# Abatement and Allocation in the Pilot Phase of the EU ETS*


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**Abstract**

We use historical industrial emissions data to assess the level of abatement and over-allocation that took place across European countries during the pilot phase (2005-2007) of the European Union Emission Trading Scheme. Using a dynamic panel data model, we estimate the counterfactual (business-as-usual) emissions scenario for EU member states. Comparing this baseline to allocated and verified emissions, we conclude that both over-allocation and abatement occurred, along with under-allocation and emissions inflation. Over the three trading years of the pilot phase we find over-allocation of approximately 376 million EUAs (6%) and total abatement at the member state level of 107 Mt $CO_2$ (1.8%). However, due to over-allocation and possible uncertainty about future allocation methodologies, we calculate that emissions inflation of approximately 119 Mt $CO_2$ (2%) occurred, resulting in emissions over the pilot phase being approximately 12 Mt $CO_2$ (0.2%) *higher* than they would have been in the absence of the EU ETS.



*JEL Classification:* C23, O13, Q54, Q58

*Keywords:* Emissions Trading Scheme, Climate Policy, Dynamic Panel Data Analysis.


## 1 Introduction

Since January 2005 over 10,000 firms involved primarily in electricity generation and heavy industry in the European Union have monitored, reported and verified their $CO_2$ emissions as participants in the European Union Emissions Trading Scheme (EU ETS), the largest greenhouse gas emissions trading program in the world. As the cornerstone of European climate policy, the EU ETS is motivated by the economic theory that market based policy tools encourage the development and adoption of pollution abatement technology and enable emissions reductions more efficiently than command and control style regulation (Milliman and Prince, 1989; Jung, Krutilla, and Boyd, 1996). The actions required to reduce emissions are theoretically mobilized by the price on $CO_2$ emissions, and emissions are reduced where the costs of doing so are less than the costs of buying the permits. Pilot phase (2005-2007) European Union emissions allowances (EUAs) were grandfathered freely to participating installations based on burden sharing obligations under the Kyoto Protocol, past emissions, and economic projections for the pilot phase trading period. According to Montgomery (1972), grandfathering should not interfere with the efficiency and performance of the system as well-defined property rights,


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and not the method of delivering those rights, should ensure an efficient outcome. Excess supply of permits during the pilot phase caused the price of EUAs to collapse in 2006 and remain close to zero throughout 2007. The excess of EUAs occurred either because emissions reductions (abatement) were much easier and cheaper than expected, or because too many EUAs were distributed (over-allocation). While it is likely that some abatement occurred during the pilot phase, over-allocation is also probable given the combination of voluntary (and largely unverified) firm level data, and overly optimistic economic growth forecasts that were used to form the cap for the entire trading system.

In this study we make use of ex post data and panel data econometric techniques to estimate what emissions would have been in the absence of the EU ETS, referred to hereafter as the counterfactual or business-as-usual (BAU) emissions. Ellerman and Buchner (2008) succinctly explain that “the counterfactual is not observed and never will be. It can only be estimated, but there are better and worse estimates and much can be done to narrow the range of uncertainty, particularly when the evaluation is done ex post when the levels of economic activity, weather, energy prices and other factors affecting the demand for allowances are known.” Once credible estimates are established for BAU emissions, we can compare them to both allocated and verified EUAs in order to gain insight into the occurrence of abatement and over-allocation in the pilot phase.

Given the circumstances surrounding the pilot phase, there is a real possibility of ‘emissions inflation’ where emissions under the EU ETS were higher during the pilot phase period than they would have been otherwise. This is possible due to the methodology used for pilot phase EUA allocation and uncertainty about future (2008-2012) trading period allocation methodologies. Most governments allocated EUAs relative to ex ante BAU projections, with past emissions strongly influencing the more detailed distribution of allowances. EU ETS participants may have learned that inflating (historical) emissions leads to more generous future allocations and if the prospect of future allowance distribution being contingent upon recent emissions (‘updating’) is likely, there is a direct incentive to inflate actual emissions (See the discussion in Grubb, Azar, and Persson, 2005).

The rest of the paper is organized as follows. Section 2 gives a brief overview of the EU ETS pilot phase and reviews the existing literature; section 3 describes that data used, and presents our econometric specification. Estimation results and EU ETS pilot phase BAU estimates are shown in section 4, along with tests for structural integrity and robustness checks, while section 5 concludes.

## 2 The EU ETS pilot phase and the relevant literature

It is possible to broadly summarize developments during the pilot phase of the EU ETS by referring to Figure 1, which shows the final differences between allocated and verified EUAs for each member state. Member states are shown on the vertical axis with gross long (allocated more EUAs than required), gross short (shortfall between allocated EUAs and the required amount) and net positions on the horizontal axis. In 2005, 2006 and 2007 the entire market was net long by 82.4 (3.9%), 36.1 (1.7%) and 26.9 (1.3%) million EUAs, respectively, according to the Community Independent Transaction Log (CITL). The net long final positions of most member states provides visual evidence of either net aggregate over-allocation or unexpected abatement. The estimation of a credible BAU emissions scenario is thus necessary determine whether over-allocation or “excessive” abatement lead to the excess supply of EUAs in the market. Similarly, the comparison of BAU emissions to allocated and verified emissions data reveals the occurrence and location of under-allocation and also emissions inflation by member state.

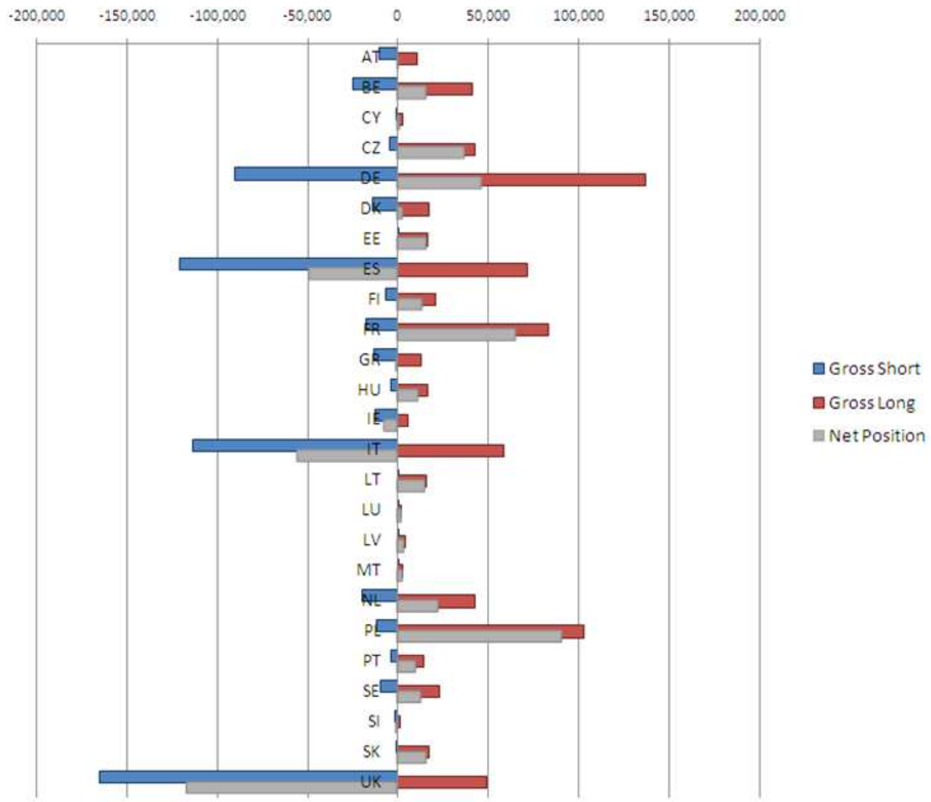


Figure 1: *Gross short/long positions for 2005-2007 at the national level (Kt $CO_2$).* Source: CITL

