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CARBON PRICE ESTIMATION IN THE EU EMISSIONS TRADING SCHEME (ETS) 2005 - 2007 BASED ON EMISSION ABATEMENT COSTS AND SUPPLY- DEMAND BALANCE OF EMISSION ALLOWANCES

Thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Technology

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Supervisors: Professors Carl-Johan Fogelholm and Tuula Pohjola

Instructor: Heikki Niininen M.Sc. (Technology)

HELSINKI UNIVERSITY OF TECHNOLOGY ABSTRACT OF THE MASTER'S THESIS

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According to EU Emissions Trading Directive 2003/87/EC, EU Emissions Trading Scheme (EU ETS) starts on 1st January, 2005. The start-up of the scheme means that carbon dioxide (CO_2) will have a monetary value for the ETS participants. EU ETS will cover some 13 000 installations, 6000 companies and around 46% of EU-wide (CO_2) emissions by 2010. EU ETS is a strategic policy instrument helping Member States to fulfil their legally binding Kyoto commitments during the period 2008 - 2012.

Allowance price estimates given in the literature vary between 1 and 15 € for the EU ETS first trading period 2005 – 2007. Allowance forward prices have fluctuated from 6 to 13 € during 2003 - 2004.

In theory, the main determinants of the allowance price are allowance supply-demand balance and CO_2 emissions marginal abatement costs (MAC). In the EU, ETS allowance supply is determined by the total allocation of allowances and Kyoto project-based mechanisms credit imports. Demand for allowances is based on the forecasted business-as-usual (BAU) emissions scenarios, which in this thesis have been estimated by a trend line analysis of historic EU ETS sector CO_2 emissions. MACs of CO_2 emissions have been studied by reviewing the literature on the topic. During the first trading period, MACs are to a great extent based on the cost of fuel switches from coal to gas in power production.

According to this study, the allowance supply-demand balance estimates during the first trading period in EU ETS will vary from a 5.1 Mt CO_2 deficit to 143.4 Mt CO_2 surplus of allowances. As the supply exceeds the demand, the estimated allowance price is predicted to remain very low. When the final allocation is set by the Commission, the allowance supply may change. If the demand exceeds the supply, the allowance market price is based on the estimated CO_2 abatement costs. Abatement potential under € 10 /t CO2 varies from 25 to 145 Mt CO_2 according to different estimates. Abatement costs increase very heavily after 150Mt CO_2 abatement has been taken.

A sensitivity analysis for the price determinants was performed. Political decisions, annual hydro power availability, fuel prices, and electricity demand forecasts cause the main fluctuations in the allowance market prices.

Key words: carbon price**,** emissions trading, CO_2 emissions, emission allowances

FOREWORD

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ABBREVIATIONS

AAU	Assigned Amount Unit
BAU	Business-as-usual
CAP	Total amount of allowances allocated for a certain period of time
CCGT	Combined cycle gas turbine
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanisms
CER	Certified emission reduction - the credits arising from a CDM project
CH_4	Methane
COP	Conference of the Parties to UNFCCC
COP/MOP	Conference of the Parties to UNFCCC serving as the Meeting of the Parties (MOP) to the Kyoto Protocol
CO_2	Carbon dioxide
EC	European Commission
ECCP	European Climate Change Programme
EEA	European Environment Agency
ERU	Emission reduction units - the credits arising from a JI project
ETS	Emissions Trading Scheme
ET	Emissions Trading
EU	European Union
EU15	Former EU15 Member States
EU10	New EU Member States
EU25	Current EU Member States
EU ETS	European Union Emissions Trading Scheme
EUA	European Union Allowance - name of the emissions rights that will be allocated and traded amongst participants under the EU ETS
GDP	Gross domestic product
GHG	Greenhouse gas
HFCs	Hydro fluorocarbons
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change

JI	Joint Implementation
MAC	Marginal abatement cost
NAP	National allocation plan
NER	New entrants' reserve
NGL	Natural gas liquids
N_2O	Nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PFCs	Per fluorocarbons
SF_6	Sulphur hexafluoride
UNFCCC	United Nations Framework Convention on Climate Change
WAM	With additional measures scenario
WM	With measures scenario

1 INTRODUCTION

1.1 Background

Climate Change has been recognised as one of the greatest environmental and economic challenges facing humanity today. Rising concentrations of greenhouse gases in the earth's atmosphere are changing the way the atmosphere absorbs energy. The result is known as the enhanced greenhouse gas effect. The greenhouse effect is however a natural part of the ecosystem. The global mean surface temperature would be some 30 degrees lower in the absence of the layer of greenhouse gases. (UNFCCC, 20031)

The rate of climate change has been projected to be more rapid than previously expected. Based on current scientific evidence, the globally averaged surface temperature is projected to increase by 1.4 to 5.8 °C over the period 1990 to 2100. The rise in temperature is predicted to have strong adverse effects including rising sea levels, more irregular precipitation patterns, and an increase in extreme weather events like droughts and storms. (IPCC, 2001)

The driving force behind international efforts to tackle adverse global environmental issues has been the United Nations, mainly the United Nations Framework Convention on Climate Change (UNFCCC) agreed in Rio in 1992, whose objective is to mitigate the global climate change. To supplement and strengthen the Framework Convention, industrial countries agreed to legally binding greenhouse gas reduction targets in Kyoto in 1997. According to the Kyoto Protocol, the European Union has committed to a common burdens sharing target to reduce greenhouse gases by 8% compared to 1990 levels.

To promote greenhouse gas emission reductions in a cost-effective and economically efficient manner, the EU has chosen emission trading as the main instrument. This was decided in the Emissions Trading (ET) Directive 2003/87/EC, which entered into force in October 2003. According to the ET Directive, EU-wide emissions trading will start on 1st January 2005. After that date some 13 000 installations in EU25 covered by the scheme are required to surrender tradable allowances (EUAs) equal to their carbon dioxide emissions after each operational year. In order to fulfil this obligation, the installations receive an initial allocation of allowances from the Member States and can subsequently trade those allowances with other covered installations.

1.2 Issues to be researched

As the EU Emissions Trading Scheme (EU ETS) starts its operation on 1st January 2005, carbon dioxide will have a monetary value. Over 90% of Fortum's CO_2 emissions will be covered by the scheme. In power and heat production, as well as in oil refining, the price of emitting carbon dioxide will be regarded as an extra cost element in the variable costs of production. Further on the prices in the energy market will be affected because of the changed cost structures.

Therefore it is essential for energy companies to estimate future carbon prices, the cost of emitting carbon dioxide (CO_2). Based on the knowledge of allowance price, the companies can make strategic decisions concerning e.g. production, new investments, allowance trading and risk policy. The price of carbon will affect company cash flows and valuations because it will influence the energy prices and affect output levels from different plant types.

1.3 Objectives

This thesis attempts to define the main determinants of carbon dioxide allowance prices and their relative importance. Based on the analysis of the EU allowance (EUA) price determinants, the goal is to estimate the allowance price under the EU Emissions Trading Scheme during the first trading period 2005 - 2007. A key desired outcome of the study is the determination of factors and their relative importance, which might cause fluctuations in the allowance price estimate.

1.4 Methodology

The allowance price estimation is based on analysing the main price determinants; demand-supply balance of allowances and marginal abatement costs of CO_2 emissions. Supply of allowances is based on the data given in the Member States National allocation plans for the first trading period 2005 - 2007. Allowance demand is analysed based on the predicted business-as-usual -based CO_2 emission scenarios given in the National allocation plans. As this data is not available for every Member State, a statistical analysis of historic emissions development from 1990 - 2002 is conducted. The statistical analysis is based on existing CO_2 emissions and energy statistics. The demand for allowances in 2005 - 2007 is estimated based on the extrapolation of historic EU ETS sector emissions. The methodology is relevant as the extrapolation interval is relatively short. Estimates of CO_2 emissions marginal abatement costs are evaluated by reviewing the existing literature on the topic.

This study attempts to estimate the allowance price only for the first trading period 2005 - 2007 under the EU ETS. Some indications of the allowance prices for the second trading period 2008 - 2012 will be given. The estimates are based on data available until 15 December, 2004.

1.5 Structure of the Master's Thesis

The thesis is structured as follows. Chapter 2 introduces the regulatory background of climate change and emissions trading. Chapter 3 provides a review of the theory of allowance price formation in an emission trading scheme under an ideal situation. Chapter 4 takes a brief look at how the global carbon market has emerged. It also presents, based on existing literature, estimates of EU allowance prices that are essential references in relation to the goals of this thesis. In Chapter 5, fundamental allowance price determinants are estimated and the basis of analysis which they are based on is introduced. Chapter 6 includes a critical consideration of sensitivities affecting the allowance price estimates. Chapter 7 puts forward the conclusions and Chapter 8 provides recommendations.

2 REGULATORY FRAMEWORK TO CONTROL CLIMATE CHANGE

2.1 United Nations Framework Convention on Climate Change (UNFCCC)

Concerns over global climate change first emerged about 25 years ago in 1979 at the First World Climate Change Conference. This was followed by increased public concern over environmental issues in the 1980s and the establishment of an Intergovernmental Panel on Climate Change (IPCC) in 1988. IPCC was founded to assess the scientific information on climate change and, already in 1990 in its first assessment report, IPCC confirmed that the threat of climate change was real. Concern over climate issues continued to increase and in 1994 one of the largest ever achieved international environmental agreements, The United Nations Framework Convention on Climate Change, UNFCCC, was agreed. The purpose of the Convention is to make an intergovernmental effort to tackle climate change and the ultimate objective is to achieve stabilisation of atmospheric concentrations of greenhouse gases at levels that would prevent dangerous anthropogenic interference with the climate system. (UNFCCC, 2003)

On 24th May, 2004, the Convention had been joined by 188 states and the European Union (UNFCCC, 2004). The Parties to the convention are divided into three main groups according to differing commitments; Annex I, Annex II and non-Annex I Parties. Annex I countries are industrialised countries which were members of the OECD in 1992, plus countries with economies in transition, called the EIT Parties. Annex II countries include OECD members of Annex I but not EIT Parties. Non-Annex I countries are developing countries. All countries that have ratified the Convention are subject to general commitments to respond to climate change. (UNFCCC, 2003)

Since entry into force in 1994, Parties to the Convention have annually met at the Conference of the Parties, known as the COP. The purpose of the COPs is to foster and monitor the implementation of the Convention and continue discussions on how to best tackle climate change. By mid-December 2004, ten COPs had been held. Out of these the most historic is COP3, held in Japan in Kyoto in 1997. In Kyoto, COP3 Parties to the Convention adopted the Kyoto Protocol, which outlined legally binding commitments for Annex I Parties to the Protocol. As the Kyoto Protocol enters into force on 16th February, 2005, the COPs will be called COP/MOPs as they can serve also Parties to the Kyoto Protocol. MOPs are however not dependent on COPs, thus MOP meetings can also be held separately. (UNFCCC, 2003)

Currently, post-2012 negotiations are ongoing. Proposals for what might replace the present Kyoto structure were expected to form a major unofficial topic for discussion at the COP10 meeting in Buenos Aires in December 2004. COP11, in autumn 2005, will start the official post-2012 negotiations. One key task will be to consider how the US, which decided to stay outside the Kyoto Protocol in 2001, can be brought within the next international climate change control agreement. (Environmental Finance, 2004a)

2.2 The Kyoto Protocol

As an extension of the United Nations Framework Convention on Climate Change, the Kyoto Protocol was agreed at COP3, held in Kyoto in 1997. The purpose of the Protocol is to supplement and strengthen the Convention goals by setting legally binding greenhouse gas emissions reduction commitments for industrialised, Annex I countries. Only Parties that have ratified the Convention can become Parties to the Kyoto Protocol. (UNFCCC, 2003)

Kyoto Protocol commitments cover six greenhouse gases: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) and sulphur hexafluoride (SF6). General commitments to reduce these six greenhouse gas emissions are set for all Parties of the Protocol. Legally binding emission reduction commitments are set only for industrialised countries, Annex I Parties of the Protocol. The individual reduction targets are listed in the Kyoto Protocol's

Annex B. Annex B covers all Annex I parties except Belarus and Turkey as they were not parties to the Convention when the Protocol was adopted. For simplicity, in this study all countries having quantitative targets in greenhouse gas emissions reductions are called Annex I in the following chapters. (UNFCCC, 2003), (UNFCCC, 2004)

Annex I parties have agreed to reduce their collective emissions of the six greenhouse gases by 5.2% below 1990 levels during the first commitment period of the Protocol 2008 - 2012. Burden sharing is divided between countries, presented in Table 1 below. The base year for calculating the Kyoto baseline is generally 1990 emissions, except for HFCs, PFCs and SF_6 optionally year 1995. For some EU10 new Member States, the base year differs from 1990/1995. For Hungary, the base year is on average 1985-1987, for Poland 1988 and for Slovenia 1986. Out of EU25 countries Malta and Cyprus do not have Kyoto targets. (COM (2003)735), (UNFCCC, 2003)

Table 1 The Kyoto Protocol's burden sharing agreement. Required reduction % in 2008 - 2012 compared to 1990/1995 base year greenhouse gas emissions. (EU, 2002)

	%
Iceland	10
Australia	8
Norway	1
Russia and Ukraine	0
New Zealand	0
Croatia	-5
Japan	-6
Canada	-6
Poland; with 1988 as the base year	-6
Hungary; with 1985-1987 average as the base year	-6
USA	-7
Baltic countries	-8
Most other Central European Countries	-8
EU15	-8

The first Parties ratified the Protocol in 1998 and by mid-December 2004, the Protocol had been ratified by 128 nations with 61.6% coverage of Annex I emissions in 1990. The Protocol will enter into force on the ninetieth day after at least 55 Parties to the

Convention have ratified it and it encompasses at least 55 per cent of total Annex I Parties carbon dioxide emissions in 1990. As Russia ratified the Protocol on 18th November, 2004, the entry into force requirement was fulfilled. Thus the Protocol will become an internationally binding agreement on 16th February, 2005 even though the world's largest GHG emitter the US as well as Australia have both refused to ratify the Protocol. (UNFCCC, 2004)

2.2.1 Kyoto Protocol flexible mechanisms

The Kyoto Protocol includes three flexible mechanisms that are designed to increase the cost-effectiveness of climate change mitigation and help Annex I countries to meet their quantitative reduction targets. These mechanisms are Joint Implementation (JI), Clean Development Mechanisms (CDM) and Emissions Trading (ET). To meet their Kyoto targets, Annex I countries can both adopt domestic policies and measures to reduce emissions and use these flexible mechanisms. The flexible mechanisms open up ways for countries to cut emissions more cost-efficiently abroad than at home. Together with the Joint Implementation, Clean Development Mechanisms are called Kyoto project-based mechanisms. (UNFCCC, 2003)

Joint Implementation (JI) allows Annex I countries to implement projects that reduce emissions or increase removals using GHG emission absorbing sinks, e.g. afforestation and reforestation activities, in other Annex I countries. JI projects create emission reduction units (ERUs). To avoid double accounting, a corresponding subtraction must be made from the host country's assigned amount of the burden. JI projects must have the approval of all Parties involved and must lead to emission reductions or removals that are additional to any that would have occurred without the project. (UNFCCC, 2003)

Clean Development Mechanism (CDM) allows Annex I industrialised, countries to implement sustainable development project activities that reduce emissions in non-Annex I developing, countries. CMD projects help non-Annex I countries work towards sustainable development. They must have the approval of all Parties involved and must lead to real, measurable emission reductions or removals that are additional to any that would have occurred without the project. (UNFCCC, 2003)

Emissions Trading (ET) enables the governments of Annex I countries to perform intergovernmental trading with their emissions rights, which are called assigned amount units (AAUs). (UNFCCC, 2003)

2.2.2 EU burden sharing agreement and EU new Member State commitments under the Kyoto Protocol

The EU and its Member States ratified the Kyoto Protocol in late May 2002 (EU, 2004). At the same time, EU15 countries confirmed a common target, called the burden sharing agreement, to limit overall greenhouse gas emissions under the Kyoto Protocol to 8% below 1990 levels in 2010. The burden sharing was politically agreed already in 1998, soon after the COP meeting in Kyoto. The target is shared between EU15 Member States according to the percentages shown in Table 2. For eight new EU Member States that are included in EU ETS, the Kyoto Protocol reduction target is 8% except for Hungary and Poland 6%. (EU, 2002)

The national reduction targets according to the burden sharing vary between countries. Countries like Luxembourg (-28%), Denmark (-21%) and Germany (-21%) must reduce their emissions from 1990 levels. In comparison, countries like Spain (+15%), Greece (+25%) and Portugal (+ 27%) are allowed to increase their emissions. (EU, 2002)

Table 2 Burden sharing between former EU15 and the targets of the new EU Member States under the Kyoto Protocol. Required reduction % in 2008 - 2012 compared to 1990/1995 base year greenhouse gas emissions. (EU, 2002)

EU-15 Member States	%	Accession countries	%
Austria	-13	Czech Republic	- 8
Belgium	-6.5	Estonia	- 8
Denmark	-21	Hungary	- 6
France	0	Latvia	- 8
Finland	0	Lithuania	- 8
Germany	-21	Poland	- 6
Greece	+25	Slovakia	- 8
Ireland	+13	Slovenia	- 8
Italy	-6.5	Cyprus	No commitment
Luxembourg	-28	Malta	No commitment
Netherlands	-6		
Portugal	+27		
Spain	+15		
Sweden	+4		
UK	-12.5		
EU15	-8		

The European Commission reports regularly on progress towards the Kyoto targets through the Monitoring Mechanism. (COM (2003)735) The greenhouse gas (GHG) emissions data presented in the above reports refer to European Environment Agency (EEA) statistics. Besides the common report at EU level, each Member States publishes annually national reports covering information on the policies and measures used or planned to be used in order to achieve the Kyoto target. National reports also cover information on GHG emission projections. See Annex A for most the recent GHG projections for EU25 Member States.

Figure 1 states the distance to Kyoto target indicators for each EU15 Member State in 2002. The distance to the target indicator is achieved by comparing a hypothetical target for 2010 and the change in emissions actually achieved by 2002. The hypothetical target assumes that the allowed change in emissions from base year to years 2008 - 2012 will be achieved in a linear way. As shown in Figure 1, only France, Sweden, Germany and the UK have already met this linear improvement of their burden sharing targets in 2002.

In comparison, the countries most behind in meeting their targets are Spain (+30.4%) and Portugal (+24.8%). Total EU15 emissions in 2002 were +1. 9% above the total EU15 distance to the target indicator. (EEA, 2004a)

As can be seen from Table 2 and Figure 1, those countries that are allocated the greatest growth in emissions in the EU15 burden sharing are still furthest away from reaching their targets. For example, the burden sharing allows Spain to increase its emissions by +27% and in 2002 Spain is furthest, 30.4%, away from the linear pathway to meet its target. The opposite concerns countries that are required to reduce most according to the burden sharing. For example the UK, whose burden sharing commitment is -12.5% is already in 2002 7.4% below the linearly measured pathway.

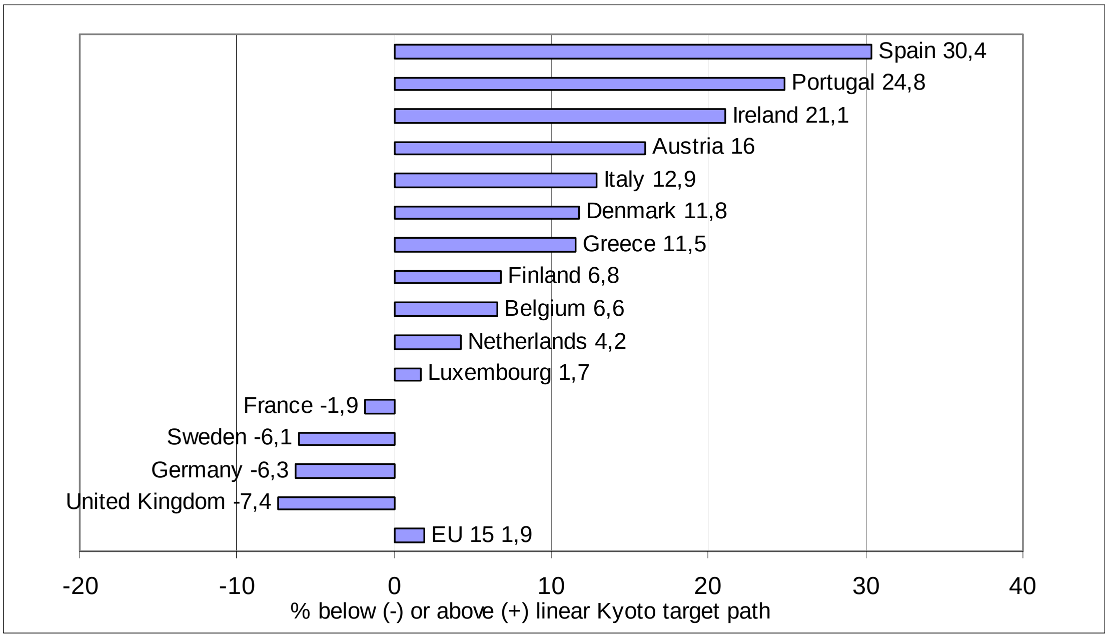

Figure 1 EU15 distance to Kyoto target indicators, 2002 (EEA, 2004a)

Figure 2 states the distance to Kyoto target indicators for each EU10 accession countries on the same basis as Figure 1 for EU15 countries, but the distance is compared to 2001 emissions. As shown in Figure 2, only Slovenia did not reach its linear Kyoto target in 2001. Most of the EU accessions countries are well on track towards their Kyoto commitment in 2008 - 2012, measured as average GHG emissions in 2010. (EEA, 2004c)

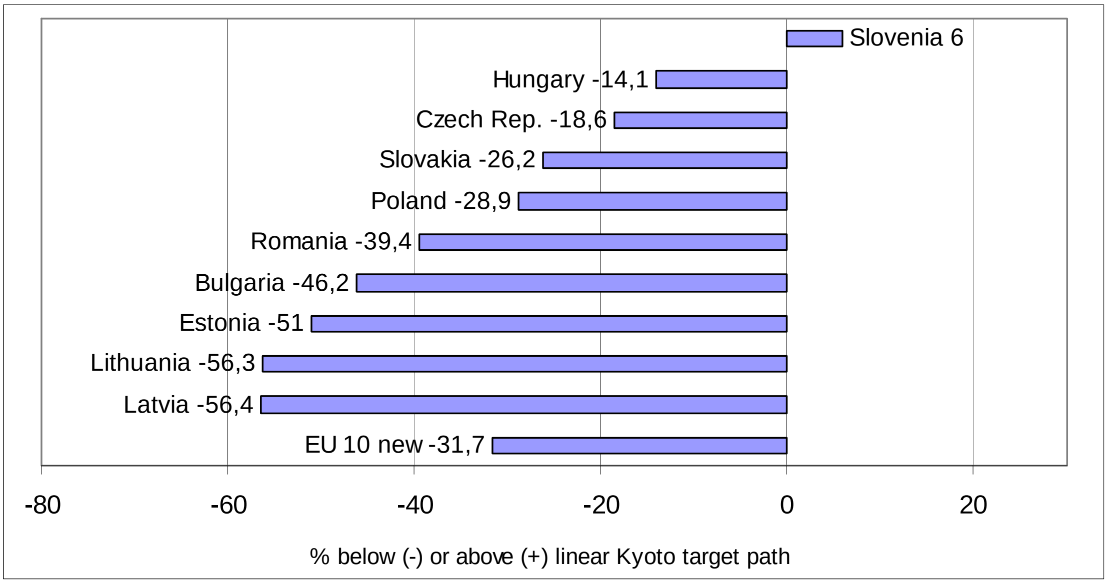

Figure 2 EU10 accession countries distance to Kyoto target indicators, 2001 (EEA, 2004c)

Figure 3 presents the GHG and CO_2 development in the EU15 region and the future target path to meet the EU burden sharing agreement in 2010. In 2002, EU15 emissions were 97.1% of the 1990/1995 baseline levels while the target is to stabilise the GHG emissions at level of 92% compared to 1990/1995 baseline. As shown in Figure 1, in 2002, total EU15 emissions were 1.9% above the linear targeted pathway, which can be seen also in Figure 3 as the difference between the realised GHG emissions in 2002 compared to the linear target path 2010. (EEA, 2004a)

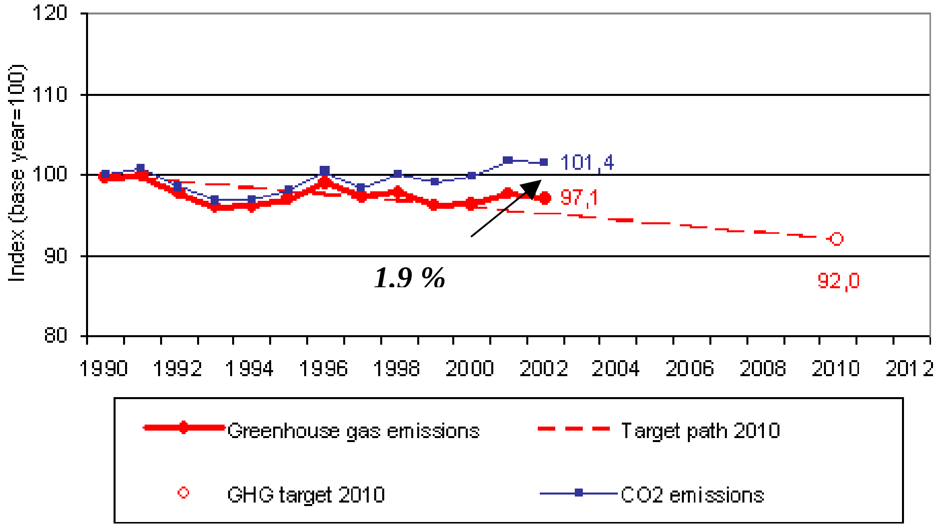

Figure 3. Total EU15 greenhouse gas emissions in relation to the Kyoto target (EEA, 2004a)

2.3 European Climate Change Programme (ECCP)

In March 2000, the European Union launched a European Climate Change Programme, ECCP, which defines the Community's strategy to reduce greenhouse gas emissions according to the EU burden sharing agreement under the Kyoto Protocol. (COM (2000)88)

The European Climate Change Programme contains policies and measures to reduce greenhouse gas emissions. One strategic instrument defined in ECCP is an EU-wide emissions trading scheme, which will cover approximately 46% of EU CO_2 emissions in 2010. Other policies and measures defined in ECCP concern, for example, increased use of renewable energy sources, energy efficiency at the end use and combined heat and power (CHP) production. (COM (2000)88), (COM (2001)581)

2.4 European Union Emissions Trading Directive

A proposal for a Directive establishing an emission allowance trading scheme in the EU was made already in October 2001 (COM (2001) 581). Two years later, in October 2003, European Union Emission Trading Directive 2003/87/EC entered into force. The ultimate objective of the Emission Trading Directive is to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner. It aims at fulfilling the commitments of the EU Member States under the Kyoto Protocol and recognises the fact that in the longer term, global emissions of greenhouse gases will need to be reduced by approximately 70% compared to 1990 levels. (EU, 2003a)

According to the Emission Trading (ET) Directive, the European Union Emission Trading Scheme (EU ETS) will start on 1st January 2005. After that, an installation covered by the scheme is not allowed to operate without an emission permit and is required to surrender allowances equal to its carbon dioxide emissions after each operating year. The annual timetable of EU ETS is presented in more detail in Annex B. The EU allowance (EUA) is the unit used in the scheme. Each allowance is equivalent to one tonne of CO_2 and a quantity of allowances will be initially allocated to each installation covered by the scheme. (EU, 2003a)

The first trading period will run for three years from 2005 to 2007. The second trading period will run for five years, from 2008 to 2012. During the first trading period the trade covers only carbon dioxide (CO_2) emissions. The scheme may be extended to cover also other GHG emissions in the second trading period. (EU, 2003a)

In the first trading period, the scheme covers large stationary emission sources from the energy, industry and manufacturing sectors. The activities covered by EU ETS in 2005-2007 period are presented in more detail in Table 3. For the second trading period in 2008 - 2012, called the Kyoto Period, the scheme might be enlarged to cover also other activities in the economy. (EU, 2003a)

Table 3 Sectors and activities covered by the EU ETS during the first trading period 2005-07. (EU, 2003a)

Energy activities	- combustion installations, thermal input > 20MW (except hazardous or municipal waste incinerators) - mineral oil refineries - coke ovens
Production and processing ferrous metals	- metal ore roasting and sintering installations - iron or steel manufacturing installations, capacity > 2.5 tonnes/ h
Mineral industry	- cement production installations, capacity > 500 t/d - lime production installations, capacity > 50 t/d - glass and glassfibre installations, capacity > 20t/d - ceramic manufacturing installations, capacity > 75t/d or a kiln capacity > 4m3 with a setting density per kiln > 300kg/m3
Other activities	- pulp and paper installations, capacity > 20 t/d

The Member States are allowed to use an opt-out option, temporarily excluding installations from the scheme, in the first trading period. The opt-out option may be used for installations providing they can demonstrate that they would have similar targets and incentives to reduce emissions as if they were in the EU ETS. There is also an opt-in possibility that enables the inclusion of installations outside the scope of the Directive defined in Table 3. This possibility has been used, e.g. in Finland by including boilers < 20 MW if they are connected to a district heating network where at least one boiler is bigger than 20 MW. (EU, 2003a)

The ET Directive sets rules for banking and borrowing EU emission allowances. Allowances may be banked for use in subsequent years within the same period, but may not necessarily be carried across periods. The rules for the banking of allowances between the trading periods are still to be clarified and may vary between Member States. Borrowing of allowances from future years within the same period is not permitted. (EU, 2003a)

According to the ET Directive, if an installation covered by EU ETS cannot present enough allowances at the end of each trading period it is obliged to pay a penalty fee.

The fee will be €40/tonne of CO_2 in the first trading period and increase to €100/ tonne of CO_2 in the second trading period. The payment of fines does not remove the obligation to achieve compliance. The installation is obliged to present an extra amount of allowances equal to those excess emissions at the end of the next trading year. (EU, 2003a)

According to the ET directive, at least 95% of the allowances allocated in the first trading period and 90% in the second trading period must be allocated free-of-charge. The initial allocation for installations will be defined in each Member State's National allocation plans. EU15 Member States were obliged to finalise and submit their National allocation plans to the Commission by 31st March 2004 and EU accession countries by 1st May 2004. In mid-December 2004 this process is still delayed in some Member States. Within three months after submission, the Commission is required to approve or reject the allocation plan. (EU, 2003a)

The Commission has an opportunity to review the Emission Trading Directive by the end of 2004. The next time the ET Directive can be reviewed is 2006. The Commission may propose future developments of the ET Directive and submit the proposal to the European Parliament by mid-2006. The future developments of the ET directive may apply from 2008 onwards and may include, for example, proposals of expansion of the scheme to incorporate additional sectors and GHGs, possible linkages of EU ETS to other emissions trading schemes and further harmonisation of the allocation method.

2.5 National allocation plans

One of the core tasks in the run-up to the implementation of the EU-wide greenhouse gas allowance trading scheme is the elaboration of National allocation plans by Member States.

The Emissions Trading Directive states that every Member State is obliged to develop a National allocation plan for each trading period. In the allocation plan, a Member State defines the total quantity of allowances it intends to allocate for the trading period and how these allowances are to be distributed among the installations. (EU 2003a)

Allowance allocation should be based on an objective and transparent criteria, which is specified accurately in Annex III to the Directive (EU, 2003a). In January 2004, the Commission published a guidance paper to assist Member States in the implementation of the criteria. The criteria consist of eleven parts, which are listed in Table 4. The criteria can be categorised on the basis of whether the implementation is mandatory or optional as can been seen from Table 4. A Member State has an obligation to apply all elements of the mandatory criteria and some elements of the criteria that are partly mandatory and partly optional. The commission will not reject a National allocation plan if all mandatory criteria and mandatory elements of the criteria are applied in the correct manner. The criteria can be also categorised depending on the distinction of whether it is applicable to all allocated allowances or at activity or sector level or at installation level as can be seen from Table 4. (COM(2003)830)

Table 4 Categorisation of the criteria for NAPs specified in Annex III of the EU Emissions Trading Directive (COM (2003)830)

Criterion	Mandatory(M)/ Optional (O)	Applies to		
		Total level	Activity/ sector	Installation
1) Kyoto commitments	M/O	+		
2) Assessment of emissions development	M	+		
3) Potential to reduce emissions	M/O	+	+	
4) Consistency with other legislation	M/O	+	+	
5) Non-discrimination between companies or sectors	M	+	+	+
6) New entrants	O			+
7) Early action	O			+
8) Clean technology	O			+
9) Involvement of the public	M			
10) List of installations	M			+
11) Competition from outside the EU	O			

In brief, the criteria states that (COM (2003)830):

1. Total allocation of allowances for the relevant period should be consistent with the Member State's obligation to limit emissions according to the Kyoto Protocol commitment. Total allocation should take into account burden sharing between EU ETS covered sectors and non- EU ETS sectors and is consistent with other national energy and climate policies.
2. Allocation should be consistent with assessments of actual and projected progress towards fulfilling the Member States' contributions to the Community's commitment under the Kyoto Protocol.
3. Quantities of allowances to be allocated should be consistent with the potential of activities covered by the scheme to reduce emissions.
4. The allocation plan shall be consistent with other Community legislative and policy instruments. An example is the new EU requirements for traffic fuels, which imply higher energy consumption at refineries.
5. The allocation shall not discriminate between companies or sectors.
6. The plans must contain information on how new entrants will be able to begin participating in the Community scheme in the Member State concerned.
7. The plans should contain information on the manner in which early action in emissions reduction is taken into account.
8. The plans should contain information on the manner in which clean technology, including energy efficient technologies, are taken into account.
9. In the plan, a Member States should include information on how the plan has been made available for public comments in early allocation stages.
10. The plan should cover a list of installations covered by the EU Emissions Trading Directive and quantities of allowances to be allocated to each installation.
11. The plan may contain information on the manner in which the existence of competition from countries or entities outside the Union will be taken into account.

