MIT Joint Program on the
Science and Policy of Global Change

Over-Allocation or Abatement?
A Preliminary Analysis of the EU Emissions Trading Scheme Based on the 2006 Emissions Data

A. Denny Ellerman and Barbara Buchner

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Over-Allocation or Abatement? *A Preliminary Analysis of the EU Emissions Trading Scheme Based on the 2005 Emissions Data*

A. Denny Ellerman and Barbara Buchner †

Abstract

This paper provides an initial analysis of the European Union Emissions Trading Scheme (EU ETS) based on the installation-level data for verified emissions and allowance allocations in the first trading year. Those data, released on May 15, 2006, and subsequent updates revealed that CO_2 emissions were about 4% lower than the allocated allowances. The main objective of the paper is to shed light on the extent to which over-allocation and abatement have taken place in 2005. We propose a measure by which over-allocation can be judged and provide estimates of abatement based on emissions data and indicators of economic activity as well as trends in energy and carbon intensity. Finally, we discuss the insights and implications that emerge from this tentative assessment.

Contents

1. INTRODUCTION

On May 15, 2006, the European Commission officially released installation-level data for verified emissions and allowance allocations for 2005, the first of the three years of the trial period for the European Union's CO_2 Emissions Trading Scheme (EU ETS). Those data and subsequent updates revealed that CO_2 emissions were about 80 million tons or 4% lower than the number of allowances distributed to installations for 2005 emissions. This long position has been interpreted as evidence of over-allocation, something that had been suspected but which seemed belied by the higher than expected prices that had prevailed before the release of these data. While over-allocation cannot be dismissed as a possibility, a long position is not *per se* evidence of over-allocation. Installations that had abated in order to sell allowances or to bank them for use in later years would appear in these data as long. In fact, it would be impossible based on a simple comparison of allocations and emissions at the installation level to determine whether a long position indicated over-allocation or abatement. Hence, the question posed by the title of this paper.

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The rest of the paper is organized in four sections. The first presents and comments on the 2005 data as well as the price movements associated with the release of these data. Although a full discussion of European Union Allowance (EUA) pricing is beyond the scope of this paper, an understanding of what EUA prices did—and perhaps more importantly what they did not do—bears on any discussion of over-allocation and abatement. The next section addresses over-allocation and proposes a measure by which over-allocation can be judged. Then, we turn to abatement and provide some estimates of abatement based on the 2005 emissions data and economy-level indicators of economic activity and trends in energy and carbon intensity. The last section concludes.

2. THE 2005 DATA AND EUA PRICES

Table 1 provides the 2005 installation-level data aggregated by member states ordered by the size of the 2005 allocation. The last two columns indicate the extent to which the installations in each member state are as a whole either long or short both in absolute and percentage terms.

A number of comments need to be made concerning these data. First, they are not complete. A number of installations in some countries have yet to report and the entries for some installations have changed since first reported in May 2006. The figures presented here are updated through 31 October 2006, as of which date information on 10,046 installations in 23

Table 1. A general picture of the EU ETS in its first year.

	Allocation 2005 (Mt CO_2)	Emissions 2005 (Mt CO_2)	Difference (Mt CO_2)	Difference (Percentage)
TOTAL	**2,087.9**	**2,006.6**	**81.3**	**3.9**
Germany	495.0	474.0	20.9	4.2
Poland	235.6	205.4	30.1	12.8
Italy	215.8	225.3	–9.5	–4.4
UK	206.0	242.5	–36.4	–17.7
Spain	172.1	182.9	–10.8	–6.3
France	150.4	131.3	19.1	12.7
Czech Republic	96.9	82.5	14.5	14.9
Netherlands	86.5	80.4	6.1	7.1
Greece	71.1	71.3	–0.1	–0.2
Belgium	58.3	55.4	3.0	5.1
Finland	44.7	33.1	11.6	25.9
Denmark	37.3	26.5	10.8	29.0
Portugal	36.9	36.4	0.5	1.3
Austria	32.4	33.4	–1.0	–3.0
Slovakia	30.5	25.2	5.2	17.2
Hungary	30.2	26.0	4.2	13.9
Sweden	22.3	19.3	3.0	13.3
Ireland	19.2	22.4	–3.2	–16.4
Estonia	16.7	12.6	4.1	24.6
Lithuania	13.5	6.6	6.9	51.1
Slovenia	9.1	8.7	0.4	4.6
Latvia	4.1	2.9	1.2	29.9
Luxembourg	3.2	2.6	0.6	19.4

Source: Own calculations based on data provided by the CITL.

member states had been made available on the CITL. [1] These installations account for 88% of the installations and 96% of the EUAs allocated directly to installations. The remaining installations are small and their emissions are not likely to change the over-all length of EU ETS in 2005 significantly.[2]

Second, the allowance totals for member states reflect the allowances distributed to installations in 2005 and not the annual average of all allowances that will be distributed during 2005-07. European Union Allowances (EUAs) reserved for new entrants, auctions, or early action awards are not included and in many cases these reserves have not yet been released. Also, the allowances received by installations in the first year are not necessarily one third of the total to be distributed to installations in the first trading period. Denmark, for instance, made annual distributions in the three years of 40%, 30%, and 30%.

Third, and finally, these data do not indicate the amount of purchases and sales made by specific facilities, although they do have implications for trading patterns. All that is indicated is the difference between the 2005 allocation and 2005 verified emissions. Installations that are shown to be short, that is, with 2005 emissions greater than the 2005 EUA allocation, can be presumed to have purchased or otherwise acquired EUAs from other installations (or from their own 2006 endowments) to be in compliance. Conversely, installations that are revealed to be long would have EUAs for sale, but that doesn't mean that they were made available to the market or transferred to another facility having common ownership, although obviously many had been sold or transferred in order for the installations that were short to be in compliance.

The release of the emissions data had a marked effect on EUA prices, as shown by the sharp break in the price of all maturities of EUAs that can be observed in late April 2006 depicted on **Figure 1**. Following announcements by the Netherlands and the Czech Republic on Tuesday, April 25 that their emissions were 7% and 15% below the respective allocations to installations, EUA prices fell by about 10%. Subsequent announcements from the Walloon region of Belgium, France, and Spain revealing similarly long positions for the first two and a smaller than expected shortage in Spain led to a closing spot price on Friday April 28 of € 13.35, 54% below the closing spot price on Monday, April 24, of € 29.20. There were further, less severe fluctuations of price until the complete data were released on May 15; however, the essential adjustment was made in these four days and after May 15 the spot price remained close to € 15 until late September when a further less pronounced adjustment occurred.

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[1] Data for Cyprus and Malta, which account for 0.3% of EU allowances and emissions, had not been reported to the CITL when this paper was being prepared. Subsequent references to EU23 refer to data without Cyprus and Malta.

[2] The main uncertainty involves Poland. In July 2006, the Commission released data for 459 installations (out of 1088) in Poland that received 90% of Poland's annual allocation, which indicated a surplus equal to 12.8% of the allowances allocated to those installations. The figures reported in Table 1 for Poland extrapolate this percent surplus to the total allocation to Polish installations. However, as of Oct. 31, 2006, the CITL data show 481 installations with data for both allowances and emissions that constitute 60% of total allowances and which indicate a surplus of 19%. Extrapolating this percentage to the whole would add another 14 million tons to Poland's and the EU surplus. This would increase the EU surplus in Table 1 from 3.9% to 4.6%. Like most analysts and until a more complete accounting is available, we rely on the Commission's more comprehensive totals where an aggregate number is required, such as in Table 1, and on the CITL when installation data are needed in our analysis.

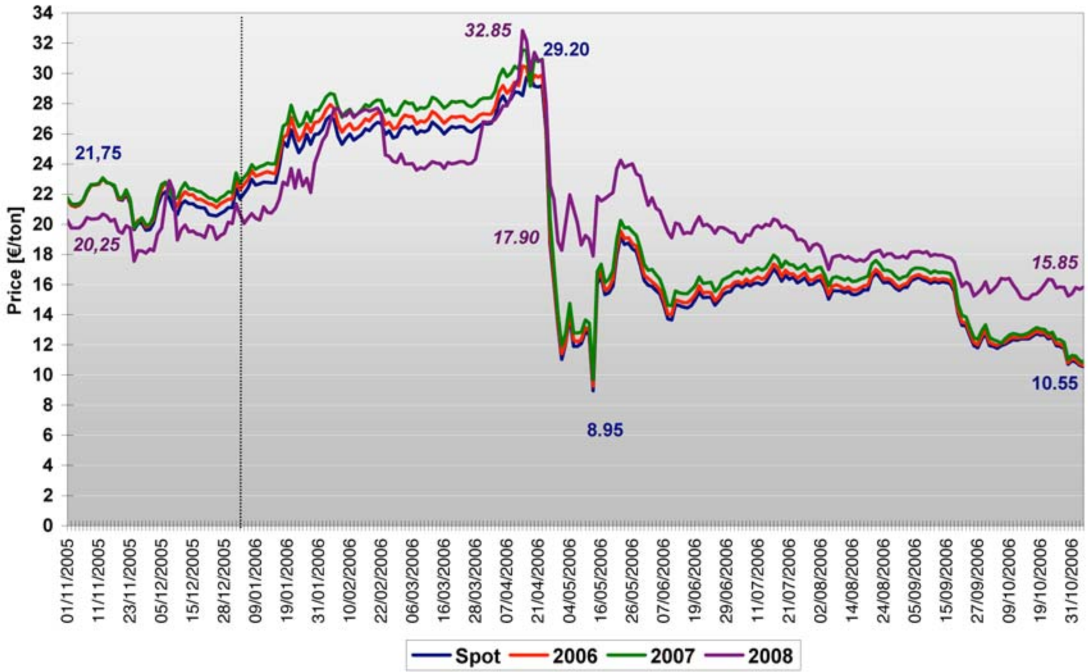

Figure 1. Price developments on the EU carbon market (OTC Market, November 2005 to October 2006). Source: Own calculations based on data from Point Carbon.

This price "collapse" demonstrated a readily observable characteristic of markets of reacting quickly (and from the standpoint of some, brutally) to relevant information. And there should be no doubt that the release of reliable information concerning emissions covered by a cap-and-trade program is highly relevant. The cap is always known, but until aggregate emission data is released no one has a really good idea of what aggregate emissions are, much less of how much emission reduction or abatement is required to comply with the cap. The same phenomenon was observed in the U.S. SO_2 emissions trading program when the first auction revealed emissions and the implied demand for allowances to be much less than expected (Ellerman *et al.*, 2000). In the case of the EU ETS, a similar adjustment of expectations concerning CO_2 emissions and the implied demand for EUAs occurred in response to the release of these data. Anyone doubting the adjustment in expectations need only refer to the headline of the guest editorial in Point Carbon's April 21 edition of *Carbon Market Europe*—"CO_2 price still too low"—and note the absence of such articles since the end of April. While the obvious explanation of the price break in late April is an adjustment of expectations, EUA prices did not go to zero and they have remained, even after the most recent adjustment, at a level that approximates the high end of the initially predicted price range.