## 2.1 Relevant literature on allocation and abatement

The literature on various aspects of the EU ETS is growing with much attention being paid to allocation issues (Ellerman and Buchner, 2007; Neuhoff, Martinez, and Sato, 2006; Ahman, Burtraw, Krueger, and Zetterberg, 2007), competitiveness concerns (Demailly and Quirion, 2006, 2008; Oberndorfer and Rennings, 2007; Grubb and Neuhoff, 2006; Reinaud, 2004; Ponssard and Walker, 2008), and the drivers of $CO_2$ prices (Mansanet-Bataller, Pardo, and Valor, 2007; Alberola, Chevallier, and Chèze, 2008). There are few published studies analyzing the levels of abatement which might have occurred as a result of the emissions constraint and the resulting $CO_2$ price signal. We are aware of only two studies that make use of EU ETS and other data to estimate BAU emissions as a step in identifying abatement. Ellerman and Buchner (2008) provide the only ex post analysis of the entire EU ETS and estimate levels of over-allocation and abatement that occurred only during 2005-2006. An "allocation ratio" is constructed to signify which countries were likely over-allocated based on the aggregated relative net/gross final positions of their installations. The ratio of net short or long to gross short or long is calculated by member state and the authors conclude that for 2005, fourteen member states that distributed 72% of all EUAs cannot be viewed as being involved in over-allocation. As for the remaining 28% of EUAs, about 24% were required to cover emissions in 2005 so that the maximum over-allocation is in the order of 6%, or 125 million EUAs, assuming that none of the length observed in these countries can be attributed to abatement or unexpected transient conditions that created length in these years. Similar results hold for 2006. The authors use GDP growth trends, national energy and $CO_2$ intensity trends, and assumptions about structural breaks in these trends to calculate BAU emissions and, as a result, ranges for levels of abatement. They conclude that between 130-200 Mt of $CO_2$ were abated in 2005, and 140-220 Mt in 2006 for all member states.

In an ex-post analysis of the largest sector in the EU ETS by share of emissions[1] Delarue, Ellerman, and D'haeseleer (2008) focus specifically on the European power sector possibilities for short term $CO_2$ abatement through fuel switching. Using both a non-calibrated and a historically calibrated simulation model the authors' estimates of abatement are between 34.4 and 63.6 Mt in 2005, and 19.2 and 35 Mt in 2006 in the power sector alone. These abatement estimates are based solely on the substitution effect of fuel switching and do not take into account the income effect of emissions reductions resulting from industrial eletricity consumers becoming more efficient due to the rise in electricity prices resulting from the pass through of $CO_2$ costs.[2]

In general, the views about levels of abatement, or the difference between BAU and verified emissions, which likely occurred during the pilot phase can be summed up by contrasting two insights. Kettner, Köppl, Schleicher, and Thenius (2008) conclude abatement played a minor role in determining the final net position of countries:

"*...it is rather unlikely that the EU ETS has already created incentives for abatement investments in the first trading years. Given the rather low carbon prices, it is also extremely unlikely that industries with a heavy $CO_2$ cost component, such as cement and lime, have reduced their production levels because of the stringency of allowances. In a few installations the option for a fuel shift may have been used. Most probably the only reduction option that was widely used was the improved operation of existing equipment. The reduction potential of this option is, however, rather limited.*"

In contrast, Ellerman and Buchner (2008) explain why the conclusion of significant early abatement and a significant gap between BAU emissions and observed emissions is logical and plausible:

"*...the refutable presumption must be that the EU ETS succeeded in abating $CO_2$ emissions in its first two years based on three observations.*

1. *A significantly positive EUA price. A significant price was paid for $CO_2$ in 2005-06, which would have the effect of reducing emissions as firms adjust to this new economic reality.*

2. *Rising real output. Real output in the EU has been rising at the same time that the rate of improvement in $CO_2$ intensity has been declining, which has led to rising $CO_2$ emissions before 2005.*

3. *Historical emissions data that indicate a reduction of emissions even after allowing for plausible bias.*"

There seem to be logical arguments in favor of either concluding that BAU emissions are very similar to the observed verified emissions levels, or that abatement or inflation created a significant difference between the counterfactual and verified emissions. In the rest of the paper we attempt to clarify this issue by estimating BAU emissions, and assess the previous claims. We begin by describing the data and the econometric methodology used for our estimates of BAU emissions for the pilot phase.

[1]According to the CITL, 'Combustion' installations were allocated approximately 70% of pilot phase EUAs.

[2]Sijm, Neuhoff, and Chen (2006) find the EUA cost pass-through rate was between 60-100% in Germany and Netherlands.

# 3 Data and econometric specification

## 3.1 Data

In order to calculate an emissions counterfactual for the EU ETS pilot phase we use historical data on European industrial emissions, industrial economic activity levels, climate effects, and energy prices. The historical and pilot phase period data for factors influencing levels of $CO_2$ emissions (our dependent variable) are obtained from public data sources. However, the only firm level data for EU ETS participants for the years prior to the trading period are the historical baseline emissions as supplied by firms which are aggregated and reported in National Allocation Plans (NAPs). This "baseline" period was generally around 2002 while different countries allowed the use of different methodologies, such as averaging or dropping certain years, for establishing a 'reasonable' historical baseline (Ellerman and Buchner, 2007). A single historical point does not allow for an econometric analysis and therefore we obtain historical emissions data from Eurostat, and match historical emissions classified by NACE codes to the sectors participating in the EU ETS.

**Industrial $CO_2$ emissions.** Eurostat aggregates emissions according to NACE classification of the emitter. Based on these classifications, we have selected a subset of total national emissions that we feel are most comparable to those sectors participating in the EU ETS. Table 1 outlines the process of matching historical emissions according to NACE classifications in Eurostat to the sectors participating in the EU ETS as outlined in Annex 1 of the EU ETS Directive (European Commission, 2003). Just as the EU ETS does not cover the entire economy, we have chosen a subset of total $CO_2$ emissions that we feel best represents emissions from those industries participating in the EU ETS. Hereafter, the chosen subset of emissions is referred to as "Eurostat emissions".