The method of allowances allocation is either free-of charge or chargeable. As stated earlier and according to the ET Directive, at least 95% of the allowances allocated in the first trading period and 90% in the second trading period must be allocated free-of-charge (EU, 2003a). The main free-of-charge allocation models are grandfathering and benchmarking. In grandfathering, each market participant receives allowances for free based on its previous emissions. In benchmarking, allowances are granted on the basis of a plant's technologies or techniques and their comparison to other plants. The main chargeable allocation model is auctioning, which requires each market participant to buy allowances through an auction procedure. (Nicholson et al., 2002)

For the purpose of this study, the most important information with regards to the National allocation plans are the total quantity of allocated allowances. This is because in theory, only the total quantity of allowances issued should affect the allowance market price, not the distribution of allowances.

2.5.1 EU25 National allocation plans status by 15th December, 2004

Originally, EU15 Member States were obliged to finalise and submit their National allocation plans (NAPs) to the Commission by 31st March, 2004 and EU accession countries by 1st May, 2004. By mid-December 2004 24 NAPs had been submitted to the Commission, of which the Commission has assessed 16. The Commission has taken the decisions in two rounds, on 7th July and on 20th October, 2004. Out of 16 assessed plans, 11 have been unconditionally approved and 5 conditionally approved. Plans from Denmark, Ireland, the Netherlands, Slovenia, Sweden, Belgium, Estonia, Latvia, Luxembourg, Slovakia and Portugal have been fully approved. Those of Austria, Germany, the UK, France and Finland are conditionally approved. Conditionally approved plans are not in line with the criteria stated in Annex III of the ET Directive and the Commission has indicated steps that need to be taken by those Member States in order to make their plans fully acceptable.

The main reasons behind the conditional approval of these 5 plans has been excessive allocation for the 2005 - 2007 trading period and the intention of these Member States to make so-called ex-post adjustments. Conditional approval of these plans due to excessive allocation results from the fact that the volume of allowances that a Member State has chosen to allocate is inconsistent with its assessment of progress towards the Kyoto target. By allowing the possibility for ex-post adjustments, a Member State retains the possibility to redistribute the issued allowances among the participating companies during the trading period, which is not in line with the Commission guidelines. In the case of Finland, the required changes are minor and purely technical. (EU, 2004a)

In the NAPs submitted to the Commission by mid-December 2004, the total quantity of allowances allocated for the first EU ETS trading period 2005 - 2007 is annually approximately 2250 Mt of CO2. Besides the total quantity of allocated allowances and the installation specific allocation, Member States were obliged to state the method of allocation in their NAPs. According to the ET Directive, at least 95% of the allocation for the first trading period must be free of charge. In the NAPs assessed by EC by mid-December 2004, the main allocation method used by Member States has been grandfathering. Only a few Member States have taken some benchmarking elements into their allocation formulas. The chargeable option of 5% has been utilised, e.g. by Denmark.

2.5.2 The Linking Directive

In April 2004, the EU Parliament agreed the Linking Directive that amends the ET Directive by linking the Kyoto Protocol project-based mechanisms to the European Union Emissions Trading Scheme. The Linking Directive was formally approved by EU ministers in September 2004. Linking project-based mechanisms; the Clean Development Mechanism (CDM) and Joint Implementation (JI) to the EU Community scheme will increase the cost-effectiveness of achieving greenhouse gas emission reductions. Linking will increase the diversity of low cost compliance options within EU

ETS leading to a reduction of the overall costs of compliance with the Kyoto Protocol. The philosophy behind linking is also that on behalf of global warming, it does not matter where in the world the emission reduction takes place. (EU, 2003b)

According to the Linking Directive, certified emissions reductions (CERs) created by Clean Development Mechanisms projects are eligible in the EU ETS from January 2005 without any restriction of utilisation. Emission Reduction Units (ERUs) created by Joint Implementation projects between different countries are eligible in EU ETS from January 2008. The use of CERs and ERUs by operators from 2008 may be allowed up to a percentage of the allocation for each installation. This percentage will be specified by each Member State in its National allocation plan for the second trading period 2008 - 2012. (EU, 2003b)

Characteristics for projects to be eligible as JI or CDM projects are defined in the Linking Directive. According to these, only projects that produce emissions reductions that are additional to any that would otherwise occur are eligible. Besides that, certain project types are excluded from being eligible to produce EU ETS credits. (EU, 2003b)

The Linking Directive may cause a problem of possible double counting of emission credits both as EU allowances, EUAs, and JI project credits (ERUs). The problem appears when JI projects are implemented in countries that belong to EU ETS. The projects producing emission reductions may produce ERUs and at the same time EUAs. Double counting can be avoided by ensuring that for each issued ERU, an equal number of EUAs is cancelled. If the JI project reduces emissions for the ET sector, a reduction of the total allocation to the ET sector will be made for the initial allocation. If the JI project does not reduce emissions from a particular company that has been initially allocated, the allowances will be cancelled from that country's national registries. Countries are thus obliged to make up an allowance set-a-side reserve in their allocation plans for the second trading period 2008 - 2012. (EU, 2003b)

2.5.3 Levels of EU emissions trading

To clarify the different levels concerning emissions trading under the Kyoto Protocol and under EU Emissions Trading Scheme, a diagram has been drawn in Figure 4. It is important to notice that by the approval of the Linking Directive, as discussed in the previous chapter, Kyoto project-based mechanisms Joint Implementation (JI) and Clean Development Mechanisms (CDM) have been linked to the EU ETS. The third Kyoto mechanism, emissions trading between the Parties to the Kyoto Protocol having quantitative emission targets, with their Assigned Amount Units (AAUs), is left only to the governmental level. On the contrary, emission trading under EU ETS is possible between all participating installations. (BALTREL, 2003)

Under EU ETS the distinction between ET and non-ET sectors must be notified. In Figure 4 the burden sharing of emissions reduction targets between these two categories inside a Member State is not taken into account. If it was taken into account in Figure 4, the reduction target for ETS and non-ETS sector would be decided at the national level. In the following chapters of this study, only the EU ETS covered sectors are taken into consideration.

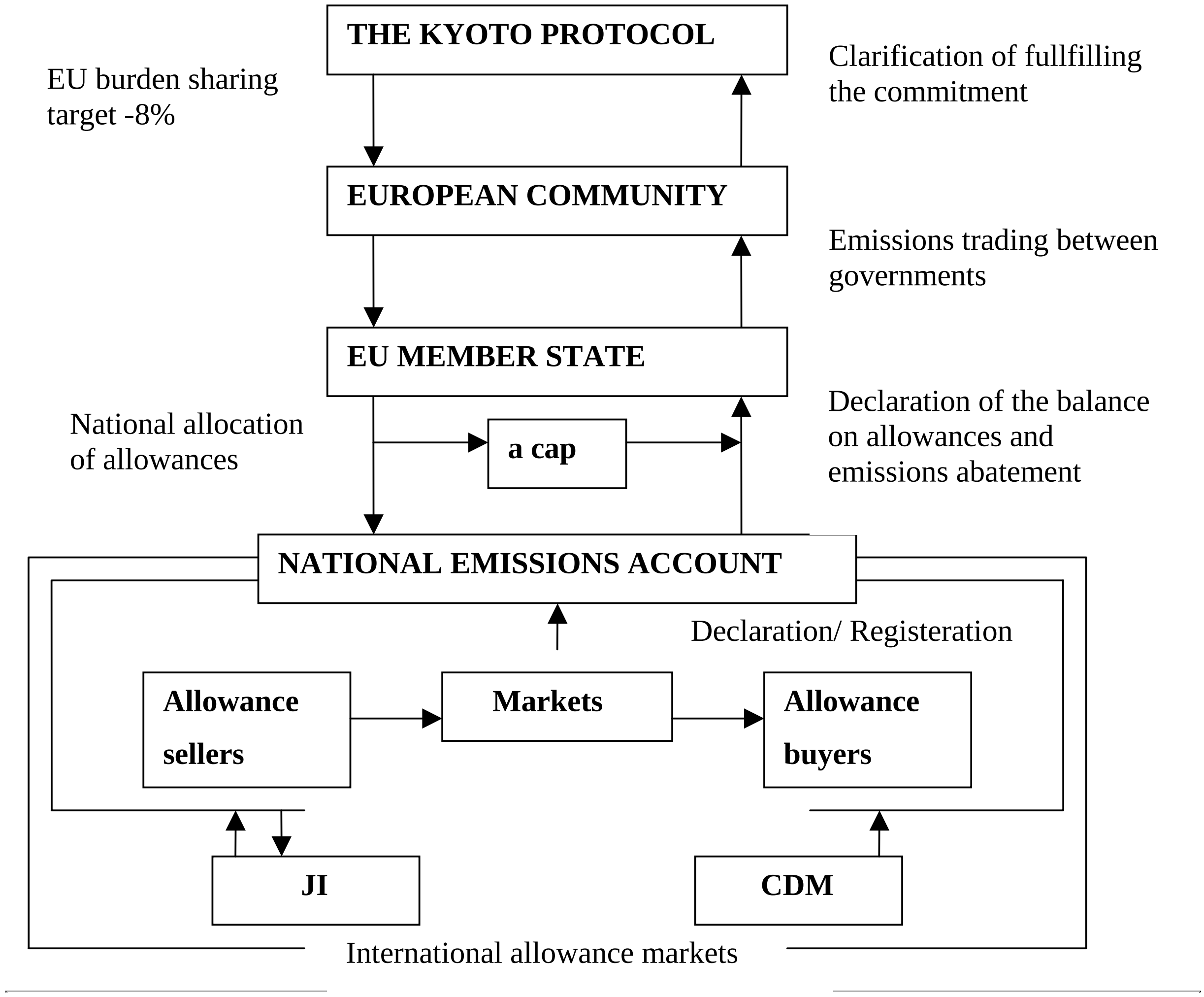

Figure 4 Levels of emissions trading (Fogelholm, 2004)

2.6 National EU ETS related legislation

According to Article 31 of the Emissions Trading Directive, Member States shall bring into force laws, regulations and administrative provisions necessary in order to comply with the Directive requirements. The deadline for national legislation and regulations was originally by the end of 2003, but only one Member State, the UK, met the original deadline. For example, in Finland and Sweden separate EU ETS legislation had been requested. The main ET-related legislation in Sweden entered into force 1st August, 2004. The Finnish Emissions Trading Act entered into force 4th August, 2004.

Each Member State shall have an authority responsible for tasks related to implementing the EU ETS. The national ET authority in Finland, for example, is responsible for granting emission permits, keeping up emission registers, registering annual allowances to installation accounts and permitting emission verifiers. (EMV, 2004)

3 THEORY OF THE CO_2 ALLOWANCE PRICE FORMATION BASED ON SUPPLY-DEMAND BALANCE AND MARGINAL ABATEMENT COSTS

Climate change is a special case in pollution control, since the damage caused by greenhouse gas emissions is independent of the location of a pollution source. The effects in the climate are the same independent of the place where pollution takes place. (Perman et al.,1996).

Traditionally, emissions have been controlled using so-called command-and-control policy instruments such as laws and standards. Emissions control through taxes, subsidies and transferable marketable emissions rights are called incentive-based policy mechanisms. The EU Emission Trading Scheme is an incentive-based policy mechanism that attempts to reduce greenhouse gas emissions cost-effectively. Cost-effectiveness in emission reduction means maximising environmental benefits at the lowest possible cost. Emissions trading cost-effectiveness is based on the microeconomic equimarginal principle that states that total pollution control cost will be minimised through the equalisation of marginal emission reduction costs across all reduction options. (Field, 2002)

In EU ETS, a cap for total CO_2 emissions will be set according to the targeted emissions level. The price for an allowance in EU ETS can be estimated based on the demand-supply equation of allowances and the CO_2 emissions marginal abatement cost curve (Niininen, 2004).

3.1 Marginal abatement cost (MAC) curve framework

Marginal abatement cost is defined as the increase in total cost from the last unit of abatement. The shape of the curve is typically assumed to increase more than linearly in abatement as further CO_2 emission reduction becomes typically increasingly expensive. In the MAC curves presented in Figure 5, the amount of abatement taken increases from left to right, and conversely the quantity of pollution from right to left. If the unit is allowed to pollute freely, it will choose not to abate at all, and its marginal cost of avoiding pollution is therefore zero. As the unit takes more and more abatement, the marginal abatement cost increases. The logic behind the shape of the curve is that starting from an unconstrained situation, there are likely to be a lot of inexpensive opportunities to reduce emissions. As these inexpensive abatement opportunities are implemented, the emissions abatement will require more costly ways, such as installing new, less polluting production equipment (Kauppi, 2003). In Figure 5, two different marginal abatement cost curves for two different emitting units A and B are presented.

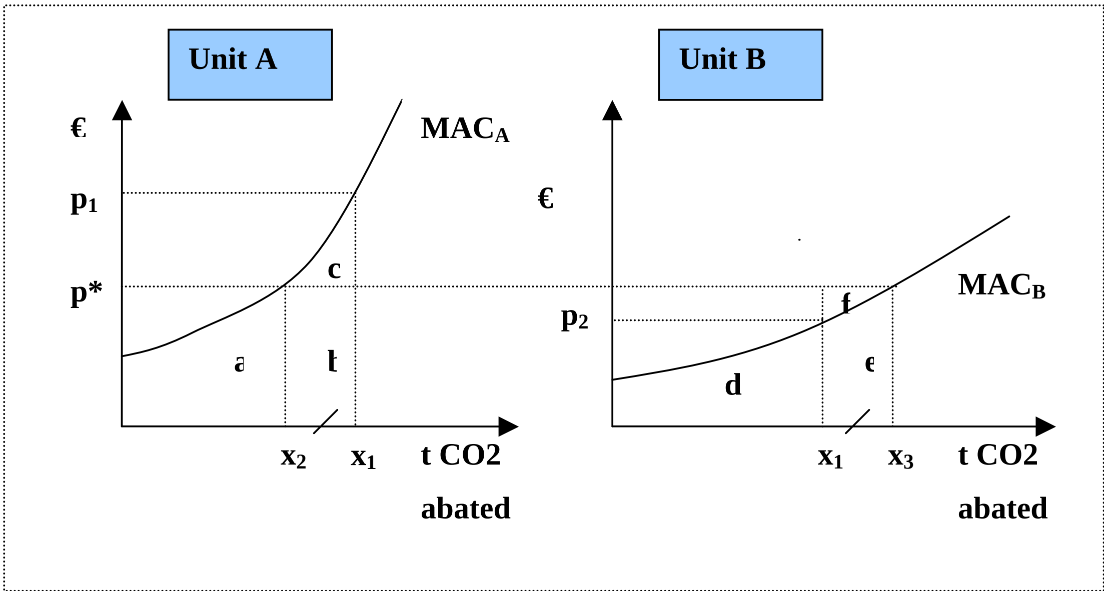

Figure 5. The marginal abatement cost curves of two emitting installations A and B. (Field, 2002)

Cost-effectiveness of emissions trading is based on the equimarginal principle. The equimarginal principle states that total pollution control cost will be minimised through the equalisation of marginal emission reduction costs across all reduction options (Field, 2002). This can be illustrated simply by taking into consideration two different emitting units having differently shaped marginal abatement costs curves. Figure 5 presents MAC curves for unit A and unit B. It can be seen from the MAC curves that abatement costs rise much more rapidly for unit A than unit B.

Considering a situation in which these two emitting units are required to abate emissions totalling 2 x_1 tonnes CO2 and both of units A and B have to abate equal amounts, each x_1 tonnes of CO_2. Unit A will abate x_1 tonnes at the marginal cost p_1 and unit B at the marginal cost p_2. The total cost of abatement will be the area (a + b + c) +d shown in Figure 5. (Field, 2002)

If these two units are covered from an emissions trading scheme, the total abatement costs can be reduced by trading emission permits between the units. Assuming that emissions abatement will be taken according into the equimarginal principle, equalising marginal abatement costs, unit A will reduce its emissions by up to x_2 tonnes at price p* and unit B by up to x_3 tonnes at price p*. Because it is cheaper for unit A to purchase x_1-x_2 tonnes than abate them, unit A will gain from buying x_1-x_2 amount of emission permits from unit B. Unit B will therefore gain from abating x_3-x_1 more at a price below p* than in the initial situation and sell that extra amount of emissions permits to unit A. The total cost of abatement will now be reduced to the area a + (d + e), see Figure 5. Net benefit for unit A from trade is represented by area c and for unit B by area f. It should be noted that x_1-x_2 = x_3-x_1 and price p* represents the market price of emissions allowances in a market balance of supply and demand of allowances. (Field, 2002), (IEA, 2001)

According to the equimarginal principle presented above, the total costs for emission reduction in EU ETS can be achieved by marginal abatement cost equalisation among all participating emitting installations. For each installation covered by the EU ETS, it is possible to construct an installation-specific marginal abatement cost curve. These installation specific marginal abatement cost curves can be aggregated so that it is possible to construct company-, industry- and country-specific marginal abatement cost curves. Aggregating all EU25 national EU ETS sector marginal abatement cost curves, a single marginal abatement curve for the whole EU ETS can be drawn. This aggregate

MAC curve can be then used to determine the CO_2 allowance market price if the total emission reduction requirement is known.

Figure 6 illustrates the formation of an aggregate marginal abatement cost curve, where MAC curves for units A and unit B are summed up in a single aggregated MAC curve for A + B. For simplicity, the MAC curves are assumed to be linear. The aggregate MAC curve is formed summing up the emissions abatement possibilities of units A and B at price level p*. At price p*, unit A can abate a tonnes of CO_2 and unit B b tonnes of CO_2. The aggregate abatement at price p* is therefore a+b as illustrated in Figure 6.

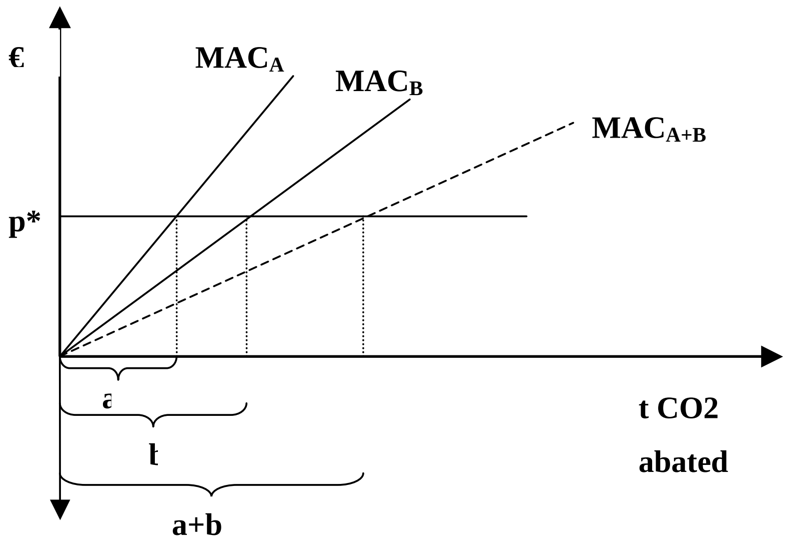

Figure 6 Illustrative example of aggregate marginal abatement cost curve formation

3.2 Demand for allowances

Demand for emissions allowances in an emission trading scheme is based on the scenarios for future emissions. Emissions scenarios are usually given as business-as-usual (BAU) scenarios. The basis of BAU scenarios vary because behind them are different assumptions of, for example, economic growth, changes in energy efficiency and carbon intensity. These assumptions create uncertainties. No one can, for example, predict precisely future weather conditions or economic growth, both of which will have major impacts on overall emissions. (ENVIROS, 2004)

Marginal abatement costs of CO_2 will affect the allowance demand elasticity. If an installation takes emissions abatement measures, the demand for allowances will be reduced.

3.3 Supply

Supply in an emission trading scheme is the total number of allowances in the market. The number of allowances in EU ETS can be determined by the number of allocated allowances and, as the utilisation of Kyoto mechanisms is allowed via the Linking Directive, imported Kyoto flexible mechanisms, JI and CDM, credits.

The total amount of allocated emissions allowances in EU ETS is determined in the National allocation plan. According to the criteria in Annex III of the ET Directive, the National allocation plan should also contain information on the manner in which new entrants will be able to begin participating in the EU ETS. The new entrants are taken into account in the annual allocation by setting aside a reserve for new entrants, called NER. Although the new entrants allowance upper limit is fixed, it creates uncertainty for the total allocation because it is not known in advance how much this NER will finally be allocated. Member States have determined in their NAPs how leftover allowances in the reserves will be treated at the end of the trading period. Possible means are auctioning, cancelling, selling to the market or allocating freely to the incumbent installations (Bakker, 2004).

Other factors that also affect the total supply of allowances are the treatment of plant closures and the possibility to bank allowances between trading periods. Treatment of plant closure allowances vary by Member States similar to the treatment of leftover allowances in the new entrant's reserves. Banking of allowances may affect supply at the earliest in the second trading period 2008 - 2012. In reality, it seems to remain very limited in any case (Niininen, 2004).

In this study, the uncertainty of allowance supply caused by NERs and plant closures are ignored as to some extent they cancel each other. In NERs, there may be unused allowances left at the end of the trading period. On the contrary, plant closures may supply extra allowances to the market compared to the real emissions that are realised. If a plant is closed after it has been allocated an annual amount of allowances according to NAP, in some Member States the plant operator may sell the extra allowances to the market. (Niininen, 2004)

The supply side is also affected by the import of Kyoto flexible mechanism credits. According to the Linking Directive, credits from CDM projects, CERs, will be valid in EU ETS from 2005 and ERUs, created by JI projects, from 2008. For the first EU ETS trading period, the amount of CER import is not limited, but there will be limits to CER and ERU imports in the EU ETS second trading period 2008 - 2012. CDM credits, CERs, are bankable between the trading periods, which offer elasticity on the allowance supply side. If extra allowances are needed at the end of the first trading period, CERs can be used. (EU, 2003b)

3.4 CO_2 allowance price formation based on demand-supply equation and marginal abatement cost curve

In an ideal situation, carbon dioxide allowance price in an emission trading scheme can be derived from the allowance supply-demand balance and the aggregate marginal abatement cost curve of CO_2 emissions. Under perfect competition, the allowance price equals the marginal costs of abatement (VTT, 2003). The allowance price formation principle under EU ETS is demonstrated in Figure 7.

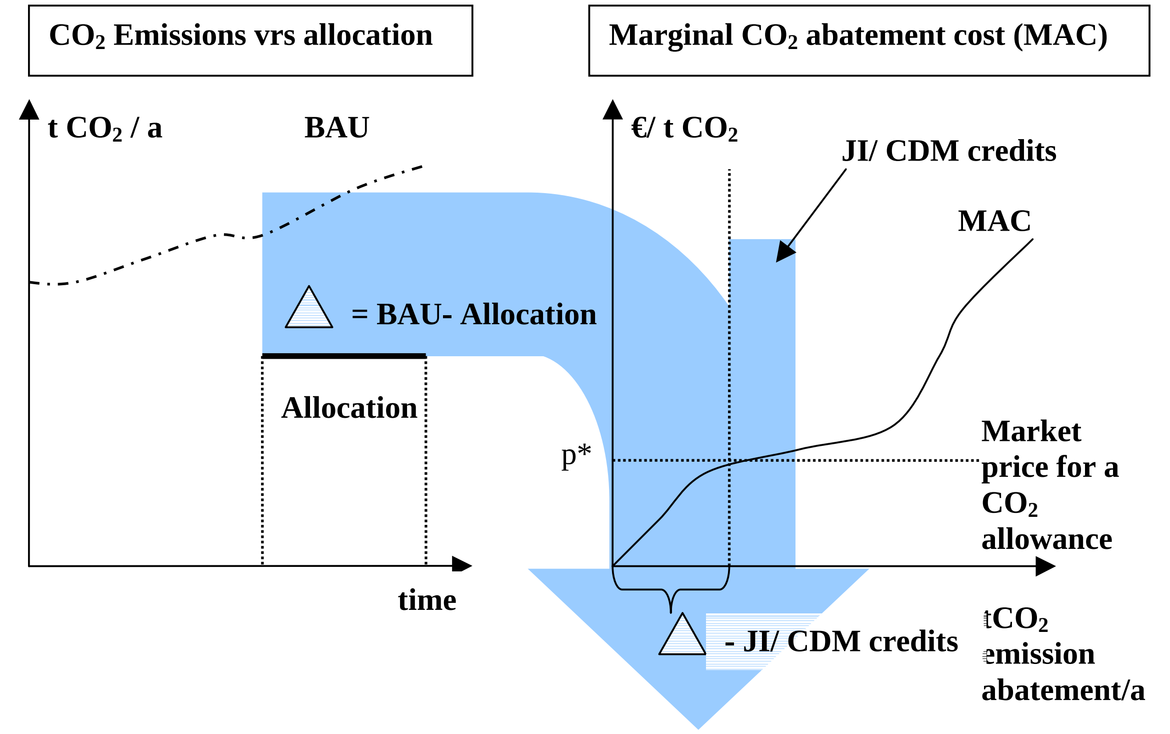

Figure 7 An illustrative figure of the carbon price formation in EU emissions trading scheme based on supply-demand balance and marginal abatement cost (MAC) curve (Niininen, 2004)

The supply-demand balance is established comparing the amount of allocated allowances in the market to the business-as-usual -based forecasted CO_2 emissions. In Figure 7, this is marked as delta between *BAU-allocation.* The gap between BAU and allocation is then placed on the aggregate EU25 ETS sector marginal abatement cost curve of CO_2 emissions. As JI and CDM credits may be imported to the EU ETS, they will affect the delta between demand and supply and must be subtracted from the delta. The theoretical market price for a CO_2 allowance can then be read from the y- axis of the MAC curve as shown in Figure 7. (Niininen, 2004)

If the delta *BAU-allocation* is negative, indicating that the allowance supply exceeds the demand for allowances, the allowance market price cannot be estimated from the MAC curve. In this case, the allowance price, assuming that some allowance trading is taking place, can be based at least partly on the allowance transactions costs. (Niininen, 2004)

3.5 EU ETS Carbon Market model

Emission Trading Schemes can be generally classified into two main categories; cap-and-trade systems and baseline-and-credit systems. The basic distinction between these two approaches is the commodity traded. (Sijm et al, 2003)

In cap-and-trade systems the trading commodities are emission rights or, as they are called in the EU ETS, emission allowances. The allowances apply to all participants, installations and gases covered by the scheme. In the cap-and-trade approach, first an overall limit, a cap, for the maximum amount of emissions is set. The cap is chosen in order to achieve the desired environmental effect. According to the desired cap, allowances are allocated to participating parties. Parties are obliged to report their emissions and the equivalent number of allowances at the end of the chosen compliance period. (EPA, 2004), (Sijm et al, 2003)

In baseline and credit systems, the trading commodities are emission reduction credits. Credits are created as emissions are reduced below an agreed baseline, i.e. a reference level of emissions during a certain period. Examples of baseline-and-credits are the two project-based mechanisms, Joint Implementation and Clean Development Mechanisms, defined in the Kyoto Protocol. (Sijm et al, 2003)

The EU Emissions Trading Scheme is a cap-and-trade -based approach for controlling aggregate EU-wide emissions. The cap in EU ETS is set by the total allocation of allowances in the National allocation plans. Allowance trading enables EU ETS covered installations to design their own compliance strategies based on individual circumstances while still achieving the overall emissions reductions required by the cap (EPA, 2004).

3.6 Main strategies of participating companies

The EU ETS covered installations can have different strategic choices to fulfil the compliance set by the cap (Field, 2002). The installation operator covered by EU ETS can choose either one or a mixture of these strategic options:

1. Reduce the emissions to the level covered by the number of allowances the installations was initially awarded.
2. Buy additional allowances and emit at levels higher than the original award level.
3. Reduce emissions below the level of the original award, and then sell the allowances it does not need.
4. Use JI and CDM credits to partly fulfil the climate obligations.

The installation operator's choice between these strategic options depends on the allowance market price and the installation specific marginal abatement cost of CO_2 emissions, or in case of Kyoto credits, the acquisition costs of them.

4 STATE AND DEVELOPMENT OF THE CARBON MARKET

A carbon market has emerged during the past ten years due to the fact that several governments, firms and individuals have started to take steps to reduce their greenhouse gas emissions either voluntarily or, increasingly, because of current or expected regulations. Most of the voluntary actions and regulations allow for the purchase of emission credits both within and outside the regulated area, thereby laying ground for the so-called carbon market (Lecocq, 2004). So far, the progress towards a global carbon market in greenhouse gas emissions has been slow but there are heroic assumptions about future trading volumes as EU ETS starts (Environmental Finance, 2004a). According to estimates, more than 100 Mt of carbon credits will be traded in 2004 in the various carbon markets worldwide, compared to 37 Mt in 2003 (Point Carbon, 2004b).

Transactions in the carbon market can be divided into trades of emission allowances and project-based transactions. An example of emission allowance trades is trading allowances, EUAs, under the EU ETS. Unlike allowance trading, project-based transactions can also occur even in the absence of a regulatory regime. They can be divided into two categories; projects intended for compliance with the Kyoto Protocol, i.e. under either Joint Implementation (JI) or the Clean Development Mechanism (CDM); and project not intended for Kyoto compliance but for voluntary purposes. Project-based transactions still account for the biggest fraction, around 95 per cent in 2004, of the total assets exchanged on the carbon market. The main reason for this is that allowance markets are still largely in their infancy but the situation is likely to change as the EU ETS starts and as allowance markets also become operational in Canada and elsewhere. (Lecocq, 2004)

The World Bank divides the Carbon Market into segments according to the assets transaction method and the compliance requirements as shown in Figure 8. The segment of project-based transactions includes the Kyoto Pre-Compliance market, Not for Kyoto Compliance market and Retail market. The allowance market segment includes several national and international allowance market schemes, one of which is the EU ETS. (Lecocq, 2004)

The sizes of the spheres in Figure 8 try to illustrate, to some extent, the size of the particular market segment in volumes of annual transactions occurred. It should be taken into account that the sizes of the segments are not fully comparable since the different carbon market segments have different existence periods. An accurate review of the transactions that have occurred in the market segments is difficult because there is currently neither a public registry of carbon transactions nor an internationally recognised price index. In fact, most transactions so far are over-the-counter, with few details, if any, made public. The World Bank has assessed the transactions data based on information from two main market brokers. (Lecocq, 2004)

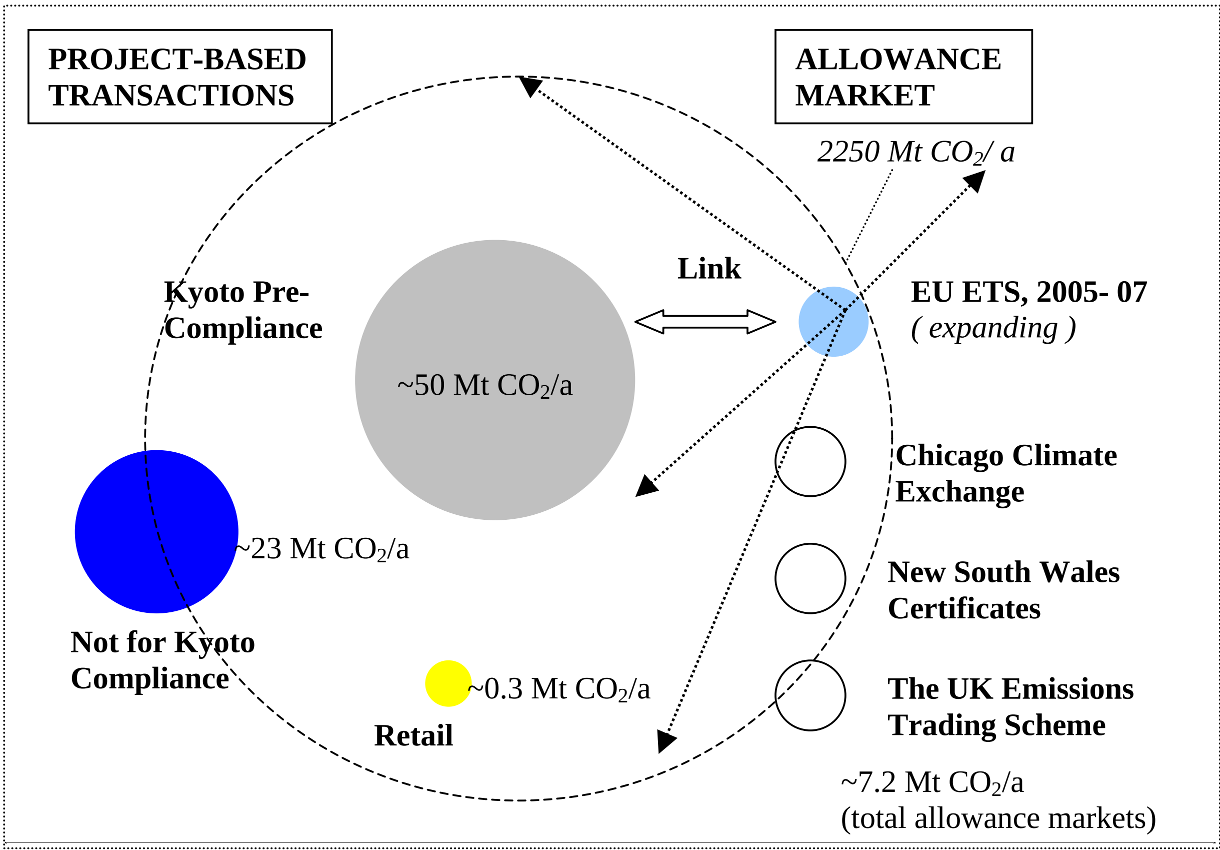

Figure 8 Structure of the global carbon market (Lecocq, 2004)

According to the World Bank, the estimated total volume of trades in the project-based transactions were around 290 Mt CO_2 eqv, representing around 50 Mt CO_2 eqv /a, from Jan 1998 to May 2004. Allowance-based trades were around 7.2 Mt CO_2 from Jan 2003 to May 2004. (Lecocq, 2004)

The Kyoto Pre-compliance segment still forms the biggest part of the global carbon market accounting for around 152 Mt CO_2 eqv starting from Jan 2001 to May 2004. The biggest share of this market segment is natural, as the Kyoto Protocol is currently the most prominent regulation setting GHG emissions targets for industrialised countries for the period 2008 - 2012. (Lecocq, 2004)

The Not for Kyoto Compliance segment, in other words the voluntary market segment, accounted for around 139 Mt CO_2 eqv from Jan 1998 to May 2004 period. The voluntary market is formed by firms that have adopted voluntary emissions targets or are participating in emission reduction transactions for other strategic reasons. (Lecocq, 2004)

The retail market forms a minor part of the project-based transactions, accounting for only around 1.5 Mt CO_2 eqv of traded volumes from Jan 1998 to May 2004. Retail market participants are the activities of companies and individuals without significant emissions who wish to be climate-neutral and act in the carbon market in order to demonstrate their social responsibility or promote a particular brand. (Lecocq, 2004)

In the allowance market, total trades from Jan 2003 to May 2004 were 7.2 Mt CO_2 eqv. Besides the forthcoming EU Emissions Trading Scheme, this segment covers three other emission allowance markets as shown in Figure 8. (Lecocq, 2004)

The UK national Emissions Trading Scheme launched in April 2002 has so far been the world's largest national GHG trading programme in operation. The Scheme covers all six greenhouse gases and companies have agreed targets to cut their emissions based on incentive money from the UK government. Trading volume totalled 2.48 Mt CO_2 eqv in

2002 and decreased to 0.5 Mt CO_2 eqv in 2003. Activity during the first five months of 2004 has been about 0.3 Mt CO_2 eqv. A national ET scheme covering the power sector has also been in operation in Denmark since 2001. (Lecocq, 2004)

The Chicago Climate Exchange, CCX, is a pilot GHG cap-and-trade system in which a group of North American companies have voluntarily agreed to limit their GHG emissions by 4% below their 1998-2001 baseline emissions by 2006. Unlike the UK ETS, CCX has been set up with no financial incentives. In the first five months of 2004, an estimated 1Mt CO_2 eqv have been exchanged on the CCX. (Environmental Finance, 2004a), (Lecocq, 2004).