3. DO THE 2005 DATA REVEAL OVER-ALLOCATION?

3.1 A Working Definition of Over-allocation

Over-allocation is not a well defined concept. The choice of words implies that too many allowances were created, but the standard by which "too many" is to be determined is rarely stated. Moreover, over-allocation tends to be conflated with being long, that is, having more allowances than emissions. Since any market presumes buyers and sellers and in an allowance trading system the former will be short and the latter long, it cannot be the case that everyone is short. Making sense of over-allocation requires both a standard of reference and some understanding of the reasons that some installations are short and others long.

Two standards of reference can be imagined. The first is what emissions would have been without the trading system, what can be called the counterfactual, and is termed BAU (for Business as Usual) emissions in modeling exercises. Probably all would agree that handing out more allowances than BAU emissions would constitute over-allocation. And if such were true, there would of course be no constraint and no market unless participants were poorly informed about the relationship between the cap and the counterfactual. A second standard of reference could be a cap that is constraining, that is, less than the counterfactual, but still judged not sufficiently ambitious. For instance, if the desired degree of ambition were a 5% reduction of emissions from the counterfactual, and allowances were distributed such as to require only a 2% reduction, the 3% difference might be considered over-allocation. While this second definition is plausible and seemingly the one intended in much of the current debate, we argue that it would be better to reserve the term "over-allocation" for the first definition to which all can agree.

Installations, or any aggregation of installations, such as a sector, member state, or even the system as a whole, can be long or short for a number of reasons other than "over-allocation." One of the most obvious is the very incentive that motivates trading, differences in the marginal cost of abatement. For any given allocation that is equitable and constraining, those installations with lower cost of abatement would be expected to reduce emissions in order to free up allowances to sell to installations that face higher costs of abatement. Such desired behavior would show up in reported installation data, as that released in May 2006, as data points that are both long and short according to the marginal cost of abatement at the covered installations.

A second reason for the appearance of a long position is uncertainty, the fact that the future is rarely what is expected. Supposing again an initial equitable and constraining allocation, it is inevitable that some installations will produce more than expected and others less. The consequences in an emissions trading system are that the former will be short and the latter long. It ought not to be argued that the installations that are long because they produced less than expected, and therefore had lower emissions, were over-allocated, unless one is prepared to argue that short installations were "under-allocated." Given uncertainty, the only way to overcome such over- and under-allocation would be to adjust allowances *ex post*, which would remove at least some of the incentive to abate.

The effects of uncertainty are not limited to the components of an aggregate. To the extent that economic activity, weather or any other factor affecting emissions deviates from what is expected, counterfactual emissions will be higher or lower than expected and any given cap will be more or less constraining with consequent effects on the positions of all the components. Since stochastic disturbances will tend to have a greater effect at the installation level, short and long positions will still occur but the proportions will change.

3.2 Presentation of the 2005 Data

With these considerations in mind, it is useful to look at the data for the sums of differences between emissions and allocations at the installation level for various aggregates. **Figure 2** and **Figure 3** do this for the EU as a whole and for the constituent member states both in absolute and relative terms. In both of these figures, the data are portrayed as the sum of the differences for all the installations having long and short positions, respectively as “gross long” and “gross short.” Each aggregate then has either a “net long” or a “net short” position (indicated by the bold red and blue bars) and that is equal to the difference between the “gross long” and “gross short” data points for that aggregate.

Figure 2, where the differences are expressed as percentages of the total allocation to installations constituting the aggregate, is the more instructive display of the information for the purposes of developing some measure of over-allocation. Lithuania can serve as an example of evident over-allocation. Only three installations were short and the difference between total emissions and total allowances allocated to installations was slightly over 50% of 2005 emissions. While over-allocation seems evident, figuring out how much would be difficult since it is quite possible that the levels of economic activity in Lithuania were not what was expected, that Lithuanian installations may have abated, or that some other factor may explain some or all of the long position.

At the other extreme is the UK where installations were both long and short, but the extent to which installations were short was much greater than the corresponding figure for installations

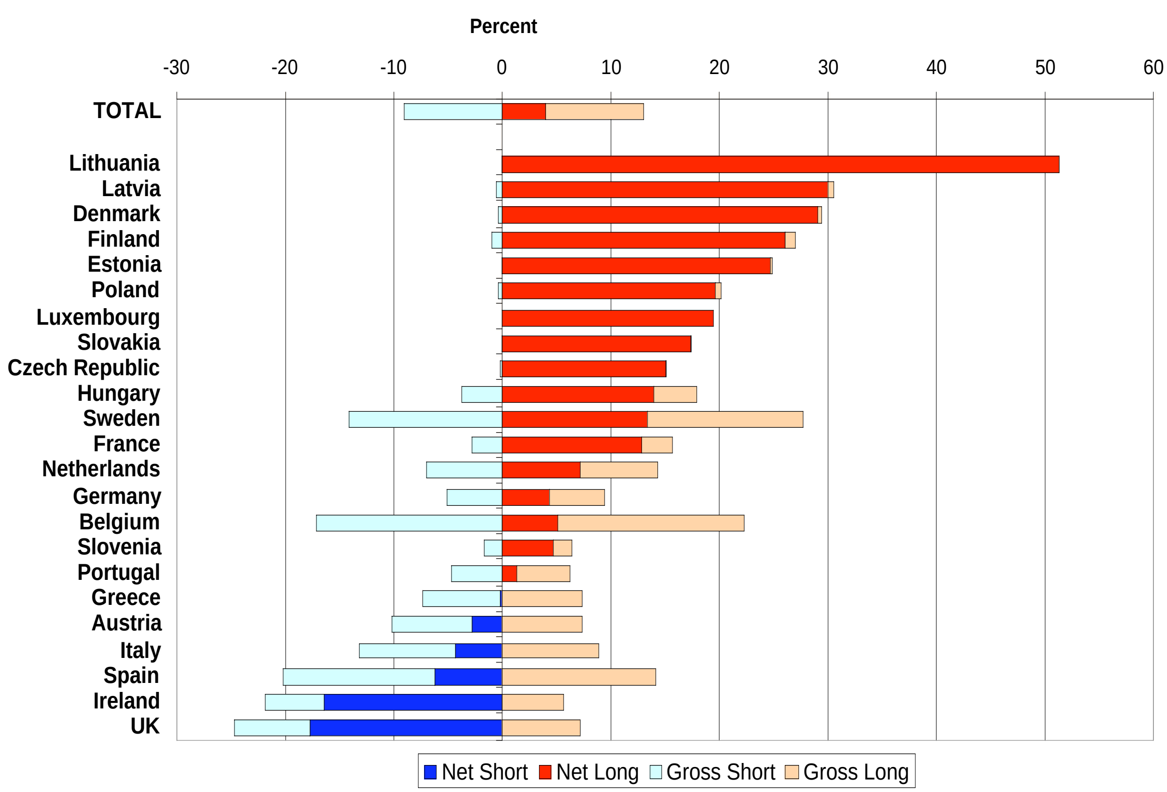

Figure 2. Short and long positions by member state in percent. Source: CITL and Kettner *et al*. (2006).

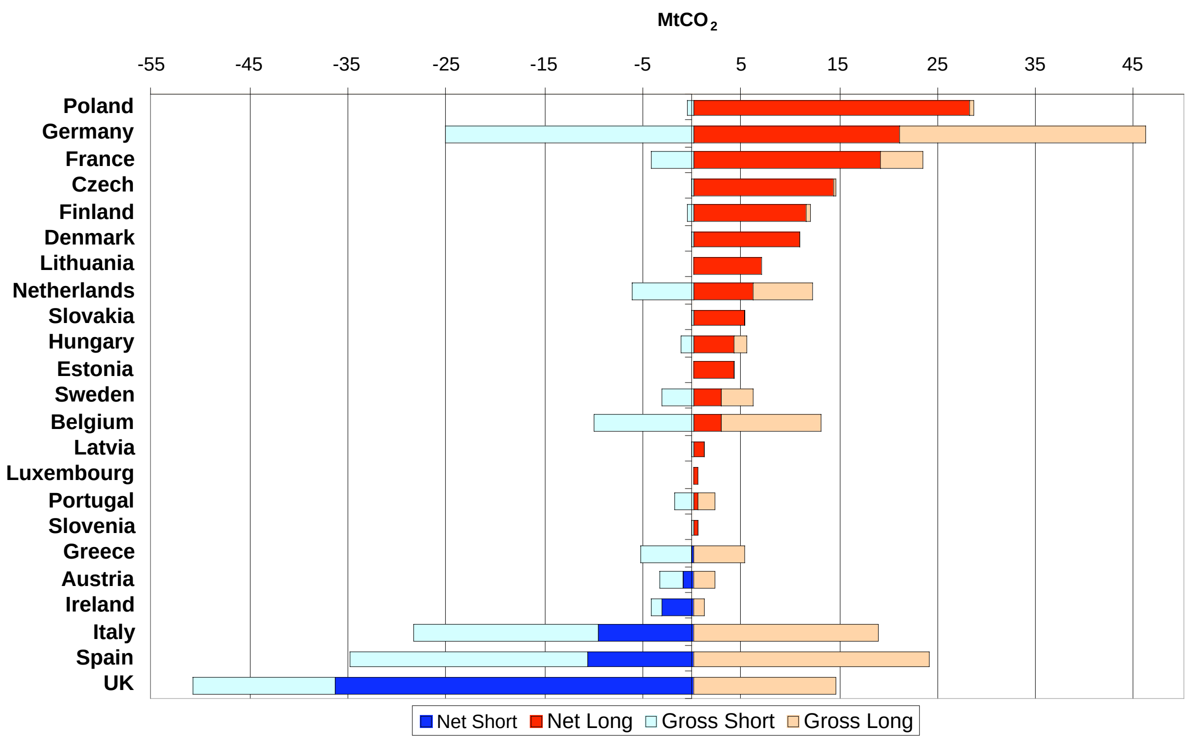

Figure 3. Short and long positions by member state in $MtCO_2$. Source: CITL and Kettner *et al*. (2006).

that were long such that emissions were 18% greater than the allocation. Clearly, the UK as a whole cannot be considered to have been over-allocated even if some firms and sectors may be long. Also, the short position may be created, not so much by intention, but by higher levels of economic activity than expected or other unexpected events, such as high natural gas prices, created a larger number of short positions. Still, these two cases illustrate the point that subject to the qualifications we have noted, it would be as hard to argue that the UK was "over-allocated" as it would be to argue that Lithuania was not.