Eurostat emissions can be considered a reasonable proxy for historical EU ETS emissions only if the matching process produces satisfactory data in terms of the absolute magnitude of emissions by country, and if the ratio between Eurostat emissions and the (unobserved) historical emissions of EU ETS firms is relatively constant over time. We use verified emissions data from 2005-2006 to analyze the quality of our chosen subset of total emissions from Eurostat. Table 2 displays Eurostat emissions, verified EU ETS emissions and the ratio of the two. A ratio close to one is indicative of a good matching between NACE classifications in Eurostat and EU ETS sectors. For most countries in both 2005 and 2006, the only years for which verified EU ETS data and Eurostat emissions data exist, we feel the chosen subset of emissions is a good proxy for EU ETS firms as most countries have ratios close to one. For the EU25 we feel the chosen subset of Eurostat emissions is a strong fit.

The last column in Table 2 contains the ratio of baseline emissions as reported in the NAPs of each member state, and summarized by the German Emissions Trading Authority (DEHSt, 2005), and Eurostat emissions. In countries where averaging was used to determine baseline emissions, averages of Eurostat emissions were also used for the relevant years to ensure consistency. These baseline figures are not verified data and, according to Ellerman and Buchner (2007), the data collection effort was largely a voluntary submission by the industries involved, conducted under severe time pressures with a lack of desirable verification. While industries cooperated in submitting the relevant emissions data, it is clear that there was an incentive to attempt to influence allocation by reporting inflated historical emissions. This point is highlighted by comparing the ratios for 2005 and 2006, to the baseline ratios. For example, Austrian EU ETS baseline emissions were very close to Eurostat emissions in magnitude with a ratio of 1.009, but in the first two years of trading, verified emissions were approximately 93-94% of

Table 1: EU ETS and Eurostat emissions matching

| Eurostat emissions sources | Eurostat emissions categories | EU ETS sectors (EC, 2003) |
|---|---|---|
| Fuel Combustion | Public Electricity and Heat Production | Combustion inst. > 20 MW |
| Fuel Combustion | Petroleum Refining | Mineral oil refineries |
| Fuel Combustion | Manufacture of Solid Fuels and other energy industries | Coke ovens<br>Combustion inst. > 20 MW |
| Fuel Combustion | Iron and steel | Pig iron or steel |
| Fuel Combustion | Non-Ferrous metals | Metal ore (including sulphide ore) roasting or sintering |
| Fuel Combustion | Chemicals | Cement, clinker and lime ion<br>Glass including glass fibre<br>Ceramic products |
| Fuel Combustion | Pulp, paper and print | pulp from timber,<br>paper and board > 20 t/d |
| Fuel Combustion | Food Processing, Beverages and Tobacco | Combustion inst. > 20 MW |
| Industrial Processes | Metal production | Pig iron or steel<br>Metal ore (including sulphide ore) roasting or sintering |
| Industrial Processes | Mineral production | Cement, clinker and lime<br>Glass and ceramics |

Source: Eurostat and European Commission (2003)

Eurostat emissions. Either Austrian baseline emissions data were inflated, or the EU ETS' share of Eurostat emissions is shrinking due to other economic factors. For most countries (18 out of 25), the historical baseline ratio is higher than the verified emissions ratios for 2005 and 2006. It is not unreasonable to assume historical inflation, given the clear incentives to do so for industry and we are comfortable that the assumption of a relatively constant share of ETS industry of the chosen industrial emissions does not invalidate the use of Eurostat emissions as a proxy for historic EU ETS emissions. In order to make projections of emissions for 2007 we assume that the EU ETS share of emissions in 2007 is the same as in 2006 since at the time of writing Eurostat emissions data for 2007 was not available.

**Industrial economic activity levels.** Eurostat provides data on industrial production levels by NACE classification. Eurostat's annual indices of production (working days adjusted) for Mining and Quarrying (NACE C), Manufacturing (NACE D), Energy (NACE E), Total Industry excluding construction (NACE C_D_E) and "Total industry excluding construction and the energy sector" are considered as potential indicators of the economic activity levels for the EU ETS sectors. Based on the activities of EU ETS firms as outlined in Annex 1 of the EU ETS Directive (European Commission, 2003) both indices of economic activity for the manufacturing and

Table 2: EU ETS verified emissions and Eurostat emissions (Kt $CO_2$)

| | 2005 | | | 2006 | | | Historical |
|---|---|---|---|---|---|---|---|
| Country | Eurostat | Verified EUAs | Ratio | Eurostat | Verified EUAs | Ratio | Ratio |
| | A | B | =B/A | C | D | =D/C | |
| AT | 35,598 | 33,373 | 0.937 | 34,962 | 32,383 | 0.926 | 1.009 |
| BE | 56,770 | 55,363 | 0.975 | 55,253 | 54,775 | 0.991 | 1.081 |
| CY | 4,416 | 5,079 | 1.150 | 4,608 | 5,259 | 1.141 | 1.021 |
| CZ | 83,411 | 82,455 | 0.989 | 86,744 | 83,625 | 0.964 | 1.261 |
| DE | 441,661 | 474,991 | 1.075 | 444,580 | 478,017 | 1.075 | 1.152 |
| DK | 26,253 | 26,476 | 1.009 | 33,547 | 34,200 | 1.019 | 1.002 |
| EE | 13,219 | 12,622 | 0.955 | 12,573 | 12,109 | 0.963 | 0.985 |
| ES | 183,219 | 183,627 | 1.002 | 174,270 | 179,697 | 1.031 | 1.054 |
| FI | 34,081 | 33,100 | 0.971 | 45,296 | 44,621 | 0.985 | 0.974 |
| FR | 137,844 | 131,264 | 0.952 | 131,409 | 126,979 | 0.966 | 1.066 |
| GR | 69,472 | 71,268 | 1.026 | 66,364 | 69,965 | 1.054 | 1.036 |
| HU | 29,612 | 26,162 | 0.883 | 29,653 | 25,846 | 0.872 | 0.928 |
| IE | 21,298 | 22,441 | 1.054 | 20,305 | 21,705 | 1.069 | 0.966 |
| IT | 224,965 | 225,989 | 1.005 | 225,186 | 227,439 | 1.010 | 1.065 |
| LT | 6,727 | 6,604 | 0.982 | 6,410 | 6,517 | 1.017 | 0.989 |
| LU | 2,338 | 2,603 | 1.113 | 2,491 | 2,713 | 1.089 | 1.213 |
| LV | 2,861 | 2,854 | 0.997 | 2,912 | 2,941 | 1.010 | 1.102 |
| MT | 1,960 | 1,971 | 1.006 | 1,976 | 1,986 | 1.005 | 1.014 |
| NL | 92,344 | 80,351 | 0.870 | 87,555 | 76,701 | 0.876 | 0.888 |
| PL | 213,054 | 203,150 | 0.954 | 223,631 | 209,616 | 0.937 | 1.004 |
| PT | 33,204 | 36,426 | 1.097 | 30,292 | 33,084 | 1.092 | 1.096 |
| SE | 21,325 | 19,382 | 0.909 | 20,876 | 19,889 | 0.953 | 0.972 |
| SI | 8,451 | 8,721 | 1.032 | 8,424 | 8,842 | 1.050 | 1.170 |
| SK | 24,640 | 25,232 | 1.024 | 24,867 | 25,543 | 1.027 | 1.083 |
| UK | 241,016 | 242,513 | 1.006 | 245,920 | 251,160 | 1.021 | 1.155 |
| EU25 | 2,009,739 | 2,014,017 | 1.002 | 2,020,104 | 2,035,612 | 1.008 | 1.051 |

