit allocation in power and heat sector according to the location are showed in **Annex Figure 3.**

[50] See Internet Sources
[51] the upper bound is estimation for complete data as at the moment there are still mission some installations in Romania, whole allocation and emissions for Bulgaria and some individual installation among EU 25

4.2. Phase 2 and beyond – Will there be real deficit?

In 2008 Phase 2 of EU ETS has already started. In this section we will first summarize the possible factors that influence the future development of prices of allowances. Subsequently, we try to look if there will be a real deficit by using data of the future economic and emission intensity development and allocation for Phase 2.

4.2.1. Factors influencing the development of Phase 2

When we are speaking about the future development of Phase 2 we have to look both on the side of demand for emission allowances and supply of emission allowances and emission reductions. The linking instrument of these two sides is the price of emission allowance that gives clear signals to all market participants. In this sense, to understand the future development of the Phase 2 we need also to understand what influence the price of emission allowance itself.

Table 11 : Factors influencing the EUA Demand and Supply

	Demand for EUA	Supply of EUA and other emission reductions
Factors of regulation and policy	o EUA installation allocation o Other emission reduction related regulation (SO_X, NO_X regulation, renewable energy obligation)	o Emission reduction target o International Agreements o Future International Agreements o EUA installation allocation
Market-based factors	o Macroeconomic Growth o Emission Growth – Carbon intensity growth o Prices of energy commodities (oil, gas, coal, electricity)	o Development of the market with emission reduction – i.e. JI and CDM projects
Other Factors	o Weather-related factors	o Weather-related factors

Source: Author's comparison

Generally, we can divide the factors influencing both sides on either factors related to the policy and regulation, market-based factors or other factors. **Table 11** gives the summary of the possible factors.

The demand side is represented by the compliance participants of the EU ETS accompanied by the financial institutions that participate in the emission trading for speculative purposes. The supply side is represented by the regulator allocating the allowances and by the suppliers of other emission reduction credits represented by the flexible mechanism of the Kyoto protocol – JI and CDM projects that can be to some extend also utilized within the EU ETS and possibly also by the participants of the EU ETS willing to sell the allowances.

The starting point is the size of the gap between the allocation of emission allowances and emitted emissions for individual installations. The price of the EUA is determined by the gap size and also by the cost of abatement options that are available to reduce the gap. There are factors that increase the gap by driving the emissions up, e.g. the macroeconomic growth or weather conditions. On the other hand, slowdown in economic growth rates that is currently apparent across the USA and Western Europe could result in a reduction in economic activity in the sectors covered by the EU ETS regulation and by lowering the demand for EUA.

Other factors that influence both the size of the gap and indirectly the EUA prices are the internal abatement of EU ETS participants and price of the abatement. In the short-term the abatement can be done only through the optimization of the existing technologies and optimization consumption of energy sources by these existing technologies. The direction of the abatement options is also determined and very limited by prices of energy sources, namely oil, gas, coal and electricity.

For example we can look on the impact of prices of oil on the level of and price of abatement options. Prices of oil and natural gas are closely linked thanks to the gas indexation to oil prices. Using gas instead of coal for energy production is a way of abatement that reduces the CO_2 emissions. This means that power plants based on coal are substituted by the gas-based installation that have been already operating but not with 100% utilization of their production capacity. This is called a power plant dispatching or fuel switching. In the current energy portfolio mix in Europe the option for this fuel switch is rather limited and available only in the Great Britain and partly also in the countries of Benelux where there is similar share of gas and coal based power plants (EGL, 2007). However with present oil prices upsurge, the gas prices are also driven up which distract the option of switching from coal-based production to gas-based one and contrary to this it shifts the European electricity mix away from low-carbon natural gas generation towards higher-carbon coal generation. Consequently, as emissions rise, coal generators have to buy more emissions allowances, which drives up the price of allowances as well.

The goal of the market-based environmental regulation is to trigger the abatement where it is the cheapest to do so. Therefore another way of abatement with the EU ETS apart from the internal abatement is to invest into the abatement where it is less costly to do so, i.e. in the developing world. The option is represented by the emission reduction credits under the Kyoto protocol flexible mechanism introduced in the Chapter 1. These credits from JI and CDM projects can be to some extent used as an equivalent to the EUAs.

Each state could define in the National Allocation Plan the level of flexible mechanisms represented by the CDM and JI projects that can be used as additionally to the EUA use. Generally, this limit is stated as a share of the individual installation allocation. The average import limit for EU ETS is around 13%. The maximum amount that can be used within the EU ETS is around 1400 Mt CO_2e in 5 years of Phase 2. The factual use of these credits depends however on the real supply of those credits. At the moment only very small part of the expected amount of emission reduction credits, (so-called CERs[52]) amounting to around 15O Mt CO_2e[53] has been already issued. The rest of the projects are remaining in the less developed stage. The expected volume that will be generated till 2012 is around 1,4000-2,200 Mt (Capoor, 2008).

The supply of EUA and emission reduction is in the long term influenced mainly by the policy and regulation factors. European Union is consistently showing its ambitions to become a leader in the field of combating the climate change and to establish a stringent emission reduction regulation. In 2007 EC published its targets toward the 2020 represented by the 20% CO_2 emission reduction compared to 1990, 20% share of renewables in the final energy consumption and 20% increase of energy efficiency. These targets were later presented in the directive proposals officially released in January 2008[54]. This sends a bullish signal on expectation about the emission reduction targets. As the future allocation of allowances will have to be in line with the political targets.

[52] CER stands for certified emission reduction
[53] According to UNFCCC body dedicated to the issuance of CER, i.e. UNFCCC CDM Executive Board. See the Internet Sources
[54] See Internet Sources – EU ETS Phase 3 Draft Proposal

4.2.2. Model Data

As we have mentioned in the previous subsection. Phase 1 terminated with the overall allocation surplus, even thought on the country and sector level we have seen some gross deficits in the allocation. Now we would like to look if the Phase 2 will be also over-allocated or not.

To make a simplified prediction about the emission development we have applied the methodology used by European Commission that was mentioned in the European Commission Decisions over National Allocation Plans for Phase 2[55]. Generally this approach combines the predictions about the future economic development expressed by GDP growth and emission intensity of the individual economies expressed by the volume of $C0_2$ emitted on unit of GDP.

In the European Commission decision there were used data from the prediction made in autumn 2006 (DG ECFIN, 2006) related to the short-term prediction of GDP growth and data from the PRIMES model[56] of growth trends up to 2030 from 2005 (DG TREN, 2005) related to the long-term economic growth forecast and forecast about the emission intensity development. We have updated the prediction using the latest data of economic forecast from spring 2008 (DG ECFIN, 2008) and updated version of growth trends up to 2030 from autumn 2007 (DG TREN, 2007) that are better reflecting the current development provided the current change and slowdown of the economic growth in the global developed world. Compared to the previous version from 2005 (DG TREN, 2005) the estimation about the economic growth has been downgraded from 2.5% to 2.2 in decade 2000-2010.