The New South Wales GHG Abatement Scheme commenced on 1st January, 2003 and is to remain in force until 2012. It imposes mandatory GHG benchmarks on all New South Wales electricity retailers and other parties. A total of 1.5 Mt CO_2 eqv have been exchanged on this market in the five first months of 2004. (Lecocq, 2004)

The next chapter deals more precisely with the state and development of the fourth allowance market segment, the EU ETS. In Figure 8, the size of the EU ETS market has been illustrated by two nested spheres. The innermost sphere, marked in blue, illustrates the volume of the forward trades already taken place and the outermost dotted circle the emerging market size for the 2005-2007 period as the EU ETS will officially start and the market will expand annually to around 2250 Mt CO_2. The Linking Directive is a key development in building a unified carbon market as it formally links the EU ETS and Kyoto agreement mechanisms; JI and CDM. (Environmental Finance, 2004a), (Lecocq, 2004)

In addition to the above described Emissions Trading Schemes, many other companies have also set themselves voluntary GHG targets. One of the pioneers is British Petroleum, BP, which announced in 1997 that the company aimed to reduce its GHG emissions to 10% below the level of 1990 by 2010. To help this goal, the company created an internal emissions market. The company achieved its target already in 2002 and reductions were even achieved with net profit for the company. (Environmental Finance, 2004a)

4.1 State and development of the EU ETS carbon market

According to Directive 2003/87/EC, the EU allowance-based emissions trading is due to start 1st January, 2005. In preparation for the EU ETS, several companies have engaged in the demonstration trades of forward EU allowances. Because allowances have not yet been allocated to any private entities, all transactions at the time of writing have been forward trades in which allowances will be transferred from the seller to the buyer at a future date.

In EU ETS, around 30 deals occurred in 2003, for an overall volume of around 0.65 Mt of CO_2 eqv (Lecocq, 2004). The weekly EU ETS volumes of forward trades during 2004 are shown in Figure 9. In November alone, a total of 2.45 Mt CO_2 were reported as being traded (Point Carbon, 2004c). The frequency of trading is still rising with an average 4.5 trades per day in September 2004 and 5.5 in October 2004. From Figure 9 it can be seen that as the start of the EU ETS in the beginning of 2005 approaches, trading activity has increased (Point Carbon, 2004d). The number of companies that are currently carrying out forward trades is around 20, which is a relatively small number compared to the approximately 6000 companies which will be included in EU ETS (Point Carbon, 2004e). It has been estimated that a total of some 8 Mt tonnes will be traded in the EU ETS in 2004 (Point Carbon, 2004b).

A frame for the total size of the EU ETS will be the final allocation in National allocation plans. In mid-December 2004, according to the NAPs accepted by EC and the draft NAPs, this figure will, in the first trading period 2005-2007, be about 2250 Mt CO_2 annually.

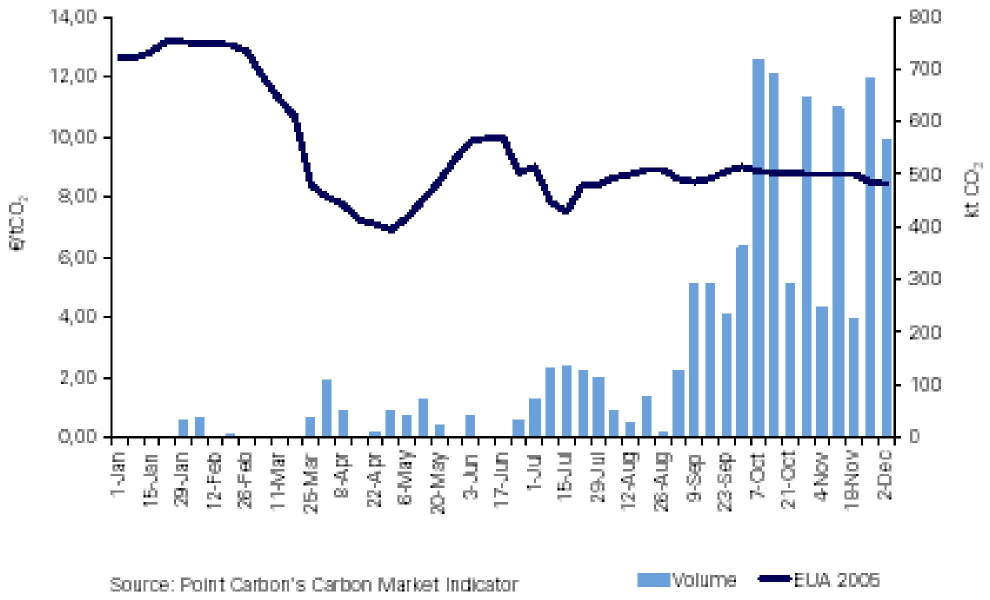

Figure 9 Weekly prices and volumes in EU ETS from January to December 2004. (Point Carbon 2004c)

Although price information is sketchy, prices in transactions have apparently increased from around €6/ tCO_2 in May 2003 to € 12/tCO_2 in November 2003, down to about € 7-8/t CO_2 in May 2004 (Lecocq, 2004). According to Point Carbon, analysis of the weekly price development of the allowance forward trades in 2004 as shown in Figure 9, the recent forward trades in October and November have taken place at a price of around € 8 per tonne of CO_2 (Point Carbon, 2004d). The remarkable price decrease in March- April 2004 is probably explained by two main reasons; the early National allocation plans were less stringent than anticipated, and the fact that the Linking Directive was agreed allowing the import of CDM credits, CERs, as early as 2005 to EU ETS. (Lecocq, 2004)

However, the prices realised so far do not necessarily reflect on what the long term equilibrium between supply and demand might be, since the market is still thin and there are many uncertainties, of which the greatest is the final allocation of allowances.

Current price development is believed to be more driven by companies' early trading strategies than by their natural position in the market (Lecocq, 2004).

The first forward EU allowance trade for the second trading period 2008 - 2012 under EU ETS took place in early November 2004 with the delivery in 2008 at a price of € 9 per tonne of CO_2. (Point Carbon, 2004f)

4.2 Existing price estimates for CO_2 allowance for 2005 - 2007 trading period in EU ETS

Various parties have conducted studies to estimate the allowance price for the EU Emissions Trading Scheme. As this thesis attempts to create its own estimate for the allowance price for the first trading period 2005 - 2007 under EU ETS, it is relevant to review the existing price estimates. Price estimates in the literature for an emissions allowance for the first trading period 2005-2007 vary between 1-15 €, and for the second trading period 2008 - 2012 between €6.9-50 € per tonne of CO_2. Existing references for the allowance price estimates have different background assumptions, which should be taken into account. The more recent the references are, the better known the supplied amount of allowances in the market is, which should be kept in mind when comparing the estimates from the various sources.

According to a background study (KPI, 2003) of the impacts of linking JI and CDM to the EU ETS, the allowance price level in 2010 is estimated to be € 26 per tonne without linking. With the different linking options of the JI and CDM project-based mechanisms to the EU ETS, the allowance price estimate for 2010 varies between € 4.8-€ 12. The allowance price during 2005 - 2007 is expected to be lower.

Credit Suisse First Boston (CSFB, 2003) has estimated the price of an emission allowance under EU ETS to be € 9.2 per tonne for 2010. The result is based on an assumption that up to a 10% shortfall of allowances under EU ETS, which corresponds to around 180 Mt CO_2, can be reduced by switching between electricity production technologies from coal to less polluting gas-based production. If the shortfall is larger, the estimated allowance price increases to € 26.9 as the amount of cheap abatement opportunities are increasingly used.

In April 2004, Grobbel (McKinsey 2004 a) estimated the allowance price for 2005 - 2007 to be between € 5- 8 and for 2010 around € 20. In November 2004, Grobbel revised the estimate for the first trading period to € 9 and for 2010 to € 10. According to Grobbel, the price of an allowance is unlikely to rise by much during 2005-2012 but could double during 2013-2017. (McKinsey 2004b)

In a European CO_2 price outlook report published in August 2004, the expected price for an allowance for 2005 is € 7.6, for 2006 € 8.0 and for 2007 € 8.4. For the 2008 - 2012 period, the price estimate is between 11.2 €-13.6 €, increasing towards 2012. The estimates are based on running a model with stochastic inputs, which gives the distribution of probable prices. For 2008 – 2012, uncertainties of the market are huge, but according to the analysis, there is considerable probability, over 80 per cent, that the level of allowance price will exceed € 10. (Global Insight, 2004)

An analysis conducted in August 2004 predicts the allowance price for 2005-2007 period to be in the region of € 5. This estimation is based on the assumption that the total market shortfall will be around 2 per cent or 65 Mt CO_2 per year. According to the analysis, the price for an allowance in the latter half of 2008 - 2012 period could potentially exceed € 50 if no new capital investments are made for less emitting generation capacity. (Enviros, 2004)

In a report on the EU ETS and its implications on the price of electricity published in September 2004, the estimate for the allowance price for the 2005-2007 period is between € 1-5. The estimate is based on an assumption of a plausible shortfall of allowances between 30-60 Mt CO_2. Shortfall for the second trading period 2008 - 2012 is estimated to be between 120-140 Mt CO_2 which corresponds to a price between € 8-13. This estimate is based on an assumption that the emission trading sector under EU

ETS stands for all emissions reductions needed and the EU will fulfil its commitments according to the Kyoto Protocol. (ECON, 2004)

An estimate from October 2004 predicts the price of an allowance for 2010 to be €17 in a fast technology development scenario and € 26.5 in a slow technology development scenario. The analysis is based on modelling EU climate change policies and by calculating the economic effects of these policies for the year 2010 under different assumptions. (COWI, 2004)

Market analysts have also predicted that the spot allowance prices 2004-2005 are expected to stay at the € 8-11 level and decline thereafter. The possibility that the spot price collapses at the end of the first trading period is caused by the risk aversive behaviour of EU ETS covered companies going long to ensure a compliance buffer. However, depending on factors like weather and fuel prices, the market may also be short at the end of the first trading period, which may heavily increase the allowance prices. (Point Carbon, 2004g)

5 ANALYSIS OF MAIN CO_2 PRICE DETERMINANTS

According to the theory presented in Chapter 3 on how the allowance price is formed, the key determinants of the price are the supplied amount of allowances, demand for allowances, amount of JI and CDM credit imports and aggregate marginal abatement cost of reducing carbon dioxide emissions in the EU25 region. For estimating the supply, the total allocation by National allocation plans is essential and the JI and CDM credit import to some extent. Demand is based on business-as-usual scenarios on how CO_2 emissions will develop in 2005 - 2007 in the EU25 region. The basis for business-as-usual scenarios for EU25 vary considerably from country to country. It is therefore relevant to analyse business-as-usual scenarios on the basis of historic emission developments. Marginal abatement costs of CO_2 emissions in the EU25 region have been estimated by various sources. In this study, the available MAC data presented in the literature is reviewed.

The analysis is carried out on the whole EU25 region except Malta and Cyprus. These two new EU Member States will participate in EU ETS but they are minor players and do not affect the whole figure much.

This chapter covers the discussion of two principal CO2 determinants; supply-demand balance of allowances and CO_2 emissions marginal abatement costs. Several other factors, also to be kept as price determinants, are dealt with in the sensitivity analysis in Chapter 6.

5.1 Aggregate supply estimate of CO_2 allowances for EU ETS 2005 - 2007

The aggregate supply of allowances to the EU ETS is the total amount of allocated allowances in the National allocation plans. In Table 5, annual allocations in each EU Member State are presented. The total amount of allocation in the EU ETS is ca. 2250 Mt CO_2/a, of which ca.1800 Mt CO_2/a is allocated to EU15 Member States and some 500 Mt CO_2/a to EU10 new Member States. The six biggest Member States according to the allocation, Germany, Poland, UK, Italy Spain and France cover over 70% of the total allocation.

Table 5 Total annual allocation for EU ETS for the first trading period 2005 - 2007(NAPs, 2004)

	Annual allocation for 2005-2007, Mt CO2/a			**Annual allocation for 2005-2007, Mt CO2/a**
EU 15			**EU 10 new**	
Austria	33,2		Cyprus*	
Belgium	62,9		Czech Republic*	99,5
Denmark	33,5		Estonia	19,0
Finland	45,5		Hungary*	29,9
France*	119,2		Latvia	4,6
Germany	503,0		Lithuania*	12,3
Greece*	73,8	**	Malta*	
Ireland	22,5		Poland*	286,2
Italy*	279,1		Slovakia	30,5
Luxembourg	3,4		Slovenia	8,3
Netherlands	98,3			**490,1**
Portugal	38,2			
Spain*	160,3		EU25	**2251,0**
Sweden	22,9			
UK	265,1		* NAP not yet approved by EC, draft	
	1760,9		**Point Carbon estimate (2004a)	

The total annual allocation figures presented in Table 5 include annual new entrants' reserves, NERs, for new installations or existing capacity extension. In total, around 84.4 Mt CO_2 MT CO_2 will be annually kept in this reserve for the 2005 - 2007 trading period. This figure includes all EU25 countries NERs except Belgium, France, Greece, Cyprus and Malta, of which no exact information is currently available. The size of NERs is only around 3.8% so it will not have much affect on the total supply of allowances, even if the reserve is partly left unused at the end of the first trading period.

Banking of allowances between trading periods could affect the total supply. Only one Member State, Poland, has NAP proposed limited banking possibilities in its draft. Banking of allowances between the two trading periods in Poland is proposed to be based on two requirements; the operator may bank only those allowances that were not used to cover actual emissions, and the banked allowances must reflect firm and stable reduction effects achieved by emissions reduction investments. (Poland, 2004)

5.1.1 Amount of Kyoto project-based mechanisms credits imports

According to the EU Linking Directive, CDM credits (CERs) are eligible in EU ETS from 2005, and JI credits (ERUs) from 2008. The amount of these credit imports to the EU25 region will affect the EU allowance price. As demonstrated earlier in Chapter 3, the amount of imported CDM and JI credits will affect the amount of abatement taken in EU ETS covered installations. Import of these credits will reduce the amount of internal CO_2 abatement taken under EU ETS covered installations by moving the equilibrium point downwards on the marginal abatement cost curve. The logic behind this is that the price of an imported CDM or JI credit is assumed to be lower than the marginal cost of abatement taken in an EU ETS covered installation. At present, the market price for CDM projects is considerably lower than the forward price for EU allowances (Environmental Finance, 2004a).

As this study attempts to estimate the allowance price under the first trading period 2005 - 2007, emphasis is on the CDM credit (CERs) imports. According to carbon market analysts, CER production from CDM projects has been estimated to be fairly limited in the short term. Some 8 million CER imports are forecasted in 2005 and around 17 million in 2006. However, from 2007, considerably larger volumes can be expected. According to the estimates, in 2008 accumulated CERs from the 2000-2007 period are likely to be some 60-80 million. As shown in Figure 10, CDM projects that are related to industrial processes, clearly dominate in terms of the volume of CERs to be produced by 2007. (Point Carbon, 2004h)

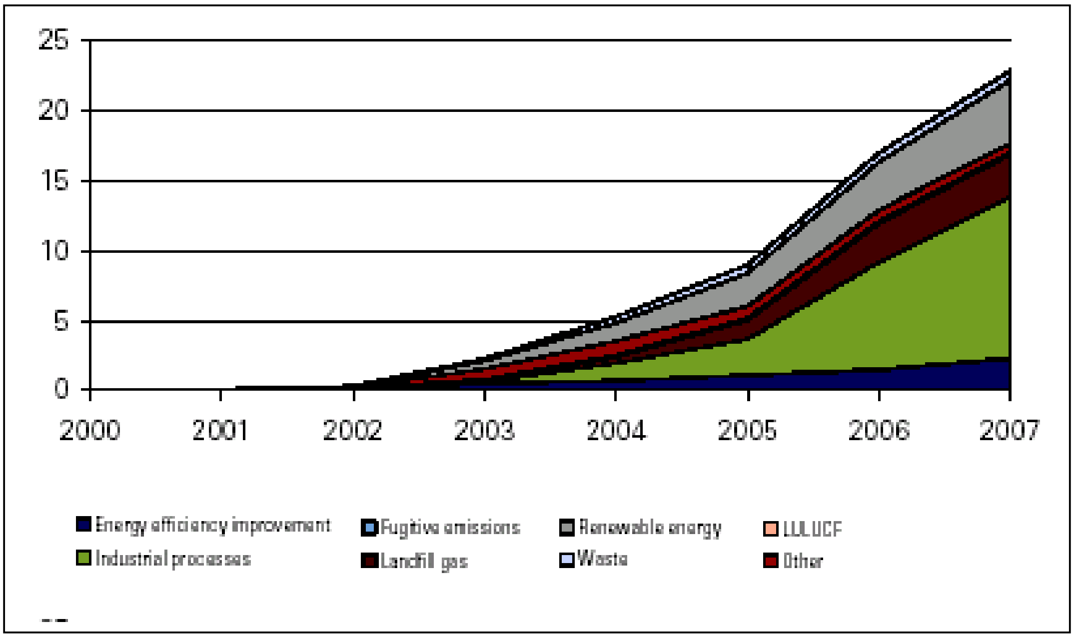

Figure 10 Risk adjusted CER production forecast until 2007 (Point Carbon, 2004h)

According to another estimate, the supply of CERs is expected to increase from 5 Mt CO_2 in 2005 to 30 Mt CO_2 in 2007. (ENVIROS, 2004)

5.2 Aggregate demand estimate of CO_2 allowances for EU ETS 2005 - 2007

The aggregate demand for CO_2 allowances in the EU ETS can be estimated by the forecasted total CO_2 emissions of EU25 countries during the trading period 2005 - 2007. Usually, emissions scenarios are given as business-as-usual (BAU) scenarios that are based on certain assumptions of future development.

In the EU25 countries, the scenarios and their basis vary from country to country. Some countries have not given any scenarios in their National allocation plans. 12 out of 25 EU nations have stated some data of business-as-usual emissions development in their NAPs. Because of lacking BAU estimates of future CO_2 emission developments, it is relevant to look into historic CO_2 emissions development. Based on historic emissions development, it is possible to try to forecast future emissions within a certain range as the extrapolation interval is relatively short, a few years, in relation to available empirical historic data. In this study, CO_2 emissions development forecast is done based on trend line approximation-based analysis.

In the chapters that follow, existing data sources for CO_2 statistics and scenarios and a methodology to derive CO_2 statistics from energy statistics are presented. A methodology on how EU ETS sector business-as-usual emissions scenario can be estimated based on trend line analysis is also presented.

5.2.1 Existing CO_2 emissions statistics and scenarios

The existence and coverage of CO_2 emissions statistics and scenarios for EU25 Member States is limited. For most EU15 countries, statistical data of historical CO_2 developments of different economic sectors exist, but for the new EU Member States, statistics are more limited. Emissions scenarios for all EU25 are to a great extent based on total national level of greenhouse gas emissions for the Kyoto Period. The main source for greenhouse gas statistics and projections are reports that Parties are obliged to produce for the UNFCCC. Existing projections for GHG emissions for EU25 countries are summarised in Annex A.

5.2.1.1 Reporting under UNFCCC

All EU25 Member States and the EU Community are parties to the UNFCCC. Article 12 of the Convention requires all Parties to report on the steps that they are taking to implement the convention (UNFCCC, 2004). Reporting requirements are different for Annex I and non-Annex I Parties to the Convention. All EU25 Member States, except Malta and Cyprus, are Annex I Parties to the Convention and have quantitative targets to reduce greenhouse gases.

Annex I countries are obliged to produce National Communications in which they describe the steps that they are taking to implement the Convention. In their national communications, the Parties also give scenarios of future greenhouse gas emissions developments. So far, most Annex I Parties have submitted their third national communication reports to the UNFCCC, which were originally due 30th November, 2001. All EU25 Annex I countries, except Lithuania, Luxembourg and Slovenia have submitted their 3rd National Communications. On 25th October, 2004 Lithuania had submitted only its second national communication and Luxembourg and Slovenia only their first national communications (UNFCCC, 2004). The deadline for the fourth submissions for Annex I Parties is 1st January, 2006 (UNFCCC, 2003). Besides national communications, Annex I parties must also submit an annual inventory of their GHG emissions and removals to the secretariat by 15th April every year. Cyprus and Malta, as non-Annex I countries, are also obliged to report on the steps they are taking to implement the Convention but they are not required to submit a separate annual emission inventory. (UNFCCC, 2003)

Besides national communication reports, Annex I EU Member States and the European Community as a whole are obliged to prepare individual GHG inventories and to submit these inventories to the Commissions every year (EEA, 2004).

5.2.1.2 Constructed EU ETS sector historic CO_2 emissions based on CO_2 statistics

The European Environment Agency, EEA, produces annually a greenhouse gas (GHG) inventory report that states EU15 Member States GHG emissions based on sector-based source categorisation (EEA, 2004). In the inventory report, GHG sources and sinks are divided into seven economic sectors; energy, industrial processes, solvent and other product use, agriculture, land-use change and forestry, waste and other. All GHG emissions and sinks are reported separately for each sector.

The statistics are not sufficiently detailed to allow an accurate calculation of CO_2 emissions for each activity under the ET Directive. However, from the inventory data, it is possible to roughly approximate the emissions for ET Directive covered activities, to approximate the EU ETS sector, which in this thesis is called the constructed EU ETS sector. As the first trading period 2005 - 2007 under EU ETS only includes CO_2 from energy and industry activities, it is relevant to include only those sectors in the constructed EU ETS. Table 6 below presents energy and industry processes sector-based sub-categorisation in the EEA report. Activities that are included in the constructed EU ETS sector in this study are marked in blue in Table 6.

The constructed EU ETS sector includes energy industries and manufacturing industries and construction. Sub-category energy industries cover electricity and heat production, petroleum refining and the manufacture of solid fuels and other energy industries. From the industrial processes sectors, all except chemical industry sub-categories have been included. The development of CO_2 emissions for the constructed EU ETS in each EU15 country from 1990 to 2002 are presented in Annex C.

There certainly exists a difference between the real EU ETS sector and the constructed EU ETS from statistics that must be taken into account. The differences may slightly vary from country to country, which must be noted when analysing the results.

Table 6 Greenhouse gas source and sink categories in the energy and industrial processes sector (EEA, 2004). Categories marked in blue are included in the constructed EU ETS sector.

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		
Total National Emissions and Removals		
1. Energy		**2. Industrial Processes**
A. Fuel Combustion	Reference Approach [2]	A. Mineral Products
	Sectoral Approach [2]	B. Chemical Industry
1. Energy Industries		C. Metal Production
2. Manufacturing Industries and Construction		D. Other Production [3]
3. Transport		E. Production of Halocarbons and SF_6
4. Other Sectors		F. Consumption of Halocarbons and SF_6
5. Other		G. Other
B. Fugitive Emissions from Fuels		
1. Solid Fuels		
2. Oil and Natural Gas		

5.2.2 CO_2 emissions statistics derived from energy statistics

Carbon dioxide emissions can be calculated indirectly from primary energy consumption using fuel-specific emission factors. For the new EU Member States in particular, for which complete CO_2 emissions statistics do not exist or they are insufficient, emissions calculation through primary energy usage is a relevant tool for the analysis. (Niininen, 2004)

5.2.2.1 Constructed EU ETS sector historic CO_2 emissions based on energy statistics

In this study, CO_2 emissions for all EU25 countries have been calculated from International Energy Agency Energy Statistics (IEA, 2004). The constructed EU ETS sector is formed by a similar methodology as the emissions statistics, presented in the previous Chapter 5.2.1.2.

In Table 7, energy and industry sector categories that have been included from the IEA energy balance sheets (IEA, 2004) in the constructed EU ETS sector emissions for OECD countries are marked in blue. There is a slight difference in the statistical sector-based classification of OECD and non-OECD countries. From the EU25 countries, all except Estonia, Latvia, Lithuania and Slovenia belong to OECD countries. Coverage of the constructed EU ETS sector in non-OECD countries is approximately the same as the coverage in OECD countries presented Table 7.

Table 7 IEA Energy statistics included sectors for constructed EU ETS sector for OECD countries are marked in blue in the table below. (IEA, 2004)

ENERGY SECTOR	INDUSTRY SECTOR
Transfers	Iron and Steel
Statistical Differences	Chemical and Petrochemical
Public Electricity Plants	Memo: Feedstock Use In Petchem. Industry
Autoproducer Electricity Plants	Non-Ferrous Metals
Public CHP Plants	Non-Metallic Minerals
Autoproducer CHP Plants	Transport Equipment
Public Heat Plants	Machinery
Autoproducer Heat Plants	Mining and Quarrying
Heat pumps	Food and Tobacco
Electric boilers	Paper, Pulp and Printing
Gas Works	Wood and Wood Products
Petroleum Refineries	Construction
Coal Transformation	Textile and Leather
Liquefaction Plants	Non-specified Industry
Other Transformation	
Own Use	
Distribution Losses	
Total Final Consumption	
Total Industry Sector	

The energy statistics that are used for CO_2 emissions calculation, the emitting primary energy sources are divided into coal products, crude oil, NGL (natural gas liquids) and feedstocks, petroleum products and natural gas. The specific emissions factors used for the fuels are presented in Table 8. Emissions factors are approximations of IPCC values (IPCC, 1996).

Table 8 Specific CO_2 emissions factors used for fuels (IPCC, 1996)

Primary energy source	**CO_2 emission factor (tCO_2/TJ)**
Coal	96.1
Crude oil, NGL and Feedstocks	73.3
Petroleum Products	77.4
Natural Gas	56.1

The time series of CO_2 emissions based on primary energy usage of EU25 Member States are mainly from 1990 to 2002 with the exception of the non-OECD Member States which are from 1997 to 2001. The development of CO_2 emissions delivered from the energy usage of the constructed EU ETS activities in each EU25 country are presented in Annex C.

5.2.3 Methodology used for CO_2 emissions development in EU ETS for the first trading period 2005 - 2007

Analysis used to estimate the CO_2 emissions development for the first trading period under EU ETS is based on a linear trend line approximation of future emissions based on historical emissions development. For most of the EU25 countries, approximation is based on historic CO_2 emissions development from 1990 to 2002 (EEA, 2004). For the 10 new EU countries, approximation is generally based on historic CO_2 emissions development from 1990 to 2002 derived from energy statistics (IEA, 2004). Accurate base periods are presented in Annex C.

The statistics are not sufficiently detailed to allow an accurate calculation of CO_2 emissions for each activity under the ET Directive and therefore the constructed EU ETS sector introduced earlier is used. To correct the possible differences between constructed and real EU ETS sectors, an adjustment has to be made. In National allocation plans, most of the EU25 countries have given some historic CO_2 emissions data for the EU ETS sector. By comparing the actual EU ETS sector emissions according to the NAPs and the constructed EU ETS from emissions or energy statistics, it is possible to calculate an average difference between the given values. As the average difference is known, it can be used to calibrate a linear trend line-based approximation of constructed EU ETS sector future CO_2 emissions for the real EU ETS sector CO_2 emissions. In this thesis, the word trend line is used to describe a linear trend line.

With the help of the diagram, Figure 11, the analysis methodology is as follows. Assuming a country, whose energy and industry sector, so-called constructed EU ETS sector, historic CO_2 emissions development from 1990 to 2002 is presented by a solid line. For this country there exists three historic years of data of real EU ETS sector emissions, which are marked as red dots. For these three years, it is possible to calculate the average difference between the real EU ETS sector emissions and the constructed EU ETS sector emissions. The average difference is marked as $DIFF_{\text{average}}$. By plotting a trend line for the constructed EU ETS emissions data, it is possible to assess the emissions for 2006, as the mid-year in the first trading period, by assuming a linear increase in emissions. To approximate the 2006 emissions scenario for the real EU ETS sector, the trend line approximation value is calibrated with the average difference $DIFF_{\text{average.}}$

For this illustrative country, the emissions forecast for 2006 based on trend line approximation is marked as a "business-as-usual" scenario "BAU". By comparing "BAU" to the annual allocation, it is possible to estimate the average deficit or surplus of allowances for the first trading period under EU ETS.

The basis of how the trend line-based analysis is conducted in each Member State is shown in Annex C. For some Member States, the trend line historic-based period differs from the 1990-2002 period.

For example, in Germany and the UK, the base period used is from 2000 to 2002. In Germany, it is not relevant to use earlier years in the trend line analysis as big renovations in Eastern Germany took place during the 1990s. The same applies to the UK as in 1990 a big switch from coal- to gas-based power production occurred.

In new Member States, which are typically Eastern European countries, the base period used differs from 1990-2002 as these countries faced huge economic degradation at the beginning of 1990s but today the economies are growing rapidly. An example is Poland, for which the trend line approximation of CO_2 emissions is based on the national total CO_2 projections, which account for the future estimates of remarkable economic growth.

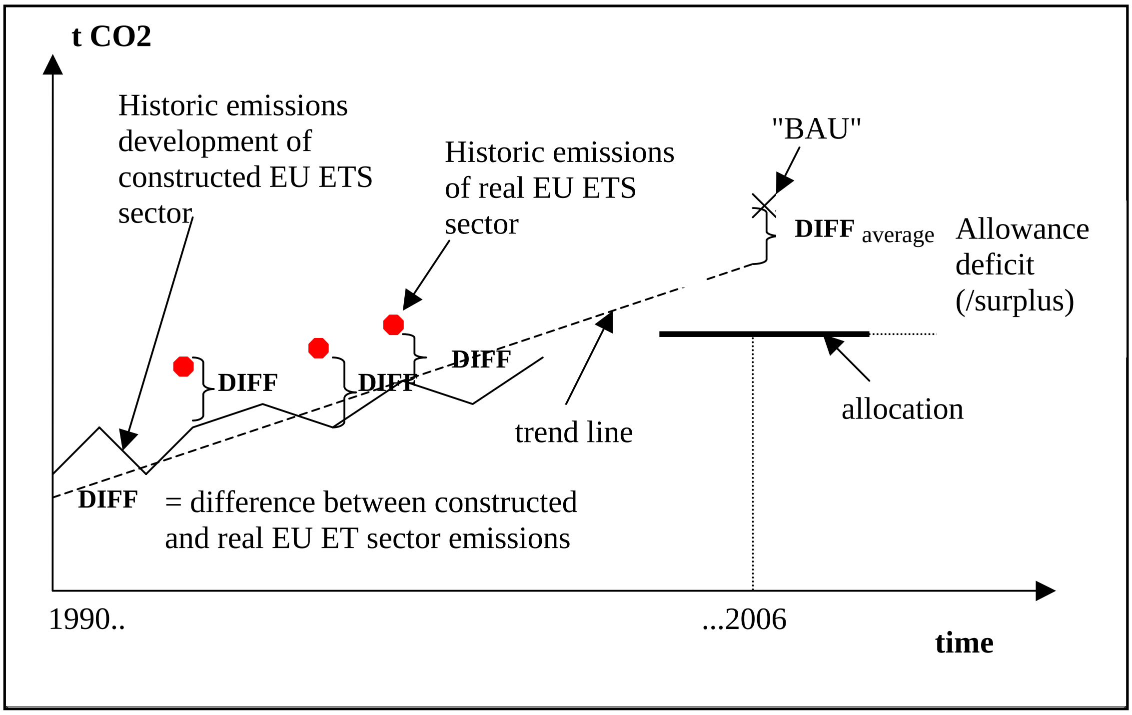

Figure 11 General trend line approximation-based methodology to estimate future CO_2 emissions development (Niininen, 2004)

5.2.4 Aggregate demand based on trend line analysis and National allocation plans

Table 9 summarises the trend line analysis-based "BAU" scenarios for EU25 countries except Malta and Cyprus. Table 9 also presents CO_2 emissions BAU scenarios given in the National allocation plans for the EU ETS sector for the first trading period 2005-2007. Only 12 countries out of 23 have given BAU estimates for CO_2 emissions development.