Source: Eurostat, DEHSt (2005), CITL and own calculations

energy sectors are used in the analysis. While these indices are likely to also include firms and industries not covered under the EU ETS, we feel them to be good indicators of the economic activity levels of EU ETS industries. As a robustness check, alternative indices are also used in a separate analysis, whose results are discussed in Section 4.2. All indices are normalized such that the 2005 level equals 100 for each member state.

**Climate factors.** Eurostat contains variables for annual heating degree days for each member state from 1990 onwards. Heating degree days are calculated as the difference between the daily mean temperature and 18 degrees Celsius, the 'heating threshold'. Each day with an average temperature below 18 degrees contributes to the annual total of heating degree days. A variable for cooling degree days is created using data from the European Climate and Assessment Database[3] (ECA&D) where daily mean temperature above 18 degrees contribute to an annual measure of cooling degree days. Precipitation data was also extracted from the ECA&D and used to create an annual precipitation variable for each country as precipitation may affect a country's ability to generate hydro electricity, if they have significant hydro generation capacity. With high precipitation levels, the possibility of producing hydroelectricity is larger, mak-

[3]See `http://eca.knmi.nl/`.

ing it easier to switch energy production from an intensive emission source to a non-intensive emission one. As a consequence, a reduction of real emissions could take place Mansanet-Bataller, Pardo, and Valor (2007). Wherever data are missing in the ECA&D, observations from `www.tutiempo.net` are used to fill the gaps.

**Electrical energy prices.** Fossil fuel prices play an important role in determining $CO_2$ emissions in both the short run – due to the substitution effect of fuel switching from emissions intensive fuels to less intensive alternatives (Delarue, Voorspools, and D'haeseleer, 2008; Delarue and D'haeseleer, 2007) – and the long run, through the income effect and the process of directed technical change. Ideally, prices for various fossil fuels used for energy production would be included as explanatory variables in our analysis. However, we do not use multiple fossil fuel prices as predictor variables for two reasons: first, a lack of data for different fuel prices for EU member states over the study period, and second, econometric difficulties of including multiple fuel price variables that are likely highly correlated. Due to these issues, we have decided to include a variable for the price of electrical energy for industrial customers in EU member states as provided by Eurostat. Using this variable is imperfect as it does not explicitly capture the effects on emissions from fuel switching, but it does offer some insight into the effect of energy prices on induced technical change and $CO_2$ emissions.

**EU ETS data.** The Community Independent Transaction Log (CITL) is the definitive EU ETS resource created by the European Commission and contains all records of issuance, transfer, cancelation, retirement and banking of allowances that take place in the registry. The data in the registry was viewed and extracted using the CITL Viewer courtesy the European Environmental Agency.[4]

## 3.2 Econometric Specification

We use dynamic panel data estimation techniques to estimate an econometric equation for industrial $CO_2$ emissions (Eurostat emissions). Dynamic models have been commonly used in energy economics to study the demand for electricity, natural gas or other sources of energy. Such studies often use a version of the flow adjustment model from Houthakker, Verleger, and Sheehan (1974) where the dependent variable is the quantity of the variable of interest, and a lagged dependent variable, price, and other explanatory variables are on the right hand side of the equation. While the purpose of our study is different from those demand studies, the methods employed are similar. The main difference between our study and energy demand studies is the price variable for electrical energy for industrial users as an explanatory variable instead of a price for $CO_2$ emissions.

The constructed panel data set is unbalanced as some countries are missing data for the early part of our study period. The missing observations primarily occur in eastern European countries that would eventually join the European Union. The existence of systematic missing observations and the $N \times T$ dimensions of the constructed data set lead us to the bias corrected least squared dummy variable (LSDVC) estimation techniques as prescribed in Bruno (2005b). Instrumental variable (IV) and General Method of Moments (GMM) dynamic panel estimators as proposed in Anderson and Hsiao (1982), Arellano and Bond (1991) and Blundell and Bond (1998) are also considered, but LSDVC techniques are preferred as IV and GMM estimator properties hold for data sets with large $N$, but can be severely biased and imprecise in panel data with a small number of cross-sectional units (Bruno, 2005a). Judson and Owen (1999) and Bun

[4]The CITL viewer is available at `http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3529`.

and Kiviet (2003) also prove the virtues of least square dummy variable (LSDV) estimation in small N panels that are common in macroeconomic studies, but only for the case of balanced panel data sets. Bruno's (2005b) LSDVC estimator is adapted for the case of unbalanced panels and is deemed the most appropriate estimation technique given the characteristics of our data set. LSDVC estimators are calculated using the algorithm outlined in (Bruno, 2005a) where consistent estimators are initially calculated using either GMM (Arellano and Bond, 1991; Blundell and Bond, 1998) or IV (Anderson and Hsiao, 1982) methods as a first step, and these estimators are then used to initiate a second step where bias in the consistent IV or GMM estimators is corrected to surrender the final bias-corrected parameter estimates.

We use an unbalanced panel data set consisting of 25 countries[5] over the period 1990-2007 to estimate the following equation:

$$CO2_{it} = \beta_1 CO2_{it-1} + \beta_2 econ\_D_{it} + \beta_3 econ\_E_{it} + \beta_4 elect_{it} + \beta_5 hdd_{it} + \beta_6 cdd_{it} + + \beta_7 rain_{it} + u_i + e_{it},$$

Where $CO2$ is Eurostat emissions, $econ\_D$ and $econ\_E$ are Eurostat's indices of production for the Manufacturing and Energy sectors, respectively, $elect$ is the price of electrical energy for industrial customers, $hdd$ and $cdd$ are heating and cooling degree days, $rain$ is an annual measure of precipitation, $u$ is the country fixed effect, and $e$ is the idiosyncratic error term. We calculate Arellano and Bond (1991) estimators in the first step of the LSDVC algorithm and include time dummies based on the requirement that 'first step' estimators must be consistent in order to initialize the bias correcting second step. We initially included time period dummies based on the recommendation of (Roodman, 2006) when calculating Arellano and Bond (1991) estimators but joint insignificance of the time dummies along with stronger model performance (as a predictor) without dummies, led us to repeat the analysis with time dummies omitted. All variables are in natural logarithms and $i$ and $t$ subscripts denote country and year, respectively.