We build up to scenarios where there is reflected different rate of carbon intensity development and we compare them with the allocation for Phase 2 on the country level:

- ***Scenario I.*** with conservative assumptions of future possible reduction of carbon intensity that use PRIMES model forecast outcomes about the carbon intensity development

[55] See European Commission Decisions on NAP in Internet sources

[56] The PRIMES model simulates the European energy system and markets on a country-by-country basis and provides detailed results about energy balances, CO_2 emissions, investment, energy technology penetration, prices and costs at 5-year intervals over a time period from 2000 to 2030.

- ***Scenario II.*** with ambitious additional developments of reduction of carbon intensity than it is predicted by PRIMES model. Using 3% of the carbon emission intensity in period 2005-2010 and than reduction of 6% between 2010-2015 and other 6% 2015-2020. The rationale for the enhanced carbon intensity reduction is that in the long-term the reduction can by achieved due to the ambitious EU targets promoting the energy efficiency, use of renewables and strict reduction of air pollutants (e.g. SO_X, NO_X regulation by LCP Directive[57])

We do our analysis in two steps – in the first step we are looking on the prediction of only Phase 2 and in the second step extending our prediction for Phase 3 till 2020. We are using economic data released by the European Commission for years 2007-2011. For years 2007-2009 we can apply the short-term forecast of the European Commission published in spring 2008 (DG ECFIN, 2008). For subsequent years 2010-2020 we use long-term prediction published by European Commission based on the updated outcomes of PRIMES model released in autumn 2007 (DG TREN, 2007).

Apart from the data about the economic development there are used data reflecting the CO_2 emissions. As a starting point there are used the average verified emission data in EU ETS Phase 1 2005-2007 taken from the CITL[58]. In later years there are applied the emission intensity forecasts on the country level mentioned in the European Commission long-term prediction. Detailed input data are in **Annex Tables 4-6**.

At the moment we already know some preliminary information about the further development after the termination of Phase 2. According the directive proposals the overall EU ETS emissions should be cut by 21% compared to historic level in 2005. In comparison to this, the reduction target for the Phase 2 compared to the 1990 historic emissions is 6.5%[59]. The reduction in Phase 3 should be reached by gradual cutting of the total allowance cap by 1.74% each year starting from 2013 to reach 1,720 Mt of CO_2 in 2020. As a starting point for the application will be the 2010 of the period of the Phase 2. The graphical illustration of the continual decrease of the allocation in Phase 2 and 3 is depicted in **Figure 10** together with the presentation of

[57] 2001/80/EC
[58] See Internet Sources
[59] According the EU ETS Directive Revision – see Internet Sources

our prediction. Before doing so we briefly tackle several parameters that influence the final level of allocation for the operating installation. In the results we present also a sensitivity analysis to these factors.

To arrive to the concrete numbers of the expected deficit or over-allocation we should have in mind several parameters that either increase or decrease the real allocation. First, it is an allocation that has to be set aside for the new installations that start to operate in the related trading Phase. On average, we should count for 5-6% of total allocation that is in so-called New Entrants Reserve (NER) and it is not directly allocated to the system. NER allocation therefore reduces the real allocation for the existing installation.

Second, it is the limit applied for the possible import of emission reduction credits from JI or CDM projects. This limit increases the real allocation for the installation. This JI CDM import limit is country specific with concrete JI CDM limits showed in **Annex Table 6**. On the EU level it represents around 13% of the annual allocation (around 280 Mt p.a. or in total around 1.400 Mt in five years of Phase 2). This limit holds for the whole allocation period in Phase 2 however according the current version of the EU ETS revision its use will be restricted in Phase 3 so that the total import limit will be 1.400 Mt in 13 years instead of only 5 years. In our analysis we assume that the whole limit will be utilized between the years 2008-2012.

Table 12 summarize the main important inputs for our analysis – there are reported the EU-27 average numbers; however, for our analysis we have used the data on the national level showed in the **Annex Tables 4-6**.

Table 12 : Main inputs for our analysis

Emission – Allocation inputs		Economic Inputs		CO_2 Emission Intensity inputs	
	Mt CO_2 p.a.		%		%
Adjusted 2005 Verified emissions	2228[60]	Average EU-27 GDP growth 2007-2011	2.2	Average EU-27 emission reduction 2005-2010	-2,7
Average Allocation in Phase 2 p.a.	2083	Average EU-27 GDP growth 2012-2020	2.4	Average EU-27 emission reduction 2010-2015	-2,5
JI and CDM import limit p.a.	278			Average EU-27 emission reduction 2015-20	-2,5
Phase 2 Cap adjusted – without NER	1958			Additional emission factor reduction applied in Scenario 2 for 2005-2010	-3
Final Phase 2 Cap adjusted – without NER with JI CDM imports	2236			Advanced emission factor reduction applied in Scenario 2 for 2010-2015 and 2015-2020	-6
Average Allocation in Phase 3	1847				
Predicted Allocation in 2020	1720				

Source: various sources – see description in Annex Tables 4 - 6

4.2.3. Results

According to our analysis we can conclude using the input for Scenario I. (our BAU scenario) that both in Phase 2 and Phase 3 the installation will be short of allowances and therefore there will be a real need for internal abatement in Phase 2 around 230 – 250 Mt CO_2 p.a. with full utilization of possible imports of emission credits from JI CDM projects and with allocation reduced by the New Entrants Reserves. Due to the reduced allocation the situation of over-allocation in Phase 1 will not be repeated.

In Phase 3 the allocation deficit will be even greater under current prediction of economic growth and emission intensity (BAU Scenario I.) reaching to 750 Mt CO_2 p.a. Thanks to the facts that allowances from Phase 2 can be banked into Phase 3 we can see Phase 2 and Phase 3 as one continuous period with average deficit ranging 500 Mt CO_2 p.a. giving the bullish long-term signals of the growing demand for allowance and consequently bullish signals for the price development.

As was described before the level of the gap between the allocation and emission will have to be covered by internal abatement and the price of internal abatement will be reflected in the prices of allowances. The arms-length way of abatement is a fuel switching among the existing coal and gas power plants in those countries where

[60] including an approximation of the emissions in 2005 of the installations that where not covered in the ETS in the first trading period but are covered in the second trading period according to EC Press Releases – see Internet Sources

such switching is available (mainly in the UK and countries of Benelux). As a result the prices of fuel costs – mainly the oil, gas and coal are expected to be the main determinants of the allowance prices over the Phase 2 and beyond (Capoor, 2008).