Table 9 Business-as-usual emissions scenarios for EU25 (except Malta and Cyprus)

	Trend line analysis based "BAU" 2006, Mt CO2	BAU given in NAP, average 2005- 2007 Mt CO2/a		Trend line analysis based "BAU" 2006, Mt CO2/a	BAU given in NAP, average 2005- 2007 Mt CO2/a
Austria	31,7	34,8	**Cyprus**		
Belgium	66,9	70,3	**Czech Republic***	92,3	
Denmark	32,3	39,3	**Estonia**	7,5	
Finland	41,3	46,9	**Hungary***	31,8	
France	102,9		**Latvia**	3,0	
Germany	517,1		**Lithuania***	6,8	14,0
Greece*,**	81,4		**Malta**		
Ireland	23,7	23,0	**Poland***	207,3	
Italy*	232,3	246,7	**Slovakia**	25,9	
Luxembourg	3,8	3,7	**Slovenia**	10,1	9,0
Netherlands	105,0	115,0	**EU 10 new**	384,6	
Portugal	37,6				
Spain*	176,0	169,8			
Sweden	21,2				
UK	252,3	278,4			
EU15	1725,4				
			Total EU25 trend line based "BAU"	2110,0	

* NAP draft, not yet assessed by EC

** Allocation estimate, no NAP draft exists (Point Carbon, 2004a)

5.3 Aggregate supply-demand balance of CO_2 allowances for EU ETS 2005 - 2007

Table 10 summarises three estimates of annual aggregate supply-demand balances of EU ETS allowances under the first trading period 2005-2007. The data on which supply-demand balances in each Member State is based, is presented in Annex C.

The first aggregate supply-demand balance of allowances is based on the balance between allocated allowances in Table 10 and the trend line analysis-based "BAU" scenario for CO_2 emissions presented in Table 10. The estimate gives a surplus of 143.4 Mt CO_2 of allowances in EU25 area. For EU15, the estimate is 35.5 Mt CO_2 surplus of allowances and for new Member States, 107. 9 Mt CO_2.

The second aggregate supply-demand balance of allowances is based on the balance between allocated allowances in Table 10 and the BAU scenario for CO_2 emissions given in the NAPs. For those countries that have not stated any BAU scenario for CO_2

emissions in their NAP, the trend line analysis-based "BAU" is used. This estimate gives a surplus of 74,5 Mt CO_2 of allowances in the EU25 area. For EU15, the estimate is 27.3 Mt CO_2 in deficit of allowances and for new Member States, 101.8 Mt CO_2 in surplus of allowances.

For reference, a third estimate given by well-known carbon market analysts, states that the aggregate allowance supply-demand balance in EU25 will be 5.2 Mt CO_2 in deficit of allowances. In the EU15 region, the allowance supply-demand balance will equal 7.3 Mt CO_2 in deficit and in new Member States, 65.1 Mt CO_2 in surplus of allowances. (Point Carbon, 2004e)

Table 10 Estimates of EU25 (except Cyprus, Malta) supply-demand balances of allowances in EU ETS for the 2005-2007 trading period.

	Estimates of annual supply-demand balances of EUAs 2005-2007		
	Trendline based "BAU"-allocation, Mt CO2	**NAP based BAU (if exists) allocation, Mt CO2**	**Literature estimate, Mt CO2 (Point Carbon, 2004e)**
Austria	-1,5	1,6	2,0
Belgium	3,9	7,4	3,3
Denmark	-1,2	5,8	1,1
Finland	-4,2	1,4	1,2
France	-16,3	*-16,3*	0,7
Germany	14,1	*14,1*	-1,4
Greece*,**	7,6	*7,6*	16,5
Ireland	1,2	0,5	2,2
Italy*	-46,9	-32,4	12,2
Luxembourg	0,4	0,3	1,6
Netherlands	6,7	16,7	5,5
Portugal	-0,6	*-0,6*	6,3
Spain*	15,7	9,6	0,4
Sweden	-1,7	*-1,7*	-0,7
UK	-12,8	13,3	19,6
Total EU15 surplus (-),deficit (+)	-35,5	27,3	70,3
Cyprus*			
Czech Republic*	-7,2	*-7,2*	-0,2
Estonia	-11,4	*-11,4*	-11,4
Hungary*	1,9	*1,9*	-0,8
Latvia	-1,5	*-1,5*	-1,0
Lithuania*	-7,9	-0,7	-7,5
Malta*			
Poland*	-78,9	*-78,9*	-45,1
Slovakia	-4,6	*-4,6*	2,4
Slovenia	1,8	0,7	-1,6
Total EU10 new surplus (-),deficit (+)	-107,9	-101,8	-65,1
Total EU25 surplus (-),deficit (+)	-143,4	-74,5	5,2

* NAP draft, not yet assessed by EC
** Allocation estimate, no NAP draft exists (Point Carbon, 2004a)
If no BAU scenario given in NAP, trendline based "BAU" used in NAP based BAU estimate

5.4 Aggregate Marginal abatement cost curves of CO_2 in EU25

One of the main determinants in carbon price estimation under EU ETS is the cost of CO_2 emissions abatement in EU25. As explained in Chapter 3, the emission allowance price can be roughly estimated from the y-axis of the marginal abatement cost if the allowance supply-demand balance is known.

The carbon dioxide abatement options are numerous in the energy and industry sector activities covered by the EU ETS. The following chapters shortly present general alternatives to abate carbon dioxide, which follows a review of the MAC curves presented in the literature.

5.4.1 Alternatives to abate CO_2

The CO_2 emissions in the energy systems are dependent on the fuel type and energy conversion technology. The possibilities to reduce CO_2 emissions in the energy systems in EU ETS covered sectors are therefore many. The most important technical measures to reduce CO_2 emissions are (EU, 2001b), (VGB, 2004):

- Changes in the fuel mix in favour of less carbon intensive fuels
- Higher adoption of carbon-free energy forms
- Higher penetration of co-generation units (CHP) for the production of electricity and heat
- Structural changes in industry leading to less energy intensive processes
- Energy conservation measures
- Carbon sequestration and storage

The primary energy sources, fuels, can be categorised according to their specific carbon content. On the basis of the carbon content of fuels, the CO_2 emissions resulting from combustion can be calculated. IPCC (1996) has defined specific emission factors for fuels in its guidelines. Emission factors are in general expressed as tCO_2/ TJ. In the short run, one of the most feasible options in energy systems is a switch to less carbon-intensive fuels. Concerning fuel switches, the most economic option currently is the replacement of coal condensing power production with an increased utilisation of combined cycle gas turbine (CCGT) plants. Switching from coal to gas almost halves CO_2 emissions due simply to the chemical composition of the fuel (VGP, 2004).

CO_2 abatement can be increased by investing in new, less carbon-emitting energy production forms. Investing in carbon-free nuclear or renewable energy forms, such as wind, solar, biomass and waste energies will lead to CO_2 abatement if they replace conventional carbon emitting energy forms, such as coal and oil. In the longer term, the use of solar energy and hydrogen as energy carriers can also be important carbon-free energy forms. (VTT, 2003)

Overall the thermal efficiency of combustion is improved by using combined heat and power technology (CHP) (VGB, 2004). As total thermal efficiency is improved, the specific CO_2 emissions per electricity and heat unit produced decrease. In the longer term, other new technologies such as gasification and pyrolysis also offer decreased CO_2 emissions by enabling increased efficient use of bio- and waste-fuels (VTT, 2003).

One CO_2 abatement option is to make structural changes to industrial processes. Structural changes in processes may, for example, be the optimisation of the processes so that energy consumption is minimised and therefore CO_2 emissions are reduced.

Energy conservation measures in energy systems are one alternative to increase CO_2 abatement. By, for example, increasing heat recovery in the utilities, the total plant efficiency improves and therefore specific CO_2 emissions per unit of heat and electricity are decreased.

Carbon sequestration and storage means the removal of carbon from burning processes and disposing of it in isolated geologic formations. Carbon sequestration and storage offers a carbon-neutral way of utilising fossil fuels. Carbon can be removed from the fuel before or after combustion and suitable disposal sites can be, for instance, depleted gas or oil fields. Carbon sequestration and storage is still a very expensive technology for CO_2 abatement. The overall costs are in the range of 20-60 € per tonne of CO_2. (VGB, 2004), (VTT, 2004)

5.4.2 European Union MAC studies behind the Emissions Trading Directive

When preparing the ET Directive, the European Union conducted studies concerning the implications of implementing the Directive. The marginal abatement cost curve presented in Figure 12 is based on a bottom-up analysis of emission reduction potentials and costs for greenhouse gases in the EU15. The form of the curve is based on an assumption of a frozen technology level, i.e. the level at which no reduction options have been implemented at all since 1990. The curve covers all CO_2 abatement options from 1990 to 2010 in all economic sectors, not only EU ETS covered sectors. The curve is based on GENESIS database information in which a total of 164 emission reduction options are incorporated. (EU, 2001)

For current EU ETS sector marginal abatement costs, it is not possible to derive much from the curve presented in Figure 12 as it is not easy to define how much emissions abatement has already been taken from 1990 to the present. Assuming linear development, a figure for 2002 frozen technology emissions development can be derived. According to this assumption, the CO_2 emissions in 2002, without any abatement taken since 1990, would have been 3919 Mt CO_2 in EU15 countries. Comparing that figure to real CO_2 emissions in EU15 in 2002, which was 3224 Mt CO_2 (EEA, 2004), the CO_2 emissions abatement taken from 1990 to 2002 is cumulatively around 695 Mt CO_2. By subtracting this amount from the curve, the curve states that around 400 Mt CO_2 emissions abatement could still be achieved without any costs. This figure is much greater compared to more recent estimations of marginal abatement costs presented in the next chapter. One obvious reason is the fact that this curve includes abatement options in all economic sectors, not only in EU ETS sector. An assumption that gas to coal fuel switches are assumed to be done with no costs might be another. (EU, 2001)

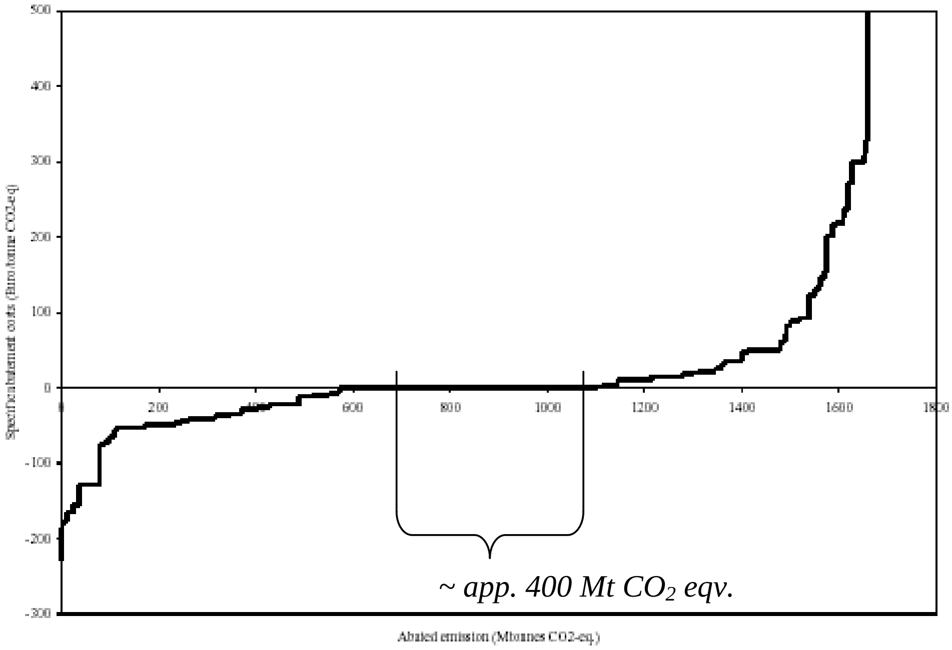

Figure 12 Cost curve for CO_2 reduction of all economic sectors in EU15 (EU, 2001)

5.4.3 Other MAC data presented in the literature

In the literature, several estimates concerning CO_2 emissions' marginal abatement curves for EU25 countries for the 2005-2012 period exist. Studying the existing MAC curves, certain ranges for the costs of carbon dioxide reduction in the EU25 area can be concluded. It must be remarked that in all estimates, the reduction potentials and associated costs of reducing CO_2 emissions rely on a range of different assumptions, for example, on future economic development, relative fuel prices, technological development and a regulatory framework for the energy markets (ECON, 2004).

According to most of the literature references, the industry sector's low cost abatement options are limited and the feasible emissions abatement is to a great extent found in the energy sector fuel switches in existing installations and after that replacing the existing coal condensing capacity by new less CO_2 emitting generation capacity. Most of the short term MAC curves therefore are based on the cost of gas to coal fuel switches in power and heat production. Figure 13 presents eight estimates of MAC curves. Their basis will be clarified in the following.

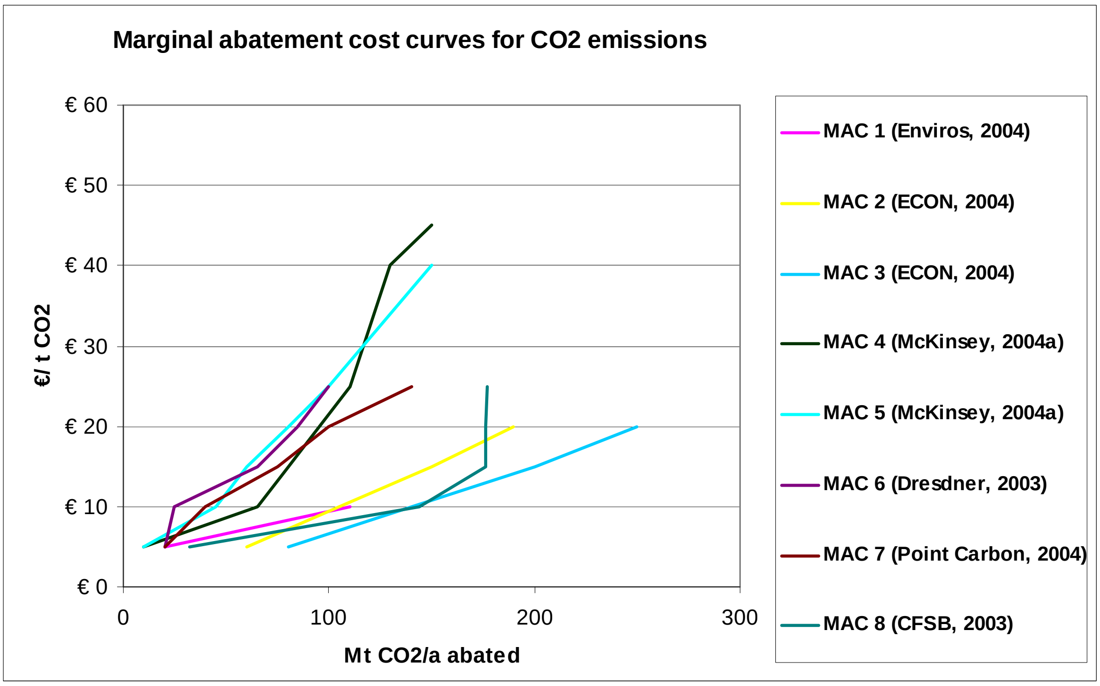

Figure 13 Different estimates for EU25 CO_2 emissions marginal abatement cost curves presented in the literature

Under the MAC 1 curve in its original form, as presented in the literature, had also been included an estimated amount of allowances in the new entrants reserve and JI and CDM credit imports. As the new entrants reserve in this study is included in the supply side of allowances and the JI and CDM credits are considered as reductions in the total demand, they are not included in the MAC curve construction shown in Figure 13. MAC 1 only covers CO_2 emission reduction options in the short run. The reduction potential consists of an estimated 20 Mt CO_2 abatement possibility at no or negative cost and around 70 Mt CO_2 abatement possibilities from fuel switches in utilities below €10 per tonne of CO_2. A longer run version of the curve estimates that investing in new CCGT capacity in the power sector can reduce emissions by a further 200 Mt CO_2 at a price below €20 per tonne. This potential might be feasible in the second trading period 2008 - 2012 under EU ETS but should be discounted as the time period up to 2012 might not be enough to justify new build CCGT plants and other industrial capital projects. (Enviros, 2004)

MAC 2 and MAC 3 are stated as being based on the EU MAC curve presented in Chapter 5.4.2. MAC 2 represents marginal abatement costs in EU15 countries and MAC 3 for the whole EU25. MAC 3 has been constructed by integrating 10 new Member States into the original MAC 2 curve and by assuming that ETS participants among the new Member States can achieve 25% more CO_2 reductions at the same price compared to EU15 countries. (ECON, 2004)

MAC 4 and MAC 5 curves assume that around 10 Mt CO_2 can be abated in industry at low cost, beyond that MAC 4 and MAC 5 are based on power sector fuel switches from coal to gas or nuclear. MAC 4 is based on a lower gas price scenario and MAC 5 on a higher gas price scenario. (Mc Kinsey, 2004a)

MAC 6 is based on an estimation that around 25 Mt CO_2 can be abated in the industry sector. 20 Mt CO_2 industry sector potential can be abated under €5 per tonne and the rest under €12 per tonne. Fuel switches from coal to gas are estimated to have a 50 Mt CO_2 reduction potential with the first tonne reduced by €12 and the last around €17. After that, reductions can be achieved by building new CCGT plants. (Dresdner, 2003)

The basis of the MAC 7 curve is the assumption that the industry sector has a small amount of cheap CO_2 reduction potential after which the CO_2 emissions abatement cost is based on a fuel switch from coal to gas in the energy sector. According to the MAC 7 curve, only around 50 Mt CO_2 can be abated under €10 per tonne. (Point Carbon, 2004e)

The most accurate literature reference for marginal abatement costs of CO_2 emissions is presented by the MAC 8 curve in Figure 13 and in more detail in Figure 14. The curve is solely based on fuel switches from gas to coal in different areas inside EU25. The abatement as € per tonne of CO_2 shown on the y-axis, is calculated for different areas in

EU25 based on the gas price information. The coal price is assumed to be same in each area. The potential CO_2 abatement in Mt CO_2, as shown on the x-axis, is calculated based on the potential to increase CCGT and CHP-based production according to the potential to increase CCGT and CHP utilisation rates in each country. The potential CO_2 emissions abatement is achieved by assuming that the increase in CCGT with an efficiency of 53% and CHP production replaces coal condensing power production with 35% efficiency. Under these assumptions, the aggregate CO_2 abatement potential by switching from coal condensing to CCGTs or CHPs in the EU is in total around 180 Mt CO_2 and it is economical to implement at a CO_2 allowance price just below €14. After that, the abatement is based on switching from coal use to new CCGT capacity at a price of around €27 per tCO_2. It should be noted that according to the MAC curve presented below, a coal to gas switch in the UK is a profitable option by itself as the abatement cost is slightly negative. (CFSB, 2004)

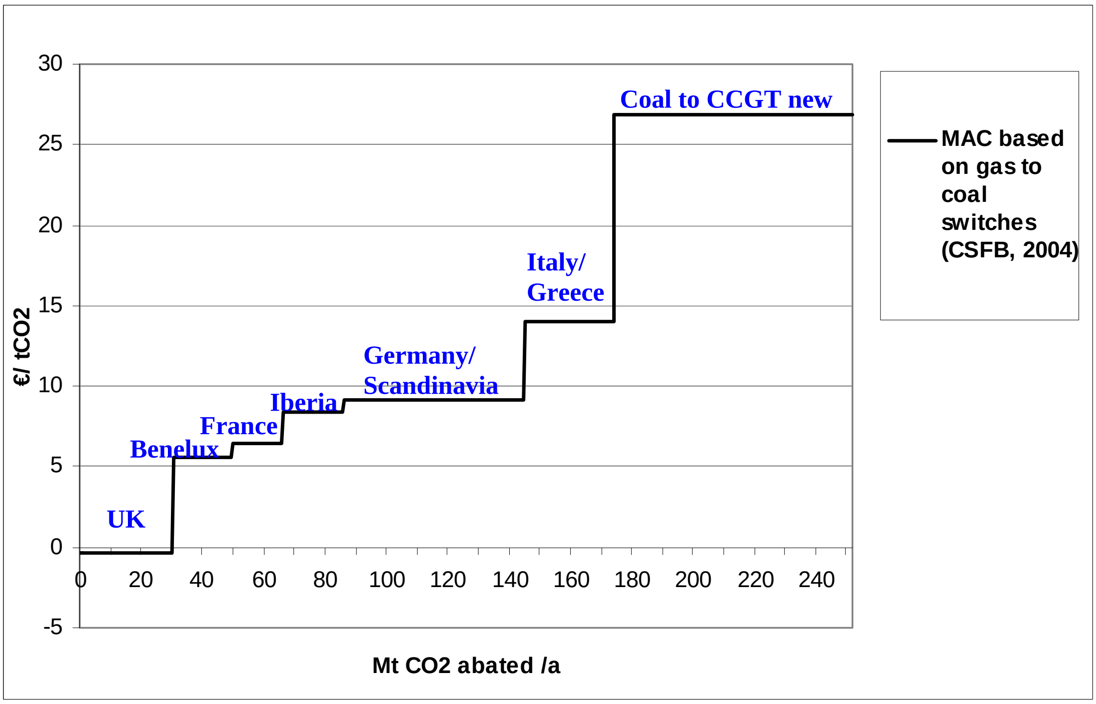

Figure 14 An estimate of CO_2 emissions marginal abatement costs in some EU regions based on potential and cost of switching from gas to coal. (CSFB, 2004)

6 SENSITIVITY ANALYSIS

Various assumptions create uncertainties in assessing the fundamental price determinants for CO_2 allowances in the EU ETS. It is therefore relevant to consider the assumptions that cause uncertainties and try to assess their relative importance.

This thesis attempts to examine the sensitivities of political decisions, final allocation of allowances, amount of imported project-based Kyoto credits, economic growth, natural conditions, fuel price volatilities, nuclear power phase out, electricity imports and exports and finally ideal market requirements for the estimated price for EU allowances.

6.1 Political decisions

Forward prices for EU ETS allowances have been to a great extent affected by political decisions during the past ten months. According to some carbon market analysts, political decisions have been so far the most important price driver in the market. (Point Carbon, 2004i)

Figure 15 presents a forward price curve for EU allowances, EUAs, which is based on reported bids and offers (Point Carbon, 2004c). Timing of certain decisions on the allocation process has been marked in the figure. As it can be seen from the changes in the allowance market price, the stages in the allocation process have likely had an effect on the forward price development. At the end of January 2004, the draft UK NAP was released, which showed some scarcity in the allocation. In March-April 2004 period, the first NAPs appeared, which were generous in terms of total allocation, and in April the European Parliament adopted the Linking Directive. Adaptation of the Linking Directive confirmed that the EU ETS participants are allowed to import JI and CDM credits into the scheme even though the Kyoto Protocol would not have entered into force. This increased the allowance supply side, at least theoretically.

At the beginning of May, the Commission called for market scarcity, warning of over-generous allocation in the National allocation plans. At the beginning of July, the European Commission announced the assessment of the first eight National allocation plans with a lenient response to the generous allocation. In mid-October 2004, the Commission assessed the second round of National allocation plans and required bigger cuts to be made in the total allocation than in the first assessment round.

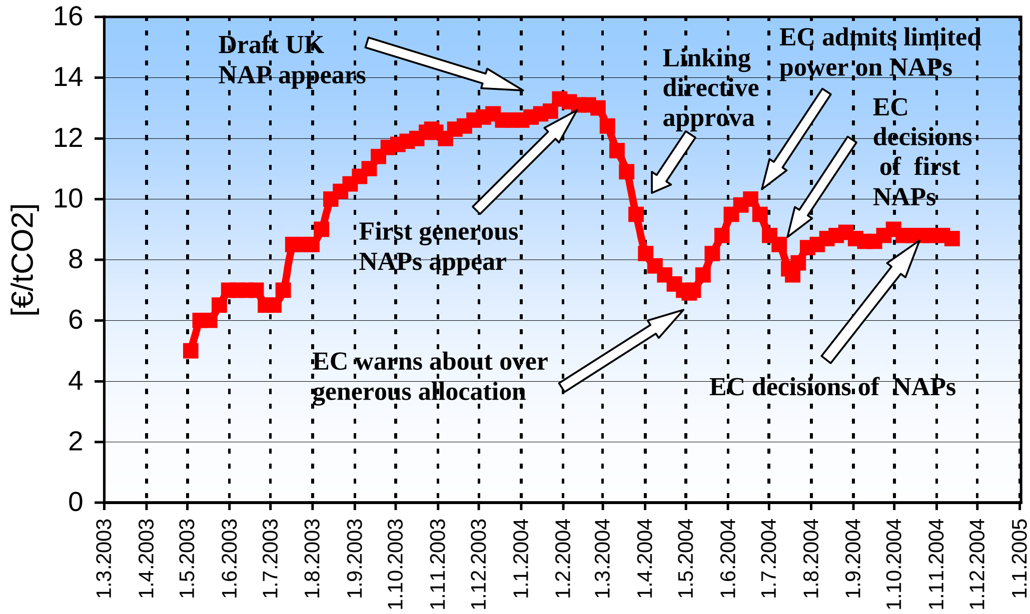

Figure 15 EU ETS allowance forward prices (Point Carbon, 2004c) and political decisions

As Figure 15 shows, forward allowance prices fluctuated between €5 and €13 during the time period from 1st May, 2003 to mid-November 2004. During the last three months of this period, the price settled quite stably at around €8-9 per tonne of CO_2.

A crucial element at the political level, which certainly affects the allowance price in the longer run, is the Russian ratification of the Kyoto Protocol. After long consideration, Russia finally decided to ratify the Protocol on 4th November, 2004 ensuring that the Kyoto Protocol will enter into force. The date of the Protocol's entry into force will be 16th February, 2005. As Kyoto will enter into force, the EU burden sharing commitments for GHG emissions will be binding in 2008 - 2012. This will likely increase the allowance prices in EU ETS as the allocation for the second trading period in 2008 - 2012 ought to be stricter than the allocation for 2005 - 2007 in order to meet the Kyoto targets. On the other hand, entry into force of the Kyoto Protocol enables Russia to sell excess allowances, so-called hot-air, to EU Member State governments. Russia's target under the Protocol is to stabilise its greenhouse gas emissions at 1990 levels over the 2008 - 2012 period and it is estimated that Russia has a substantial surplus of emissions allowances to sell. (Environmental finance, 2004c)

Russia can sell the excess allowances as AAUs under the Kyoto Protocol 2008 - 2012 period or bank them for future commitment periods. The Russian economy is also believed to have a large supply of low-cost abatement options. As long as these domestic abatement costs are lower than the international price for emission allowances, Russia can exercise these options and either sell further AAUs where there is an excess or sell ERUs under Joint Implementation for a profit. ERUs from JI projects will be valid under EU ETS from 2008. AAUs will not be valid in EU ETS but will be valid for EU Member States for the Kyoto compliance, which again could affect the EU ETS indirectly in the allocation possibilities for the second trading period 2008 - 2012. AAUs are bankable for possible future commitment periods only if the country that intends to bank them has fulfilled the prevailing Kyoto period commitment. (Lecocq et al, 2004a), (IEA, 2001)

According to various analyses, the estimated potential of surplus AAUs in Russia is in the range of 300 to 1000 Mt CO_2 eqv per year between 2008 and 2012. The Russian JI committee is hoping to complete a first portfolio of around 20-25 JI projects, promising reductions equivalent to 70 Mt of CO_2 already by early 2005. Considering the potential for 2005, it must be taken into account that Russia still does not have the institutional framework for JI projects. If EU ETS participants buy ERUs, it will affect the market balance during the EU ETS second trading period 2008 - 2012. Increased imports of cheap ERUs will decrease the demand for EUAs, reducing the EUA allowance prices. On the other hand, Russian ratification may also increase the allowance prices as companies in the EU, Canada and Japan realise that Kyoto is, indeed, going ahead and the Kyoto Targets must be met. (Environmental finance, 2004c)

Other political factors that might affect the price of an EUA are potential links of other allowance trading schemes to EU ETS. As an example, the Norwegian government has launched a draft bill for the country's emissions trading scheme, set to start parallel with EU ETS on 1st January, 2005. The draft allows Norwegian companies to purchase EU allowances and CDM credits for compliance. It has been estimated that Norwegian companies would be approximately 1Mt CO_2 short of allowances over the 2005-2007 period. 1 Mt CO_2 is small compared to the EU ETS market size of around 2250 Mt CO_2 but if other national trading schemes, as planned for example in Canada and Japan, would also be linked to the EU ETS, the effect on EUA prices would be bigger as the potential demand of EUAs would increase. Canada and Japan may link to the EU ETS from 2008, which could then have an effect on the allowance prices for the EU ETS second trading period 2008 - 2012. (Point Carbon, 2004j), (Point Carbon, 2004g)

Post-2012 negotiations on climate issues have started. If any successful agreements are achieved, the future GHG emission reduction targets will probably be stricter than for the Kyoto period. This might affect the allowance prices already in the EU ETS first trading periods 2005 - 2007 as the market participants will have prospects for future stricter commitments. The investments in emissions abatement at installations will probably increase if the future is more predictable. This might imply lowering the allowance prices.

6.2 Final allocation of allowances

By mid-December, the Commission has assessed, and accepted with our without conditions, 16 National allocation plans out of all 25. The total allocation of allowances for the first trading period under the EU ETS is therefore not yet finally fixed. In the second NAP assessment round in October, the Commission required especially the new Member States of Estonia, Latvia and Slovakia to cut their allocation by around 15%. If the Commission requires the same size cuts of the NAPs that have not been assessed yet, the supply-demand balance of allowances could be changed. Much uncertainty concerns the second trading period 2008 - 2012 allocation, of which only a few NAPs have given some indication. (Point Carbon, 2004k)

6.3 Amount of imported Kyoto project-based mechanisms credits

The exact estimation of imported Kyoto project-based mechanism credit into the EU ETS scheme is difficult. For the first trading period 2005 – 2007, only CERs created by CDM projects will be valid. ERUs from JI project credits (ERUs) will be eligible from 2008. In theory, these credits offer a large supply, but the complex and time consuming administrative processes required to bring them to market has to date severely limited the supply (ENVIROS, 2004). For the second trading period, supply may also be limited due to the fact that there will be limits on the CER and ERU imports depending on how the supplementarity will be interpreted (EU, 2003b).

Estimation of CER imports for the first trading period is difficult because the majority of CDM projects face considerable risks that are likely to reduce the number of CERs they produce. These risks can be put into three categories. First, many CDM projects face a risk that they will not be approved by UNFCCC bodies due to methodology or additionality issues. Secondly, CDM projects must be approved by host countries, which is not always obvious. CDM projects are also prone to failures and delays. Reasons for delays and cancellations as well as other circumstances that could affect CER generation are very project specific. (Point Carbon, 2004h)

The World Bank has assessed that the CDM market to bring CERs to the EU ETS could essentially close for the second trading period 2008 - 2012 already in 2006 or 2007 (Environmental Finance, 2004a). Market closure means that unless CDM projects are in operation by then, many will be unable to deliver credits before 2012. The CER utilisation might be very limited in the first trading period as these credits are fully bankable for the following trading periods and the prices in the second trading period 2008 - 2012 are estimated to be higher.

According to one estimate, a decrease of CERs imports by 20 Mt CO_2 to EU ETS in the first trading period 2005 - 2007 will increase the allowance price by €3. (Point Carbon, 2004e)

6.4 Economic growth

6.4.1 GDP development in EU25 versus CO_2 emissions

A general statement is that an important factor behind CO_2 emission projections is estimated economic growth rate, measured as GDP increase. It is therefore relevant to study how GDP and CO_2 emissions have developed and possibly correlate in recent history. Figure 16 presents EU15 GDP growth and CO_2 emissions development for the constructed EU ETS sector for the period 1991- 2002 relative to 1990 levels. Figure 17 presents the same but for the whole EU25 area and for the time period 1997- 2002. As it can be seen from the development, there are no clear indications of a strong correlation between GDP and CO_2 emissions in the EU25 area.

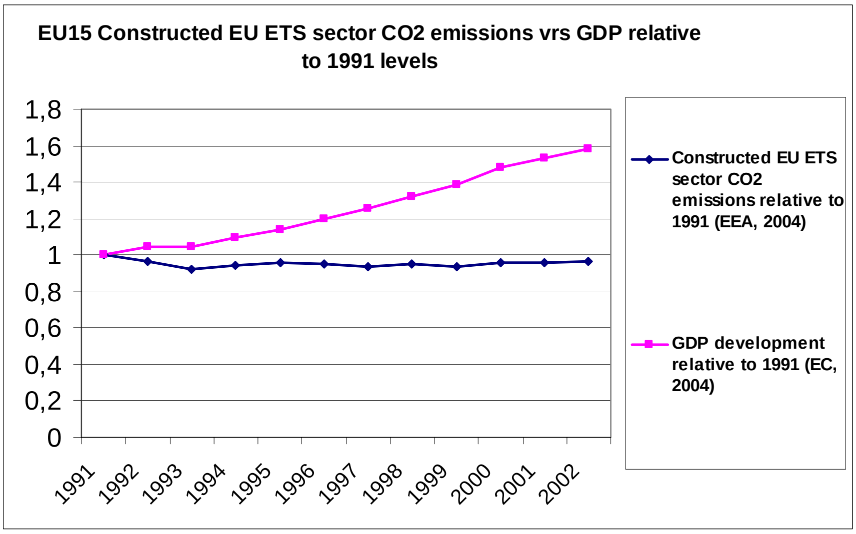

Figure 16 EU15 constructed EU ETS sector CO_2 emissions GDP relative to 1991 levels, except Greece.