# 4 Econometric Results

## 4.1 Estimation Results

The dynamic panel estimation is done in Stata using the techniques explained in Bruno (2005b) where Arellano and Bond (1991) (AB hereafter) estimators are generated in the first step to initiate bias correction in the second step of the algorithm. Table 3 gives the estimation results for two specifications: equation (1) on the left of the table is the original estimation, and equation (2) contains interaction variables that allow us to perform a Chow test for the structural integrity of the parameters over the study period. The results of the Chow test are discussed further in Section 4.2

The significance of the lagged dependent variable is as expected in Equation (1), and is of similar magnitude to the lagged dependent variable coefficients in Kamerschen and Porter (2004) but slightly smaller than those for the industrial energy demand equation in Considine (2000). The signs and statistical significance of the economic variables for the energy and manufacturing sectors are also not surprising as a major source of emissions in manufacturing is from electrical energy consumption, while only a small portion of manufacturing emissions arise from industrial processes. This is reflected in the positive but statistically insignificant coefficient on $NACE\_D$ coupled with strong significance of the $NACE\_E$ parameter estimate. The

[5] Romania and Bulgaria are excluded from the analysis as they joined the scheme in 2007, and there are issues concerning their EU ETS and historical data.

Table 3: Estimation Results

| Equation | (1) | | (2) | |
|---|---|---|---|---|
| | Coeff. | St. Err | Coeff. | St. Err |
| $CO2_{t-1}$ | 0.6542*** | (0.0710) | 0.6525*** | (0.0723) |
| NACE_D | 0.0076 | (0.0439) | 0.0135 | (0.0523) |
| NACE_E | 0.2336*** | (0.0688) | 0.2649*** | (0.0859) |
| elect | -0.0371 | (0.0511) | -0.0057 | (0.0578) |
| hdd | 0.0875 | (0.0839) | 0.0843 | (0.0846) |
| cdd | 0.0094 | (0.0108) | 0.0098 | (0.0106) |
| rain | -0.0242 | (0.0224) | -0.044 | (0.0244) |
| euets | | | 0.1601 | (0.5660) |
| NACE_D_euets | | | -0.0116 | (0.1040) |
| NACE_E_euets | | | -0.0293 | (0.1135) |
| elect_euets | | | 0.0008 | (0.0665) |

Number of observations = 251, Number of groups = 25.

Notes: *** indicates significance at the 1% level;

Joint test for significance of interaction and euets terms: $\chi^2(4) = 5.56$, Prob > $\chi^2 = 0.2349$.

coefficient estimate on the electrical energy price variable is of the expected sign but lacks statistical significance, likely due to the fact that substitution between (energy and non-energy) factors of production according to relative prices is not an immediate process.

The climate variables for heating and cooling degree days are not statistically significant and these results are similar to those found in earlier industrial energy demand studies by Polemis (2007) and Kamerschen and Porter (2004). This study focuses only on industrial emissions, and not residential or total national emissions. If the focus were shifted to residential or commercial emissions, or emissions arising solely from the electricity sector, climatic variables would be expected to grow both in magnitude and statistical significance, as found in Considine (2000) and Pardo, Meneu, and Valor (2002). The coefficient on the precipitation variable is of the expected sign, but lacks statistical significance; this is reasonable as not all member states have considerable hydro power capacity in their utility mix and as a result, precipitation levels are not expected to have an effect on $CO_2$ across all countries.

### 4.2 Parameter stability and robustness checks

It possible that the parameter estimates displayed in equation (1) of Table 3 are not stable over the study period, due to a structural break caused by the the start of the EU ETS in 2005. We perform a Chow test for structural change of parameters across time as explained in (Wooldridge, 1999) to test if a structural break occurred as a result of the presence of the EU ETS. We create a dummy variable (called '$euets$') that takes a value of 1 for 2005-2007 and 0 for the previous years for all countries. The dummy is interacted with the economic activity variables for manufacturing and energy sectors and the price of electrical energy for industrial consumers, and the joint significance of the interaction terms is tested.

Given the value of the test statistic for the joint significance of $euets$ and the interaction terms, and the associated probability value (Prob > $\chi^2$ = 0.2349), we cannot reject the null hypothesis of no structural break, and conclude that the existence of the EU ETS did not significantly change the relationship between the level of $CO_2$ emissions, and the potentially endogenous explanatory variables. This finding is in line with the literature on the EU ETS and EU industrial "competitiveness". In an ex-ante study Reinaud (2004) concludes that the cost impacts of the EU ETS on some key industrial sectors are not likely to lead to major negative impacts on the competitiveness in the near term.[6] Anger and Oberndorfer (2008) use German firm level data to empirically support the same conclusion of no economic disadvantage to EU ETS firms in the pilot phase by econometrically examining EU ETS firms' revenues and employment levels. Most of the competitiveness concerns associated with the EU ETS were focused on sectors that participated in global markets with competitors that did not face emissions constraints, such as iron/steel and the cement industry. The iron and steel industry experienced weak production losses and profitability losses – as measured by changes in EBITDA[7] – are likely to be positive given the level of free allocation in the pilot phase (Demailly and Quirion, 2008). Demailly and Quirion (2006) conclude that given the pilot phase allocations, neither the production level nor the EBITDA of the European cement industry is significantly impacted, even for a very high $CO_2$ price. In an ex-ante study, Smale, Hartley, Hepburn, Ward, and Grubb (2006) have similar findings where most UK participating sectors (cement, newsprint, petroleum, steel and aluminum) would be expected to profit in general, although with a modest loss of market share in the case of steel and cement, and closures in the case of aluminum.

While it is imperative that the econometric estimation give results that are in line with a priori expectations in terms of coefficient sign and significance, the purpose of our estimation is not to draw inference from parameter estimates, but to calculate in-sample projections for EU ETS $CO_2$ emissions. Accordingly, we compare fitted values from the above specification to observed emissions data in order to analyze the model's performance as a tool for predicting national emissions. The high level of correlation (0.9992) between past emissions and fitted values from our model gives us confidence that our specification is appropriate for calculating EU ETS BAU emissions.