If we presume that the emission intensity will be reduced faster and to the greater extend that is assumed under the BAU development in Scenario I. we can apply our Scenario II. By application of additional measures to reduce the GHG emissions we expect the emissions can additionally decrease by 200 Mt. The possible allocation average deficit can be in longer-term in Phase 2 and Phase 3 together reduced to 354 Mt CO_2 p.a. The detailed results are compared in **Table 13.**

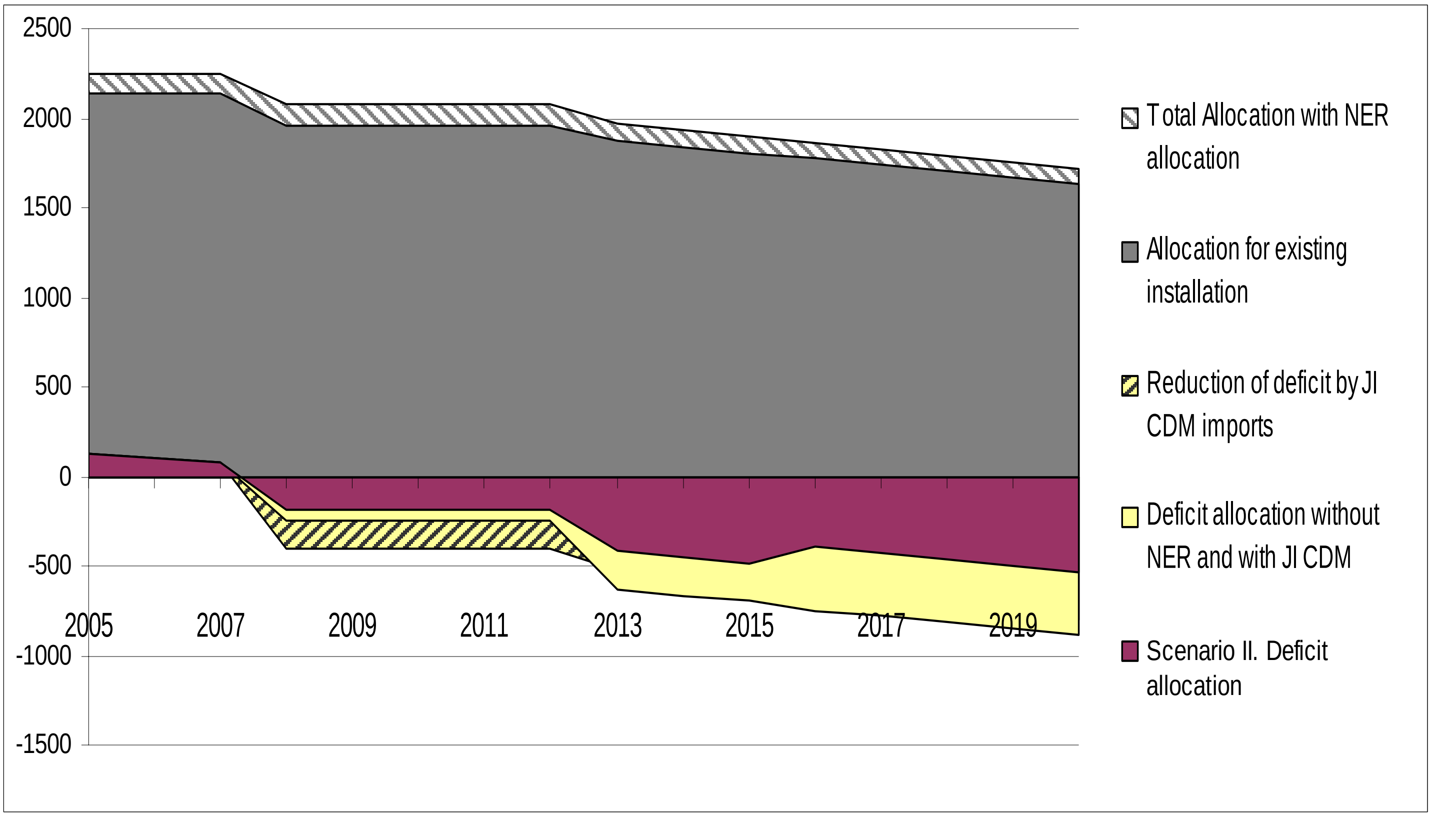
Table 13 : Comparison of scenarios

	Mt CO_2 p.a.	Scenario I.	Scenario II.
PHASE 2	Total emissions p.a.	2488	2422
	Total allocation p.a. - Phase 2	2083	2083
	Gross deficit	405	339
	NER reserves	125	125
	JI CDM Import	278	278
	Net Deficit (- JICDM + NER)	252	186
PHASE 3	Total average emissions p.a.	2503	2293
	Total allocation p.a. - average	1847	1847
	Average Deficit	759	459
PHASE 2+3	Average Deficit	564	354

Source: Author's computation according to the inputs – see Annex Tables 4 -6

We can also look on the sensitivity of emission allocation gap on the changes of economic growth. If we increase our prediction of the economic growth by 0.5% in every period the average deficit over the whole period would change by more then 60 Mt p.a. to nearly 640 Mt in Scenario I. and 420 Mt in Scenario II.

Figure 10 : Scenario I. – Allocation Deficit in Phase 1 and Phase 2



Source: Author's computations according to the input data – see Annex Tables 4 - 6

Figure 10 gives the graphical result for Scenario I. and compares it with Scenario II. The total allocation is compound area of allocation for existing installation (grey area) and the set-a-side allocation for the new installations that may start to operate in Phase 2 and 3 (white-grey striped area). The deficit in Phase 2 and Phase 3 is also compound area. The overall deficit is made of the gross deficit without the utilization of credits from JI CDM programs (yellow-black striped area) and net deficit (yellow area) that represents the real deficit that the installations will face within the EU ETS. The purple area shows how the deficit would be reduced under Scenario II.

To sum up, with current prediction about the economic growth and development of emission reduction the outlook to Phase 2 and Phase 3 predicts a significant deficit that will have to be covered by enhanced internal abatement of the EU ETS participants.

Summary

The emission trading is an example of a market-oriented environmental regulation that has been in the centre of interest both of academic society and politicians over the last several decades. It has been already implemented in various cases with focus on reduction of diverse kinds of pollution and emissions. One of the last examples of a practical implementation of emission trading is the regulation of greenhouse gas emissions – namely the European Union Emission Trading System (EU ETS).

We have chosen the EU ETS for deeper evaluation for several reasons. The EU ETS is the biggest ETS ever implemented encompassing almost 11 thousand of individual installations and nearly 50% of GHG emission of the EU. It is a long-term policy tool that will probably influence the European and presumably also the global policy for another more than decade. The Phase 1 (2005-2007) of the EU ETS has already finished giving the possibility to evaluate the outcomes and the overall design of the system. In the same time allocation for Phase 2 (2008-2012) has been already known and the general outline of Phase 3 (2012-2020) has been also announced that enable us the grossly estimate the possible further development.