Having set up two polar cases, Figure 2 illustrates the great diversity among the EU member states. As indicated by the top bar, the situation of the EU as a whole is balanced, but the member states fall roughly into four categories. The first includes those like Lithuania where all or nearly all the installations are long and by a considerable amount. This group comprises the first nine member states from the top in Figure 2. In addition to having no or few installations that were short, the long position is in excess of 15% of the total allocation. The next three member states, Hungary, Sweden and France, constitute a second group that are similar in having significant long positions, between 10% and 15% of the allowance allocation, but with more short installations, especially in Sweden. The third group consists of the next five member states—Holland, Germany, Belgium, Slovenia, and Portugal—that are long on balance but by relatively modest amounts that would fall well within what might be expected as a result of a relative advantage in abatement or less favorable economic, meteorological, or other circumstances in 2005. The final group is of course the six member states who were on balance short: Greece, Austria, Italy, Ireland, Spain, and the UK.

While Figure 2 is the more helpful of these two diagrams for evaluating the presence of over-allocation, Figure 3 is necessary to put the phenomenon in perspective and it provides a good picture of the main sources of demand and potential supply of EUAs in the market in 2005. The gross shorts, totaling 180 $MtCO_2$, are located mostly (80%) in four countries: the UK, Spain, Italy, and Germany. The same four countries, plus France and Poland, constitute the largest part of the potential sellers' side of the market with approximately 150 of the 250 $MtCO_2$ allocated to installations that were not needed to cover their emissions in 2005, or about 60% of the total. Many of the trades were undoubtedly within the same countries, but there were also net transfers of EUAs among member states and borrowing from the 2006 allocation. An analysis conducted by the Italian registry of the trading patterns of Italian companies and the origin of surrendered permits revealed that 7.8 million of the 43.3 million EUAs by which Italian installations were short were covered by borrowing and that 7.0 million of surrendered EUAs were initially issued to installations outside of Italy (*Point Carbon News*, Oct. 30, 2006). Thus, 66% of the gross short position of Italy was covered by redistribution of EUAs among installations in Italy, 18% by borrowing from the installations' forward allocation, and 16% by purchases outside of Italy.

The net positions displayed in Figures 2 and 3 imply transfers of allowances among member states although internal borrowing would also be a possibility. The net balances imply that 60% of the demand for international trading came from the UK with another 18% from Spain, 16% from Italy and the remaining 6% from Ireland, Austria, and Greece. The potential suppliers were more evenly distributed with Germany, Poland, and France accounting for about half of the total. The analysis by the Italian registry indicates that 74% of Italy's net short position of 9.5 million EUAs was covered by purchases from abroad and the remainder by within-country borrowing. The remaining 5.4 million tons of borrowed EUAs substituted for purchases or transfers from other installations within Italy.

Member states are not the only aggregates into which the installation data can be aggregated. Another break-out is by economic sector, as is done in **Figures 4** and **5**. By this grouping, the power sector is in the aggregate modestly short (by about 3%), while all the other sectors are long by more significant percentages. Among these industrial sectors, three—ceramics, bricks and tile; iron, steel and coke; and pulp and paper—are long by more than 15% of the allocation to these sectors. When placed in the perspective of the volume of emissions, as in Figure 5, the power sector dominates the potential market. Virtually all of the compliance demand for EUAs in 2005 came from the power sector, as well as about half of the total potential supply.

When sector and regional classifications are combined, an even clearer picture of the implied redistribution of allowances is obtained. In **Figure 6**, the sectors are grouped into power and heat and all others (generically industry) and aggregated into regions defined as the EU 15 and the 8 East European accession states. The power and heat sector in the EU15 is the only player in the EU ETS that has been characterized by an overall net short position. More than half of the net length is located in Eastern Europe, although given the registry problems in Eastern Europe, most of the net short position of the EU15 power and heat sector was probably covered by purchases from the EU15 industrial sectors.

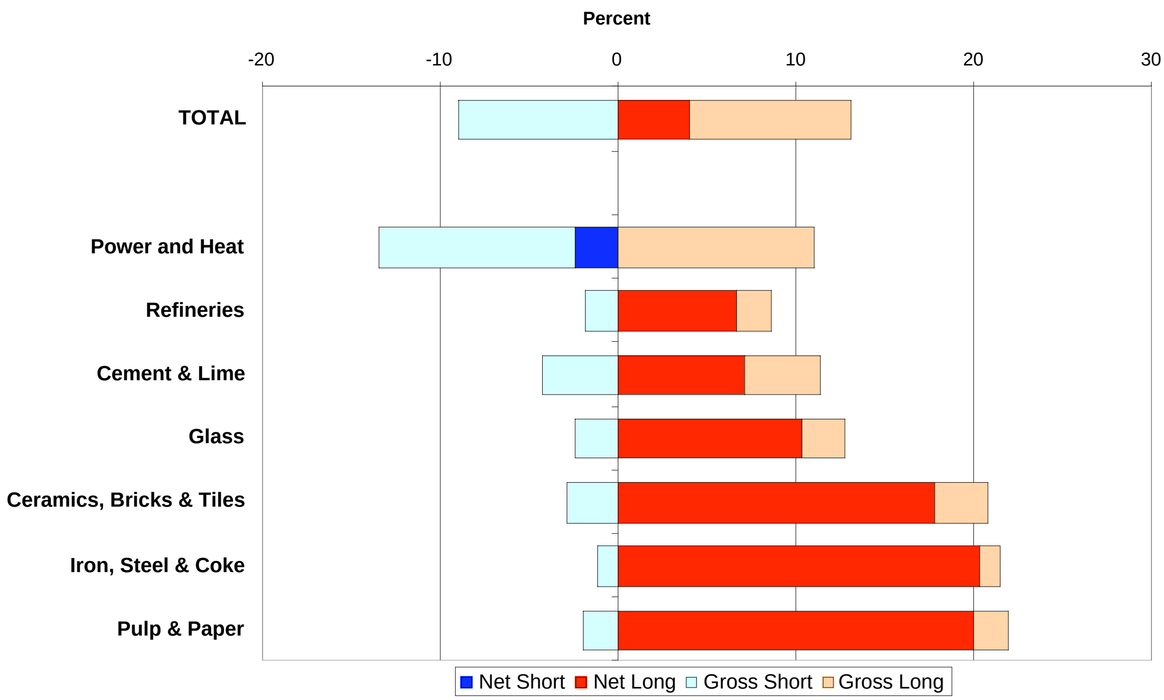

Figure 4. Short and long positions by EU-wide sectors.
Source: CITL and Kettner *et al*. (2006).

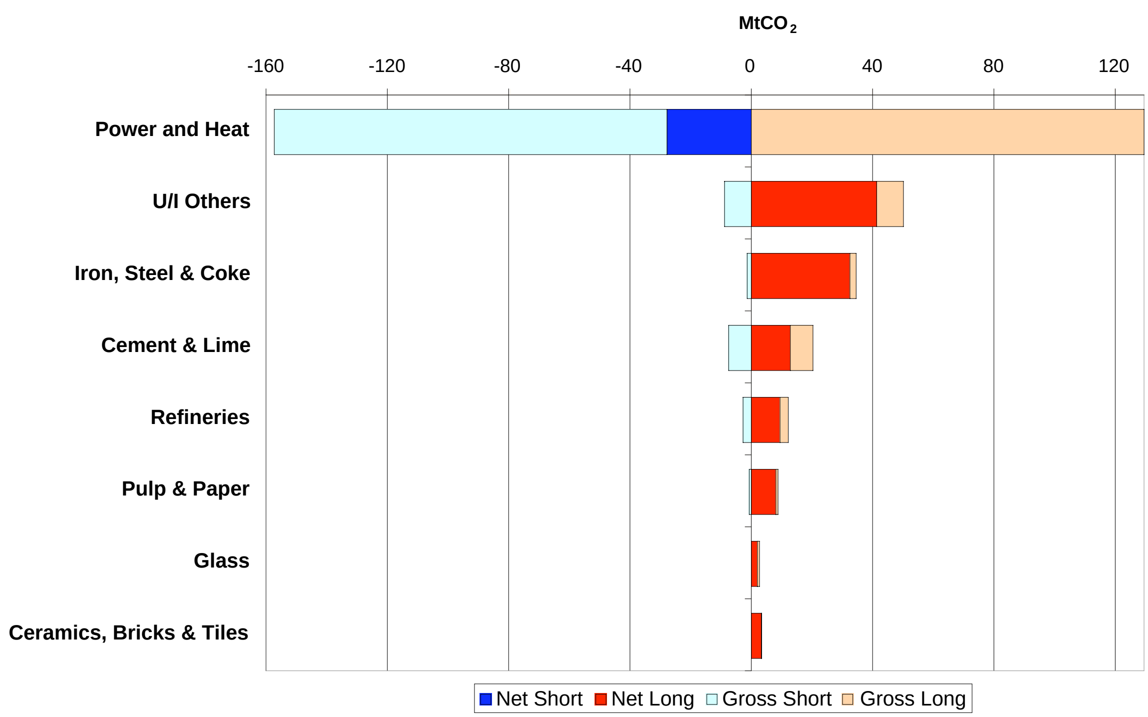

Figure 5. Short and long positions by EU-wide sectors in absolute terms.
Source: CITL and Kettner *et al.* (2006).