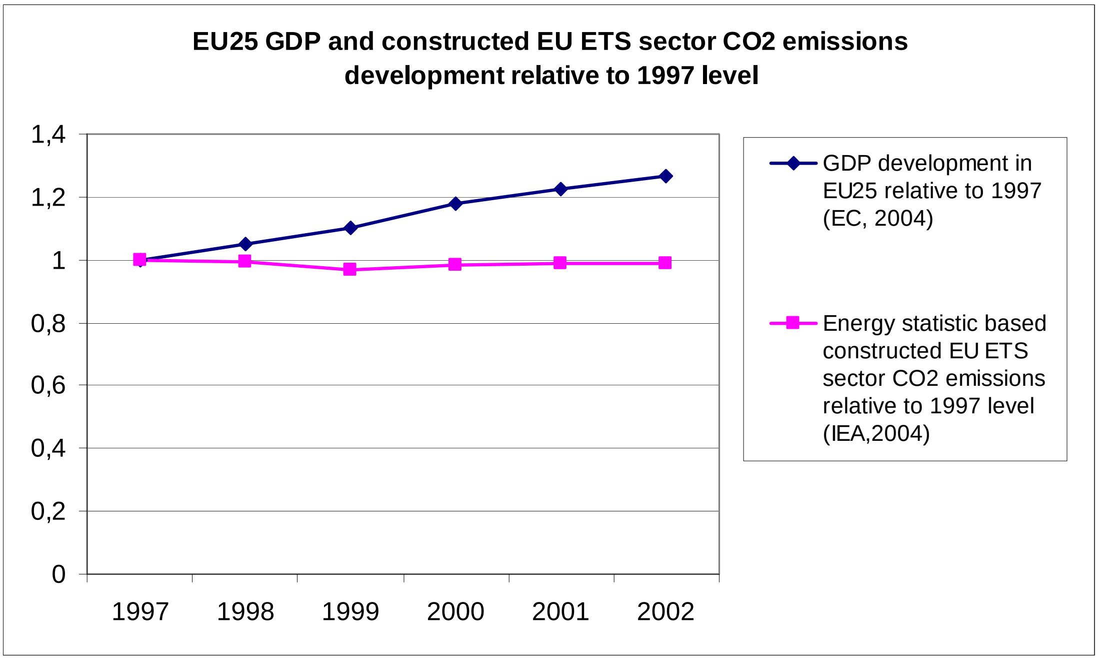

Figure 17 EU25 (except Greece, Malta and Cyprus) GDP and constructed EU ETS sector CO_2 emissions development relative to 1997 level.

As GDP and CO_2 emissions do not strongly correlate with each other in the EU25 area, it is more relevant to study the correlation at the micro-level between electricity demand and CO_2 emissions. This consideration is relevant as electricity production is one of the most dominant factors influencing CO_2 emissions.

6.4.2 Electricity consumption increase in EU25 versus CO_2 emissions

Total electricity production in the EU25 area in 2002 amounted to 3018 TWh and CO_2 emissions from electricity production were 1254 Mt CO_2 (FORATOM, 2004). Total EU ETS sector CO2 emissions in 2002 were approximately 1846 Mt CO_2 (Point Carbon, 2004c). Therefore, the share of electricity production CO_2 emissions in 2002 was about 68% of the total EU ETS sector CO_2 emissions.

Statistics (Europrog, 2004) give projections for electricity consumption in EU25 for the years 2005 and 2010. According to these estimates, the electricity demand increases annually 1.9%. The fluctuations in CO_2 emissions can be estimated by considering a low and high scenario for electricity growth rates as shown in Table 11 (Vile, 2004). In the low scenario, the annual electricity demand increase is assumed to be only 1.3% and in the high scenario 2.3%. With these growth rates, it is possible to calculate the amount of electricity demand increases in 2006 and 2010 compared to 2005 demand. By assuming that the increased amount of electricity demand is produced by coal condensing, with an efficiency of 35%, it is possible to estimate the increase in CO_2 emissions.

Table 11 Scenarios for electricity demand increases in EU25 and their effects on CO_2 emissions

		Electricity consumption		If increased electricity demand produced by coal condensing, with efficiency 35 %	
EU25	**Annual demand increase %**	**Increase from 2005 to 2006, TWh**	**Increase from 2005 to 2010, TWh**	**Increase 2005-2006 Mt CO2**	**Increase 2005-2010 Mt CO2**
Reference scenario (Eurprog, 2004)	1,9	57,3	286,4	56,6	283,1
Low scenario	1,3	39,1	200,7	38,6	198,3
High scenario	2,3	69,2	362,2	68,4	358,0

As shown in Table 11, the CO_2 emission fluctuations according to these two electricity growth rate scenarios are around +/- 15Mt CO_2 for 2006 and +/- 80 Mt CO_2 for 2010. These estimates are of a similar magnitude as another estimate (Bakker S, 2004), which states that if average EU-wide emissions growth from 2002 to 2006 is 0.5% per annum higher than currently projected, the emissions will be 40 Mt CO_2 higher.

6.4.3 Iron and steel sector production growth in EU25 versus CO_2 emissions

Another reasonable method for studying the possible fluctuations in CO_2 emissions due to the forecasted economic growth is to consider increases in iron and steel industry production volumes (Vile, 2004). As iron and steel industries are the largest energy consuming industries in the world, they are also one of the most important sources of CO_2 emissions

By assuming for the iron and steel industry the same growth rate scenarios, 1.3% and 2.3%, as in the electricity demand increase scenarios, it is possible to calculate the forecasted CO_2 emission increases for 2006 and 2010 compared to 2002 levels. The base year emissions for EU25 iron and steel industry, as shown in Table 12, are derived from the energy statistics (IEA, 2004). In IEA (2004), energy statistics for the iron and steel sector are included in ISIC Group 271 and Class 2731 activities. CO_2 fluctuations in the iron and steel industry sector according to two given growth scenarios are around +/- 2.1 Mt CO_2 for 2006 and +/- 4.5 Mt CO_2 for 2010.

Table 12 Scenarios for EU25 iron and steel industry production volume increases and their effects on CO_2 emissions

Production volume increase (%)	Base year 2002 emissions, Mt CO2	Forecasted emissions increase in 2006, Mt CO2	Forecasted emissions increase in 2010, Mt CO2
1,3 %	99,5	5,3	10,8
2,3 %	99,5	9,5	19,9

6.4.4 Economic indicators of EU25 CO_2 emissions

Based on the previous sub-chapters' analyses of economic growth and CO_2 emissions correlations, some conclusions can be drawn. At the macro-level, economic growth, measured in GDP growth, does not seem to correlate directly to CO_2 emissions development. But micro-level economic factors, electricity consumption and iron and steel sector production volumes, can be thought of as affecting the aggregate EU ETS sector CO_2 emissions in the EU25 area as they cover more than two thirds of the total EU ETS sector CO_2 emissions. The effect is remarkable over a very short time period, as the increased electricity demand will first be satisfied with existing power production capacity. Usually, coal condensing is the marginal power production technology and therefore each TWh increased electricity demand increases the emissions a bit less than 1 Mt CO_2.

However, it can be assumed that over a longer time period, the structural changes, e.g. in electricity and iron and steel production processes (for example energy conservation measures and changes to less carbon emitting technologies) cancel the macro-level correlation of GDP growth and CO2 emissions. As can be seen from Figures 16 and 17, this has been the case also in the historic time period.

6.5 Natural conditions

In general, the business-as-usual projections of CO_2 emissions development rely on forecasted demand data that is based on an average weather year. The weather conditions however cause fluctuations to CO_2 emissions levels in EU25, which will affect the CO_2 allowance prices.

The weather affects CO_2 emission levels in two ways. First, temperature variations change energy consumption in heating and cooling. Second, rainfall and wind speeds affect the share of power generated by non-emitting sources and thus emission levels. As wind power's share of energy production is very small, significant connections between wind speed and the CO_2 emissions have not been noticed, but rainfall does have a bearing on CO_2 allowance prices as it affects directly hydro-power availability.

Weather-caused deviations in CO_2 emissions levels in a single country can be large, but what is important for the EU ETS allowance price levels is the level of emissions across all participating countries. (Global Insight, 2004) According to analysts, allowance trading will be encouraged if one part of Europe is wet and another is dry as the EU ETS starts. (Environmental Finance, 2004b)

According to another estimate, weather changes in Northern Europe increase or decrease coal condensing utilisation by +/- 5% and will affect the allowance price by +/- €7.5 and in Southern Europe by +/- €3. (Point Carbon, 2004e)

6.5.1 Power demand volatility (temperature)

Temperature affects the heating and cooling amount needed. In cold winters, more heat is needed, which means that more carbon emitting fuels are burned (Environmental Finance, 2004b). This will increase the demand for allowances and therefore increase allowance prices. In southern countries, hot summers increase the need for cooling. Electricity needed for increased demand for cooling production increases CO_2 emissions thus increasing the price for CO_2 allowances.

In an analysis of EU25 power sector emissions over a seven year period 1995-2001, the temperature corrected fluctuations are +/- 50 Mt CO_2 . (Global Insight, 2004)

6.5.2 Power supply volatility (water reserves)

Hydro-power production is to a great extent dependent on the amount of rainfall. Out of the EU25 countries, notably in Scandinavia and Austria, hydro-power production capacity has a large share. In these countries, power prices are highly correlated with rainfall. In dry years, the shortfall of hydro-power is usually replaced by CO_2 emitting fossil fuel generation. As such, rainfall will likely have a significant impact on CO_2 allowance prices. According to analyses by Rowland (Environmental Finance, 2004b), in a wet year, the allowance price could drop to €5 and in a dry year raise to around €18 as their estimate of the allowance price over the first trading period is €15. (Environmental Finance, 2004b)

6.5.2.1 CASE: Nordic hydropower production versus Nordic carbon dioxide emissions

In the Nordic power exchange area, the amount of electricity production by hydro-power alters according to the rainfall and amount of melting water. In a normal year, hydropower production in the Nordic region is approximately 200 TWh, but it can vary between 160 and 240 TWh. The fluctuation range is therefore approximately 80 TWh, which equals the total annual electricity consumption in Finland. (Kara, 2004)

This fluctuation is balanced by altering amounts of thermal power production, which is most often coal condensing (Kara, 2004). Hydro-power does not produce any carbon dioxide emissions and in coal condensing power production carbon dioxide emissions are about 1 Mt CO_2 per produced TWh, assuming coal condensing with 38% efficiency (IPCC,1996). According to Niininen (2004), it should been possible to see a correlation between the amount of hydropower production in Nordic and Nordic total annual CO_2 emissions.

In Figure 18, the total CO_2 emissions in Nordic countries including Finland, Denmark, Norway and Sweden in the period 1990- 2002 are presented as well as the total amount of hydropower production in the Nordic area 1990- 2002. From Figure 18 the correlation between Nordic CO_2 emissions and hydropower can be seen. For example, the year 1996, which according to Nieminen (2004) was an extremely dry year, the CO_2 emissions are very high, amounting to around 258 Mt CO_2. In the same year, hydro production was very low, around 167 TWh. In year 2000, which was a very wet year, the hydro production was around 234 TWh. The hydro production maximum variance is therefore around +/- 33 TWh. Over a longer run, the natural hydropower variations are around +/- 30 TWh (Nieminen, 2004) Assuming that coal condensing, with an assumed average of 38% efficiency, is on the marginal production, the average fluctuation in Nordic CO_2 emissions caused by hydro fluctuation is around +/- 25-30 Mt CO_2 if coal condensing is the marginal power production technology.

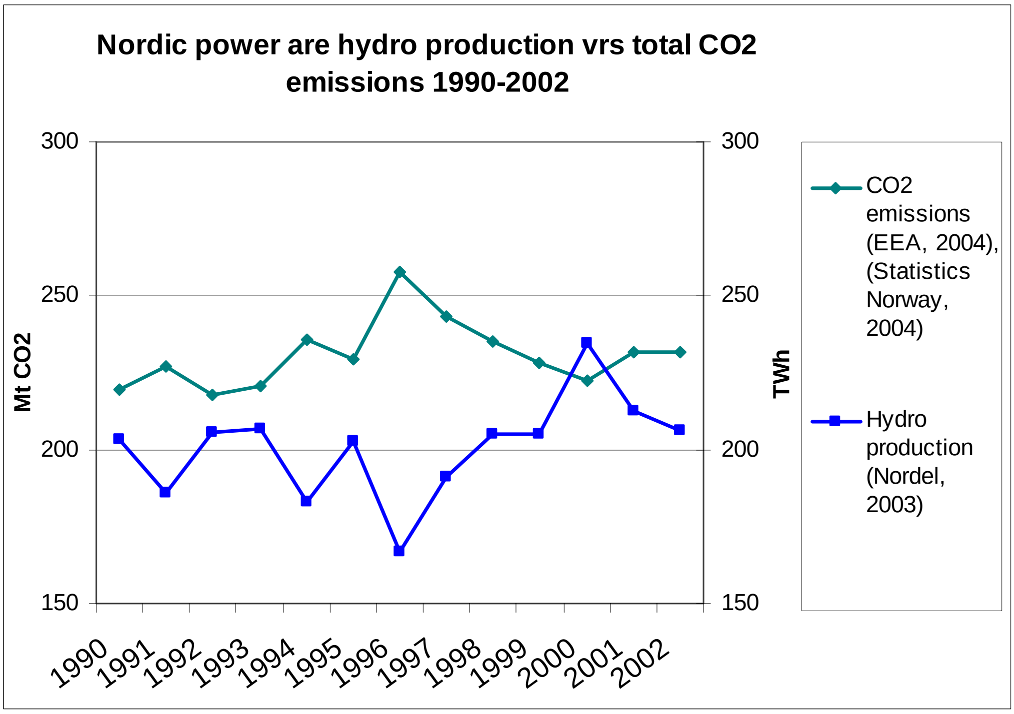

Figure 18 Nordic hydropower production versus total CO_2 emissions in Nordic countries 1990-2002

As it can be seen from Figure 18, the correlation between the Nordic CO_2 emissions and the Nordic hydropower is not perfect. This is due to the fact that the amount of imported electricity from Europe and Russia varies. Small increases in production capacities may also have slightly increased the amount of hydro production and CO_2 emissions during the period 1990-2002. (Niininen, 2004)

6.5.2.2 CASE: Austrian hydropower production versus constructed EU ETS sector CO_2 emissions

Currently about 70% of electricity in Austria is generated by hydropower (Austria, 2002). In Figure 19, historic hydropower production in Austria and constructed EU ETS sector CO_2 emissions for period 1990- 2002 in relative terms, compared to 1990 levels is presented. Hydropower production in 1990 equalled 31.5 TWh (IEA, 2004). Constructed EU ETS CO_2 emissions, which are estimated EU ETS sector emissions delivered from national CO_2 emissions statistic, were 33.4 Mt CO_2 in 1990 (EEA, 2004). As it can be seen from Figure 19, the emissions have fluctuated between 0.9-1.1 compared to 1990 levels which equals around +/- 3 Mt CO_2. Hydropower production has varied between 1.0-1.3 compared to the production level in 1990, which equals around +/- 5.2 TWh.

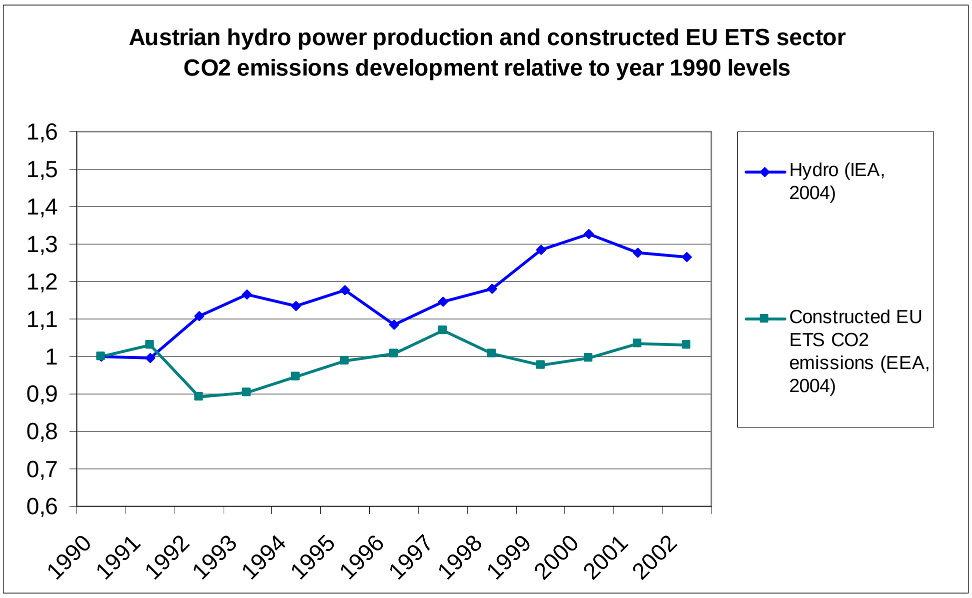

Figure 19 Austrian hydropower production and constructed EU ETS sector CO_2 emissions development relative to 1990 levels

6.6 Fuel price volatility

In liberalised electricity markets, the electricity price is based on marginal costs of electricity production. Marginal production costs therefore determine the plant merit order. In the short-run, marginal production costs are based on the variable costs of power generation. Variable costs include, e.g. fuel costs and variable operation and maintenance costs. (Reinaud, 2003)

As EU emissions trading starts, carbon prices ought to be included in the variable costs of production since an emission allowance will be needed for each unit of CO_2 produced. As the carbon intensity of different fuels varies, the variable costs for different power plants will vary according to the fuel carbon content and allowance price. Therefore, introducing a CO_2 allowance price may change the existing plant merit order as illustrated in Figure 20. In Figure 20, the merit order of plants before introducing emissions trading is 1-2-3 and after including a cost for carbon 2-1-3. (Reinaud, 2003)

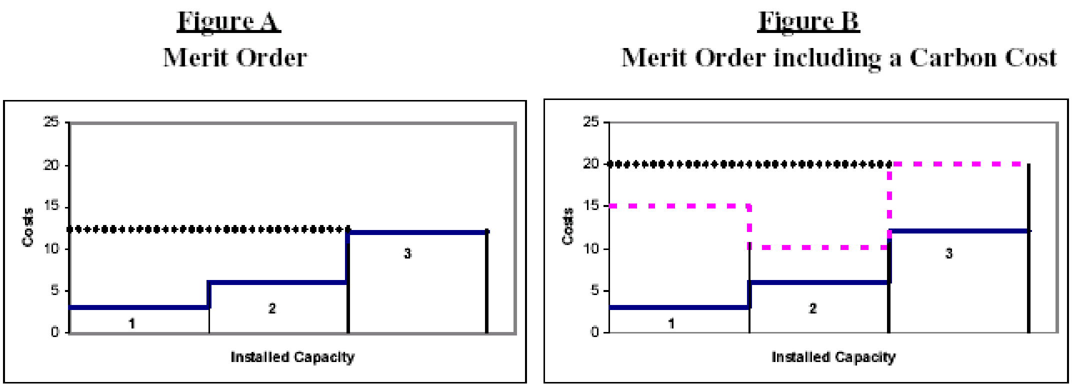

Figure 20 Impact of carbon cost on variable costs of electricity production (Reinaud, 2003)

As concluded from the MAC data for CO_2 emissions in EU25 presented in Chapter 5, the short run CO_2 abatement options are to a great extent based on fuel switches from coal to gas in the utilities. It is therefore essential to study the effect of fuel price changes on allowance prices, the economic level of coal to gas arbitrage.

According to one estimate, a gas price increase of +20% will increase the CO_2 emissions by around 50 Mt CO_2 in the EU25 region. If gas prices fluctuate between +/- 20%, the effect on an allowance prices will be +/- €4. Instead, if coal prices increase by 20%, the CO_2 emissions will decrease by around 55 Mt CO_2. If coal prices fluctuate +/- 20%, the effect on an allowance price will be +/- €3. (Point Carbon, 2004e)

6.6.1 Hypothetical MAC curve based on coal to gas switch economics

To examine the sensitivity of gas and coal prices on the CO_2 allowance price, an illustrative case study has been performed.

The original MAC curve presented earlier in Chapter 5 in Figure 14, is based on utilities gas to coal arbitrage economics in different EU regions based on several assumptions (CSFB, 2004). The assumptions are:

- gas and coal prices
- specific CO_2 emissions factors for gas and coal
- variable costs of a coal condensing plant
- variable costs of combined cycle gas turbine plants (CCGTs)
- plant efficiencies
- potential load factor increases of CCGT plants in different EU areas

The original assumptions of these parameters, on which the original literature reference MAC curve is based, are presented in more detail in Annex D. The CO_2 allowance price for a certain region can be delivered from an equation in which the variable cost for coal condensing power production equals the variable costs of CCGT-based power production including the CO_2 allowance price. The CO_2 allowance price, in other words economic price for coal to gas arbitrage, can be thus derived from the following formula (1):

Variable cost of coal condensing = Variable costs of CCGT

$$\frac{a*X}{\eta_C}+b=\frac{c*X}{\eta_G}+d$$

$$X=\frac{1}{\frac{a}{\eta_C}-\frac{c}{\eta_G}}*(d-b) \qquad (1)$$

Where,

$a =$ specific CO_2 emissions of coal condensing $\left[{tCO_2}/{MWh}\right]$

$b =$ variable costs of coal condensing other than CO_2 allowance price, including fuel price $\left[€/_{MWh} \right]$

$c =$ specific CO_2 emissions of CCGT $\left[{tCO_2}/_{MWh} \right]$

$d =$ variable costs of CCGT other than CO_2 allowance price, including fuel price $\left[€/_{MWh} \right]$

$\eta_C =$ efficiency of burning in coal condensing

$\eta_G =$ efficiency of power generation in CCGT

$X =$ allowance price $\left[€/_{tCO_2} \right]$

The equation (1) shows that the allowance price is linearly dependent on the total variable production cost difference between using gas or coal.

To find the fluctuations of CO_2 allowance prices according to at which coal and gas price levels the coal to gas arbitrage is economical, three different price scenarios have been studied. In the first scenario, presented as MAC A in Figure 22, both the coal and gas prices have been increased by 25% from the original. In the second scenario, MAC B, coal and gas prices have been decreased by 25% from the original. MAC C in Figure 22 presents the third scenario in which coal price has not been changed; only gas price has been increased by 25% from the original. The steps in MAC curves have been calculated using formula [1] by changing the factors *b* and *d* according to the assumed changes in fuel prices.

According to Vile (2004), the scenarios presented in Figure 22 are relevant to consider since gas and coal prices are to some extent interdependent. Gas and coal prices are indirectly dependent on the price of oil, sea freight costs and the US dollar rate. Again the prices of coal and gas may also diverge if, for example, global CO_2 emissions gaps decrease coal utilisation and increase gas consumption. In the EU region, the gas price might also increase only due to the start of EU ETS. In Figure 21 historic coal and natural gas price developments are presented.

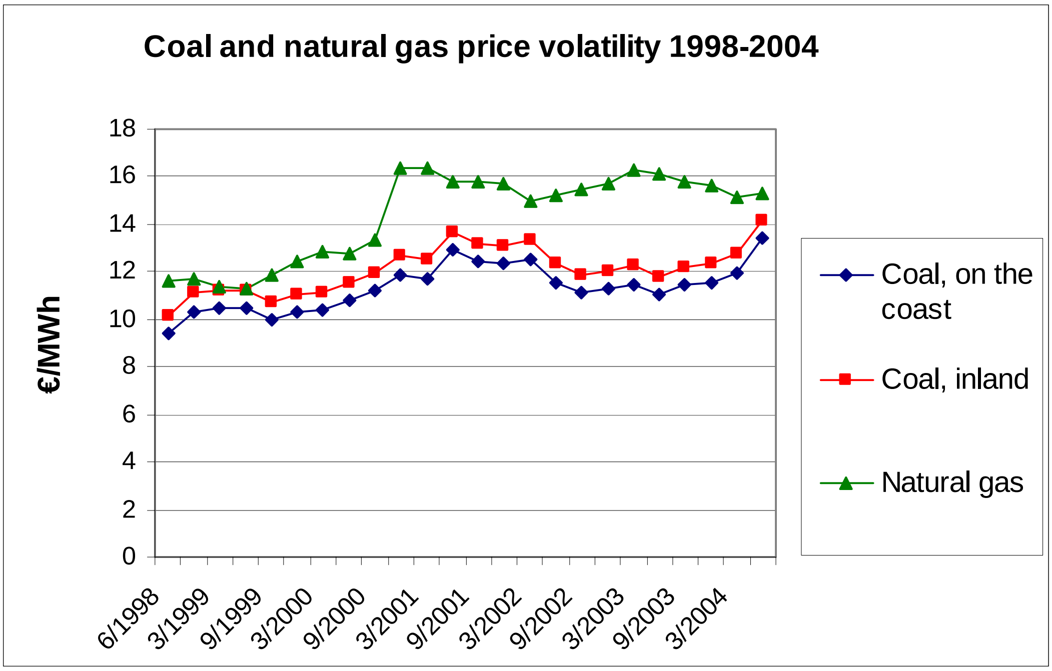

Figure 21 Coal and natural gas price volatility 1998-2004(Energiakatsaus, 2004)

The amount of CO_2 abatement taken in each region, the length of the steps in Figure 22 MAC curves, are based on CCGT capacity increase potential in each region. The potential is based on Eurprog (2004) statistics that give CCGT capacity potential for years 2005 and 2010. Year 2006 CCGT potential has been calculated assuming linear capacity development. As the potential capacity for year 2006 is assumed, it is expected to have a 6000 hours per year utilisation rate. The amount of CO2 emissions abatement taken is achieved by expecting the CCGT production, with efficiency of 55%, to replace coal condensing power production with efficiency of 35%.

Table 13 presents two estimates of the CO2 abatement potential based on coal to gas switches in different EU25 regions; the original estimate by CFSB (2004) and the Eurprog statistic- (2004) based estimate. The Eurprog (2004) statistic-based estimation is used in the MAC curves in Figure 22.

Table 13 Two estimates of CO_2 abatement potential in different EU25 regions based on gas to coal arbitrage.

	Abatement potential, Mt CO2 (Eurprog, 2004)	Original abatement potential, Mt CO2 (CFSB, 2004)
UK	2,5	30,0
Benelux	21,8	19,8
France	9,4	16,2
Iberia	25,2	19,8
Germany/ Scandinavia	60,4	59,4
Italy/ Greece	45,7	28,8

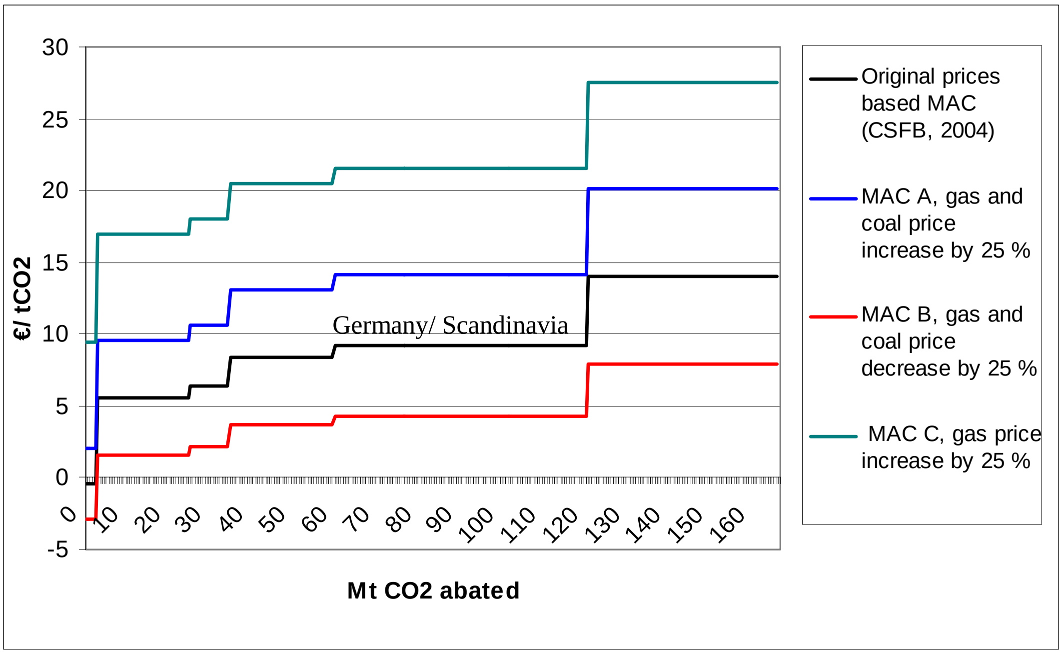

Figure 22 An illustrative example of MAC curves and CO_2 allowance prices based on different gas and coal prices. Germany and Scandinavia region is marked in the figure.

From the MAC curves presented in Figure 22, it can be seen how the coal and gas price variation by +/- 25% reflects the allowance prices, increased fuel prices increase the allowance price and decreased fuel prices lower the allowance price. The change in the price is in relative terms the bigger, the smaller the original price was. In absolute terms, the change is the bigger, the bigger the original allowance price was.

If the gas price is only increased by +25%, as illustrated by the MAC C curve in the figure, the allowance price increases more heavily than if both fuel prices were increased by the same percentage. For example, in Germany and the Scandinavia region, shown in Figure 22, the original economic level of coal to gas arbitrage, the allowance price, is stated to be €9.2. By changing coal and gas prices +/- 25%, the allowance price will fluctuate between €4.3 - 14.1. If the gas price is oly increased by +25% the allowance price will be as high as €21.5.

6.7 Nuclear power

Some EU25 countries (Germany, Lithuania and Sweden) have launched official nuclear power phase-out programmes, while in Finland a decision has been made to increase nuclear power. During the first trading period under EU ETS 2005 - 2007 nuclear reactors closures will slightly affect the EU25 emissions. Closure of carbon-free nuclear power stations will increase the demand on other power production sources. If nuclear power is replaced by conventional power production, it will increase the CO_2 emissions.

In Sweden, the Barsebäck-2 nuclear power reactor, with generation capacity of 600 MW will be closed by 31st May, 2005 (ENDS, 2004). The closure of Barsebäck-2 reactor will require around 4 TWh electricity generation from other sources (Kockum, 2002). If coal condensing, which is usually the marginal production source, is used, the CO_2 emissions in Sweden or elsewhere in the open electricity market area will increase by around 4 Mt CO_2 annually.

The first unit of Ignalina nuclear power plant in Lithuania is planned to be shut down by the end of 2004 and the second unit in 2009. The closure of the first unit will increase the need for electricity from Lithuanian fossil fuel fired thermal power plants from 3.0 TWh/a in 2003 to 8.8 TWh/ a for the 2005 - 2007 period. Annual CO_2 emissions in Lithuania will therefore increase by 5.5 Mt CO_2. The closure will also affect CO_2 emissions in Latvia, which imports electricity from Ignalina. (Point Carbon, 2004l)

For the period 2005 – 2007, the closure of the nuclear power stations at Stade and Obrigheim is to be compensated by an annual total of 1.5 Mt CO_2 (NAP Germany, 2004).

Due to nuclear power phase-outs, the CO_2 emissions in EU ETS sector during the 2005-2007 period will slightly increase and therefore increase the demand for emissions allowances. Increased allowance demand will increase the allowance price.

An extreme scenario to consider is how the EU25 CO_2 emissions would behave if all nuclear-based electricity generation in EU25 would be replaced by other generation sources. According to a recent study, the total nuclear generation in EU25 in 2002 was 964 TWh. If this amount of electricity generation were replaced by current EU25 energy mix without nuclear, emissions would increase to about 600 Mt CO_2. This hypothetical situation would mean that emissions from electricity generation in EU25 would rise by almost 47%. (FORATOM, 2004)

6.8 Electricity imports and exports

Electricity imports into EU25 and exports from EU25 will have an effect on the total balance of CO_2 emissions in EU25 countries. If imports increase, the need for internal electricity generation in EU25 decreases. As electricity generated abroad and imported to the EU25 region is regarded as CO_2 emissions-free under the EU ETS, increased imports will reduce CO_2 emissions in EU25. Reduced CO_2 emissions will decrease the allowance demand and thus lower the allowance prices. An increase in exports from EU25 will have the reverse effect.

In the EU25 region, the net electricity imports in 2002 amounted to 15.8 TWh (EURPROG, 2004). If the amount of imported electricity in 2002 were produced inside EU25 by coal condensing, with 38% efficiency, the EU25 CO_2 emissions would increase by around 14.4 Mt CO_2.

6.9 Criteria for efficient emissions markets

As stated earlier in the marginal abatement cost framework, the promise of emissions trading lies in economic efficiency. A precondition for this economic efficiency to materialise is the proper functioning of markets, i.e. the absence of distortions. (Nicholson et al., 2004)

The promise of economic efficiency of an emissions market, meaning least-cost abatement and long-term price signal, will only occur if the basic requirements for that are met (Nicholson et al., 2004). The first requirement is that as emissions rights are intangible assets, they need to be expressed in tradable units, such as t CO_2. Secondly, in order to be efficient, the market requires liquidity. Liquidity is increased as the number of participants in the market increases. The market needs confidence and stability, which is however not obvious in the climate regime where changes in the rules triggered by international negotiations will be indispensable. In an economically efficient market, the market participants need information to make reliable enough price scenarios in order to manage risk. In other words, the market is required to be transparent. Clear market rules are also required for a market to function properly.

7 CONCLUSIONS

According to EU Emissions Trading Directive 2003/87/EC, the EU Emissions Trading Scheme (ETS) starts on the 1st January, 2005. The start-up of the scheme means that carbon dioxide emissions will have a monetary value for ETS participants. As the world's largest emission trading scheme, EU ETS will cover around 13 000 installations, 6000 companies and around 46% of EU-wide CO_2 emissions in 2010. In the first trading period 2005 – 2007, the scheme covers CO_2 emissions from large stationary sources in the energy, industry and manufacturing sectors; for the following five year trading periods, also other gases and sectors might be added to the scheme.

EU ETS is a strategic instrument defined in the European Climate Change Programme (ECCP) to reduce greenhouse gases in a cost-effective and economically efficient manner. The aim is to help EU Member States to fulfil their legally binding commitments under the Kyoto Protocol, which will enter into force on the 16th February, 2005. EU15 Member States are currently above their Kyoto targets by around 1.9% assuming linear development towards 2010. EU10 new Member States are well on track to meeting their Kyoto commitments.

Several estimates of the CO_2 allowance price under EU ETS are reported in the literature. These estimates are based on various background assumptions which must be considered when interpreting the estimates. The existing estimates of the EU allowance price in the first trading period 2005 - 2007 vary between €1-15 and for the second trading periods 2008 - 2012 between €6.9-50. Small amounts of EU allowances have been traded on a forward basis. The allowance price for forward trades from May 2003 to December 2004 has fluctuated between €6-13, settling down to around €8 towards the end of 2004. Only around 30 companies have participated in these trades, which should be considered when analysing the price volatility.