We have tackled different issues related to the implementation and efficiency of the emission trading system. In the theoretical part we have questioned whether it is better to regulate emission via price-based instruments or via quantity-based instruments such as emission trading. We have concluded that even though the price-based instruments are by theory more favored in issues related to the regulation of GHG emissions, emission trading system is politically more feasible to implement both on the national level and even more in the international field of negotiation.

The crucial issue of each emission trading system is the way of allocation of emission allowances. We have described the two main methods of allocation: grandfathering (allocation for free) and auctioning both theoretically and practically on the examples of existing ETS. The majority of existing ETS is based on free allocation to the participants reflecting the historical emission in some cases with combination with general technology benchmarks. However, the future development of the EU ETS and

other planned ETS reveals the general movement towards greater utilization of auctioning.

The allocation methodology during the Phase 1 of the EU ETS shows high degree of heterogeneity among the member states and among the sectors even though all states have allocated majority of allowances for free. In some countries of EU-15 (e.g. UK, Sweden, Denmark) there is noticeable more stringent approach towards power sector compared to the rest of sectors. Among the EU-12, generally, the allocation allows for moderate emission growth that is predicted due to the enhanced economic growth.

The purpose of Phase 1 of the EU ETS was to establish a functioning emission market. From this point of view the EU ETS was a great success. The EU ETS was less successful in triggering the real reduction of GHG emissions. Generally, Phase 1 terminated with not negligible over-allocation. The only countries with short allocation were the UK, Italy Spain, Greece and Slovenia. On the other hand the countries with the biggest allocation surplus were Poland, France and Germany. Only the sector of power and heat generation finished with gross allocation deficit.

Our outlook to Phase 2 and beyond shows that the failure of over-allocation should not be repeated in Phase 2 and beyond. On the contrary, significant deficit between the allocation and real emission may be expected. There are several reasons for it. Allowances can be banked between the subsequent periods that provide the participants with long-term stable conditions. Allocation is further cut both in Phase 2 and more significantly in Phase 3 to reach goal of 21% EU ETS emission reduction target compared to 2005. The proposed revision of the architecture of EU ETS is movement towards more harmonized thus transparent and efficient regulatory instrument.

Annexes

Annex Table 1 : Summary of possible benchmarking approaches

Type	Name of Benchmarking method	Output	Benchmark emission factor	Fuel input	Benchmark fuel emission factor	Historical emissions	Benchmark based correction factor
1.	Standardized output-based (or capacity-based) benchmarks	Site specific info on capacity * Standardized sector load factor	Emissions per unit of site specific output Or specific energy consumption * emissions per unit of fuel (standardized)	x	x	x	x
2.	Site Specific Output-based benchmarks	Site specific info on capacity* Site specific load factor	Same as Type 1	x	x	x	x
3.	Input-based benchmarks	x	x	Site specific fuel use	Standardized fuel emission factor	x	x
4.	Site-specific energy efficiency factors	x	x	x	x	Site specific historical emissions	Industry/ Sector specific value for emission

Source: Summary based on proposals in Entec UK Limited and NERA Economic Consulting (2005)
Note: x = not used in benchmark computing

Annex Table 2 : Summary of different types of auctioning formats

	Type	Description	Real-life application	Real-life application related to emission trading
Single-Round Auctions (Sealed Bid Auctions)	Uniform-price	Bidders can submit bids at different prices. When the aggregated amount of all bidders (Q*) equals to the amount to auction set by regulator, all the bids for the Q* allowances obtain allowances at the market clearing price.	Electricity Auction	EU ETS Phase 1 : Ireland, Hungary, Latvia, Denmark
	Vickrey price	Winning bidders pay the price of bid by the second highest bidder for the units of emission permits.	Similar type used at eBay auction	-
	Discriminatory price	Bidders can submit bids at different prices. When the aggregated amount of all bidders (Q*) equals to the amount to auction set by regulator, the highest bids for the Q* allowances obtain allowances at their own bid prices		USA Acid Rain SO_2 allowance auction
Multi-Round Auctions (Open Auctions)	Ascending (English) clock	The regulator - auctioneer regularly posts a sequence of raising prices. Bidders reveal the quantity they are to buy at the given price. The process stops when the aggregated demand (Q*) equals to the amount offered for sale.	Auction of antiques	Virginia NO_X SIP Call
	Demand Schedule	Multi round version of discriminatory price single-round auction		-
	Descending (Dutch) clock	The auction starts with the highest price, which decrease with each round. In each round, bidders can "lock in" some amount to buy at the current offered or they can wait for the price to fall. The auction stops when the number of allowances locked in is greater than or equal to the amount dedicated to be auctioned by the regulator.	Dutch Tulip Auction	UK ETS
	Shot clock	The regulator - auctioneer regularly increase the prices. It stops when the total number of units requested falls to a threshold level = specified share of total amount offered for sale by regulator (e.g. 5%) + amount offered for sale. When the price stops, all bidders can submit a final set of bids in the form of quantities and prices (prices greater than the closing price) in so-called shoot-out round. The highest bids obtain allowances at their own bid prices; participants that did not enter into the shoot-out round pay the price of the previous round for the remaining permits.		

Source: Authors description according to various sources[61]

[61] Hepburn (2006), Cramton, P., and S. Kerr (2002), various internet sources related to the individual trading schemes

Annex Table 3 : Comparison of Allocation Methodologies of National Allocation Plans in Phase 1 - Focused on Power Sector Allocation