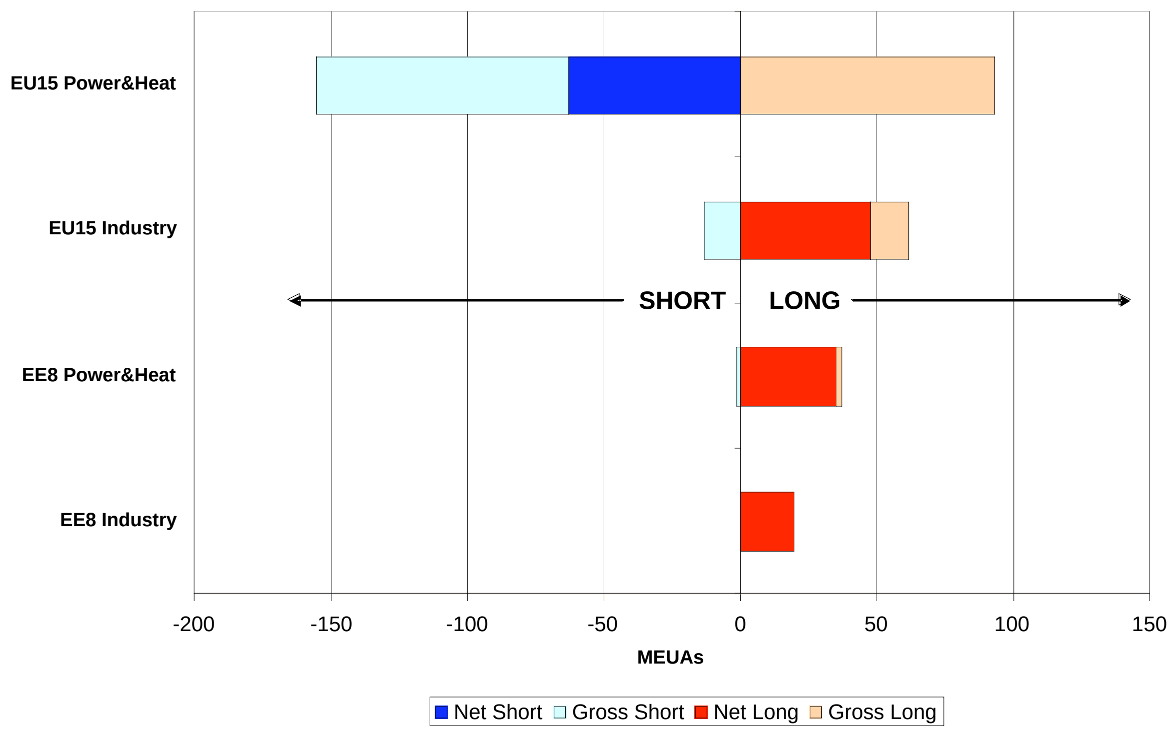

Figure 6. A breakdown of short and long positions by major sectors and regions.

3.3 A Measure of Over-allocation

A measure of the likelihood of over-allocation can be calculated from this data based on the earlier discussion of what might cause long positions. Any aggregate of installation data will typically show the group to be either long or net on balance and to have some component long and others short. For each, a ratio can be calculated from the net position in relation to the corresponding long or short position, such as indicated below:

$$Net\ Ratio = \frac{Net\ Long\ or\ Short}{Gross\ Long\ or\ Short}.$$

To take our earlier examples, Lithuania would have a ratio of +1.0 since it was long and its net long position is identical to its gross long position. Conversely, the UK has a ratio of –0.72 since its net short position is 72% of the sum of the amounts by which all short installations were short. By definition, the net ratio is limited to values between –1.0 and +1.0 with negative numbers indicated that the aggregate or member state is short over-all and positive values indicating the opposite.

A negative net ratio suggests that no obvious over-allocation has taken place. Sectors within a member state may be over-allocated, but if the member state as a whole is not, the over-allocation is compensated by an implied under-allocation to other sectors. While such differentiation can create problems for sectors that compete across national boundaries, this differentiation can be regarded as an internal matter not significantly different from other forms of assistance or regulatory treatment that may advantage or disadvantage a sector relative to competitors in other countries.

Member states that have positive ratios would need to be divided into two groups depending on where the line is drawn for indicating over-allocation. The first sub-group would be those with a high positive ratio indicated few installations that were short. This leaves a second group with a net ratio that is positive but not excessive. There is no *a priori* answer concerning where to draw the line between these two groups, but the data clusters in a manner that allows some to be clearly assigned to one group or the other.

Figure 7 represents the distribution of allowances by member states expressed as a percentage of the EU25 allocation according to their net ratios. The part of the columns labeled "base" represents emissions that were covered by allocated allowances. The blue parts of the columns labeled "purchase" indicate emissions that were greater that the allocation for those member states with a net ratio from –1.0 to zero. The red parts of the columns labeled "sold" indicate allocated allowances in excess of emissions for those countries with a net ratio between 0 and +1.

The UK and Ireland, representing about 12% of the overall EU25 allocation, are the two countries characterized by the shortest positions and a net short that is approximately 2% of all the EUAs issued by the EU25. The next four countries—Spain, Italy, Austria, and Greece—account for about 25% of total EUAs and they are all short but less so than the UK and Ireland. On the side of the longs, Belgium and Portugal, have relatively balanced positions not unlike the previous four on the short side of the ledger. Germany's size will cause the category in which it falls to dominate all the others and so it is for the group with net ratios between +0.4 and +0.6,

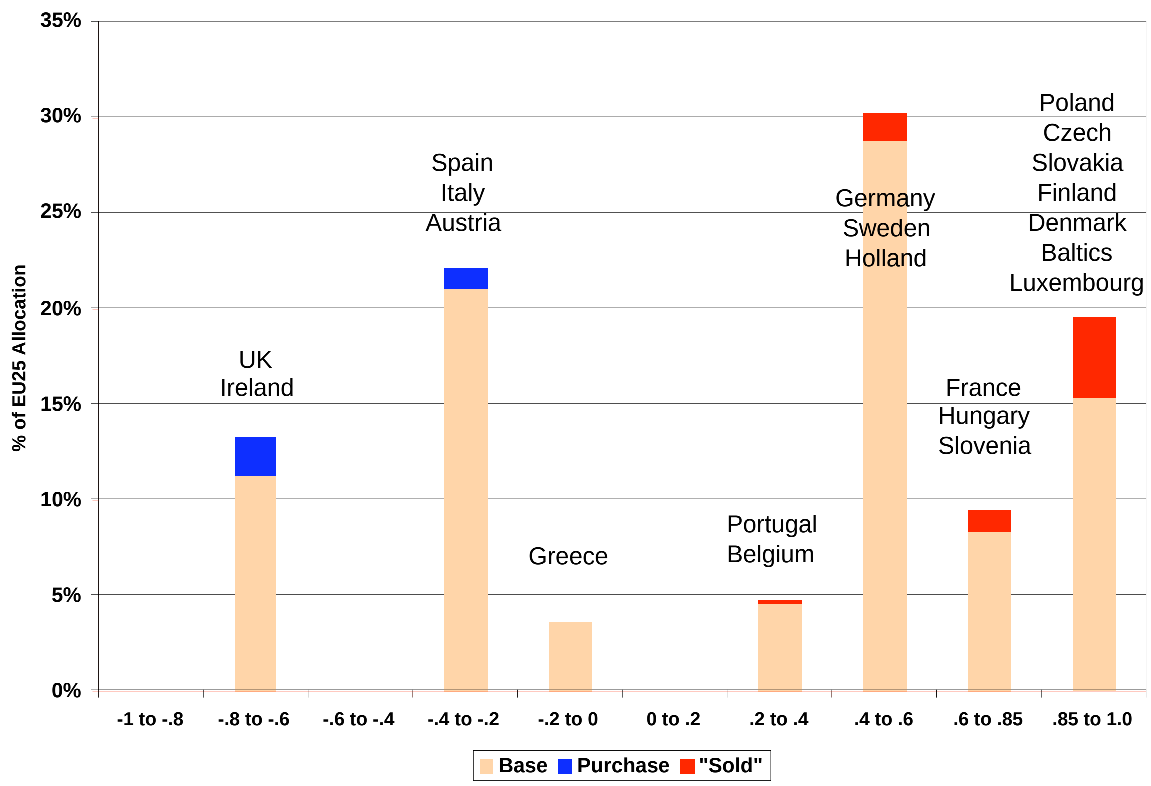

Figure 7. Distribution of EUAs by Net Ratio.

which constitutes almost one third of the total allocation. The next two groups, with net ratios higher than +0.6 include the member states for which the evidence of over-allocation is much stronger. They constitute about 29% of the EU25 total and their combined surplus is about 5%.

Where to place the threshold for what might be considered a presumption of over-allocation is obviously a difficult decision. It should be drawn at a relatively high net positive ratio for the reasons explained earlier and even then other factors should be considered before coming to a definitive conclusion. The important point is not that there were some member states for which over-allocation is indicated, but that there were so many for which that was not the case. Even with a relatively low presumptive threshold for over-allocation of +0.60, eleven member states that distributed 71% of all EUAs cannot be viewed as involving over-allocation. And for the 29% remaining, about 24% of the allowances were required to cover emissions in 2005 so that the net potential over-allocation is on the order of 5% or 100 million EUAs, assuming that none of the length can be attributed to abatement or unexpected conditions that create length in 2005 but could not be expected to do so in the future.

Whatever the correct magnitude of this estimate, it needs to be placed in context. First, it is not necessarily a complete indicator of the over-all length of the EU ETS at this point in time since the allowances reported are those distributed to installations in 2005. It does not include many of the allowances in reserves for new entrants, auctions, or other purposes that had not been distributed by the end of 2005. While these reserves are not specifically reserved for any single year, most of them will become available before the end of 2007. If the three-year total for all EUAs is divided by three, another 85 million EUAs are indicated as 2005 allowances not yet distributed. A second observation concerns the greater over-allocation that was avoided by the cuts that the Commission required from a number of first period National Allocation Plans (NAPs). These totaled 290 million EUAs, approximately equal on an annual average to the potential over-allocation indicated by an analysis of the 2005 data. Finally, over-allocation indicates very little about abatement or the reduction of emissions that is the fundamental object of the EU ETS. We now turn to this second part of the question that we pose in the title to this paper.

4. HAS THE EU ETS REDUCED CO_2 EMISSIONS?

4.1 Some Initial Considerations

Just as being long or short is a difference between emissions and allocation, so abatement is a difference between emissions and the counterfactual, or what CO_2 emissions would have been in the absence of the EU ETS. And, while the first difference can be readily deduced from two observable data points, the second difference can never be determined with certainty because 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.

In the case of the EU ETS, forming a good estimate of the counterfactual is complicated by the lack of historical data corresponding to the installations included in the scheme. Reasonably good data exist for the CO_2 emissions of the EU member states, however the EU ETS includes only a part—ranging from 30% to 70%—of each member state's emissions. And, prior to the start of the EU ETS, there was no reason to collect or to publish data on sectors or installations that were to constitute the EU ETS. One not entirely satisfactory source of the data for these installations is that collected to establish an historical "baseline." All the member states collected recent emissions data in the process of developing the first set of National Allocation Plans during 2004 in order to establish an initial point for projecting what emissions were expected to be in 2005-07 for the trading sector as a whole, and for specific industrial sectors, and for allocating allowances to the installations included in the scheme. While this data source provides a much needed reference point, it suffers from two problems: potential bias and imperfect comparability.