In theory, in an ideal situation, the carbon dioxide allowance price can be derived from the allowance supply-demand balance and CO_2 emissions marginal abatement cost curve. The allowance price under perfect competition and in a totally liquid market situation equals the aggregate marginal cost of emissions abatement among the participants. The cost-effectiveness of emissions trading is therefore based on the equimarginal principle, which states that total pollution control cost will be minimised through the equalisation of marginal emission reduction costs across all reduction options.

In this thesis, the allowance supply-demand balance in EU ETS is estimated by the allocated amount of allowances in the Member State National allocation plans and the forecasted business-as-usual (BAU) CO_2 emissions of the installations covered by the scheme. Besides the total allocation in National allocation plans, the supply side in the 2005 - 2007 trading period is affected by the imported amount of Kyoto project-based Clean Development Mechanism (CDM) credits into the EU scheme. The demand for allowances, the forecasted CO_2 emissions of EU ETS is usually given as BAU scenarios. Only some Member States have given BAU scenarios in their National allocation plans and the basis of the existing ones vary. Therefore, in this study, the emission scenarios have been estimated by a trend line analysis from EU ETS sector historic emissions development between the years 1990 and 2002 and in some cases a shorter reference period as explained in Annex C.

Two estimates of EU25 Member States' aggregate allowance supply-demand balances in 2006 representing the mid-point of the first trading period have been derived. In the first estimate, the allowance demand is derived from the trend line analysis based on EU25 historic CO_2 emissions data. In this case, the total allowance balance in EU25 is 143.4 Mt CO_2 surplus of allowances per annum. This can be compared to the total number of allowances in the first period, which is some 2250 Mt CO_2 per year. In the second estimate, the National allocation plans based BAU CO_2 emission scenarios are used, if available. If these are not available, the figures in the first case are used. Then the allowance balance shows an allowance surplus of 74.5 Mt CO_2. A reference literature estimate of the allowance supply-demand balance equal to 5.2 Mt CO_2 deficit of allowances. In conclusion, according to the current allocation estimates, there would not be scarcity of allowances in the first trading period 2005 - 2007. However, there are still big uncertainties as explained later in the conclusions.

The supply of the project-based Clean Development Mechanisms credits (CER) according to the Kyoto Protocol in the EU ETS is forecasted to be low, around 5 and 8 Mt CO_2 in 2005, increasing to 17 Mt CO_2 in 2006 and to 30 Mt CO_2 in 2008. According to the estimates of the allowance demand-supply balance, the market in the first trading period 2005 - 2007 would be long even without CER imports. Therefore the utilisation of the CER supply to EU ETS is likely to be very limited as these credits are fully bankable for the following trading period and the prices in the second trading period 2008 - 2012 are estimated to be higher.

Marginal abatement costs of CO_2 emissions in the first trading period 2005 - 2007 are to a great extent based on the cost of fuel switches from coal to gas in existing utilities. Only a small amount of low cost abatement in the industry sector is estimated to be available. Different literature references of the marginal abatement cost curves give largely different shapes of the marginal CO_2 abatement cost curves. According to eight estimates, the possible amount of CO_2 abatement at € 5/ tCO_2 varies in the range of 10-80 Mt CO_2, at €10/ tCO_2 in the range of 25-145 Mt CO_2, at 15 €/ tCO_2 in the range of 60-200 Mt CO_2. Most of the estimates predict that after 150Mt CO_2 abated, the abatement costs increase very heavily.

If the market in the first trading period 2005 - 2007 has a surplus of allowances, thus the aggregate supply exceeds the aggregate demand, it is not possible to draw a market price for the allowance from the supply-demand and marginal abatement cost framework. But as some market participants will need to buy allowances and others are willing to sell, there will be trading taking place. In theory, the trading would take place at the price levels corresponding to the transaction costs.

Various assumptions create uncertainties in the allowance price determinants. Therefore, sensitivities have been estimated qualitatively and quantitatively measured as fluctuations in the emissions of Mt CO_2 and in monetary terms.

The past statistics indicate that the forward prices for allowances have been to a great extent affected by political decision. This is mainly due to the gradual publication of National allocation plans (NAPs) and Commission comments on them, as the final allowance supply will be fixed according to the NAPs. Approval of the Linking Directive, which enabled project-based Kyoto credits to import to the EU ETS, even the Kyoto Protocol would not enter into force, theoretically confirmed that the allowance supply side is to some extent flexible. A key political level decision, which might have major impacts on the allowance prices in the future, was the Russian ratification of the Kyoto Protocol confirming that the Protocol will enter into force. The Protocol's entry into force means that the Kyoto commitments will be legally binding. This is likely to increase the allowance prices as the allocation for the second trading period 2008 - 2012 ought to be stricter than for the first period. On the other hand, Russia has got a large surplus of allowances to sell. EU Member States can buy these credits either at governmental level as Kyoto-based emission rights, called assigned amount units (AAUs) or as JI project credits (ERUs), which might lower the EU allowance prices.

Currently, post-2012 Climate negotiations are ongoing. If any successful agreements are achieved, the future GHG emission reduction targets will probably be stricter than for the Kyoto period. This might affect the allowance prices already in the EU ETS first trading periods 2005 - 2007 as the market participants will have prospects of future stricter commitments. The investments in emissions abatement at installations will probably increase if the future is more predictable. This might imply lowering the allowance prices.

As the final allocation of allowances for the first trading period 2005 - 2007 is not yet fixed as the Commission has not yet assessed all the National allocation plans, the allowance demand-supply balance might still change. If the Commission requires similar size cuts as in the previous assessment rounds, the market might be slightly on the deficit side for the first trading period. The estimated amount of CDM credit imports into the EU ETS might also change as CDM projects face considerable risks, which might reduce the supply.

Recent historic GDP and CO_2 emissions developments for EU25 do not show a strong correlation at the macro-level. At the micro-level, electricity consumption certainly affects the CO_2 emission levels. The forecasted annual electricity demand increases in the EU25 region is 1.9%. If the forecast is varied between 1.3- 2.3%, the fluctuations in EU25 CO_2 emissions will be +/- 15 Mt CO_2 in 2006 and +/- 80 Mt CO_2 in 2010.

Weather conditions affect emissions in two different ways. Temperature variations change energy consumption in heating and cooling. Rainfall and wind speeds affect the share of power generated by non-emitting sources and thus emission levels. Hydropower has a large share in Nordic electricity production, long term annual variations account around +/- 25 - 30 Mt CO_2. Temperature corrected natural fluctuations of EU25 power sector emissions are on average +/- 50 Mt CO_2. Therefore, the Nordic hydro situation explains about half of the CO_2 emission fluctuations in EU25 area.

Fuel prices affect the allowance prices as, in the short run, CO_2 abatement options are to a great extent based on fuel switches from coal to natural gas. Increased fuel prices increase the allowance price and decreased fuel prices lower the allowance price. According to one estimate, if gas prices fluctuate between +/- 20%, the effect on allowance prices will be +/- €4. If coal price increases by 20%, the CO_2 emissions will decrease by around 55 Mt CO_2. If coal prices fluctuate +/- 20%, the effect on an allowance price will be +/- €3.

Nuclear power phase-out in some EU25 countries is assumed to slightly increase the aggregate CO_2 emissions. The emission increase is estimated to be around 11 Mt CO_2 but this is likely to lead to no remarkable CO_2 price implications. The present amount of nuclear power in the EU corresponds annually to 600 Mt CO2 emissions.

If electricity imports and exports balance to the EU25 area change, it might affect the aggregate CO_2 emissions. Electricity generated abroad and imported to EU25 is regarded as CO_2 emissions-free. If the net electricity imports in 2002 to the EU25 region were produced inside EU25 by coal condensing, with 38% efficiency, the aggregate CO_2 emissions would increase by around 14.4 Mt CO_2.

Preconditions for a properly functioning emissions market are the absence of distortions and predictability of regulations. One important condition for the market to function properly is sufficient market liquidity. Liquidity is mostly affected by the number of active participants.

In conclusion, the allowance price will be very low if the allowance supply to the market in the first trading period 2005 - 2007 exceeds the predicted demand, as estimated in this thesis. However, if the supply-demand balance of allowances changes so that the market is on the deficit side, the allowance price will be based on the marginal abatement costs of CO_2 emissions. In the first trading period, the marginal abatement costs in the EU25 region are to a great extent based on the cost of switching from coal- to gas-based power production.

8 RECOMMENDATIONS

As the trading under the EU Emissions Trading Scheme gets started, many uncertain factors affecting allowance prices will be seen. Therefore, for the further estimation of allowance prices, some time should be given in order to see how the market will behave. It will be particularly interesting to see market behaviour in a situation where the supply-demand balance is close to zero or on the long side.

Estimates of the of CO_2 emissions abatement costs in the EU25 area, as seen in this study, vary over a quite wide range. As the CO_2 abatement costs are a key allowance price determinant, a more accurate estimation would be meaningful. But as the abatement options in the installations covered by the EU ETS are very many, accurate data gathering may be very hard task.

The trend line-based methodology used in this study could be reviewed as more accurate statistics are published. Based on detailed EU ETS sector statistics future CO_2 emissions scenarios, the allowance demand could be estimated more accurately.

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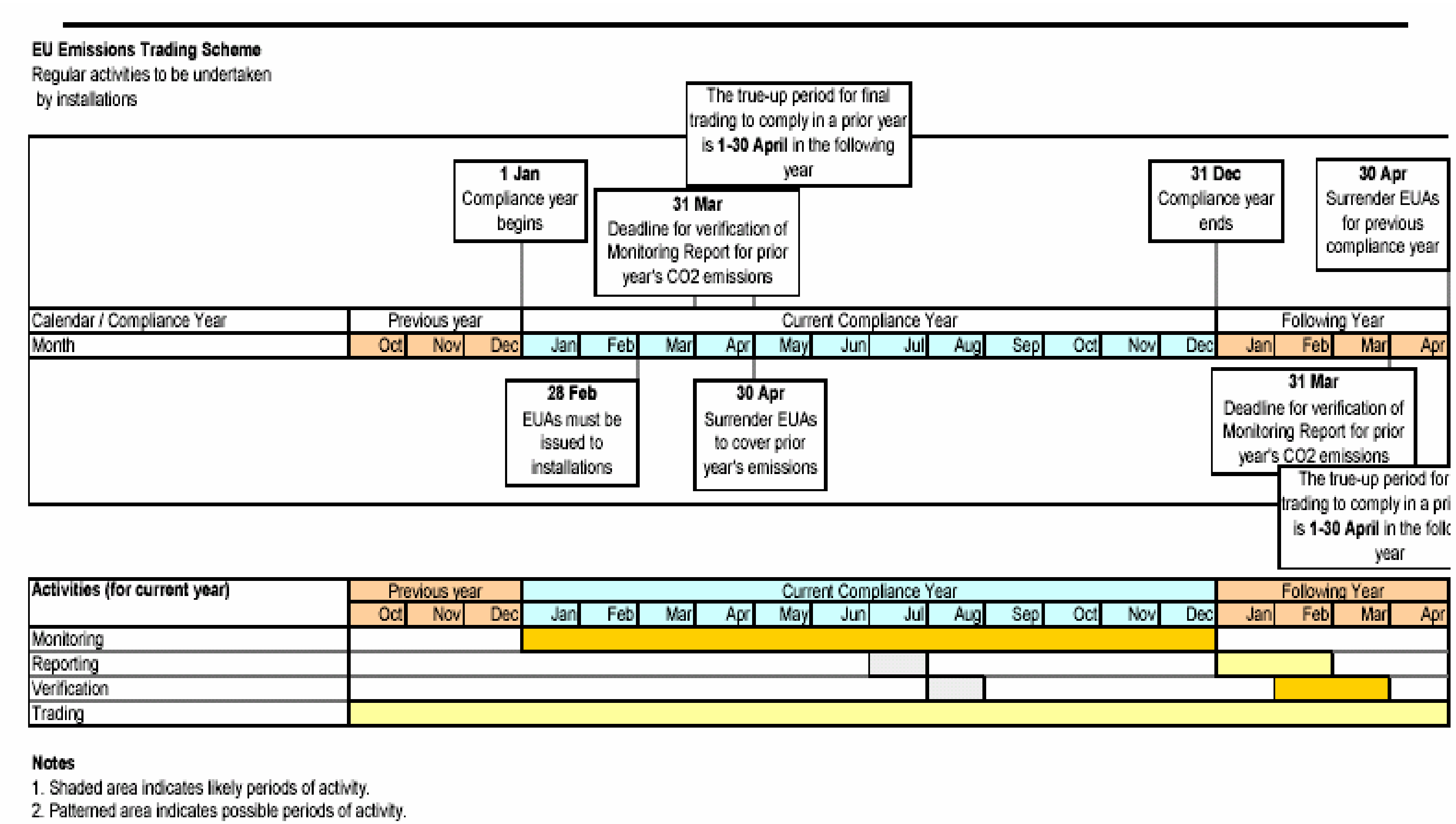
Annex A. Kyoto Protocol targets and existing GHG emissions projections for EU25 countries

	Kyoto Target % of baseline	Base year emissions, Mt CO2 eqv (EEA 2004b, COM(2003)735)	2010 Kyoto target, Mt CO2 eqv	GHG emissions* 2002 (EU15), 2001 (EU10 new	EEA REPORT: GHG emission trends and projections in Europe 2003 (EEA, 2004b)		National Communications (UNFCCC, 2004a)		EEA evaluation of projections (EEA, 2003)		COM(2003) 735		SUMMARY: WM AND WAM PROJECTIONS RANGE	
					WM 2010	WAM 2010	WM 2010	WAM 2010	WM 2010	WAM 2010	WM 2010	WAM 2010	WM Range	WAM Range
Austria	-13,0 %	78,3	68,1	84,6	87,3	72,6	84,4	70,7	86,1	71,6	86,1		84,4- 87,3	70,7- 72,6
Belgium	-7,5 %	141,2	130,6	150	162,9	149,5	116,0	106,4	165,4	151,6	167,4		116,0- 167,4	106,4- 151,6
Denmark	-21,0 %	69,5	54,9	68,5	81,1	79,3	80,1	79,2	80,0	78,1	81,2		80,0- 81,2	78,1- 79,3
Finland	0,0 %	77,2	77,2	82	89,9	76,8	89,9	75,8	89,9	76,8	89,9		89,9	75,8- 79,3
France	0,0 %	558,4	558,4	553,9	611,4	551,7	577,0*	519,0*	594,3	536,0	594,3		594,3- 611,4	519,0- 536,0
Germany	-21,0 %	1216,2	960,8	1016	976,6				977,8*		977,8		976,6- 977,8	
Greece	25,0 %	107,0	133,8	135,4	145,2	132,9	147,2	134,9	147,2	134,9	145,2		145,2- 147,2	132,9- 134,9
Ireland	13,0 %	53,4	60,3	68,9	74,7	60,2	66,5		72,6	58,6	75,2		66,5- 75,2	58,6- 60,2
Italy	-6,5 %	509,3	476,2	553,8	528,1	492,0	579,7		528,1	491,2	540,1		528,1- 579,7	491,2- 492,0
Luxembourg	-28,0 %	10,9	7,8	10,8	8,5				15,0	9,6	9,9		8,5- 15	9,6
Netherlands	-6,0 %	211,1	198,4	213,8	224,0	221,0	256,0	230,0	225,0	219,0-,222,0	225,0		224,0- 256,0	219,0- 230,0
Portugal	27,0 %	61,4	78,0	81,6	83,8	86,6	99,7*	95,1*	88,3		91,5		83,8- 99,7	86,6- 95,1
Spain	15,0 %	289,9	333,4	399,7	429,9	371,1					307,0		307,0- 429,9	371,1
Sweden	4,0 %	72,9	75,8	69,6	73,4		70,9		70,9		70,9		70,9- 73,4	
UK	-12,5 %	747,2	653,8	634,8	643,3	579,1	651,3		651,2	585,4	640,9		640,9- 651,3	579,1- 585,4
Cyprus														
Czech Republic	-8,0 %	192,1	176,3	148	145,2	138,9	141,7	135,2	131,7-145,2*		131,7	125,3	131,7- 145,2	125,3- 138,9
Estonia	-8,0 %	43,5	40,0	19,4	13,6	10,7			11,7	9,1	18,9	17,4	11,7- 18,9	9,1- 17,4
Hungary	-6,0 %	102,6	96,4	84,3	94,4						95,6		94,4- 95,6	
Latvia	-8,0 %	29,0	26,7	11,4	12,1		15,7	14,0	3,3		12,8		3,3-12,8	14,0
Lithuania	-8,0 %	51,5	47,4	20,2										
Malta														
Poland	-6,0 %	565,3	531,4	382,8	482,8	456,2					394,0	372,0	394,0- 482,2	372,0-456,2
Slovakia	-8,0 %	72,2	66,4	50,1	53	48	51,4	46	53,2*	48,2*	53,2	48,2	51,4- 53,2	46,0-48,2
Slovenia	-8,0 %	19,9	18,3	20,2	21,8	19,6	22,1	19,9			22,1	19,9	21,8-22,1	19,6- 19,9

Projections which do not count LUCF (land use change and forestry) emission sinks are marked with *

Annex B. EU emissions trading scheme- annual timetable (ERM, 2004)



Annex C. Supply- demand balances of the allowances in each EU25 Member state (except Cyprus and Malta)

Each Member state annex includes mainly the following data (if available):

- Total allowance allocation and new entrants reserve given in NAP (if available) for the EU ETS first trading period 2005-2007

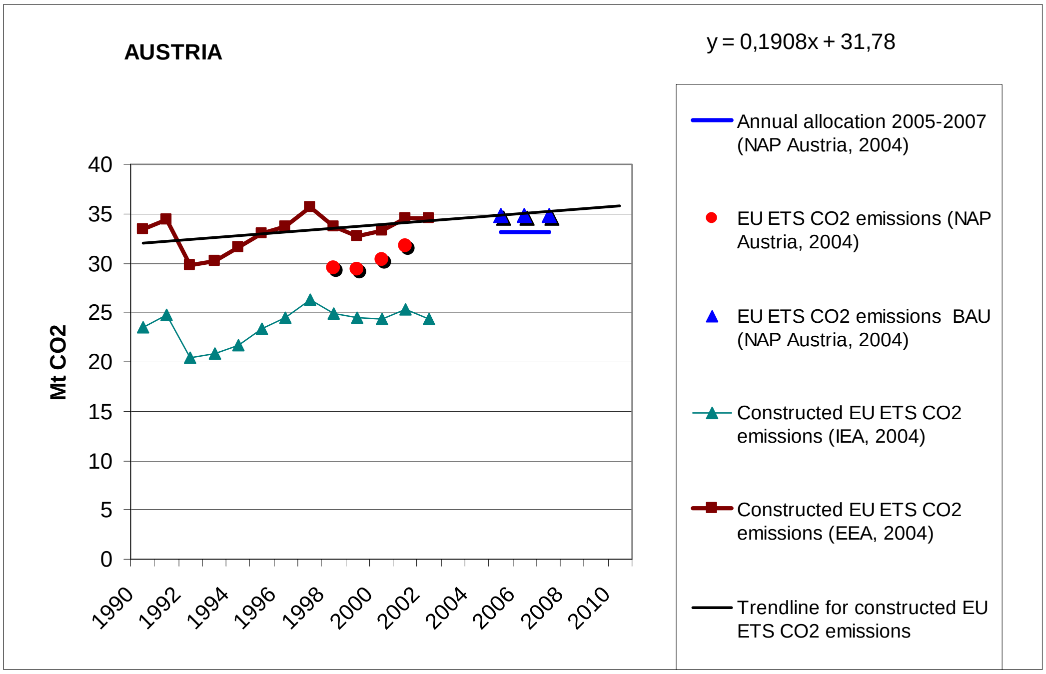
- CO_2 emissions business-as-usual (BAU estimation by trend line approximation and BAU given in Member state's NAP

- Basis of trend line approximation based CO_2 emissions BAU

- Demand-supply based estimates of surplus or deficit of allowances in the first trading period 2005-2007 under the EU ETS

- Member state's Kyoto target and projections of GHG emissions in 2010

Annex C1**:** Supply-demand balance for allowances in Austria



Total allocation in NAP

Austrian NAP allocates 33, 2 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. At least 1 % of the annual allocation, equaling annually to 0,3 Mt CO2, will be kept in new entrant reserve. Any remaining allowances in the reserve on 30 November 2007 will be auctioned. (NAP Austria, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -3,3 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 31,7 Mt CO2. BAU estimate given in NAP equals annually to 34, 8 Mt CO2 for 2005-2007.

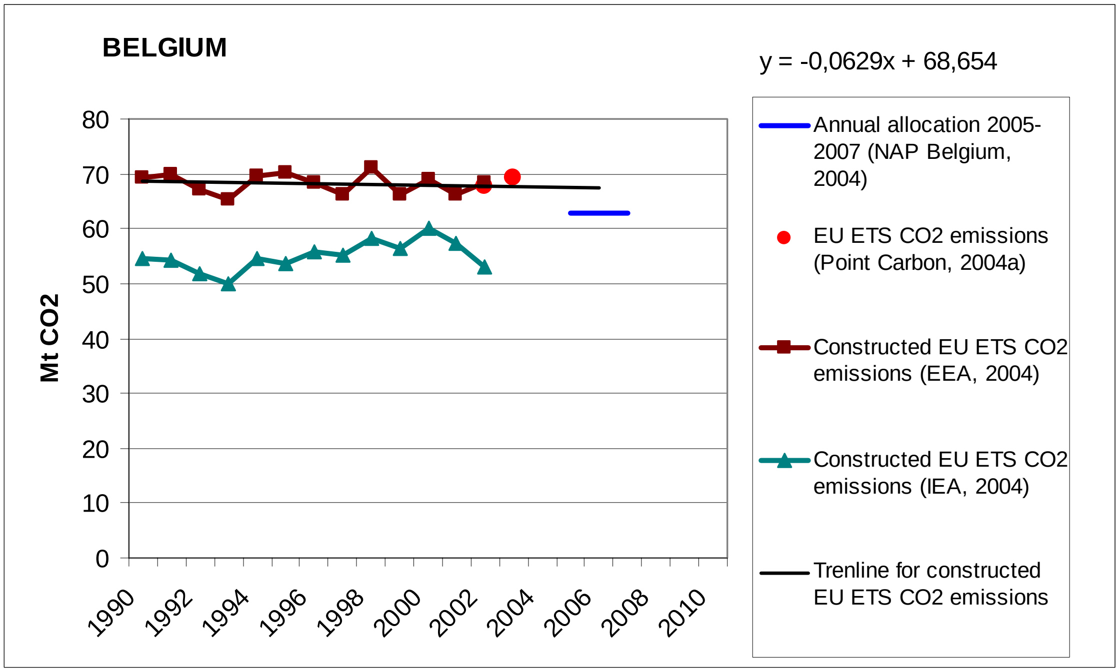
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1, 5 Mt surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 1, 6 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Austria's Kyoto commitment is to stabilize GHG emissions to 68,1 Mt CO2 eqv by 2010, -13 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 84,6 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 84,4-87,3 Mt CO2 eqv and in WAM scenario between 70,7-72,6 Mt CO2 eqv. To achieve the Kyoto target Belgium's federal government plans to purchase 3- 5 Mt CO2 eqv of the Kyoto project-based flexible mechanisms certificates (NAP Austria, 2004). Meeting Kyoto Target is stated to be challenging (ECOFYS, 2004).

Annex C2**:** Supply-demand balance for allowances in Belgium



Total allocation in NAP

NAP allocates 62, 9 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. (NAP Belgium, 2004). Belgium has divided the NAP between its third regions; Flemish, Brussels and Walloon region each separately quantifying the amount of allocated allowances.

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -0,7 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 66,9 Mt CO2. BAU estimates in NAP are given separately to each three Regions. As Bryssels region EU ETS covered installations allocation account only around 0,1 % of total Belgium allocation (NAP, Belgium 2004) , the total BAU can be approximated exact enough accounting only Flemish and Walloon regions BAUs. Flemish and Walloon region total BAU for EU ETS covered installations according to the NAP for 2005-2007 trading period is annually around 70,3 Mt CO2. (ECOFYS, 2004).

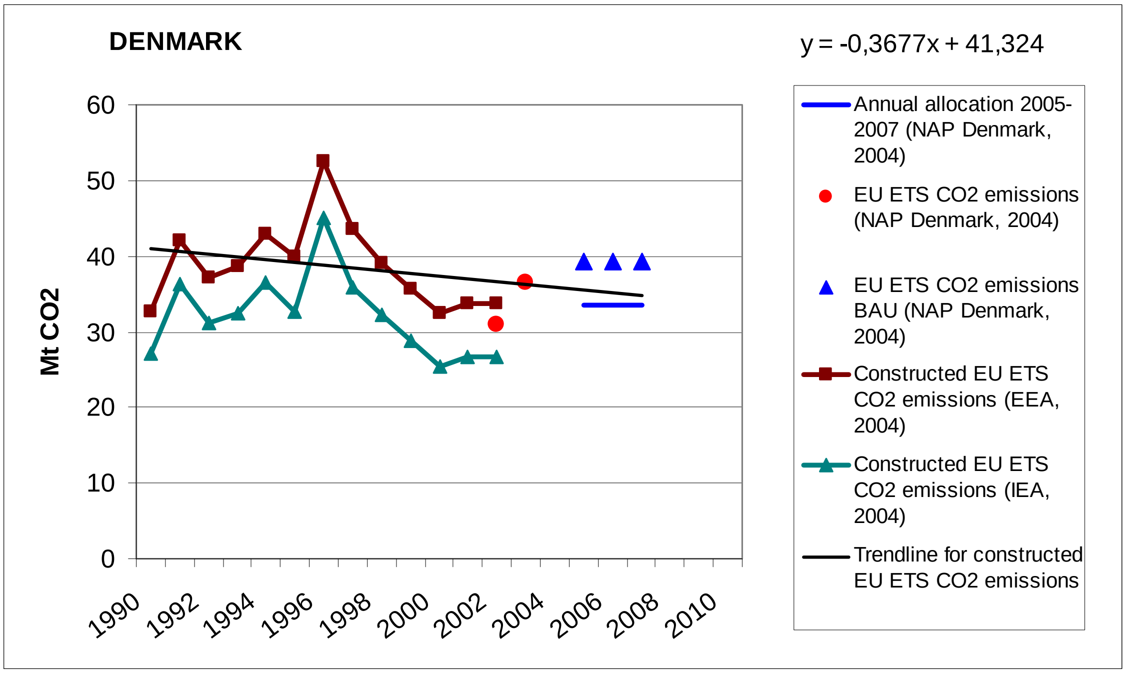
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 3, 9 Mt CO2 deficit of allowances. BAU scenario for Walloon and Flemish regions given in NAP compared to allocated allowances for Walloon and Flemish regions predict 8, 3 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Belgium's Kyoto commitment is to stabilize GHG emissions to 130, 6 Mt CO2 eqv by 2010, -7,5 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 150 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 116,0-167,4 Mt CO2 eqv and in WAM scenario between 106,4-151,6 Mt CO2 eqv. To achieve the Kyoto target Belgium's federal government plans to purchase 12, 28 Mt CO2 eqv of the Kyoto project-based flexible mechanisms certificates. (NAP Belgium, 2004)

Annex C3**:** Supply-demand balance for allowances in Denmark



Total allocation in NAP

NAP allocates average 33, 5 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 1 Mt CO2 of the annual allocation will be kept in new entrant reserve and 1,7 Mt CO2 will be auctioned annually. (NAP Denmark, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -2,8 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 32,3 Mt CO2. BAU estimate given in NAP equals annually to 39, 3 Mt CO2 for 2005-2007.

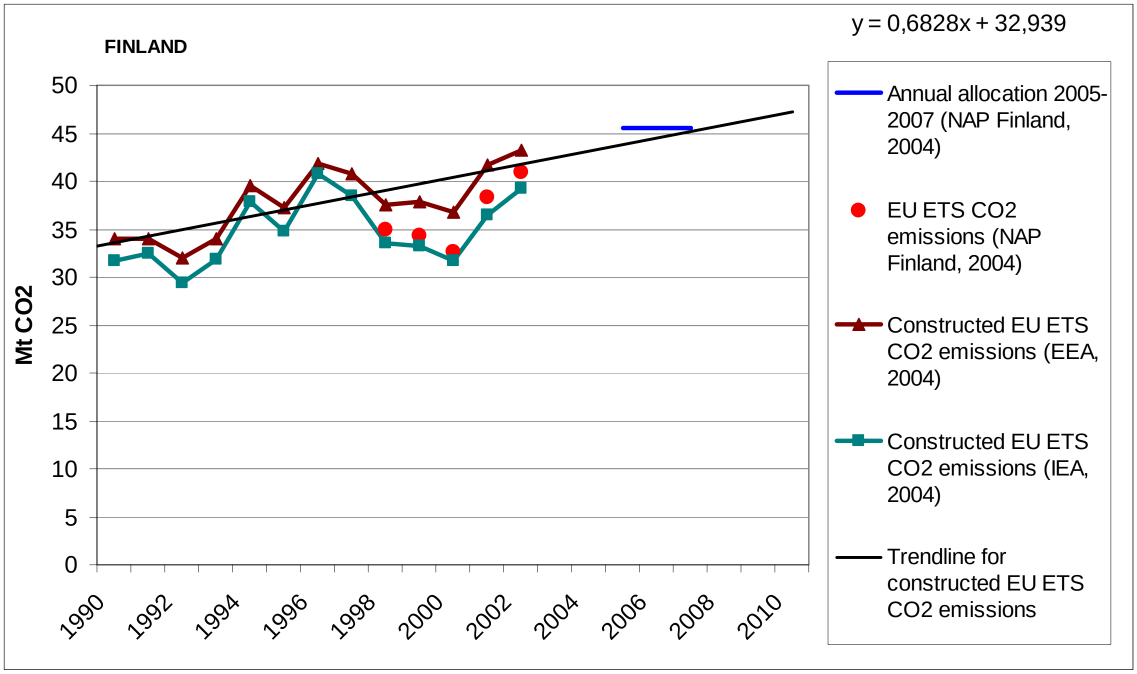
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1, 2 Mt CO2 surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 5, 8 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Denmark's Kyoto commitment is to stabilize GHG emissions to 54, 9 Mt CO2 eqv by 2010, -21 % compared to 1990 levels. As in 1990 Denmark imported a large amount of electricity from Norway and Sweden it is still negotiating a compensation which could increase the Kyoto target near 60 Mt CO2 eqv in 2010 (NAP Denmark, 2004). In 2002 GHG emissions (without LUCF) were 68, 5 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 80, 0-81,2 Mt CO2 eqv and in WAM scenario between 78,1-79,3 Mt CO2 eqv. Denmark claims that it is on the way fulfilling the Kyoto Target, but even if the emissions reduction plans are fully realized in 2005-2007 the actual emissions will remain far beyond the Kyoto Target (ECOFYS, 2004).

Annex C4**:** Supply demand-balance for allowances in Finland



Total allocation in NAP

NAP allocates average 45,5 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. Allocation for 2005 is 44,4 Mt CO2, for 2006 45,9 Mt CO2 and for 2007 46,2 Mt CO2. 2 % of the annual allocation, equaling annually to 0,8 Mt CO2, will be kept in new entrant reserve. (NAP Finland, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -3,2 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 41,3 Mt CO2. BAU estimate equals annually to 46, 9 Mt CO2 for 2005-2007 (NAP Finland, 2004).

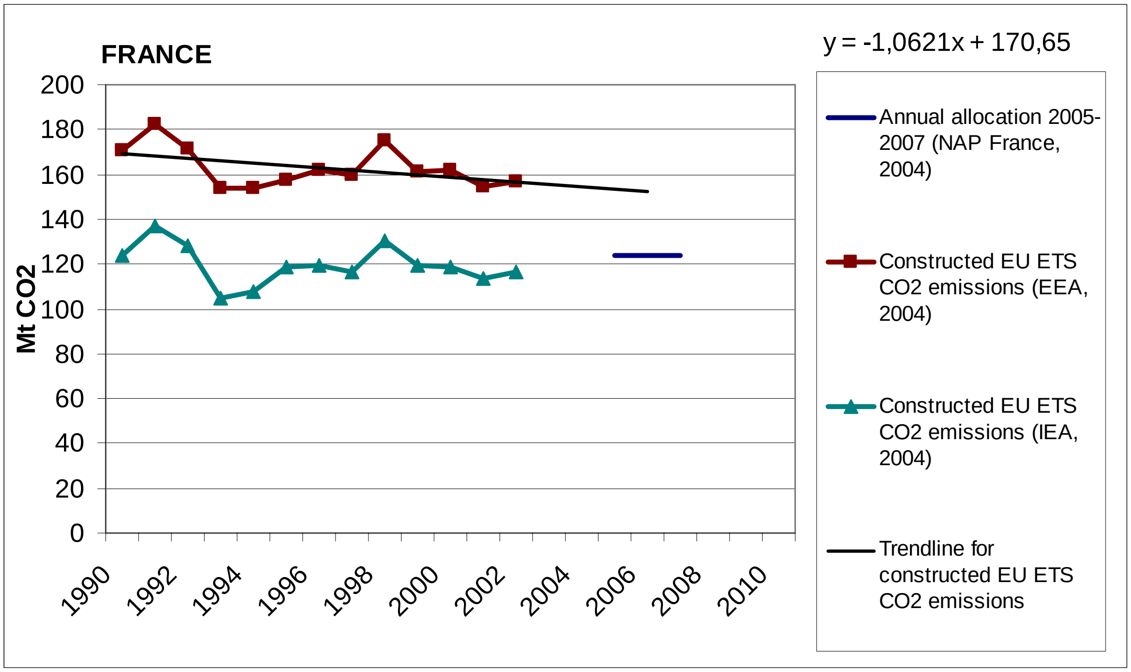
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 4,2 Mt surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 1,4 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Finland's Kyoto commitment is to stabilize GHG emissions to 77,2 Mt CO2 eqv by 2010, 0 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 82 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. WM scenario projection is 89,0 X Mt CO2 eqv and in WAM scenario projections vary between 75,8-79,3 Mt CO2 eqv. Kyoto Target is stated to be challenging (ECOFYS, 2004).