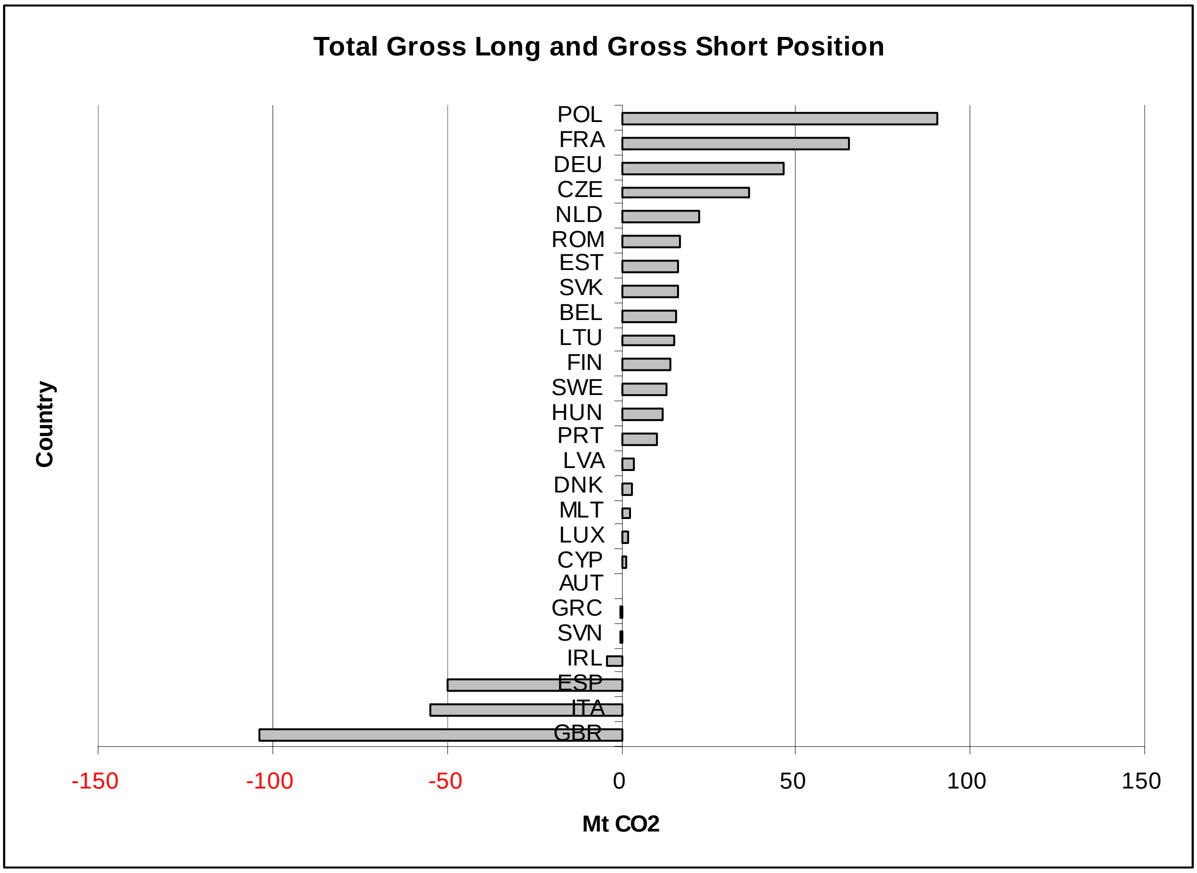
Country	Allocation mech.	Allocation Power Sector	Note to Allocation	A (Mt)	Base Year
Austria	G+B	Historical installation emissions multiplied by potential reduction factor and by compliance factor expressing the share of the historic installation in the industry emission. Potential reduction factor for lignite: 0.88 (corresponds to a reduction by 12%), for natural gas 0is used; for a 0.96 (-4 % reduction).	BAU forecast based on historic emission multiplied by emission reduction potential	0	1998 -2001
Belgium	G+B	Projected emissions *emission factor by fuel type*BAT benchmark (Flemish), Historic emissions* BAU with 5%reduction, benchmark(for gas using CCGT technology)(Walloon)	Different for Flemish, Walloon and The Brussels capital regions. Based on the historical emission and projected emissions.	0	2000-2002
Bulgaria	G	no specific rule	Allocation Rules same for all sectors. The quantity of allowances allocated to each installation each year is proportional to the product of emissions from the installations during the base year corrected with the projected increase in emissions in the sector compared to the base year.	0	2002-2004
Cyprus	G	no specific rule	Development of the BAU scenario with reduction potentials	0	2001-2003
Czech Rep.	G	no specific rule	BAU forecast till 2007 based on historic emission. Growth Coefficients in individual sectors	0	1998-2001
Denmark	G+A	Allocation of allowances according to historical electricity production. Allocation is reduced slightly compared to the ceiling in 2003 and 2004. which, since 2001, have been covered by the Danish national quota system for large electricity producers	BAU forecast based on historic emission reduced by 15% (Power sector bears major part of the reduction)	5	1998-2002
Estonia	G	no specific rule	Allocation set no definite restrictions. Individual development trends at each installation were prepared by the operators.	0	2000-2003, 1995-2003 only for heat power plants
Finland	G	no specific rule	Development of the BAU scenario with reduction potentials	0	1998-2002, in some cases 2000-2003
France	G	no specific rule	Historic emission multiplied by national emission reduction	0	1998-2001

			potential (0,97) and by industry growth factor		
Germany	G+B for new entrants	no specific rule	The emission allowance issued to an installation is derived by multiplying its historical annualized CO_2 emissions during the reference period by a standardized compliance factor 0.9755	0	2000-2002
Greece	G	Stricter electricity compliance factor : 0,94 compared to other industries	The emission allowance issued to an installation is derived by multiplying its historical annualized CO_2 emissions during the reference period by a industry specific compliance factor	0	2000-2003
Hungary	G+B for new entrants	no specific rule	Allowances to be allocated to each sector was determined uniformly on the basis of the projections assuming a BAU scenario	2.4	1998-2001
Ireland	G+A	Adjusted Compliance factor for power generation installation : 0,74	Development of the BAU scenario with reduction potentials	0.5	2002-2003
Italy	G+B(power sector)	Differentiated and stricter growth rates were assumed (1.1% between 2000 and 2005, -0.6% between 2005 and 2006, -0.3% between 2006 and 2007) that are multiplied by the emission in 2000. For Setting the installation allocation for electricity producers benchmark indicating the number of operation hours and emission coefficient	Industry based growth rates multiplied by emission in base year	0	2000-2003
Latvia	G+B	Technology based fuel emission factors multiplied by emissions in the base year	Technology based fuel emission factors multiplied by emissions in the base year	0	1997, 2002 or 2003
Lithuania	G+B+A	Projected production multiplied by technology based benchmark. Allowances for auction are subtracted from the allocation to the power sector.	Historic emission from the base year multiplied by emission reduction potential and by projected growth (industry specific growth). Different allocation for the power sector	0.2	1998-2002
Luxembourg	G	no specific rule	BAU scenario multiplied with reduction potentials0: 0,95	0	2001
Malta	G	Allocation was done based on prediction of future electricity demand growth and energy efficiency improvement base on extrapolating the data in the base year	Malta has only one sector - power generation sector - within the EU ETS.	0	1995-2004
Netherlands	G+B(power sector)	No expected sector growth allowed. The efficiency requirements concerned have been derived from the values used in the Benchmarking covenant (Separate regulation of the power sector prior EU ETS since 1999 concerning the voluntary energy efficiency commitments)	The quantity of allowances for allocation per installation has been based on historic emissions, expected sector growth, the degree of energy efficiency (for combustion emissions) and a correction factor 0.97.	0	2001-2002