The potential bias in the data arises from the process by which the data were collected. As described in Ellerman, Buchner and Carraro (forthcoming), the data collection effort was largely a voluntary submission by the industries involved and it was conducted under severe time pressures that did not allow for as much verification as could be desired. Cooperation in submitting the data is reported as good, perhaps not surprisingly since allowance allocations would depend on the data submitted; but for that reason there was also an incentive to resolve uncertainties in favor of higher emissions. While this incentive clearly existed, its role should not be exaggerated. The government officials cross-checked the data submitted with other information that was often available, as well as checking it for internal consistency. Also, a certain degree of internal discipline could be expected within the process from firms who would not be indifferent to inflated claims by competitors. The important point is not that these data should be accepted as is, or rejected out-of-hand, but that the extent of bias be measured or at least taken into account. It would be wonderful if there were other more reliable data that could be used, but in its absence, the baseline data is all that exists to enable an estimate of the extent to which the EU ETS met its primary objective of reducing CO_2 emissions.

The second problem with the baseline data is that the components to be summed across the EU are not fully comparable. Although all member states sought a measure of recent emissions in developing their baselines, the definitions varied. For all, it was an average of recent years ending with 2003, the last year for which data was available, but the years included in the average varied from two to six. Moreover, special provisions were sometimes adopted that let minimum observations be dropped, as in the UK, or for more recent 2004 data to be used instead of the historical average, as in the Czech Republic. Nevertheless, there are presently no other data and the historical baseline data have the merit of reflecting relatively recent years (*e.g.*, around 2001-2003) for the installations in the EU ETS. As with the problem of bias, the solution is not to throw out the baseline data but to understand and to measure the errors that may be created by incomplete comparability.

4.2 Verified Emissions Compared to Baseline Emissions

With these significant qualifications in mind, we now present the historical baseline data in comparison with corresponding data on allowances and verified emissions. Historical emissions must not be thought of as the counterfactual for 2005; it is the starting point before taking account of changes that would have occurred between the historical reference point and the year of the counterfactual, as we will do in the next section. **Figure 8** provides the comparison on a country-specific basis. In each cluster, the historical baseline is the right-hand column, the 2005 allocation, the center column; and verified emissions, the left hand column.

There are six different combinations in which verified emissions, allowances, and baseline emissions can be combined as shown in **Table 2**.

Member states can be divided into two groups: those will allowance totals less than baseline emissions (7 member states with 53% of allowances) and those with the opposite relation

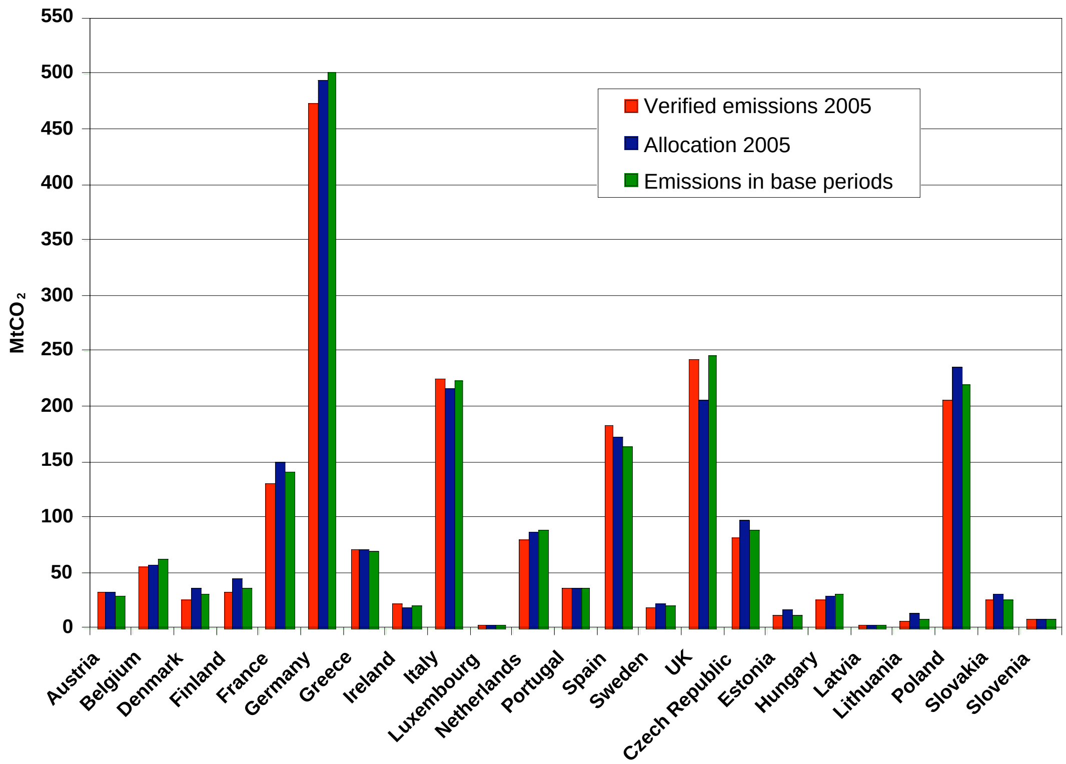

Figure 8. Comparison of 2005 emissions with base period emissions.
Source: Own calculations based on data from the CITL, the EC, and DEHSt (2005).

Table 2. Allowances (A), emissions (E), and baseline (B) relations.

Combination	**Countries**	**% of Allocation**	**Combination**	**Countries**	**% of Allocation**
Allowances less than Baseline			***Allowances more than Baseline***		
E < A < B	Belgium Germany Netherlands Hungary	32%	**E < B < A**	Denmark Finland France Luxemburg Portugal Sweden Czech Rep Latvia Lithuania Poland Slovakia Slovenia	33%
A < E < B	UK	10%	**B < E < A**	Estonia	1%
A < B < E	Italy Ireland	11%	**B < A < E**	Austria Greece Spain	13%

Source: Derived by authors from CITL data.

(16 member states with 47% of allowances). The former would be countries who expect emissions to decline from baseline levels, such as the UK, or that have challenging Kyoto targets through the European Burden Sharing Agreement (BSA) for which they are preparing, such as Italy and Ireland. The latter group typically includes those who do not appear likely to have difficulty in meeting their Kyoto obligation and for which emissions are expected to grow from historical baseline levels, such as the countries in Eastern Europe. The majority of EU15 member states also fall into this category, even some who face significant problems meeting their Kyoto obligations. Whatever the relation between the allowance total and baseline emissions, verified emissions may be lower than allowances and baseline emissions (16 countries with 65% of allowances) and which are all long in the 2005 data, higher than both (5 countries with 24% of allowances) and which are all short, or between the two (2 countries with 11% of allowances).

Figure 9 presents these country-specific data points summed into a whole for the EU23 and for the regional distinction between the EU15 and the 8 East European accession states (subsequently EE8). For the EU23, verified emissions are 3.4% less than baseline emissions and the corresponding percentages for the EU15 and the EE8 are –2.4% and –7.8%. In these three aggregated comparisons, the middle column representing allowances indicates the allowances distributed directly to installations by the solid color. The hatched area at the top of each column indicates the difference between the number of allowances distributed to installations in 2005 and one-third of the cumulative three-year total for each member state. These are allowances that

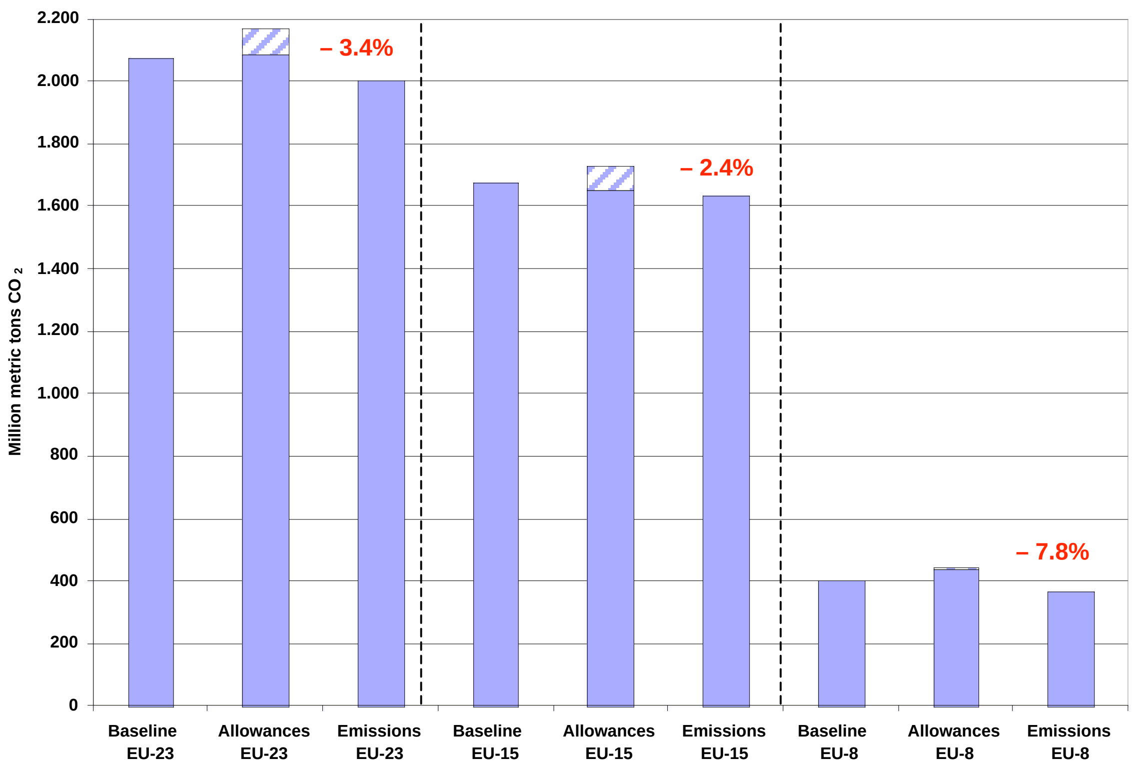

Figure 9. 2005 emissions, base period emissions and total allowances: a regional breakup.
Source: Own calculations based on data from the CITL, the EC, and DEHSt (2005).

have been reserved for auctions, new entrant or early action reserves, or other special provisions. Most of these reserved allowances were not distributed in 2005, but most of them will be issued before the end of 2007. It is to be noted that when the reserves are included the over-all long position for the EU ETS in 2005 is 8% and not the 4% figure that is based on the distribution to installations. This extra length has definite implications for the price of EUAs, but for the purpose of determining abatement in 2005 that extra length is not relevant although it may be for abatement in 2006 and 2007 to the extent that prices decline as a consequence and have an effect on abatement.