To verify the robustness of our results, we repeat the analysis using different indices of industrial production as indicators of economic activity, and different dynamic panel data estimators to initialize bias correction and compute LSDVC estimators. The different indices are those explained in section 3, while AB, Anderson and Hsiao (1982) and Blundell and Bond (1998) estimators are used as first step estimators for each economic index. We judge the performance of the alternative specifications based on the correlation and variance between fitted values from the model and observed values. We conclude that the specification using AB estimators to initialize bias correction, and $NACE\_D$ and $NACE\_E$ as economic variables performs strongest as a prediction tool.[8]

### 4.3 Pilot Phase Projections

Pilot phase BAU emissions are calculated by taking the projections for industrial $CO_2$ emissions and multiplying that by the percentage of Eurostat emissions that are attributable to the ETS sectors as shown in Table 2. For example, Austria's EU ETS BAU emissions for 2005 are calculated as follows:

EU ETS BAU emissions are compared to allocated and verified EUA's to determine the levels of misallocation, abatement and emissions inflation in each member state for each year. For

[6] Reinaud (2004) defines competitiveness losses as a loss of output through $CO_2$ leakage while considering the effects of $CO_2$ costs pass through, allocation and market structure.

[7] Earnings Before Interest Taxes Depreciation and Amortization

[8] The full results of these robustness tests are available from the authors upon request.

Table 4: Calculating EU ETS projected emissions for Austria, 2005 (Kt $CO_2$)

| Year | Allocated<br>A | Verified<br>B | Eurostat $CO_2$<br>C | Projection<br>D | Ratio[a]<br>E=B/C | EU ETS BAU<br>F =E∗D |
|---|---|---|---|---|---|---|
| 2005 | 32,413 | 33,373 | 35,598 | 35,158 | 0.937 | 32,960 |

Source: Own Calculations on NAPs, CITL and Eurostat data.

Notes: *a*. as shown in Table 2

example, in 2005 Austria experienced emissions inflation of 413 Kt $CO_2$ (33,373-32,960) of emissions inflation, and zero tonnes of abatement since verified EUAs are greater than the EU ETS BAU estimate. Continuing with allocation, Austrian firms were under-allocated 547 thousand (32,960-32,413) EUAs with no over-allocation occurring since the amount of allocated EUAs is less than the BAU level. Calculations for each member state by year for the levels of misallocation, abatement and emissions inflation are displayed in Appendix A, but we provide a summary for the EU25 in Table 5 in order to conserve space[9]. The third column in Table 5 contains our estimate of BAU emissions for EU25 member states over the pilot phase period. In 2005 and 2006 there was net abatement of 30.4 and 1.2 Mt $CO_2$ with 43.8 Mt $CO_2$ of net inflation in 2007 likely due to the price collapse of EUAs. In 2005, 2006 and 2007 there was net over-allocation of the whole system of 52, 34.9 and 71 million EUA's respectively.

Table 5: Summary of observed vs. BAU emissions for EU25 Mt $CO_2$

| | Year | Allocated | Verified | BAU | Abatement | Inflation | Over-all. | Under-all. |
|---|---|---|---|---|---|---|---|---|
| EU25 | 2005 | 2,096.4 | 2,014.0 | 2,044.4 | 46.7 | 16.3 | 109.2 | 57.2 |
| EU25 | 2006 | 2,071.7 | 2,035.6 | 2,036.9 | 37.1 | 35.8 | 123.6 | 88.7 |
| EU25 | 2007 | 2,078.7 | 2,051.5 | 2,007.8 | 23.5 | 67.2 | 143.2 | 72.2 |
| EU25 | 2005-7 | 6,246.9 | 6,101.2 | 6,089.1 | 107.2 | 119.3 | 376.0 | 218.2 |

Source: Own Calculations on NAPs, CITL and Eurostat data.

## 5 Discussion

The goal of this paper is to perform an ex-post evaluation of the pilot trading period and estimate a credible BAU emissions scenario for EU member states. Comparing the BAU to allocated and verified EUAs allows us to identify any misallocation, abatement and/or emissions inflation that may have occurred. The quantitative findings of this study, i.e. 2% emissions inflation and 6% over-allocation at the EU25 level, refer to the pilot phase of the EU ETS and cannot thus be generalized to other emissions trading programs. The details regarding allocation methodologies, and uncertainty about the future of European climate policy are unique to this policy. Our quantitative results are only intended to give insights into the overall performance of the EU ETS in the pilot phase under its unique circumstances.

In Table 6 we compare our estimates to those of Ellerman and Buchner (2008), the only study that estimates abatement and over-allocation for the whole trading system. For 2005-2006 the

[9] As with any econometric exercise, there is a certain level of uncertainty in our parameter and BAU estimates. However, errors operate in both directions and we have no reason to believe that our parameter or BAU estimates contain significant systematic bias. While yearly BAU estimates might be stronger for some member states than others, we feel the aggregate of the estimates is a credible estimate for EU25 BAU emissions given the high correlation of fitted values and observed emissions in the past for the entire data set

over-allocation numbers are comparable. But the abatement estimates are much higher in the Ellerman and Buchner (2008) study as a result of the timing of their study, the data and analytic techniques used to estimate the counterfactual. For the most part, Ellerman and Buchner use national level data for economic activity, carbon intensity, and energy intensity. The country level trends are compared with industry specific data and the authors assume that there is sufficient correlation to rely on national level data. Due to timing, our study benefits instead from the availability of ex post data, and we feel that our estimates of BAU emissions, and the resulting gross abatement calculations are a refinement of those in Ellerman and Buchner (2008) thanks to the use of econometric techniques, industry level data on emissions, economic activity, electric energy prices and climate factors.

Table 6: Comparison with Ellerman and Buchner (2008) (Mt $CO_2$)

| Year | Ellerman and Buchner (2008) | | Anderson and Di Maria (2009) | | | |
|---|---|---|---|---|---|---|
| | Over-Alloc. | Abatement | Gross Over-Alloc. | Net Over-Alloc. | Gross Abatement | Net Abatement |
| 2005 | ≤125 | 130-200 | 109 | 52 | 47 | 30 |
| 2006 | ≤125 | 140-220 | 124 | 35 | 37 | 1 |
| 2007 | – | – | 143 | 71 | 23 | -44 |

Source: Ellerman and Buchner (2008), and own calculations.
Note: Numbers may not add up due to rounding.

The results of our analysis highlight the importance of reliable and accurate data when designing an emissions trading scheme to create incentives to reduce emissions. By observing in Table 2 that 18 of 25 member states have higher ratios of Eurostat emissions to EU ETS emissions in the baseline period than in the pilot phase, we are forced to question the integrity of the historical baseline data. Table 7 displays the average verified emissions by member state, our EU ETS BAU emissions estimates, and the BAU projections from the NAPs as reported by the German Emissions Trading Authority (DEHSt, 2005). The last column in Table 7 is the percentage of emissions reductions achieved by each member state, if we consider the ex ante BAU emissions from the NAPs accurate and trustworthy. We must either conclude that 15 of the 25 member states achieved double digit percentage reductions in emissions and the pilot phase was very successful, or that the ex-ante projections of pilot phase BAU emissions were of questionable quality.

When questionable baseline data is combined with overly optimistic ex-ante economic projections, the likely result is inflated BAU emissions projections and almost certainly permit misallocation. Misallocation (including over-allocation) undoubtedly leads to equity issues, market distortions and perverse incentives when it comes to reducing emissions, which is the primary objective of any emissions trading scheme.