Poland	G	Growth factor for electricity production sector 17% (2nd lowest industry growth factor). On the installation level there were reflected emission in the base year and the technical and achieved potential (=capacity of power plant utilization).	Emission from the base year multiplied by the sector based growth factor	0	1999-2002
Portugal	G+B for new entrants	The allocation takes into consideration information on trends in demand and supply mix in accordance as per the projections. In this specific case, the allocation will be based on projections. The proposed correction results in a reduction of 1.8 $MtCO_2$ in allowances allocated, compared with an allocation based on historical data.	Historical Emissions multiplied by global adjustment factor	0	2000-2003
Romania	G	no specific rule	Combination of the historical approach and forecast approach. Growth factor 1,03-1,05	0	2001-2004
Slovakia	G	Planned production multiplied by emission factor	Base year emission multiplied by industry growth factor or planned production multiplied by emission factor for several industries (energy, cement production)	0	2000-2002
Slovenia	G+B (industry sector)	Forecast emissions multiplied by sector emission reduction factor 0,894 stricter than for industry sector emission reduction (0,958)	2 approaches: for Power sector and for Industry. For Power sector -see the column, for Industry : base year emissions multiplied by sector emission reduction, benchmarks for CHP	0	1999-2002
Spain	G	no specific rule	Emission projections based on historical emission levels. These projections were used to calculate each sector's emission reduction capability for the purposes of allocation at sector level.	0	2000-2002
Sweden	G+B for new entrants	Correction factor is 0,8 for energy sector and 1 for other industries	Base year emission multiplied by correction factor and corrected for projection of raw-material related emissions of non-energy sector	0	1998-2001
UK	G	Power Station sector responsible for delivering the additional savings which the UK expects the EU ETS to deliver. Power sector has the greatest -21% change between annual emissions in 2003 and total allocation	Allocations at sector level will be made on the basis of the sector projected emissions. Some sectors allowed growth, only power sector reduced significantly.	0	1998-2001

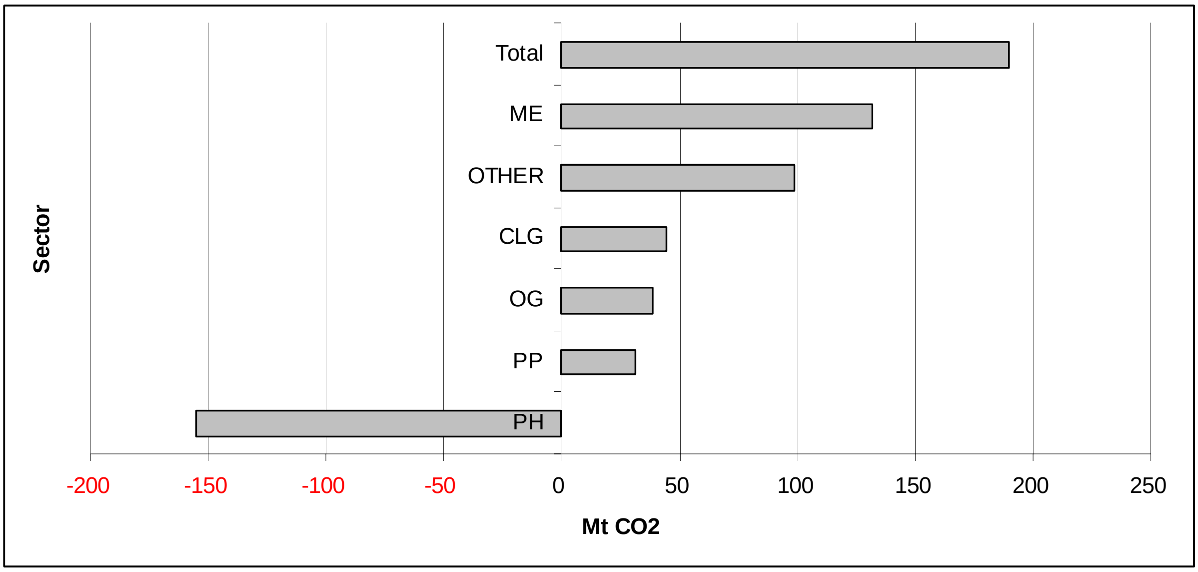
Source: Author's own comparison of National Allocation Plan of EU 27(see Internet sources)
Note: G=Grandfathering, B=benchmarking, A=Auctions, Base Year = Average Emissions in relevant years

Annex Figure 1 : Total Deficit and Over-Allocation in Phase 1 EU ETS



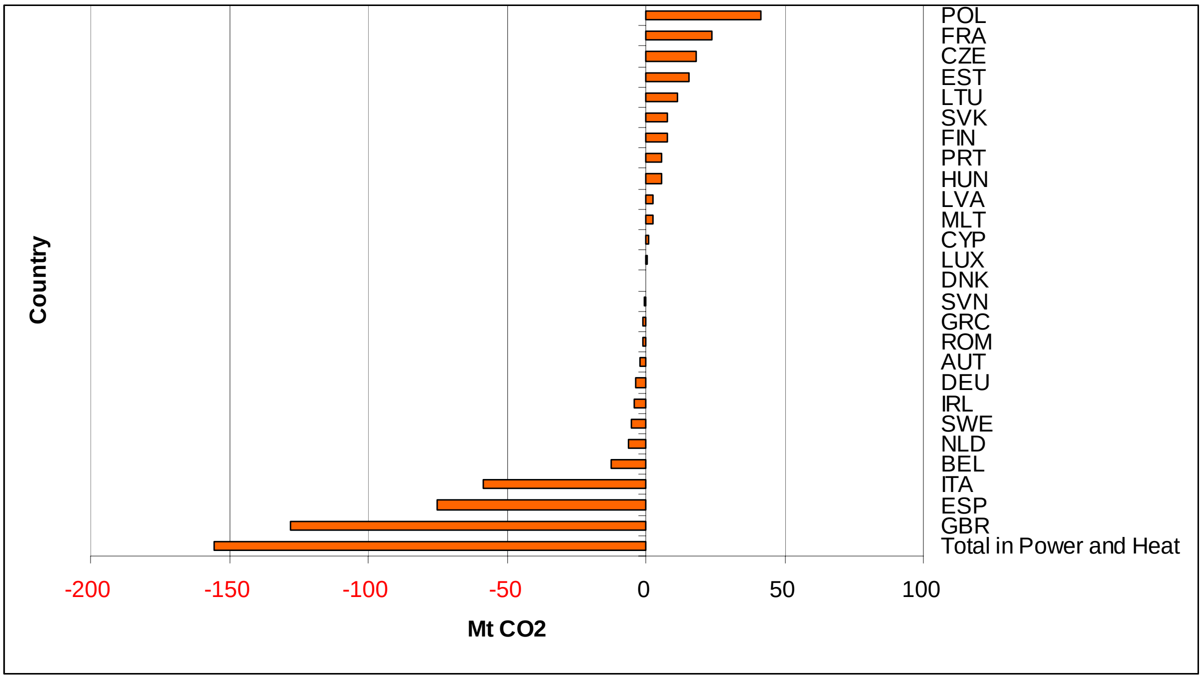
Source: Own computation according to the CITL data (see Internet Sources)

Annex Figure 2 : Sector Deficit and Over-allocation in Phase 1 EU ETS



Source: Own computation according to the CITL data (see Internet Sources)
Note: PH = power and heat, PP = paper production, OG = oil and gas production, CLG = cement, lime and glass, ME = metal production, OTHER = other installations