Annex C5**:** Supply-demand balance for allowances in France



Total allocation in NAP

Draft NAP allocates 123, 7 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. No information of the new entrants reserve yet available. (NAP draft France, 2004)

BAU estimate by trend line approximation and BAU given in NAP

No data yet available.

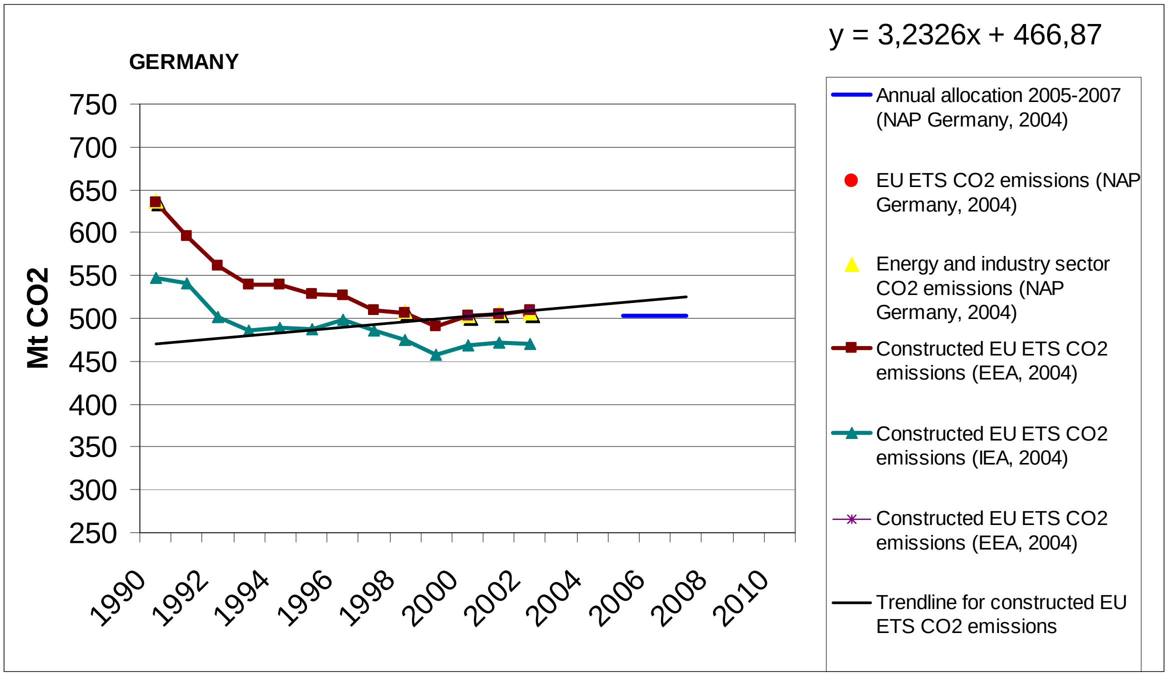
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

No data yet available.

Kyoto target and projections of GHG emissions in 2010

France's Kyoto commitment is to stabilize GHG emissions to 555, 8 Mt CO2 eqv by 2010, 0 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 553, 9 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 594,3-611,4 Mt CO2 eqv and in WAM scenario between 519,0-536,0 Mt CO2 eqv.

Annex C6**:** Supply-demand balance for allowances Germany



Total allocation in NAP

NAP allocates 503 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 3 Mt CO2 of the annual allocation will be kept in new entrant reserve. Any remaining allowances in the reserve in the on of 2007 will be cancelled. (NAP Germany, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 2000-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -4,7 Mt CO2. Trend line approximated is based on historic emissions from 2000 to 2002. It is not relevant to account earlier years into the trend line analysis as big renovations in Eastern Europe took place in 1990s and due to that emissions reduced radically (Nieminen, 2004).

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 517,1 Mt CO2. No estimate of the BAU for 2005-2007 has been given in the NAP.

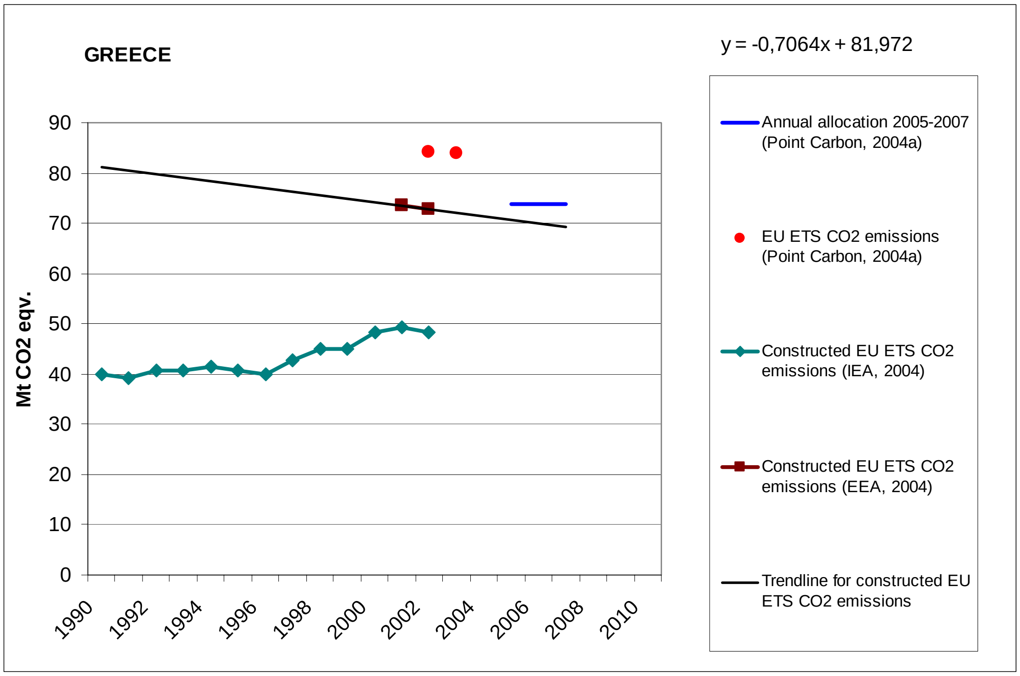
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 14, 1 Mt deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Germany's Kyoto commitment is to stabilize GHG emissions to 960, 8 Mt CO2 eqv by 2010, -21 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 1016 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 976, 6-977,8 Mt CO2 eqv. Germany aims to reach its national target under the Kyoto Protocol through domestic measures alone. Thus it has no real need for credits from JI or CDM projects (Point Carbon, 2004c). Germany is stated to be on tract achieving its Kyoto target (ECOFYS, 2004).

Annex C7**:** Supply-demand balance for allowances in Greece



Total allocation in NAP

At date, November 19 2004 Greece has not yet published even a draft NAP. Total allocation of allowances as assumed by Point Carbon market analysts (Point Carbon, 2004a) is 73,8 Mt CO2 annually for the first trading period 2005- 2007. No information of the new entrants reserve yet available.

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 2001-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +11,4 Mt CO2. The trend line approximation is based only to two historic years as there is no older emissions statistics data available from the same source.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 81, 4 Mt CO2.

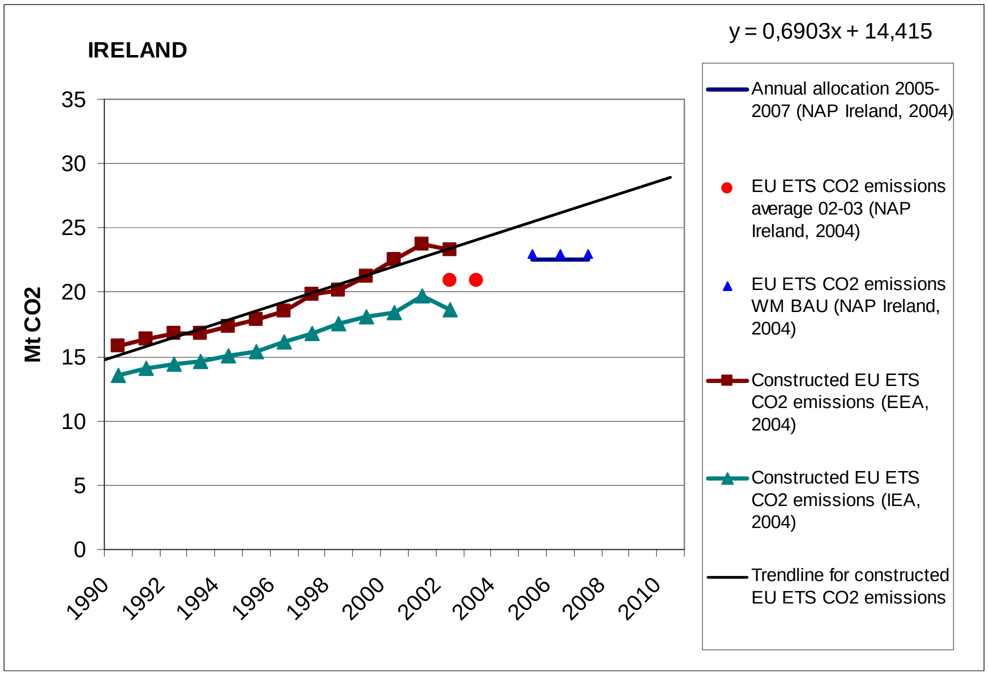
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 7, 6 Mt deficit of allowances..

Kyoto target and projections of GHG emissions in 2010

Greece's Kyoto commitment is to stabilize GHG emissions to 133,8 Mt CO2 eqv by 2010, 25 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 135,4 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 145,2-147,2 Mt CO2 eqv and in WAM scenario between 132,9-134,9 Mt CO2 eqv.

Annex C8**:** Supply-demand balance for allowances in Ireland



Total allocation in NAP

NAP allocates 22,5 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 1,5 % of the annual allocation, equaling annually to 0,3 Mt CO2, will be kept in new entrants reserve and 0,75 % of the allowances will be auctioned. The unused new entrants reserve will be auctioned in 2007. (NAP Ireland, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -2,4 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 23,7 Mt CO2. According to the Irish NAP the total quantity of allowances to be allocated for the period 2005-2007 is 98 % of forecasted emissions with existing measures. Thus BAU estimate given in NAP equals annually to Mt 23,0 CO2 for 2005-2007.

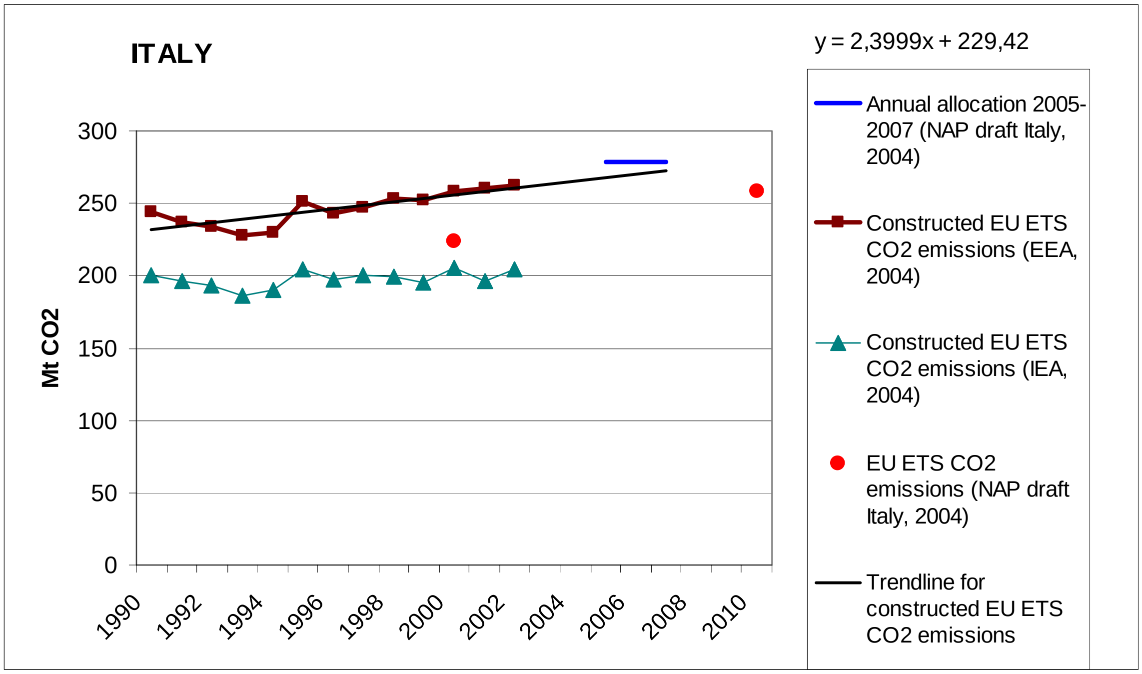
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1, 2 Mt CO2 deficit of allowances. BAU scenario given in NAP compared to allocated allowances predicts 0, 5 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Ireland's Kyoto commitment is to stabilize GHG emissions to 60, 3 Mt CO2 eqv by 2010, 13 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 68, 9 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 66,5-75,2 Mt CO2 eqv and in WAM scenario between 58,6-60,2 Mt CO2 eqv. Ireland relies heavily on non-ETS sector emission reductions and expects high reduction delivery of other policies to reach it's Kyoto target (ECOFYS, 2004).

Annex C9**:** Supply-demand balance for allowances in Italy



Total allocation in NAP
NAP allocates on average 279, 1 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. Allocation for 2005 is 239, 96 Mt CO2, for 2006 240, 57 Mt CO2 and for 2007 241, 64 Mt CO2. 16 % of the annual allocation, equaling annually around 38, 7 Mt CO2, will be kept in new entrant reserve. Any remaining allowances in the new entrants reserve at the end of 2007 may be sold by the competent authority to the extent necessary to recover the financial resources previously required to replenish the new entrant reserves. (NAP draft Italy, 2004)

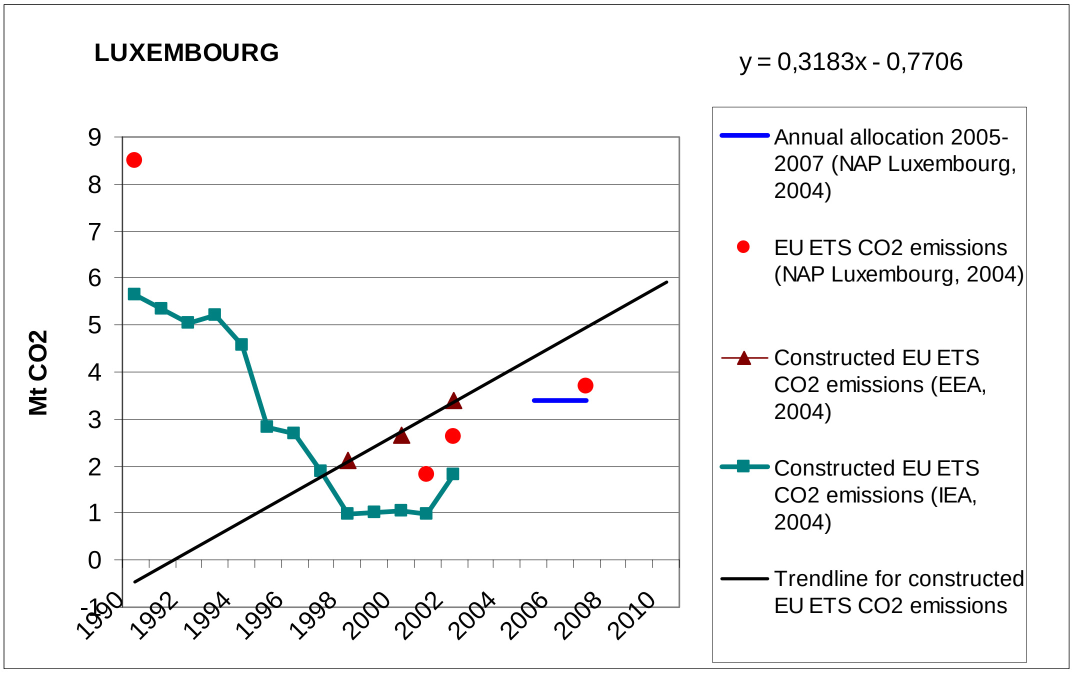
BAU estimate by trend line approximation and BAU given in NAP
Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -37,9 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 232,3 Mt CO2. In the Italian NAP are given a BAU estimate for EU ETS for year 2010 based on the national GHG plan. According to the so-called reference scenario EU ETS CO2 emissions is 2010 will be 258,1 Mt CO2. If linear CO2 emissions development from year 2000 to 2010 is assumed this scenario gives respectively for 2006 CO2 emissions forecast of 246, 74 Mt CO2.

Demand- supply based estimates of surplus or deficit of allowances 2005-2007
Trend line based approximation of emissions development in 2006 predicts 46,9Mt CO2 surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 32, 4 Mt CO2 surplus of allowances in 2006.

Kyoto target and projections of GHG emissions in 2010
Italy's Kyoto commitment is to stabilize GHG emissions to 476, 2 Mt CO2 eqv by 2010, -6, 5 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 553, 8 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 528,1-579,7 Mt CO2 eqv and in WAM scenario between 491,2-492,0 Mt CO2 eqv. To meet Kyoto target is stated to be very challenging to Italy and the country relies heavily on JI and CDM credit imports (ECOFYS, 2004).

Annex C10**:** Supply-demand balance for allowances in Luxembourg



Total allocation in NAP
NAP allocates 3, 4 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 11, 4 % of the annual allocation, equaling annually to 0,4 Mt CO2, will be kept in new entrants reserve. (NAP Luxembourg, 2004)

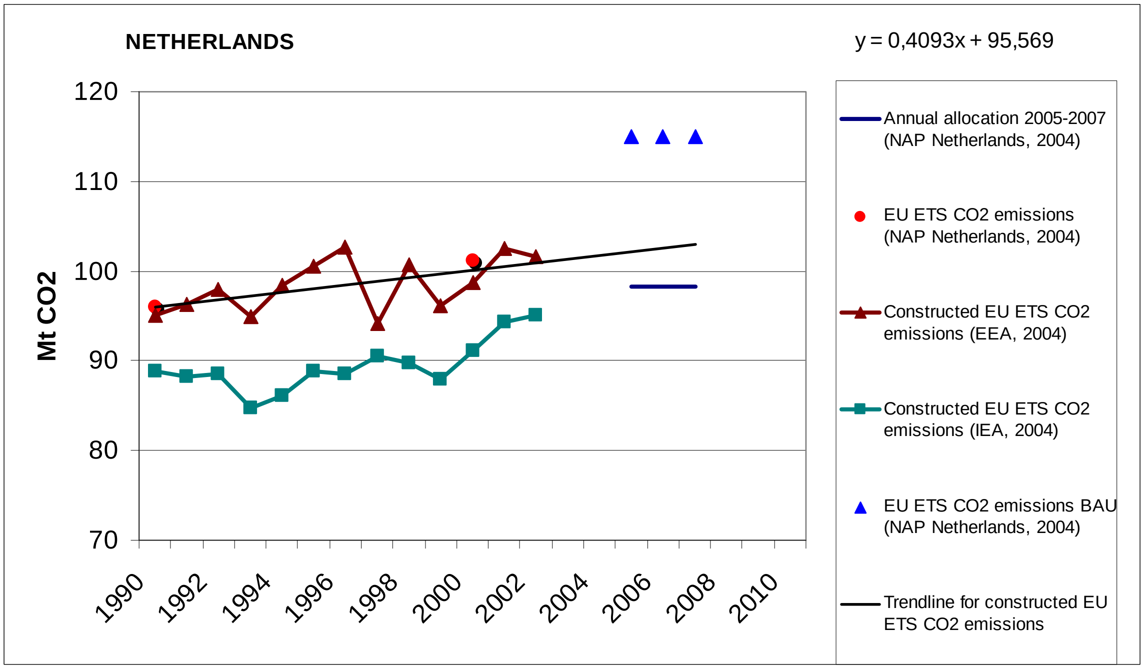
BAU estimate by trend line approximation and BAU given in NAP
Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1998, 2000 and 2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -0,8 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 3, 8 Mt CO2. BAU estimate given in NAP equals annually to 3, 7 Mt CO2 for 2005-2007.

Demand- supply based estimates of surplus or deficit of allowances 2005-2007
Trend line based approximation of emissions development in 2006 predicts 0, 4 Mt CO2 deficit of allowances. BAU scenario given in NAP compared to allocated allowances predicts 0, 3 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010
Luxembourg's Kyoto commitment is to stabilize GHG emissions to 7, 8 Mt CO2 eqv by 2010, -28 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 10, 8 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 8,5-15 Mt CO2 eqv and WAM scenario projection is 9,6 Mt CO2 eqv. To fulfill the Kyoto commitment it is approximated that Luxembourg will have to import around 3Mt CO2 eqv JI and CDM credits during 2008-2012 (IVL, 2004).

Annex C11**:** Supply-demand balance for allowances in the Netherlands



Total allocation in NAP

NAP allocates 98, 3 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 4 % of the annual allocation, equaling annually to 4 Mt CO2, will be kept in new entrant reserve. If this reserve is not empty on 31 December, the remaining allowances will be given back to the participants proportionally to the initial allocation. (NAP Netherlands, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +2,5 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 105 Mt CO2. BAU estimate given in NAP equals annually to 115 Mt CO2 for 2005-2007.

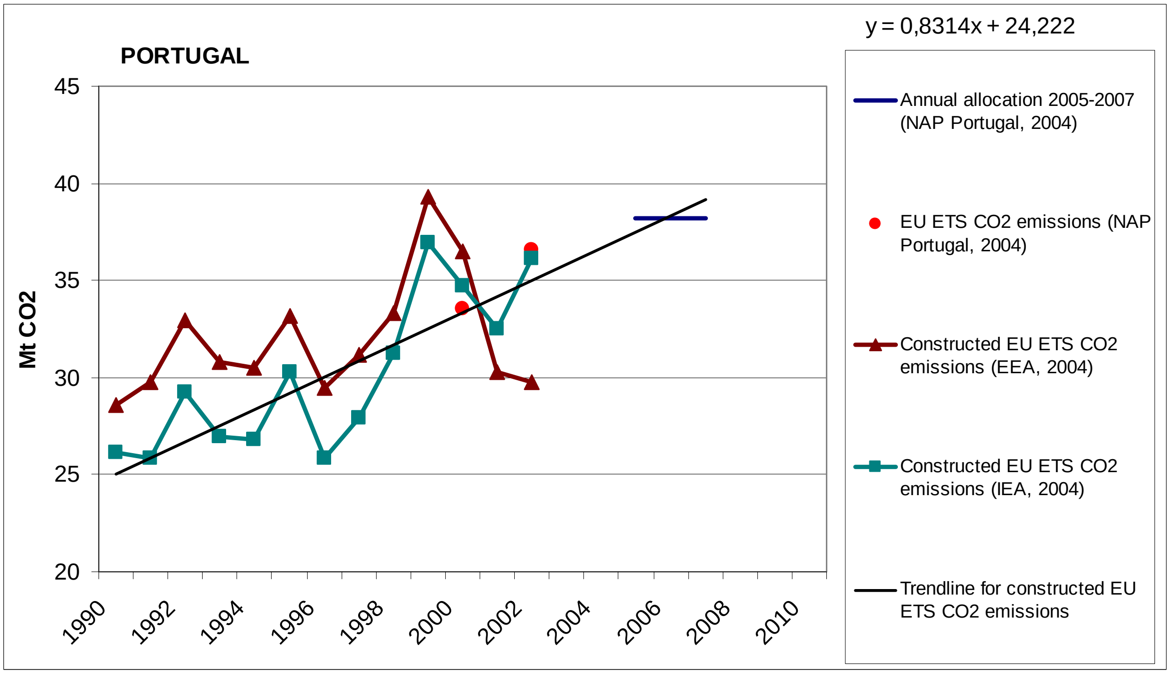
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 6, 7 Mt deficit of allowances. BAU scenario given in NAP compared to allocated allowances predicts 16,7 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Netherland's Kyoto commitment is to stabilize GHG emissions to 198, 4 Mt CO2 eqv by 2010, -6 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 213, 8 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 224, 0-256, 0 Mt CO2 eqv and in WAM scenario between 219,0-230,0 Mt CO2 eqv. To fulfill the Kyoto commitment it is approximated that Netherlands will use around 20 Mt CO2 eqv JI and CDM credits during 2008-2012 (NAP Netherlands, 2004).

Annex C12**:** Supply-demand balance for allowances in Portugal



Total allocation in NAP

NAP allocates 38, 2 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 3, 1 Mt CO2 of the annual allocation will be kept in new entrant reserve. In case that not all new entrants reserve allowances are allocated, the remainder will be auctioned at the end of the period. (NAP Portugal, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1990-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -0,7 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 37,6 Mt CO2. NAP does not give any value for EU ETS sector BAU for 2005 -2007 period.

Fluctuations in the EU ETS sector historic emissions between 2000 and 2002 are explained as the fact that year 2002 was a dry year and year 2000 was an abnormal year for the Sines refinery, which had its activity suspended for a number of months. (NAP Portugal, 2004).

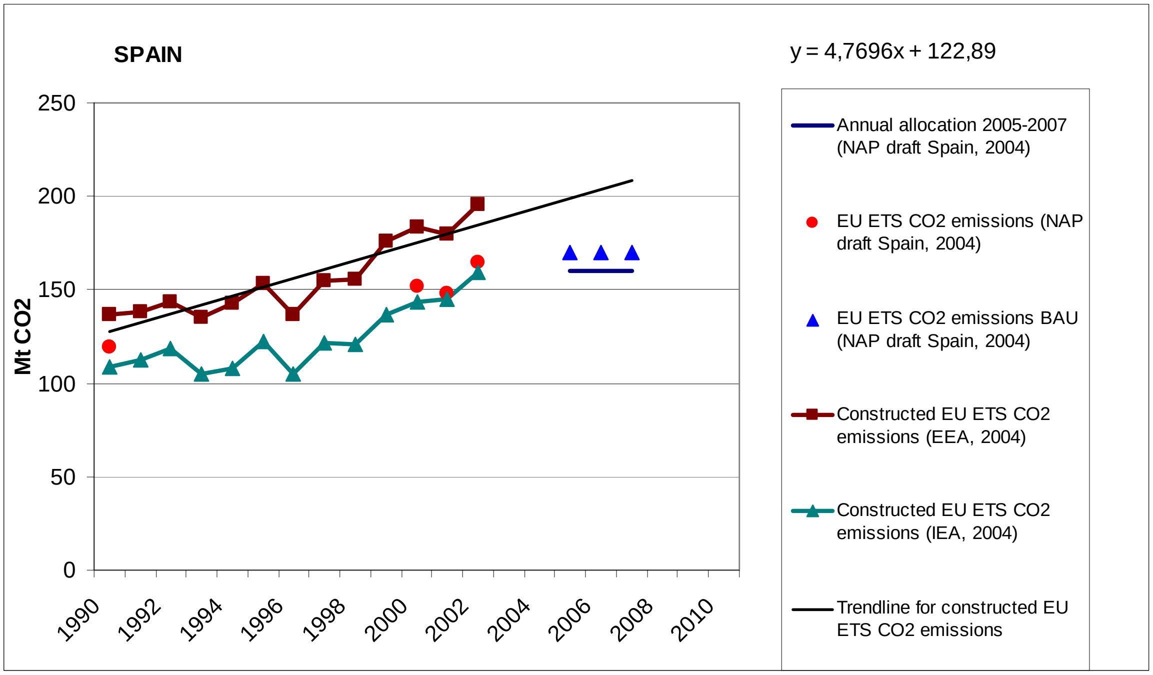
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 0, 6 Mt surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Portugal's Kyoto commitment is to stabilize GHG emissions to 78, 0 Mt CO2 eqv by 2010, 27 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 81, 6 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 83,8-99,7 Mt CO2 eqv and in WAM scenario between 86,6-95,1 Mt CO2 eqv. Emission trends in Portugal are not in line with Kyoto Commitment. Current emissions need to be reduced by 9 % in order to meet Kyoto Target, but projected emissions are rising. (IVL, 2004)

Annex C13**:** Supply-demand balance for allowances in Spain



Total allocation in NAP

NAP allocates 160, 3 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 3, 5 % of the annual allocation, equaling to 5, 4 Mt CO2, will be kept in new entrant reserve. If there are unallocated allowances as at 30 June 2007, the State may dispose of these pursuant to Law 33/2003 on Assets of the Public agencies. (NAP draft Spain, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -28 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 176,0 Mt CO2. BAU estimate given in NAP equals annually to 169, 8 Mt CO2 for 2005-2007.

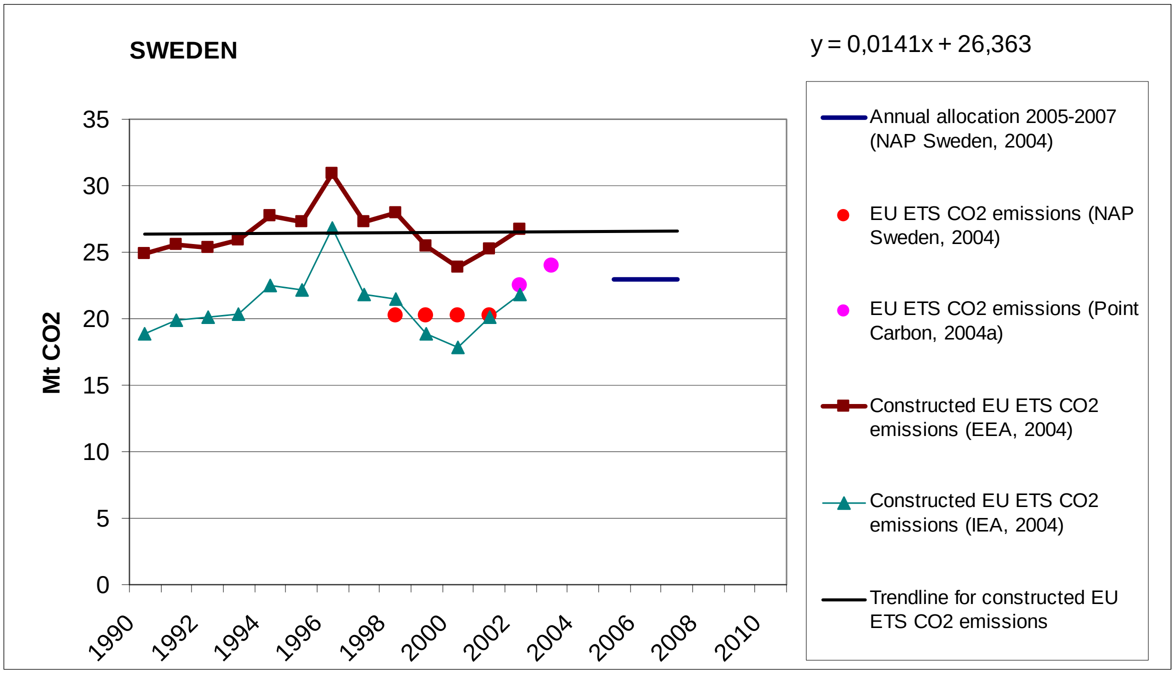
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 15, 7 Mt CO2 deficit of allowances. BAU scenario given in NAP compared to allocated allowances predicts 9, 6 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Spain's Kyoto commitment is to stabilize GHG emissions to 333, 4 Mt CO2 eqv by 2010, 15 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 399, 7 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 307, 0-429,9 Mt CO2 eqv and WAM scenario projection is 371,1 Mt CO2 eqv. To reach the Kyoto Target 2 % of the compliance is planned to be fulfilled by sinks and 7 % (compared 1990 GHG emissions), equaling to 100 Mt CO2 eqv 2008-2012, by JI and CDM credits (NAP draft Spain, 2004).

Annex C14**:** Supply-demand balance for allowances in Sweden



Total allocation in NAP

NAP allocates 22, 9 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 8 % of the annual allocation, equaling to 1, 8 Mt CO2, will be kept in new entrant reserve. (NAP Sweden, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -5,4 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 21,2 Mt CO2. NAP does not give any value for EU ETS sector BAU for 2005 -2007 period.

In Sweden Barsebäck-2 nuclear power reactor, with generation capacity of 600 MW will be closed by 31 May, 2005 (ENDS, 2004). The closure of Barsebäck-2 reactor will require around 4TWh electricity generation from other sources (Kockum, 2002). If coal condensing, which usually is the marginal Nordic production source, is used the CO2 emissions will increase by around 4 Mt CO2 annually

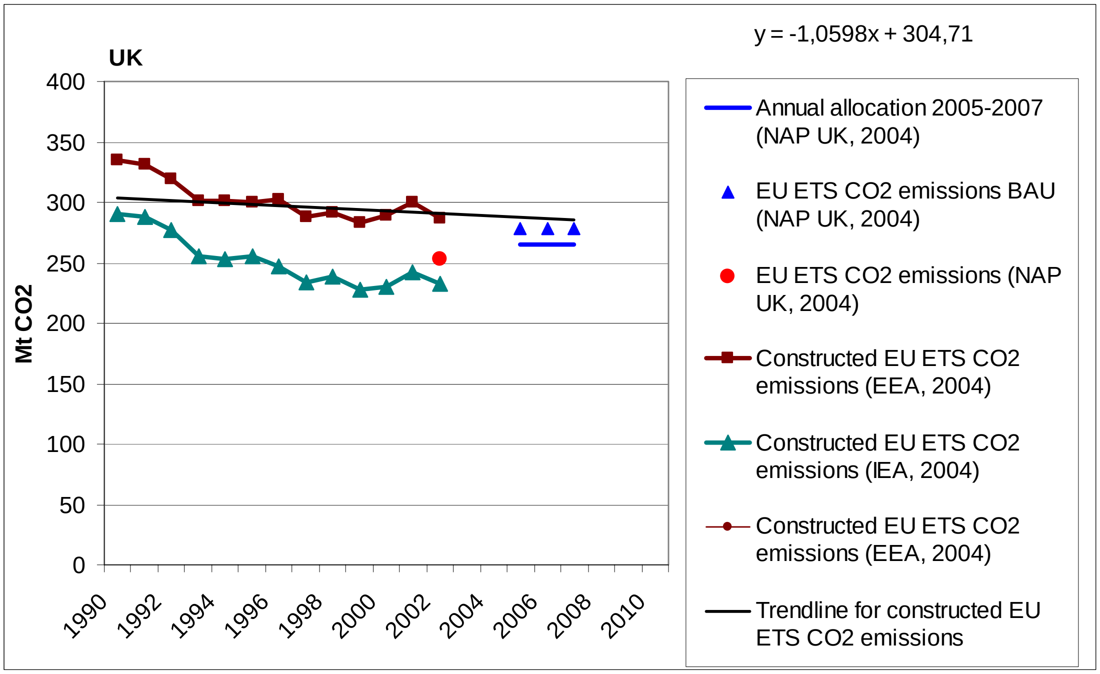
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1,7 Mt surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Sweden's Kyoto commitment is to stabilize GHG emissions to 75, 8 Mt CO2 eqv by 2010, 4 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 69, 6 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 70,9-73,4 Mt CO2 eqv. Sweden is going towards meeting the Kyoto Target (ECOFYS, 2004). CDM and JI credits will not be used in order to fulfill Kyoto Commitment. Sweden may use JI and CDM creidts in order to reduce GHG emissions further as it's national target to reduce GHG emissions by 4 percent compared to 1990 levels (IVL, 2004).