4.3 Changes in Real Output and Carbon Intensity since 2002

The comparison of verified emissions with the baseline in the preceding section does not take account of factors that would influence the level of CO_2 emissions between 2002 and 2005. Continuing GDP growth, or more specifically in growth in the output of the sectors included in the EU ETS, would be expected to causes emissions to increase and for the 2005 counterfactual to be higher than the historical baseline. Also, CO_2 emissions typically do not grow at the same rate as real output because of the observed, long standing tendency towards improved carbon intensity for most economies. In addition to these trend factors, there are a number of unpredictable conditions, such as the weather and energy prices, that will increase or decrease counterfactual emissions and the demand for allowances depending on their realization relative to the initial expectation.

Economic growth since 2002 has been relatively robust in the EU and particularly in the East European accession states as shown in **Figure 10** where an index describing developments in GDP measured in constant prices in Europe in relation to the year 2002 is depicted. For the EU as a whole, GDP has grown by almost 6% by 2005 compared to 2002. The figure is slightly lower for the EU15 where most of the economic activity occurs and significantly higher, +15%, for the Eastern European countries. We use 2002 as an approximate center point for the baseline emissions although for some countries with longer baseline periods, it might more appropriately be earlier.

GDP reflects a broader definition of economic activity than what is included in the EU ETS, but the same pattern is obtained when more sector–specific indices of economic activity are used, as shown by **Figure 11**. These indices show monthly activity since the beginning of 2002 through mid-2006 and each series is normalized to its average value in 2002. All of these indices indicate higher levels of real output in 2005 than in 2002. The two most important series, electricity and industrial output excluding construction, are about 5.5% and 4.0% above the average 2002 level of output. More specific, industrial sector indices show increases of about 6% for cement, 5% for pulp and paper, 3% for iron and steel, and 2.3% for glass, bricks, tiles, and ceramics. Temporary declines in output of iron and steel and of pulp and paper can be observed in 2005, but these were temporary and the output levels observed as of mid-2006 for all sectors are higher than in 2005.

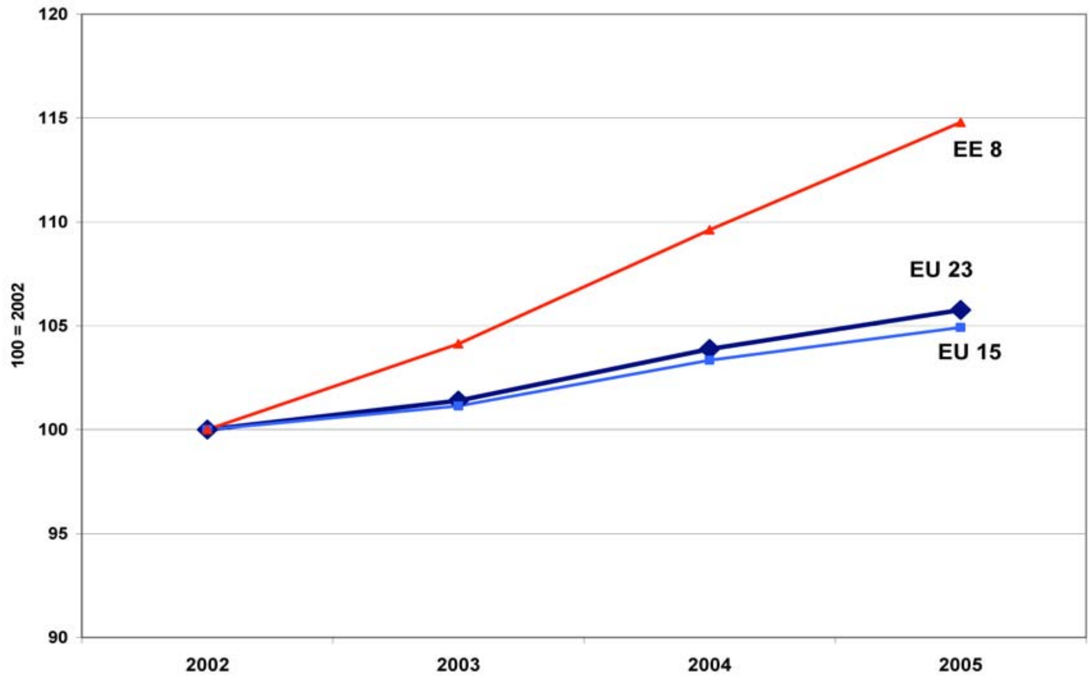

Figure 10. GDP growth in the European Union.
Source: Own calculations based on IMF data.

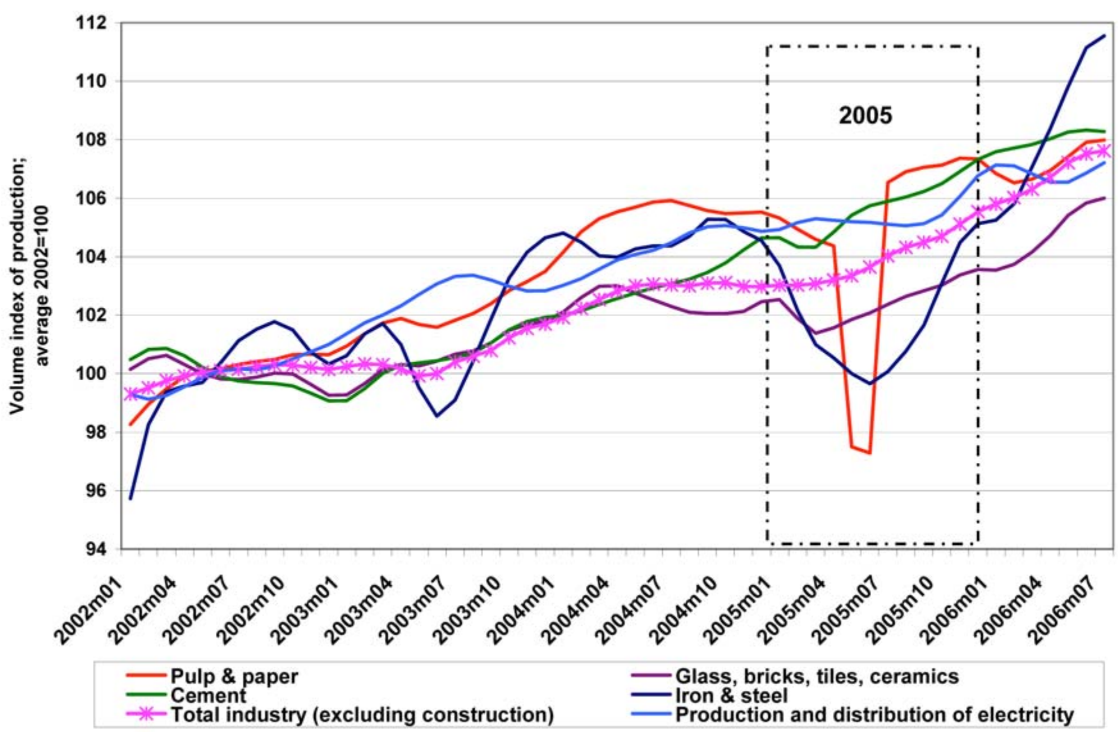

Figure 11. Indicators of economic activity in the EU25 (2002-2006).
Source: Own calculations based on Eurostat data.

Since CO_2 emissions typically do not increase at the same rate as broad indicators of economic activity, some estimate of the improvement in CO_2 intensity must be taken into account in estimating a counterfactual for 2005. Because of the paucity of industry-specific data on carbon intensity, we examine first the trends in carbon intensity for the economy as a whole for the EU and its constituent parts and then consider whether the economy-wide data can be considered representative of the EU ETS sectors based on the sector specific data that is available.

Table 3 provides a comparison of the annual rates of growth for real GDP, CO_2 emissions, and the implied change in CO_2 intensity between 1995-2000 and 2000-2004 for the EU23, the EU15 and the EE8. Real GDP growth has been less in recent years than in the last half of the 1990s but the recent rate of increase in CO_2 emissions has been greater than in the earlier period. The inescapable result is that the rate in improvement in CO_2 intensity slowed noticeably around 2000. These trends are especially pronounced in the EU15, but they are also true for the new East European member states. CO_2 intensity is still improving, especially in Eastern Europe, has diminished sufficiently that the CO_2 emissions are increasing at a faster rate than they were in the late 1990s despite slower growth in real GDP.

This slowing in the rate of decline in CO_2 intensity since 2000 raises an obvious problem with extrapolating the declines in carbon and energy intensity experienced during the 1990s beyond 2000. For the purpose of establishing a counterfactual for 2005, we assume that the trend prevailing since 2000 is the appropriate one. Economy-wide CO_2 emissions data are available for two of the three years between 2002 and 2005 and nothing in the data for 2005 suggests that the trend has reversed. In fact, given the 2004 data and the increase in real output between 2004 and 2005, a return to the 2002 emissions level (without the EU ETS) would imply a one-year improvement in carbon intensity on the order of 6%, which is outside the range of historical experience.

The critical issue with the use of economy-wide data is whether it is representative of the sub-set of the economy that the EU ETS comprises. Fortunately, data is available that can help resolve this dilemma. Eurostat publishes data on the energy intensity of the EU economy as a whole and of industry as distinct from transportation, households, agriculture, etc. While energy intensity is not identical with CO_2 intensity, it is an important determinant. **Table 4** presents that comparison.

Table 3. Trends in Real GDP, CO_2 emissions, and CO_2 intensity.

		Annual changes in percent	
		1995-2000	**2000-2004**
EU23	Real GDP	+2.9	+1.8
	CO_2 Emissions	+0.1	+1.0
	CO_2 Intensity	–2.7	–0.8
EU15	Real GDP	+2.8	+1.6
	CO_2 Emissions	+0.4	+1.1
	CO_2 Intensity	–2.3	–0.5
EE8	Real GDP	+4.3	+3.6
	CO_2 Emissions	–1.8	+0.2
	CO_2 Intensity	–5.8	–3.3

Source: CO_2 emissions from EEA (2006a). Own calculations for GDP based on IMF data weighted at 2004 PPP values. Intensity calculated.

Table 4. Annual rates of improvement in European energy intensity.