It appears the European Commission learned its lesson during the pilot phase and amendments to the original EU ETS Directive were adopted by the European Commission in January, 2008.[10] The main changes in EU ETS design are a clearly announced move towards increased auctioning of allowances, dismissal of NAPs, and a tightening of the overall cap from 2013 en route to a target of 21% reduction below 2005 verified EU ETS levels. Auctioning, combined with top down cap formation is necessary so that distortions arising from free-riding incentives for both industries and governments in the generation of projections do not repeat themselves. From 2013 onwards, it appears that any strategic behaviour carried out in the early years

[10] See adopted text at `http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=3529`

Table 7: NAP projections and verified EUAs (Mt $CO_2$)

| Country | Ave. vfd. EUAs | Anderson et al. (2009) BAU Ave. | NAP BAU Ave. (DEHSt, 2005) | % Difference verified EUA and NAP BAU (%) |
|---|---|---|---|---|
| AT | 32.5 | 33.0 | 34.7 | 6.8 |
| BE | 54.3 | 57.7 | 64 | 17.9 |
| CY | 5.2 | 5.4 | 5.7 | 9.6 |
| CZ | 84.6 | 85.0 | 103.7 | 22.6 |
| DE | 480 | 474.2 | 499 | 4.0 |
| DK | 30 | 30.5 | 39.3 | 31.0 |
| EE | 13.4 | 13.0 | 14 | 4.5 |
| ES | 183.2 | 177.9 | 181.6 | -0.9 |
| FI | 40.1 | 41.3 | 46.6 | 16.2 |
| FR | 128.3 | 131.2 | 163.8 | 27.7 |
| GR | 71.3 | 73.0 | 76 | 6.6 |
| HU | 26.3 | 26.7 | 31.3 | 19.0 |
| IE | 21.8 | 22.9 | 23 | 5.5 |
| IT | 226.6 | 232.9 | 244.5 | 7.9 |
| LT | 6.4 | 6.5 | 14 | 118.8 |
| LU | 2.6 | 2.4 | 3.7 | 42.3 |
| LV | 2.9 | 2.9 | 4.4 | 51.7 |
| MT | 1.3 | 2.0 | 2.9 | 123.1 |
| NL | 79 | 78.5 | 98.6 | 24.8 |
| PL | 207.5 | 205.6 | 263 | 26.7 |
| PT | 33.6 | 35.4 | 38.9 | 15.8 |
| SE | 18.2 | 20.2 | 26.6 | 46.2 |
| SI | 8.9 | 8.8 | 9.5 | 6.7 |
| SK | 25.1 | 25.2 | 36.2 | 44.2 |
| UK | 250.1 | 237.4 | 267.3 | 6.9 |
| EU25 | 2033.2 | 2029.7 | 2292.3 | 12.7 |

Source: Own Calculations on NAPs, CITL and DEHSt (2005).

of trading will have a muted effect as only firms that are exposed to international competition will be awarded partial free allocations.

At the time of writing, it seems unlikely that any rewards will be gained by strategic activities in the second phase (2008-2012) of trading. While the fact that 2005 verified EU ETS emissions are above our corresponding BAU estimates for 16 of the 25 member states (See Appendix A) supports our claim that at least some strategic behavior was rewarded, as 2005 verified emissions data was used for the 2008-2012 allocation process, it is doubtful that benefits are accruing to any firm. Indeed, as the recession in Europe continues to deepen and industrial activity falls there is much downward pressure on EUA prices. The dramatic difference between the projected economic path at the time of 2008-2012 allowance allocation, and the current economic circumstances has altered the emissions trading landscape in the short term, and allocations that may have been somewhat of a strategic reward, are likely to have little value in the current economic environment.

Various countries of the world are in the process of designing climate change policy with emissions trading as a key feature. The most prominent is the United States where cap and trade is already occurring at the regional level with the likelihood of federal legislation growing constantly as support spreads from environmental groups, to some companies and other non-traditional sources such as religious groups (Stavins, 2008). As the one of the largest emitters in the world[11], U.S. climate change policy is important due to the magnitude of its emissions, but also in political terms. Credible climate policy leading to a reasonable $CO_2$ price in the U.S. is a necessary step towards the sort of global agreement that is likely required to deal with the global nature of climate change. We would like to conclude summarizing the main insights of our study for trading schemes beyond the EU ETS. Our analysis points at three key elements for the success of an emissions trading scheme: first, we highlight the necessity of reliable emissions data to establish a sound footing for the construction of the BAU scenario; second, our discussion of the incentives for member states and industry, implies that a system of centralized cap setting (top-down) is less prone to produce lax caps and to lead to overallocation; finally, auctioning allowances, by limiting the possibility of windfall gains for the participants in the scheme is likely to reduce strategic behaviour, and rent seeking.

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[11] China passed the U.S. in 2006 to become the world's largest emitter

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# A Full Output

Table A.1: Summary of observed vs. BAU emissions for EU25 countries, 2005-2007 (Mt $CO_2$)