Annex C15**:** Supply-demand balance for allowances in the UK



Total allocation in NAP

NAP allocates 265, 1 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. Around 18, 9 Mt of the annual allocation will be kept in new entrant reserve. If there are any surplus of the allowances remaining in the new entrants reserve at the end of any year 2005-2007 these will be auctioned. (NAP UK, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions statistics 1990-2002 of constructed EU ETS sector (EEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -34,4 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 252, 3 Mt CO2. BAU estimate given in NAP equals annually to 278, 4 Mt CO2 for 2005-2007. The trend line approximation is based on years 2000-2002. It is not relevant to base the trend line on 1990s emissions development because in the UK big change from coal to gas based electricity production occurred during 1990s. (Nieminen, 2004)

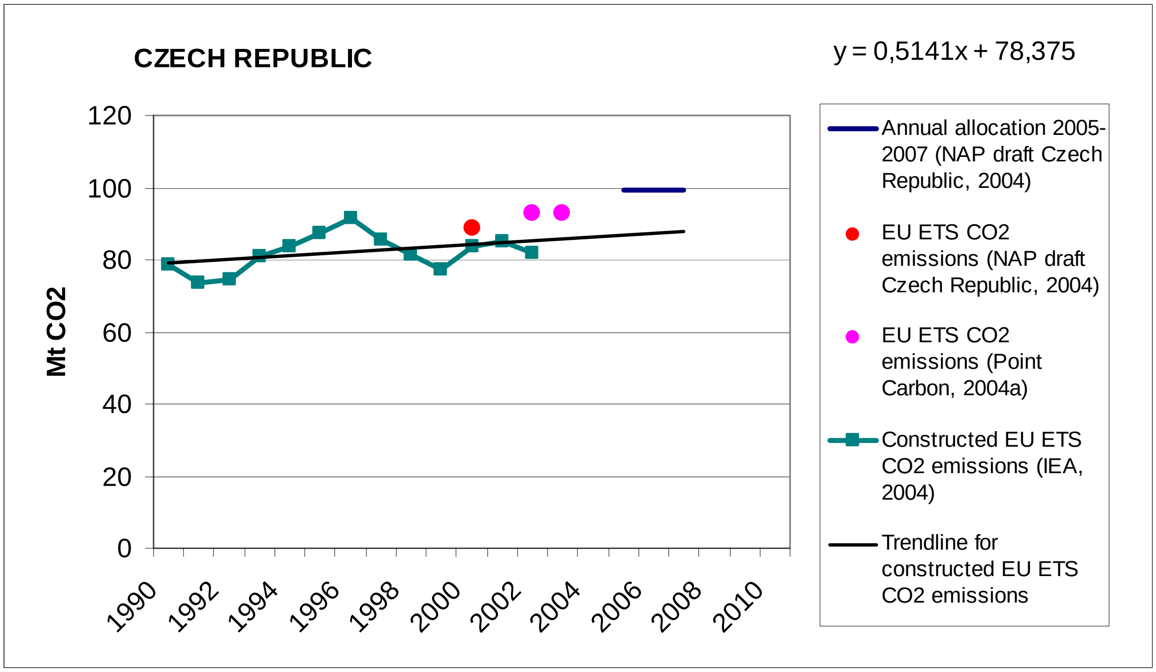
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 12, 8 Mt surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 13, 3 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

UK's Kyoto commitment is to stabilize GHG emissions to 653, 8 Mt CO2 eqv by 2010, -12,5 % compared to 1990 levels. In 2002 GHG emissions (without LUCF) were 634, 8 Mt CO2 eqv (EEA, 2004b). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 640,9-651,3 Mt CO2 eqv and in WAM scenario between 579,1-585,4 Mt CO2 eqv. UK is on track to achieve its Kyoto Target and therefore does not intend to use Kyoto project-based mechanisms JI and CDM credits to meet it's target (ECOFYS, 2004). UK is firmly committed to its domestic goal of moving towards a 20 % reduction in CO2 emissions below 1990 levels by 2010. (NAP UK, 2004)

Annex C16**:** Supply-demand balance for allowances in Czech Republic



Total allocation in NAP

NAP allocates 99,5 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. (NAP draft Czech Republic, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1990-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +5,2 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 92,3 Mt CO2.

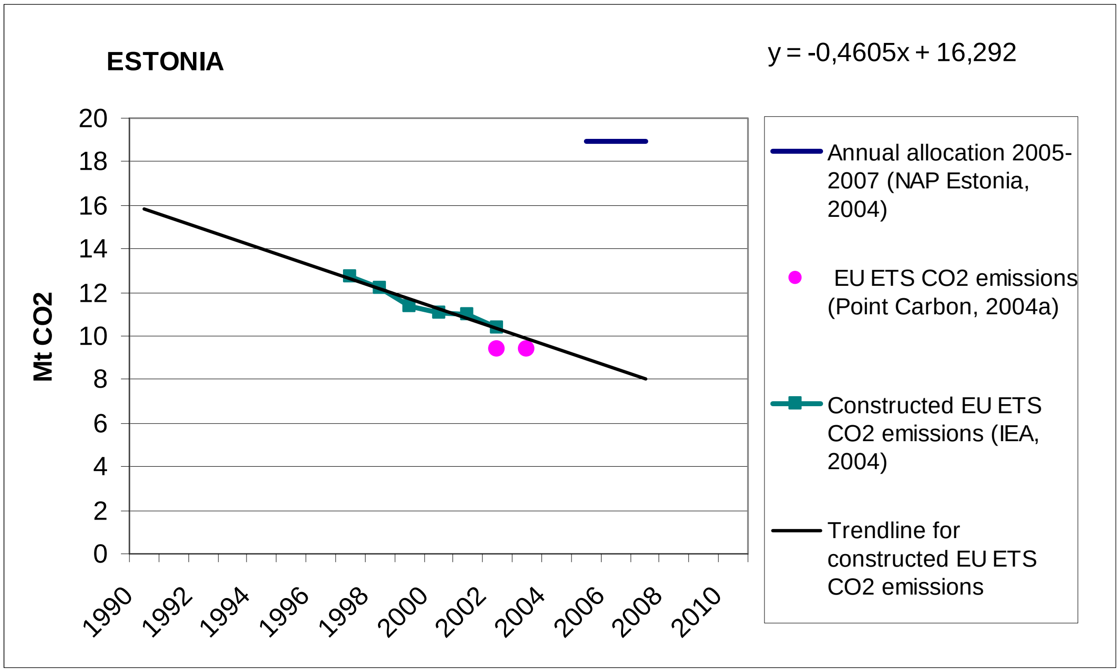
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 7,2 Mt surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Czech Republic's Kyoto commitment is to stabilize GHG emissions to 176,3 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. In 2001 GHG emissions were 148, 0 Mt CO2 eqv (COM(2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 131,7-145,2 Mt CO2 eqv and in WAM scenario between 125,3-138,9 Mt CO2 eqv.

Annex C17**:** Supply-demand balance for allowances in Estonia



Total allocation in NAP

Austrian NAP 19,0 allocates Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007(NAP Estonia, 2004). 3 % of the annual allocation, equaling around 0,6 Mt will be kept in new entrant reserve. (ECOFYS, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1997-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is -0,9 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 7,5 Mt CO2. The NAP does not state anything of the BAU emissions development for EU ETS covered installations.

The closure of nuclear power plant first unit in Ignalina in Lithuania by 31 December 2004 might increase Estonia's CO2 emissions as electricity exports from Estonia to Latvia and Lithuania may increase (Vile, 2004).

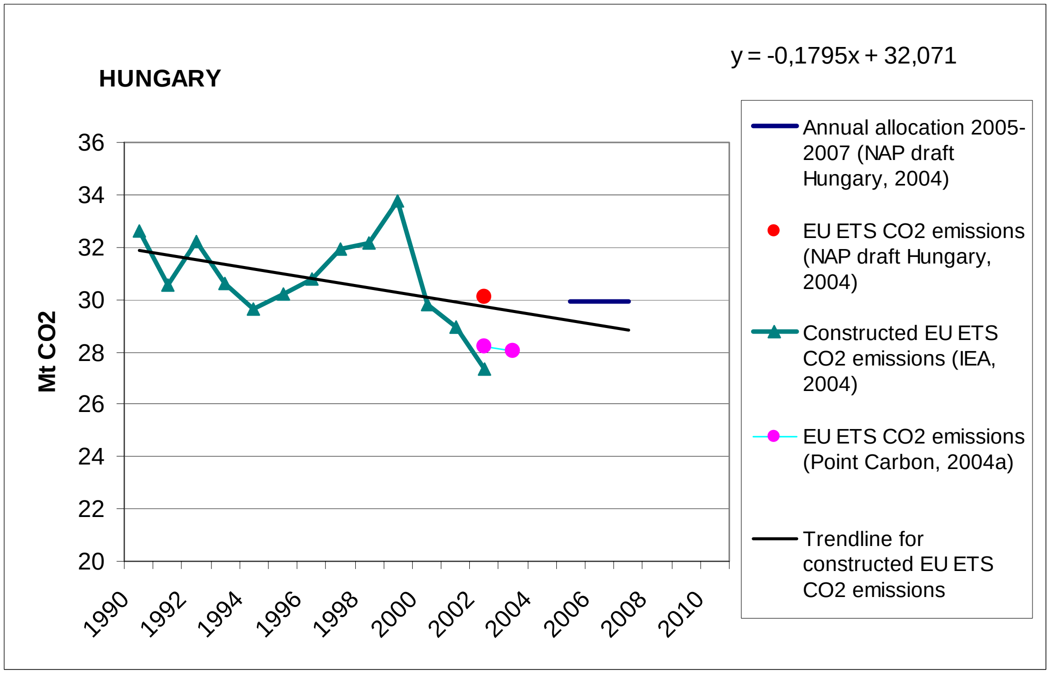
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 11,4 Mt surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Estonia's Kyoto commitment is to stabilize GHG emissions to 40,0 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. . In 2001 GHG emissions were 19, 4 Mt CO2 eqv (COM (2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 11,7-18,9 Mt CO2 eqv and in WAM scenario between 9,1-17,4 Mt CO2 eqv.

Annex C18**:** Supply demand-balance for allowances in Hungary



Total allocation in NAP

NAP allocates 29, 9 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 2 % of the annual allocation, equaling annually around 0, 6 Mt CO2, will be kept in new entrant reserve. A maximum of 1 % of all allowances will be distributed by auction. Allowances remaining in the new entrants reserve at the end of 2007 will be auctioned. (NAP draft Hungary, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1990-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +2,7 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 31,8 Mt CO2. Draft NAP does not give any value for EU ETS sector BAU for 2005 -2007 period.

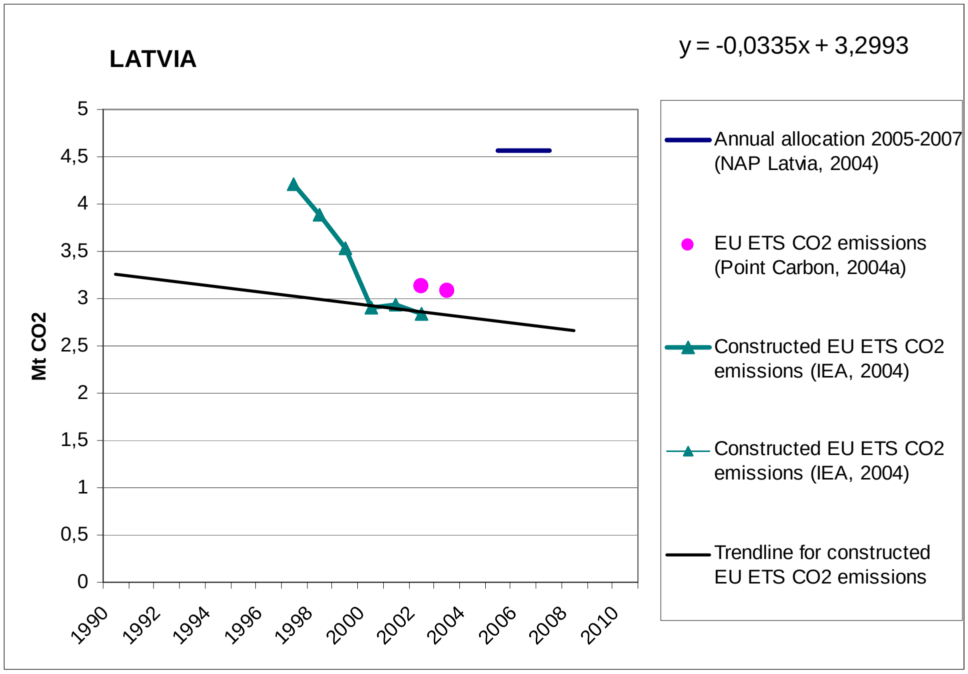
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1,9 Mt deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Hungary's Kyoto commitment is to stabilize GHG emissions to 96,4 Mt CO2 eqv by 2010, -6 % compared to 1990 levels. In 2001 GHG emissions were 84,3 Mt CO2 eqv (COM(2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 94,4- 95,6 Mt CO2 eqv.

Annex C19**:** Supply-demand balance for allowances in Latvia



Total allocation in NAP

NAP allocates 4, 6 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 0, 74 Mt CO2 of the annual allocation will be kept in new entrant reserve. (NAP Latvia, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1997-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is + 0,3 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 3,0 Mt CO2. NAP does not give any value for EU ETS sector BAU for 2005 -2007 period.

The closure of nuclear power plant first unit in Ignalina in Lithuania by 31 December 2004 will have an effect on Latvia's CO2 emissions as Latvia imports carbon free nuclear power from Ignalina (Point Carbon, 2004c). The power demand will be satisfied partly by increasing electricity imports from Estonia and partly by increasing gas based power production at own installations in Latvia. Latvia may also increase imports from Russia. Closure of the first unit in Ignalina does not necessarily affect the imports to Latvia as it may in only reduce the exports to Russia and Belarus. (Vile, 2004)

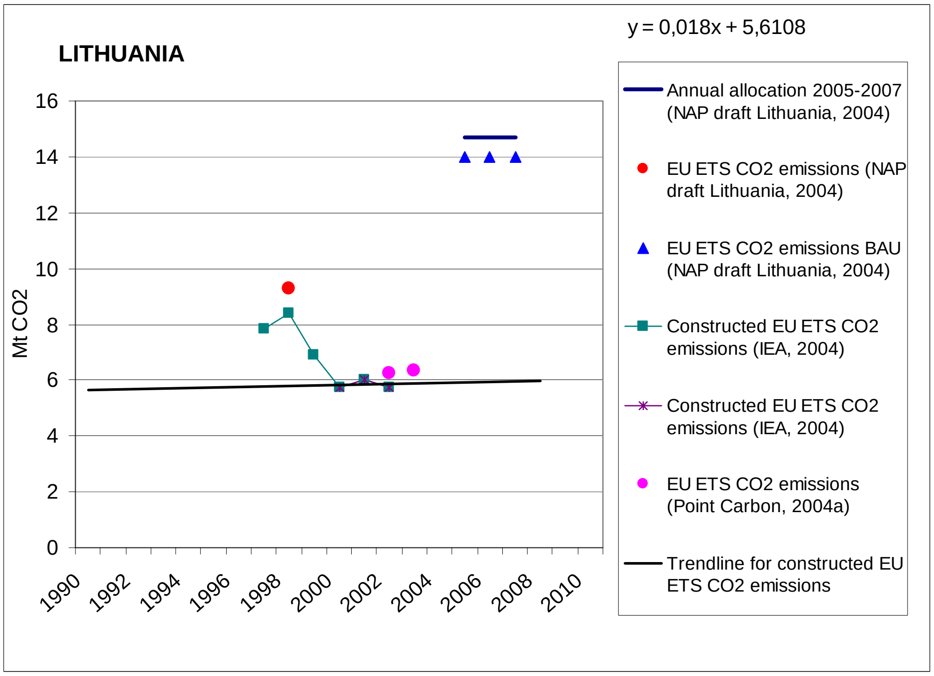
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1,5 Mt surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Latvia's Kyoto commitment is to stabilize GHG emissions to 26, 7 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. In 2001 GHG emissions were 11,4 Mt CO2 eqv (COM(2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 3,3-12,8 Mt CO2 eqv and WAM scenario projection is 14,0 Mt CO2 eqv. Latvia is on track to meet it' s Kyoto Target (ECOFYS, 2004).

Annex C20**:** Supply-demand balance for allowances in Lithuania



Total allocation in NAP

NAP allocates on average 14, 7 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. Allocation for 2005 is 14, 7 Mt CO2, for 2006 14,1 5 Mt CO2 and for 2007 13,66 Mt . 5 % of the annual allocation, equaling annually on average 0, 7 Mt CO2 will be kept in new entrant reserve and 1,5 % will be auctioned. Unused allowances for new entrants will be auctioned. (NAP draft Lithuania, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 2000-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +0,9 Mt CO2. The trend line is based only for 2000-20002 period as Lithuania faced a strong economic degradation in the 1990s and the emissions decreased heavily. In the near future the economy is expected to grow at high rate.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 6,8 Mt CO2. BAU estimate given in NAP equals annually to 14, 0 Mt CO2 for 2005-2007.
Trend line approximation is based on years 2000-2002 as the economic development has been stabilized and it's not declining. According to the Lithuanian draft NAP the main difference between present emissions and projected emissions in the energy sector is due to closure of first nuclear reactor at Ingalina. The reactor will be shut down by 31 December 2004 (ENDS, 2004). This will increase the need for electricity from Lithuanian fossil fuel fired thermal power plants from 3,0 TWh/a in 2003 to 8,8 TWh/a for 2005- 2007 period. Annual CO2 emissions will increase by 5,5 Mt CO2 (Point Carbon, 2004c). Another reason to consider when approximating the projected emissions in most sectors is the expected high economic growth. The expected growth in cement industry is 78 % and in other sectors 52 % between 1998-2002 and 2005-2007. Electricity consumption in Lithuania is estimated to increase from 12,0 TWh in 2003 to 18,0 TWh in 2010. (NAP draft Lithuania, 2004).

These factors are not taken into account in the trend line based approximation of EU ETS covered installations CO2 emissions development. Therefore the trend line approximation is not very relevant and the BAU given in the NAP is more reliable as it accounts the factors mentioned above.

Annex C20**:** Supply-demand balance for allowances in Lithuania

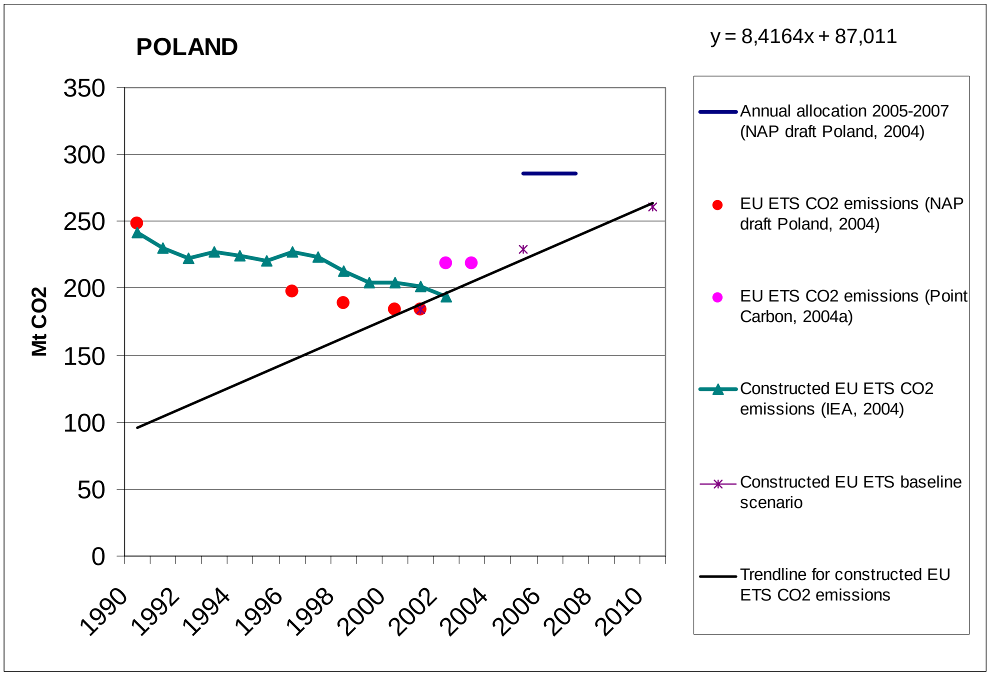
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 7,9 Mt CO2 surplus of allowances. BAU scenario given in NAP compared to allocated allowances predicts 0,7 Mt CO2 surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Lithuania's Kyoto commitment is to stabilize GHG emissions to 47,4 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. In 2001 GHG emissions were 47,4 Mt CO2 eqv (COM(2003)735). Lithuania has not given any WM or WAM scenarios for GHG emissions. Lithuania is on track to meet it's Kyoto Target (ECOFYS, 2004).

Annex C21**:** Supply-demand balance for allowances in Poland



Total allocation in NAP

NAP allocates 286, 2 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 8, 8 Mt CO2 of the annual allocation will be set aside for a reserve of which 3,3 Mt CO2 for new entrants. The allowances from the new entrant reserve which are not allocated by 30 September 2006 may be auctioned but the remaining allowances may also be used to cover the growth of emissions in the non-ETS sector in order to meet the national cap, if the emission balance requires it. (NAP draft Poland, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line based approximation of the CO2 emissions in 2006 is based on a baseline scenario, BLN, for Poland's economic development and the corresponding projections of CO2 emissions given in the Polish draft NAP. The BLN scenario is based on the assumption that the GDP will grow by 4,5 % on avarage until 2015 (NAP draft Poland, 2004). The constructed EU ETS sector emissions were expected to develop with the same rate as the national total CO2 emissions in BLN scenario. The share of EU ETS CO2 emissions of the national total is based on this trend line analysis on the average of constructed EU ETS sector share of national CO2 emissions in the period 1991-2000. According to the trend line analysis, with the correction of the constructed EU ETS sector to the real EU ETS sector emissions, the business-as-usual emissions in 2006 equal to 207,3 Mt CO2.

Polish draft NAP does not give any accurate estimate of the EU ETS sector BAU emissions development for 2005-2007. GDP growth rates in the last quarters of 2003 and the first quarters of 2004 have exceed the BLN scenario assumptions, which indicates that as the economic growth rate will be bigger the emissions might also exceed the BLN scenario forecast. (NAP draft Poland, 2004)

The coal based electricity production is not very profitable in Poland. If old plants be replaced by new more efficient plants or by gas based production, or if Polish power exports are reduced, the CO2 emissions will decrease and surplus of allowances to be sold will increase. (Vile, 2004)

Annex C21**:** Supply-demand balance for allowances in Poland

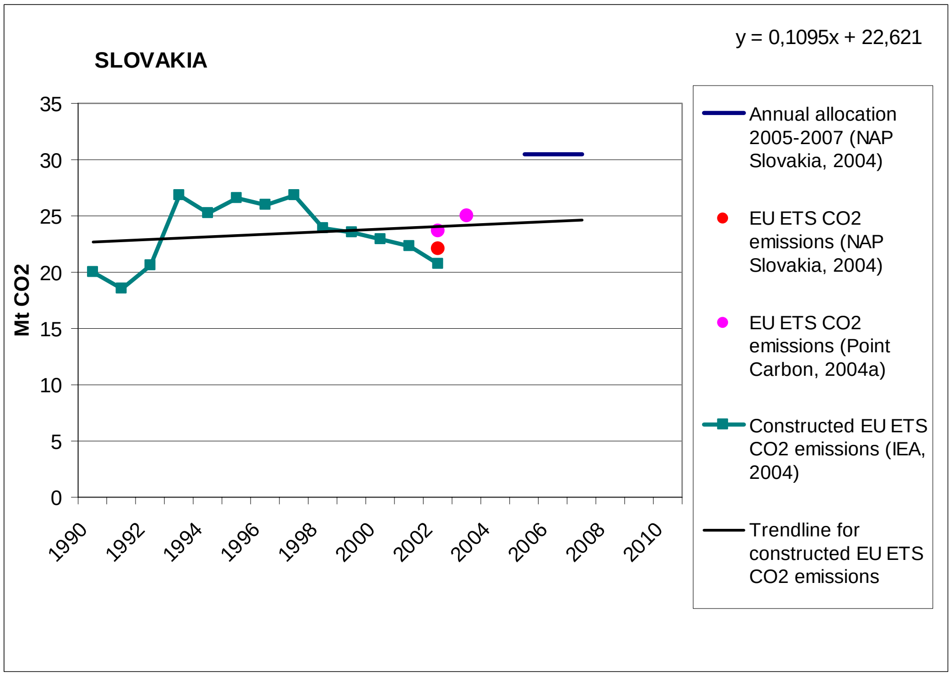
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

BLN scenario based trend line approximation of emissions development in 2006 predicts 78,9 Mt surplus of allowances. If the economic growth will exceed the BLN assumption the surplus might be less but if the coal based electricity production will be replaced by natural gas emissions the surplus might be greater.

Kyoto target and projections of GHG emissions in 2010

Poland's Kyoto commitment is to stabilize GHG emissions to 531, 4 Mt CO_2 eqv by 2010, -6 % compared to 1990 levels. In 2001 GHG emissions were 148,3Mt CO_2 eqv (COM(2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 394,0-482,2 Mt CO_2 eqv and in WAM scenario between 372,0-456,2 Mt CO_2 eqv.

Annex C22**:** Supply-demand balance for allowances in Slovakia



Total allocation in NAP

NAP allocates 30,5 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007.0,7 Mt CO2 of the annual allocation will be kept1 in new entrant reserve At the end of the first trading period unused allowances in the new entrants reserve will be auctioned (NAP Slovakia, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1990-2002 of constructed EU ETS sector (IEA, 2004). Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +1,4 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 25,9 Mt CO2. NAP does not give any estimate of the EU ETS sector BAU emissions development for 2005-2007

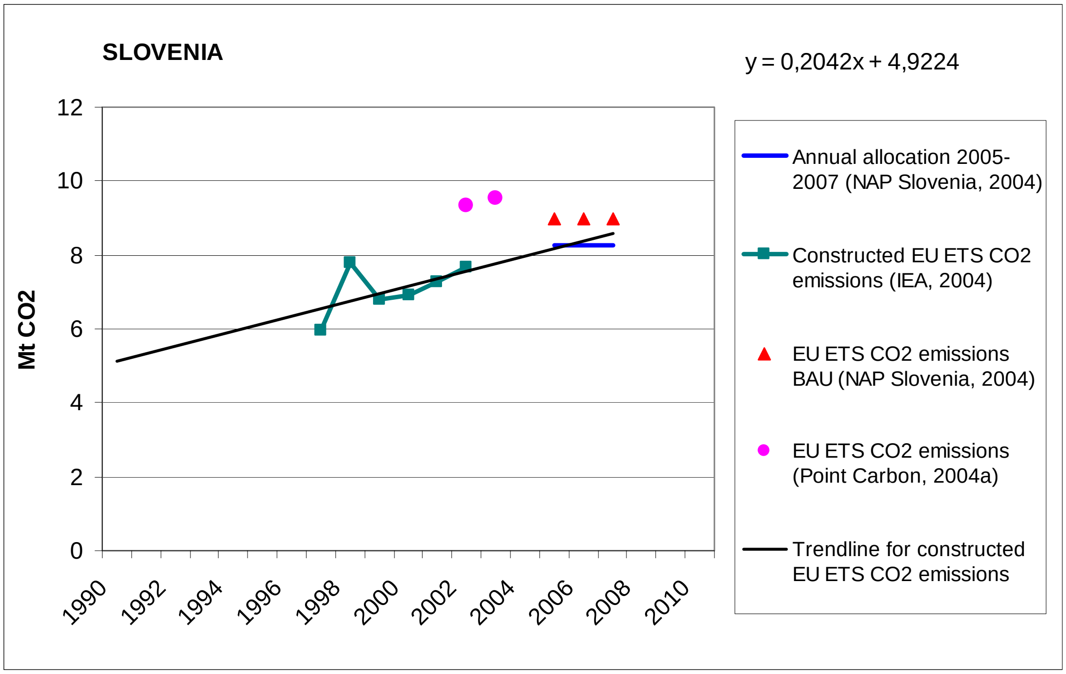
Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 4, 6 Mt CO2 surplus of allowances.

Kyoto target and projections of GHG emissions in 2010

Slovakia's Kyoto commitment is to stabilize GHG emissions to 66, 4 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. In 2001 GHG emissions were 50, 1 Mt CO2 eqv (COM (2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 51,4-53,2 Mt CO2 eqv and in WAM scenario between 46,0-48,2 Mt CO2 eqv.

Annex C23**:** Supply-demand balance for allowances in Slovenia



Total allocation in NAP

NAP allocates 8,3 Mt CO2 annually for the EU ETS covered installations during the first trading period 2005-2007. 0,76 % of the annual allocation, equaling to 0,07Mt CO2, will be kept in new entrant reserve. Any surplus allowances left in the new entrants reserve at the end of the trading period will be auctioned. (NAP Slovenia, 2004)

BAU estimate by trend line approximation and BAU given in NAP

Trend line approximation of the EU ETS sector business -as-usual emissions in 2006 is based on CO2 emissions derived from primary energy usage statistics 1997-2002 of constructed EU ETS sector (IEA, 2004). Trend line is based only on six historic years as no earlier statistics were available from the same statistical source. Adjustment used in the analysis between constructed EU ETS sector and real EU ETS sector is +1,7 Mt CO2.

Trend line based approximation of the CO2 emissions in 2006 assumes the EU ETS sector BAU equal to 10, 1 Mt CO2. BAU estimate given in NAP equals annually to 9, 0 Mt CO2 for 2005-2007.

Demand- supply based estimates of surplus or deficit of allowances 2005-2007

Trend line based approximation of emissions development in 2006 predicts 1, 8 Mt deficit of allowances. BAU scenario given in NAP compared to allocated allowances predicts 0, 7 Mt CO2 deficit of allowances.

Kyoto target and projections of GHG emissions in 2010

Slovenia's Kyoto commitment is to stabilize GHG emissions to 18, 3 Mt CO2 eqv by 2010, -8 % compared to 1990 levels. In 2001 GHG emissions were 20, 2 Mt CO2 eqv (COM(2003)735). Different GHG projections for 2010 are stated in Annex X. Projections in WM scenario vary between 21,8-22,1 Mt CO2 eqv and in WAM scenario between 19,6-19,9 Mt CO2 eqv. Slovenia is stated to be just on track to meet its Kyoto Target (ECOFYS, 2004).

Annex D. The original assumptions behind MAC curve (CSFB, 2004)

Figure 34: **Calculating the arbitrage cost of carbon for pollution substitution**

	Coa	CCGT / CHP UK	CCGT / CHP Benelux	CCGT / CHP France	CCGT / CHP Iberia	CCGT / CHP Central Europe	CCGT / CHP Italy	Renewables 30% utilisation	Renewables 25% utilisation
Efficiency	35%	53%	53%	53%	53%	53%	53%		
Fuel cost (eu/MWh)	14.8	19.8	22.8	23.2	24.2	24.6	27.0	0	0
Other marginal costs (eu/MWh)	6.4	1.2	1.2	1.2	1.2	1.2	1.2	2.8	2.8
Marginal cost	21.2	21.0	24.0	24.4	25.4	25.8	28.2	2.8	2.8
Fixed costs	3.4	3.7	3.7	3.7	3.7	3.7	3.7	6.9	8.2
Capital costs	23.0	10.0	10.0	10.0	10.0	10.0	10.0	44.3	53.8
Cost of new entry	47.6	34.7	37.7	38.1	39.1	39.5	41.9	54.0	64.8
tonnes CO2 / MWh	0.9	0.4	0.4	0.4	0.4	0.4	0.4	0	0
Marginal price arbitrage									
Carbon price	-0.5	-0.5							
Marginal cost plus carbon	20.8	20.8							
Carbon price	5.6		5.6						
Marginal cost plus carbon	26.2		26.2						
Carbon price	6.4			6.4					
Marginal cost plus carbon	27.0			27.0					
Carbon price	8.3				8.3				
Marginal cost plus carbon	28.7				28.7				
Carbon price	9.2					9.2			
Marginal cost plus carbon	29.5					29.5			
Carbon price	13.9						13.9		
Marginal cost plus carbon	33.7						33.7		
New entry arbitrage									
Carbon price	26.9	26.9							
CCGT new entry	45.4	45.4							
Carbon price	33.0		33.0						
CCGT new entry	50.9		50.9						
Carbon price	33.8			33.8					
CCGT new entry	51.6			51.6					
Carbon price	35.7				35.7				
CCGT new entry	53.3				53.3				
Carbon price	36.9							36.9	
CCGT new entry	54.0							54.0	
Carbon price	36.7					36.7			
CCGT new entry	54.2					54.2			
Carbon price	41.3						41.3		
Renewables new entry	58.4						58.4		
Carbon price	48.4								48.4
Renewables new entry	64.8								64.8

Source: CSFB estimates.