	Rate of improvement in the economy's energy intensity		Rate of improvement in the industry's energy intensity	
	1995-2000	2000-2004	1995-2000	2000-2003
EU25	−1.9	−0.5	−1.6	−0.1
EU15	−1.4	−0.4	−1.0	0.2
Austria	−1.6	2.2	−0.5	1.8
Belgium	*−0.2*	*−3.0*	*−0.3*	*−0.4*
Denmark	−3.0	−0.9	−2.9	0.3
Finland	−2.1	1.1	−2.4	−0.7
France	−1.3	−0.2	–	–
Germany	−1.8	−0.1	−1.4	−0.3
Greece	*−0.4*	*−2.2*	*−1.5*	*−5.3*
Ireland	−3.9	−2.6	–	–
Italy	−0.6	0.3	*1.1*	*−0.3*
Luxembourg	−4.5	1.0	−6.6	−5.1
Netherlands	−2.8	0.6	−0.5	1.7
Portugal	*0.4*	*−0.2*	1.5	2.1
Spain	*−0.1*	*−0.5*	0.1	1.9
Sweden	−3.8	0.3	*−3.5*	*−3.8*
UK	*−1.9*	*−2.2*	−1.3	0.6
Cyprus	*0.1*	*−1.8*	*1.8*	*−2.9*
CZ	−1.6	−1.0	−5.1	−3.9
Estonia	−6.8	−1.5	−9.6	−5.9
Hungary	−3.8	−2.8	−6.7	−2.3
Latvia	−4.8	−2.0	*−3.8*	*−4.4*
Lithuania	−5.7	−1.5	−7.6	−0.9
Malta	−1.1	−0.9	–	–
Poland	−5.9	−3.1	−7.5	−3.7
Slovakia	−3.5	−2.7	−2.3	0.4
Slovenia	−2.8	−0.9	*−0.8*	*−1.2*

Source: Eurostat and own calculations.

While the industry data do not extend to 2004, it is evident that for the EU as a whole, the trends observed for energy intensity in the economy wide aggregates are true for the industrial sector. The same break in trend around 2000 can be observed in energy intensity for the industrial sectors and for the economy as a whole for the EU25 and the EU15, as well as for fifteen of the twenty-five member states. For the ten member states with highlighted (in yellow) figures in Table 4, a trend to increasing energy efficiency can be observed in either the economy-wide or industry figures rates of change. However, when aggregated to the EU25 or EU15 level, the data is consistent with a trend to less improvement in carbon intensity since 2000. Moreover, the rates of improvement in energy intensity for the industrial sectors are generally not as great for the economy as a whole and the slowdown in improvement is more pronounced for the industrial sectors than for the economy as a whole.

A second source of data on emissions has been recently released by the European Environmental Agency in its annual assessment of progress towards the Kyoto goals (EEA, 2006b). It provides indices of greenhouse gas (GHG) emissions for industry excluding construction through 2004 that permit comparison of late 1990s trends with the years since 2000. Again, GHG emissions are not the same as CO_2 emissions, but the latter constitute most of the former. These data series show the same break in emissions trends around 2000 and rising GHG emissions between 2002 and 2004.

Based on these two sources of data that are more directly applicable to the EU ETS sectors, we believe that it is unlikely that the trends in CO_2 intensity that were evident through 2004 for the EU economies as a whole were not also broadly true for the EU ETS sectors. Given the observed increase in real output for the EU ETS sectors, it is very unlikely that CO_2 emissions from the installations included in the scheme would have declined in the absence of the EU ETS and the significant price that was paid for CO_2 emissions in 2005.

4.4 Estimating the Counterfactual and Abatement

Figure 12 summarizes the problem of estimating the counterfactual and thereby determining the amount of CO_2 emission reduction that was effected by the EU ETS in 2005. There are two data points: the imperfect baseline emissions, which we take to reflect approximately 2002 emissions of the EU ETS installations, and verified emissions in 2005. The critical issue is: What would have been the rate of change in BAU emissions in the absence of the EU ETS?

Real GDP and the relevant sector-specific indicators of economic activity indicate annual growth of about 2% for the EU as a whole. While the decline in carbon intensity since 2000 has been significantly less than what was experienced in the 1990s, it has not stopped, so that 2% annual growth in counterfactual CO_2 emissions would seem to be an upper limit that would also

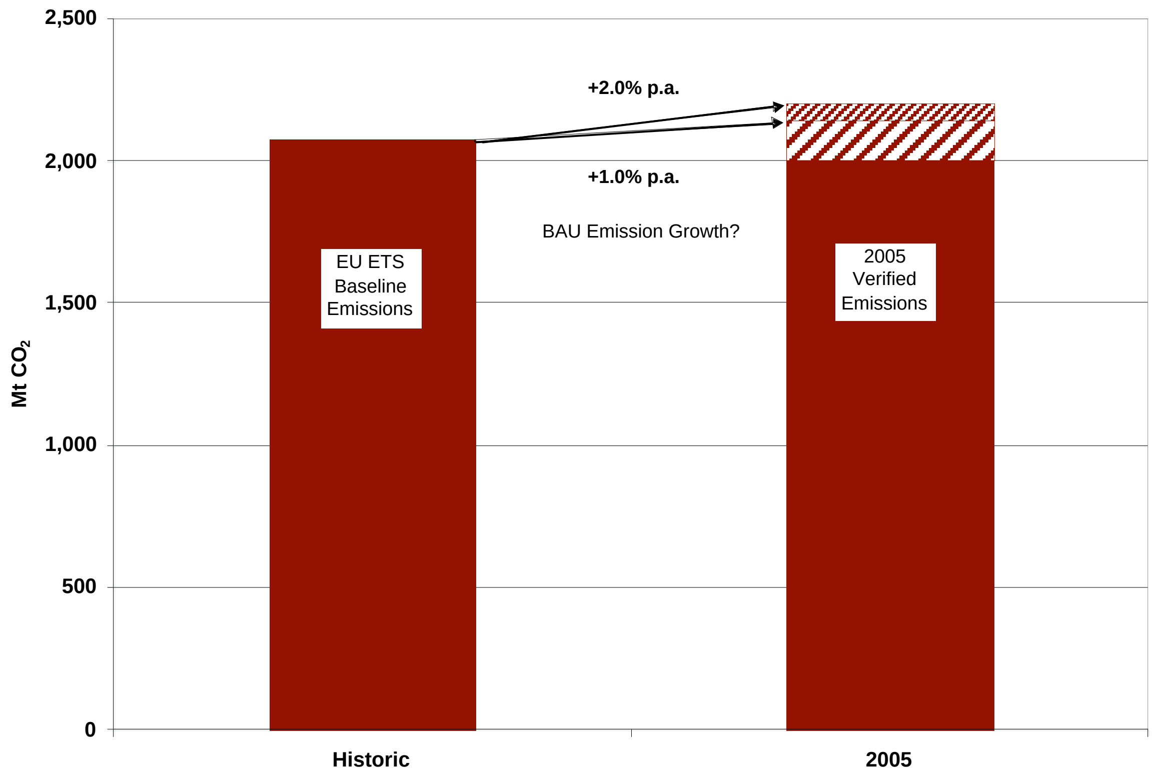

Figure 12. A scenario for BAU emissions in the absence of the EU ETS.

take account of the effect of the generally adverse weather conditions in 2005 and the effects of higher natural gas prices on counterfactual emissions and the demand for EUAs. Given the growth in real GDP and the post-2000 trend in CO_2 intensity, it is unlikely that the lower limit on the feasible growth of BAU emissions would be less than one percent. Accordingly, it appears likely that counterfactual emissions increased to a level that in 2005 would have been from 3% to 6% higher than the level of emissions for the EU ETS installations in 2002. The two arrows in Figure 12 represent these two limiting assumptions about the growth of CO_2 emissions absent the EU ETS, given what we can now observe concerning the growth in real output in the EU ETS sectors, the post-2000 trend in CO_2 intensity, and the evolution of CO_2 emissions through 2004.

Assuming for the moment that the baseline emissions accurately reflect 2002 emissions for the EU ETS installations, these limiting assumptions imply that the counterfactual lies between 2.14 and 2.21 billion tons of CO_2. Since verified emissions are 2.01 billion tons, the indicated reduction of CO_2 emissions is between approximately 130 and 200 million tons, or 7% to 10% of what emissions would otherwise have been. However, the assumption of an accurate baseline is open to serious challenge because of the less than ideal conditions under which the baseline data on installation level emissions were collected. These conditions undoubtedly produced errors, but errors operate in both directions. The more serious concern in estimating a counterfactual is the likelihood of bias, which would imply that the errors are disproportionately and systematically in one direction. To the best of our knowledge, no one has done the empirical work to prove the bias or to develop a better estimate of the level of historical emissions for the EU ETS installations prior to 2005 or of counterfactual emissions in 2005. In any case, the critical issue is: What is the magnitude of bias? Or to turn the question around: How much bias would have to be assumed to support a conclusion of no abatement of CO_2 emissions by EU ETS installations in 2005?

One way of addressing this question is to take a country-specific approach to estimating counterfactual emissions that allows a distinction to be made among member states in adjusting baselines. The primary distinction would be between the new accession countries of Eastern Europe and the EU 15. For the former, historical data were of poor quality and of questionable relevance given the ongoing rapid structural change in those economies. Consequently, there was a greater tendency to rely on projections instead of historical data in allocating allowances at the installation level. Generally, these conditions did not exist among the EU15 or nearly to the same degree. Accordingly, it is plausible that more bias exists in the baselines of the East European states than in those of the EU15.

To develop the alternative estimate of the counterfactual, we take the reported baseline emissions (without adjustment) and assume that CO_2 emissions in the EU ETS sectors increased at an annual rate that is the product of the annual increase in observed real GDP between 2002 and 2005 and the rate of decline in CO_2 intensity that was experienced between 2000 and 2004 for each country. That calculation and the resulting data are provided in detail in Appendix VI and summarized in the first panel of **Table 5**.

Table 5. A country-specific approach to calculating emission reductions.

	Baseline Emissions (Mt CO_2)	2005 BAU Emissions (Mt CO_2)	Verified Emissions (Mt CO_2)	Indicated Reduction (Mt CO_2)	Percent Reduction
Without adjustment of baseline emissions					
EU23	2,078	2,150 (+3.5%)	2,007	–144	–6.7%
EU15	1,677	1,729 (+3.1%)	1,637	–93	–5.4%
EE8	401	421 (+4.8%)	370	–51	–12.1%
With adjustment of baseline emissions					
EU23	1,946 (–6.4%)	2,014 (+3.5%)	2,007	–7.6	–0.4%
EU15	1,593 (–5.0%)	1,642 (+3.1%)	1,637	–5.5	–0.3%
EE8	353 (–12.0%)	370 (+4.8%)	370	–0.2	–0.1%

Source: Own calculations based on data from CITL, DEHSt (2005), EEA (2006a) and IMF.

The indicated growth in counterfactual emissions for the EU15 and EE8 between 2002 and 2005 is 3.1% and 4.8%, respectively, or 3.5% for the EU as a whole. The indicated abatement is nearly 145 million tons or 7% with percentage reductions of 5.4% for the EU15 and 12.1% for the eight East European member states.