| Country | Year | Allocated | Verified | BAU | Abatement | Inflation | Over-all. | Under-all. |
|---|---|---|---|---|---|---|---|---|
| AT | 2005 | 32,413 | 33,373 | 32,960 | - | 413 | - | 547 |
| BE | 2005 | 58,310 | 55,363 | 58,506 | 3,143 | - | - | 196 |
| CY | 2005 | 5,471 | 5,079 | 5,482 | 403 | - | - | 11 |
| CZ | 2005 | 96,920 | 82,455 | 85,214 | 2,759 | - | 11,706 | - |
| DE | 2005 | 493,482 | 474,991 | 482,935 | 7,944 | - | 10,547 | - |
| DK | 2005 | 37,304 | 26,476 | 30,661 | 4,185 | - | 6,643 | - |
| EE | 2005 | 16,747 | 12,622 | 13,297 | 675 | - | 3,450 | - |
| ES | 2005 | 172,161 | 183,627 | 173,689 | - | 9,938 | - | 1,528 |
| FI | 2005 | 44,666 | 33,100 | 42,471 | 9,371 | - | 2,195 | - |
| FR | 2005 | 150,412 | 131,264 | 131,269 | 5 | - | 19,143 | - |
| GR | 2005 | 71,162 | 71,268 | 72,311 | 1,043 | - | - | 1,149 |
| HU | 2005 | 30,236 | 26,162 | 27,132 | 970 | - | 3,104 | - |
| IE | 2005 | 19,237 | 22,441 | 22,874 | 433 | - | - | 3,637 |
| IT | 2005 | 216,150 | 225,989 | 234,257 | 8,268 | - | - | 18,107 |
| LT | 2005 | 13,499 | 6,604 | 6,477 | - | 127 | 7,022 | - |
| LU | 2005 | 3,229 | 2,603 | 2,463 | - | 140 | 766 | - |
| LV | 2005 | 4,070 | 2,854 | 2,828 | - | 26 | 1,242 | - |
| MT | 2005 | 2,086 | 1,971 | 1,992 | 21 | - | 94 | - |
| NL | 2005 | 86,452 | 80,351 | 80,831 | 480 | - | 5,621 | - |
| PL | 2005 | 237,558 | 203,150 | 208,200 | 5,050 | - | 29,358 | - |
| PT | 2005 | 36,909 | 36,426 | 35,174 | - | 1,252 | 1,735 | - |
| SE | 2005 | 22,289 | 19,382 | 20,754 | 1,372 | - | 1,535 | - |
| SI | 2005 | 9,138 | 8,721 | 8,803 | 82 | - | 335 | - |
| SK | 2005 | 30,471 | 25,232 | 25,769 | 537 | - | 4,702 | - |
| UK | 2005 | 206,072 | 242,513 | 238,104 | - | 4,409 | - | 32,032 |
| EU25 | 2005 | 2,096,444 | 2,014,017 | 2,044,450 | 46,738 | 16,305 | 109,200 | 57,206 |
| AT | 2006 | 32,649 | 32,383 | 33,511 | 1,128 | - | - | 862 |
| BE | 2006 | 59,952 | 54,775 | 58,372 | 3,597 | - | 1,580 | - |
| CY | 2006 | 5,612 | 5,259 | 5,328 | 69 | - | 284 | - |
| CZ | 2006 | 96,920 | 83,625 | 84,183 | 558 | - | 12,737 | - |
| DE | 2006 | 495,488 | 478,017 | 475,035 | - | 2,982 | 20,453 | - |
| DK | 2006 | 27,908 | 34,200 | 28,761 | - | 5,439 | - | 853 |
| EE | 2006 | 18,200 | 12,109 | 12,915 | 806 | - | 5,285 | - |
| ES | 2006 | 166,186 | 179,697 | 182,983 | 3,286 | - | - | 16,797 |
| FI | 2006 | 44,618 | 44,621 | 37,479 | - | 7,142 | 7,139 | - |
| FR | 2006 | 149,967 | 126,979 | 133,933 | 6,954 | - | 16,034 | - |
| GR | 2006 | 71,162 | 69,965 | 74,288 | 4,323 | - | - | 3,126 |
| HU | 2006 | 30,236 | 25,846 | 26,350 | 504 | - | 3,886 | - |
| IE | 2006 | 19,238 | 21,705 | 23,695 | 1,990 | - | - | 4,457 |
| IT | 2006 | 205,050 | 227,439 | 234,025 | 6,586 | - | - | 28,975 |
| LT | 2006 | 10,577 | 6,517 | 6,820 | 303 | - | 3,757 | - |
| LU | 2006 | 3,229 | 2,713 | 2,332 | - | 381 | 897 | - |
| LV | 2006 | 4,058 | 2,941 | 2,924 | - | 17 | 1,134 | - |
| MT | 2006 | 2,167 | 1,986 | 1,969 | - | 17 | 198 | - |
| NL | 2006 | 86,388 | 76,701 | 79,455 | 2,754 | - | 6,933 | - |
| PL | 2006 | 237,558 | 209,616 | 201,960 | - | 7,656 | 35,598 | - |
| PT | 2006 | 36,909 | 33,084 | 36,880 | 3,796 | - | 29 | - |
| SE | 2006 | 22,484 | 19,889 | 20,132 | 243 | - | 2,352 | - |
| SI | 2006 | 8,692 | 8,842 | 9,000 | 158 | - | - | 308 |
| SK | 2006 | 30,487 | 25,543 | 25,158 | - | 385 | 5,329 | - |
| UK | 2006 | 206,005 | 251,160 | 239,370 | - | 11,790 | - | 33,365 |
| EU25 | 2006 | 2,071,740 | 2,035,612 | 2,036,858 | 37,057 | 35,811 | 123,625 | 88,743 |
| AT | 2007 | 32,649 | 31,751 | 32,642 | 891 | - | 7 | - |
| BE | 2007 | 60,429 | 52,795 | 56,075 | 3,280 | - | 4,354 | - |

*Continued on next page*

| Country | Year | Allocated | Verified | BAU | Abatement | Inflation | Over-all. | Under-all. |
|---|---|---|---|---|---|---|---|---|
| CY | 2007 | 5,899 | 5,396 | 5,424 | 28 | - | 475 | - |
| CZ | 2007 | 96,920 | 87,738 | 85,569 | - | 2,169 | 11,351 | - |
| DE | 2007 | 497,302 | 487,004 | 464,588 | - | 22,416 | 32,714 | - |
| DK | 2007 | 27,903 | 29,407 | 32,146 | 2,739 | - | - | 4,243 |
| EE | 2007 | 21,344 | 15,330 | 12,748 | - | 2,582 | 8,596 | - |
| ES | 2007 | 159,717 | 186,184 | 177,158 | - | 9,026 | - | 17,441 |
| FI | 2007 | 44,620 | 42,541 | 44,000 | 1,459 | - | 620 | - |
| FR | 2007 | 149,776 | 126,635 | 128,475 | 1,840 | - | 21,301 | - |
| GR | 2007 | 71,162 | 72,717 | 72,268 | - | 449 | - | 1,106 |
| HU | 2007 | 30,236 | 26,835 | 26,475 | - | 360 | 3,761 | - |
| IE | 2007 | 19,240 | 21,246 | 22,229 | 983 | - | - | 2,989 |
| IT | 2007 | 203,255 | 226,369 | 230,514 | 4,145 | - | - | 27,259 |
| LT | 2007 | 10,318 | 5,999 | 6,282 | 283 | - | 4,036 | - |
| LU | 2007 | 3,229 | 2,567 | 2,360 | - | 207 | 869 | - |
| LV | 2007 | 4,035 | 2,849 | 2,919 | 70 | - | 1,116 | - |
| MT | 2007 | 2,286 | 2,027 | 1,910 | - | 118 | 376 | - |
| NL | 2007 | 86,477 | 79,875 | 75,257 | - | 4,618 | 11,220 | - |
| PL | 2007 | 237,543 | 209,602 | 206,622 | - | 2,980 | 30,921 | - |
| PT | 2007 | 36,909 | 31,183 | 34,211 | 3,028 | - | 2,698 | - |
| SE | 2007 | 22,846 | 15,348 | 19,838 | 4,490 | - | 3,008 | - |
| SI | 2007 | 8,246 | 9,049 | 8,691 | - | 358 | - | 445 |
| SK | 2007 | 30,487 | 24,517 | 24,734 | 217 | - | 5,753 | - |
| UK | 2007 | 215,875 | 256,581 | 234,634 | - | 21,947 | - | 18,759 |
| EU25 | 2007 | 2,078,703 | 2,051,545 | 2,007,768 | 23,453 | 67,229 | 143,175 | 72,241 |