Annex Figure 3 : Short position in power sector



Source: Own computation according to CITL data (see Internet Sources)

Annex Figure 4: EUA Price Development

Source: PointCarbon data (see Internet Sources)

EUA 2008 Spot Price

Annex Table 4 : Input Data for the Analysis - GDP Trends

	GDP Forecast						Relative development factor of economic growth 2007-2011	Relative development factor of economic growth 2012-2020
	Annual % change							
	2007	2008	2009	2010	2011	2012-2020		
Austria	3.4%	2.2%	1.8%	2.0%	1.9%	1.9%	1.12	1.019
Belgium	2.7%	1.7%	1.5%	1.9%	2.0%	2.0%	1.10	1.020
Bulgaria	6.2%	5.8%	5.6%	5.2%	5.8%	5.8%	1.32	1.058
Cyprus	4.4%	3.7%	3.7%	3.4%	3.6%	3.6%	1.20	1.036
Czech Rep.	6.5%	4.7%	5.0%	4.1%	3.6%	3.6%	1.26	1.036
Denmark	1.8%	1.3%	1.1%	1.9%	1.8%	1.8%	1.08	1.018
Estonia	7.1%	2.7%	4.3%	8.1%	3.8%	3.8%	1.29	1.038
Finland	4.4%	2.8%	2.6%	2.8%	1.9%	1.9%	1.15	1.019
France	1.9%	1.6%	1.4%	1.9%	2.4%	2.4%	1.10	1.024
Germany	2.5%	1.8%	1.5%	1.3%	1.7%	1.7%	1.09	1.017
Greece	4.0%	3.4%	3.3%	4.0%	2.8%	2.8%	1.19	1.028
Hungary	1.3%	1.9%	3.2%	3.8%	3.5%	3.5%	1.14	1.035
Ireland	5.3%	2.3%	3.2%	5.0%	3.5%	3.5%	1.21	1.035
Italy	1.5%	0.5%	0.8%	1.2%	1.9%	1.9%	1.06	1.019
Latvia	10.3%	3.8%	2.5%	8.1%	5.4%	5.4%	1.34	1.054
Lithuania	8.8%	6.1%	3.7%	7.1%	4.7%	4.7%	1.34	1.047
Luxembourg	5.1%	3.6%	3.5%	3.8%	3.4%	3.4%	1.21	1.034
Malta	3.8%	2.6%	2.5%	1.4%	3.7%	3.7%	1.15	1.037
Netherlands	3.5%	2.6%	1.8%	2.0%	1.9%	1.9%	1.12	1.019
Poland	6.5%	5.3%	5.0%	3.7%	4.6%	4.6%	1.28	1.046
Portugal	1.9%	1.7%	1.6%	1.3%	2.7%	2.7%	1.10	1.027
Romania	6.0%	6.2%	5.1%	5.7%	5.8%	5.8%	1.32	1.058
Slovakia	10.4%	7.0%	6.2%	5.1%	4.5%	4.5%	1.38	1.045
Slovenia	6.1%	4.2%	3.8%	3.7%	2.6%	2.6%	1.22	1.026
Spain	3.8%	2.2%	1.8%	3.3%	2.9%	2.9%	1.15	1.029
Sweden	2.6%	2.2%	1.8%	2.8%	2.3%	2.3%	1.12	1.023
UK	3.0%	1.7%	1.6%	2.5%	2.3%	2.3%	1.12	1.023
Source:	DG ECFIN (2008) Economic Forecasts Spring 2008			DG TREN (2007) European Energy and Transport - Trends to 2030 - update 2007				

Annex Table 5 : Input Data for the Analysis - CO_2 Emissions

	Trends to 2030 Update 2030				Inputs for Scenario I.			Inputs for Scenario II.		
	CO_2 Emissions to GDP (tonne of CO_2/million Euro value year 2005				Carbon Intensity Factor			Adjusted Carbon Intensity Factor with emission reduction 2,5% every 5 years		
	2005	2010	2015	2020	2005-2010	2010-2015	2015-2020	2005-2010	2010-2015	2015-2020
Austria	300.6	267.9	257.8	240.2	0.98	0.99	0.99	0.97	0.94	0.94
Belgium	361.2	315.6	291.3	282.5	0.97	0.98	0.99	0.97	0.94	0.94
Bulgaria	2101.9	1729.1	1341.6	1060.5	0.96	0.95	0.95	0.97	0.94	0.94
Cyprus	539.7	487.1	377.0	320.2	0.98	0.95	0.97	0.97	0.94	0.94
Czech Rep.	1151.3	935.0	741.2	637.8	0.96	0.95	0.97	0.97	0.94	0.94
Denmark	234.8	210.7	190.4	175.0	0.98	0.98	0.98	0.97	0.94	0.94
Estonia	1371.0	1038.8	911.1	751.1	0.95	0.97	0.96	0.97	0.94	0.94
Finland	343.7	310.9	297.2	253.8	0.98	0.99	0.97	0.97	0.94	0.94
France	221.3	197.0	175.7	157.2	0.98	0.98	0.98	0.97	0.94	0.94
Germany	359.1	309.3	291.5	277.0	0.97	0.99	0.99	0.97	0.94	0.94
Greece	531.2	465.5	396.6	363.6	0.97	0.97	0.98	0.97	0.94	0.94
Hungary	619.5	539.8	481.7	433.3	0.97	0.98	0.98	0.97	0.94	0.94
Ireland	283.3	245.3	208.3	182.7	0.97	0.97	0.97	0.97	0.94	0.94
Italy	318.2	304.3	292.2	278.1	0.99	0.99	0.99	0.97	0.94	0.94
Latvia	569.2	473.1	416.3	361.9	0.96	0.97	0.97	0.97	0.94	0.94
Lithuania	612.6	571.4	505.3	368.0	0.99	0.98	0.94	0.97	0.94	0.94
Luxembourg	421.3	355.0	312.3	270.9	0.97	0.97	0.97	0.97	0.94	0.94
Malta	652.5	585.8	413.0	323.0	0.98	0.93	0.95	0.97	0.94	0.94
Netherlands	339.3	299.1	289.4	274.4	0.98	0.99	0.99	0.97	0.94	0.94
Poland	1192.6	1011.6	850.8	714.7	0.97	0.97	0.97	0.97	0.94	0.94
Portugal	416.9	387.7	370.6	346.3	0.99	0.99	0.99	0.97	0.94	0.94
Romania	1131.3	923.2	748.0	650.1	0.96	0.96	0.97	0.97	0.94	0.94
Slovakia	974.5	787.6	667.8	572.5	0.96	0.97	0.97	0.97	0.94	0.94
Slovenia	551.0	509.8	452.6	432.4	0.98	0.98	0.99	0.97	0.94	0.94
Spain	374.8	335.9	302.5	266.0	0.98	0.98	0.97	0.97	0.94	0.94
Sweden	168.7	159.6	161.5	145.9	0.99	1.00	0.98	0.97	0.94	0.94
UK	312.3	272.7	247.5	218.7	0.97	0.98	0.98	0.97	0.94	0.94
Source:	DG TREN (2007) European Energy and Transport - Trends to 2030 - update 2007				Computation from DG TREN (2007)			Computation from DG TREN (2007)		

Annex Table 6 : Input Data for the Analysis - EU ETS Allocation and Emissions

In Mt CO_2 p.a.	Phase 1. Allocation	Phase 1. Emissions				Installations added in Phase 2	Adjusted emission Phase 1	Phase 2. Allocation		Phase 3. Allocation							
	Average								JI-CDM import limit p.a.								
	2005-2007	2005	2006	2007	Average			2008-2012		2013	2014	2015	2016	2017	2018	2019	2020
Austria	33	33.4	32.4	31.7	32.5	0.4	32.9	30.7	3.1	29.1	28.6	28.1	27.6	27.2	26.7	26.2	25.8
Belgium	62.1	55.6	54.8	52.8	54.4	5.0	59.4	58.5	4.9	55.5	54.5	53.6	52.7	51.7	50.8	50.0	49.1
Bulgaria	42.8	40.6	41	42.3	41.3	0.0	41.3	42.3	5.3	40.1	39.4	38.7	38.1	37.4	36.8	36.1	35.5
Cyprus	5.7	5.1	5.1	5.4	5.2	0.0	5.2	5.5	0.5	5.2	5.1	5.0	4.9	4.8	4.8	4.7	4.6
Czech Rep.	97	82.5	83.6	87.8	84.6	0.0	84.6	86.8	8.7	82.3	80.9	79.5	78.1	76.8	75.4	74.1	72.8
Denmark	31	26.5	34.2	29.4	30.0	0.0	30.0	24.5	4.2	23.2	22.8	22.4	22.1	21.7	21.3	20.9	20.6
Estonia	18.96	12.6	12.1	15.3	13.3	0.0	13.3	12.7	0.0	12.1	11.9	11.7	11.4	11.2	11.1	10.9	10.7
Finland	45.5	33.1	44.6	42.5	40.1	0.4	40.5	37.6	3.8	35.7	35.1	34.4	33.8	33.3	32.7	32.1	31.5
France	156.4	131.2	123.3	126.6	127.1	5.1	132.2	132.8	17.9	126.0	123.8	121.6	119.5	117.4	115.4	113.4	111.4
Germany	499	474.0	477.6	487.0	479.5	11.0	490.5	453.1	90.6	429.9	422.4	415.0	407.8	400.7	393.7	386.9	380.2
Greece	74.4	71.3	70	72.7	71.3	0.0	71.3	69.1	6.2	65.6	64.4	63.3	62.2	61.1	60.0	59.0	58.0
Hungary	30.236	25.8	25.8	26.8	26.1	1.4	27.5	26.9	2.7	25.5	25.1	24.6	24.2	23.8	23.4	23.0	22.6
Ireland	22.3	22.4	21.7	21.2	21.8	0.0	21.8	22.3	2.2	21.2	20.8	20.4	20.1	19.7	19.4	19.0	18.7
Italy	215.7	225.5	227.1	226.0	226.2	0.0	226.2	195.8	29.4	185.8	182.5	179.3	176.2	173.2	170.1	167.2	164.3
Latvia	4.63	2.9	2.9	2.8	2.9	0.0	2.9	3.4	0.3	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9
Lithuania	12.3	6.6	6.5	6.0	6.4	0.1	6.5	8.8	1.8	8.3	8.2	8.1	7.9	7.8	7.6	7.5	7.4
Luxembourg	3.2	2.6	2.7	2.6	2.6	0.0	2.6	2.5	0.3	2.4	2.3	2.3	2.3	2.2	2.2	2.1	2.1
Malta	2.944	2.0	2	4.0	2.6	0.0	2.6	2.1	0.0	2.0	2.0	1.9	1.9	1.9	1.8	1.8	1.8

Netherlands	88.9	80.4	76.7	79.8	79.0	4.0	83.0	85.8	8.6	81.4	80.0	78.6	77.2	75.9	74.6	73.3	72.0
Poland	237.9	203.1	208.6	209.6	207.1	6.3	213.4	208.5	20.9	197.8	194.4	191.0	187.7	184.4	181.2	178.0	174.9
Portugal	38.16	36.4	33.1	31.2	33.6	0.8	34.4	34.8	3.5	33.0	32.4	31.9	31.3	30.8	30.2	29.7	29.2
Romania	84.2	70.8	71.5	71.5	71.3	0.0	71.3	75.9	7.6	72.0	70.8	69.5	68.3	67.1	66.0	64.8	63.7
Slovakia	30.7	25.2	25.5	24.4	25.1	1.7	26.8	32.6	2.3	30.9	30.4	29.9	29.3	28.8	28.3	27.8	27.4
Slovenia	8.7	8.7	8.8	9.0	8.8	0.0	8.8	8.3	1.3	7.9	7.7	7.6	7.5	7.3	7.2	7.1	7.0
Spain	171.9	182.9	178.6	186.4	182.6	6.7	189.3	152.3	30.5	144.5	142.0	139.5	137.1	134.7	132.3	130.0	127.8
Sweden	22.7	19.3	19.9	15.3	18.2	2.0	20.2	22.8	2.3	21.6	21.3	20.9	20.5	20.2	19.8	19.5	19.1
UK	206	242.5	251.1	256.6	250.1	39.5	289.6	246.2	19.7	233.6	229.5	225.5	221.6	217.7	213.9	210.2	206.6
	2246	2123	2141	2167	2144	84	2228	2083	278	1976	1941	1908	1874	1842	1810	1778	1747
									*	1974	1937	1901	1865	1829	1792	1756	1720
	EC Press Release from 7.12.2007	CITL - (see Internet Sources) (as of May 2008)				EC Press Release from 7.12.2007		EC Press Release from 7.12.2007		Own Computation according to the EU ETS Revision Directive Proposal. (Annual reduction factor : 1.74%							

Note : * Adjusted allocation for Phase 3 according to the EC communication

List of Abbreviations

AAU	*Assigned Amount Unit*
BAT	*Best Available Technology*
BAU	*Business as usual*
CDM	*Clean Development Mechanism*
CER	*Certified Emission Reduction*
CITL	*Community independent transaction log*
EC	*European Commission*
EUA	*European Union Allowances*
EU ETS	*European Union Emission Trading Scheme*
ETS	*Emission Trading Scheme*
GHG	*Greenhouse gas*
JI	*Joint Implementation*
NER	*New Entrants Reserve*
RGGI	*Regional Greenhouse Gas Initiative*
UNFCCC	*United Nation Convention on Climate Change*

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