The greater proportionate reduction in the East than in the West seems unlikely. There probably was some abatement in the East, and no doubt cheaper abatement opportunities exist there than in the EU15; but firms in Eastern Europe are less attuned to market opportunities than those in the EU15; and, if they are, they would have been impeded from trading by the delays in final approvals of several NAPs and in setting up the East European registries. A more likely explanation is that the baseline emissions for the East European countries contain more bias than those of the EU15. Accordingly, the second panel of Table 5 repeats the same calculation concerning growth of emissions that was made in the first panel but from baselines that have been lowered by percentages that would be required to sustain a conclusion of no abatement in the EU15 and EE8. The implied adjustments are 5% for EU15 countries and 12% for the eight new accession members. Both of these seem unlikely to us as estimates of cumulative, systemic bias, although undoubtedly errors of this magnitude will exist in the data for individual installations or small sub-sets.

Until better estimates based on more detailed country- and sector-specific research have been done, it is not possible to make a reliable estimate of abatement. Nevertheless, it is unlikely that there was no abatement in 2005. It is also unlikely that the abatement was as much as 200 million tons. The tentative calculations presented in Table 5 would suggest 140 million tons adjusted downward by however much is the bias in the baseline emissions data. An amount half this much—abatement of slightly over 3%—seems not unreasonable, but it is arbitrary and must remain so until better data and more careful assessments can be made.

In the meantime, the refutable presumption must be that the EU ETS succeeded in abating CO_2 emissions in 2005 based on three observations.

1. **A Positive EUA Price**. A significant price is being paid for CO_2, which reason suggests 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** indicate a reduction of emissions even after allowing for plausible bias.

The amount of emission reduction in 2005 may be modest, but so is the ambition of the first period cap. Given the problems of getting the system started and the changes in management and regulatory practice implied, even a modest amount of abatement may seem surprising, but the available evidence makes it hard to argue that there was none.

5. CONCLUDING COMMENTS

The question posed in the title of this paper is whether the 2005 emissions data reveal over-allocation or abatement. Any reasonable answer to this question will acknowledge that both have occurred and this paper has attempted to develop estimates of the magnitude of both.

Over-allocation has the unfortunate attribute of depending on the eye of the beholder, especially when viewed *ex post*. Nevertheless, there are plausible, empirical measures that can be developed. The one that we suggest is the ratio of an aggregate's net long (short) position to the sum of the long (short) positions of that aggregate's components. When some sizeable aggregate is long on balance and this ratio is close to unity, the likelihood of over-allocation is high. As we have noted, there are circumstances that would produce a high ratio without over-allocation, so that the presumption of over-allocation can be refuted if such circumstance can be convincingly shown. It is also possible that the over-allocation was intentional, as was arguably the case for the industrial sectors included in the EU ETS, in which case the attribute is the reflection of some equity consideration. Our analysis based on the application of the net ratio indicates that over-allocation occurred and that its magnitude may have been as much as 100 million EUAs.

Whatever the extent of over-allocation, that estimate does not say much about abatement. In a trading system, it is not the allocation to an installation that causes a firm to reduce emissions, but the price that it must pay, even if in opportunity cost, for its emissions. Whatever one thinks of the allocation in the first period, there can be no doubt that a price was paid and a cost incurred for CO_2 emissions emitted by covered installations in 2005. Therefore, the question can be posed: What was the effect of this price? The data to answer this question are not nearly as good as they should be, but our analysis of what is available indicates that CO_2 emissions were reduced by an amount that was probably larger than 50 million tons and less than 200 million tons.

These very tentative estimates of over-allocation and abatement have important implications. If abatement was at least 50 million tons, more than half (and perhaps all) of the long position revealed for the EU as a whole by the 2005 emissions data cannot be attributed to over-allocation. If over-allocation has occurred, even if on the order of 100 million tons, the clear implication is that EUA prices are lower because of the over-allocation, assuming those EUAs have found (or will find) their way to the market.

This reasoning raises the interesting question of what was the source of the surprise that caused EUA prices to drop so sharply when the 2005 emissions data were revealed in April and May of 2006. It cannot have been the total number of allowances, which had been known since at least mid-2005 when the last first period NAP was approved. Moreover, that total included whatever “over-allocation” had occurred and all observers recognized that this cap was not very demanding. The surprise concerned the revealed level of emissions. One plausible explanation is that market observers had over-estimated the level of CO_2 emissions and the demand for allowances caused by rising real output, the adverse weather in 2005, and the higher prices for natural gas relative to coal. But, another more intriguing possibility is that market observers under-estimated the amount of abatement that would occur in the first year of the EU ETS as the managers of affected facilities incorporated CO_2 prices into their production decisions. When revealed to be wrong, an under-estimate of abatement would have the same effect on EUA prices as an over-estimate of counterfactual emissions. Our analysis suggests that such an under-estimate is a distinct possibility. Moreover, experience with emissions trading regimes in the U.S. has shown that unexpected abatement always occurs. And it is unexpected because abatement is so often conceived as resulting only from large machines that engineers can design and regulators mandate and not from the small, incremental changes in production and production processes that managers of existing facilities make in adjusting to new economic realities. These pedestrian changes can cumulatively make a perceptible difference and they are one of the main reasons for choosing market-based instruments, such as the EU ETS.

Acknowledgments

We are greatly indebted to continuing discussions with a number of observers and analysts of the EU ETS and to comments received in response to a presentation of this paper to the WIFO-MIT Global Change Forum held in Vienna in October 2006. Our greatest debt is to Angela Koeppl from the Austrian Institute of Economic Research (WIFO) in Vienna and Stefan Schleicher from the Wegener Center for Climate and Global Change at the University of Graz whose initial compilation of the Community Independent Transaction Log (CITL) data, subsequently updated by us, made this evaluation possible. The usual disclaimer applies to the responsibility of all who have helped us for the interpretations of the data that we present here.

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Point Carbon (2006). Italian companies covered 18 per cent of 2005 shortage by borrowing, Point Carbon News, 30 October 2006.

Appendix I: An overview on the situation in each member state.

	Allocation 2005 (t CO_2)	Verified emissions 2005 (t CO_2)	Total number of instal-lations	Gross Short			Gross Long			Net Short / Net Long		Installations where allowances equal emissions
				t CO_2	%	instal-lations	t CO_2	%	instal-lations	t CO_2	%	
TOTAL	***1,995,439,047***	***1,916,174,516***	***10,046***	***180,359,321***	***9.0***	***2,903***	***259,623,852***	***13.0***	***6,800***	***79.3***	***4.0***	***343***
Austria	32,414,872	33,372,841	203	3,311,430	10.2	78	2,353,461	7.3	122	−1.0	−3.0	3
Belgium	58,312,155	55,354,096	308	9,986,382	17.1	73	12,944,441	22.2	235	3.0	5.1	0
Denmark	37,303,720	26,475,718	381	132,605	0.4	59	10,960,607	29.4	316	10.8	29.0	6
Finland	44,657,504	33,099,660	600	461,390	1.0	185	12,019,234	26.9	327	11.6	25.9	88
France	150,393,692	131,257,908	1086	4,218,956	2.8	178	23,354,740	15.5	895	19.1	12.7	13
Germany	494,951,117	474,005,179	1850	25,256,328	5.1	605	46,202,266	9.3	1,239	20.9	4.2	6
Greece	71,135,034	71,250,370	140	5,324,854	7.5	68	5,209,518	7.3	72	−0.1	−0.2	0
Ireland	19,236,747	22,397,678	114	4,231,567	22.0	53	1,070,636	5.6	56	−3.2	−16.4	5
Italy	215,799,016	225,335,126	955	28,453,211	13.2	538	18,917,101	8.8	404	−9.5	−4.4	13
Luxembourg	3,229,321	2,603,349	15	0	0.0	0	625,972	19.4	15	0.6	19.4	0
Netherlands	86,452,491	80,351,292	209	6,151,089	7.1	54	12,252,288	14.2	153	6.1	7.1	2
Portugal	36,898,516	36,425,933	244	1,771,813	4.8	56	2,244,396	6.1	184	0.5	1.3	4
Spain	172,130,788	182,893,568	827	34,816,872	20.2	221	24,054,092	14.0	573	−10.8	−6.3	33
Sweden	22,281,227	19,315,482	705	3,171,150	14.2	204	6,136,895	27.5	436	3.0	13.3	65
UK	206,025,867	242,464,097	779	50,927,842	24.7	348	14,489,612	7.0	344	−36.4	−17.7	87
Cz Republic	96,910,587	82,454,636	395	168,911	0.2	42	14,624,862	15.1	352	14.5	14.9	1
Estonia	16,747,054	12,621,824	43	14,832	0.1	2	4,140,062	24.7	40	4.1	24.6	1
Hungary	30,236,166	26,027,616	235	1,178,982	3.9	49	5,387,532	17.8	185	4.2	13.9	1
Latvia	4,070,078	2,854,424	96	23,834	0.6	12	1,239,488	30.5	78	1.2	29.9	6
Lithuania	13,503,454	6,603,869	100	7,046	0.1	3	6,906,631	51.1	90	6.9	51.1	7
Poland	143,140,900	115,057,531	488	549,754	0.4	34	28,633,123	20.0	454	28.1	19.6	0
Slovakia	30,470,677	25,231,769	175	46,789	0.2	18	5,285,697	17.3	156	5.2	17.2	1
Slovenia	9,138,064	8,720,550	98	153,684	1.7	23	571,198	6.3	74	0.4	4.6	1

Appendix II. An overview on each sector's situation.

	Allocation 2005 (t CO_2)	2005 verified emissions (t CO_2)	Total number of installations	Gross Short		Gross Long		Net Short / Net Long	
				t CO_2	%	t CO_2	%	t CO_2	%
POWER&HEAT									
EU23	1,170,783,068	1,198,708,781	3570	157,660,503	13.5	129,208,590	11.0	28,451,913	2.4
EU15	935,411,200	998,243,257	2723	155,936,049	16.7	92,571,173	9.9	63,364,876	6.8
EE8	235,371,868	200,465,524	847	1,724,454	0.7	36,637,417	15.6	−34,912,963	−14.8
REFINERIES									
EU23	142,553,291	132,997,989	136	2,687,055	1.9	12,204,279	8.6	−9,517,224	−6.7
EU15	137,067,072	128,756,423	126	2,687,055	2.0	10,959,626	8.0	−8,272,571	−6.0
EE8	5,486,219	4,241,566	10		0.0	1,244,653	22.7	−1,244,653	−22.7
IRON, STEEL & COKE									
EU23	159,638,364	127,241,724	235	1,816,331	1.1	34,203,974	21.4	−32,387,643	−20.3
EU15	141,054,277	119,159,278	210	1,791,809	1.3	23,677,811	16.8	−21,886,002	−15.5
EE8	18,584,087	8,082,446	25	24,522	0.1	10,526,163	56.6	−10,501,641	−56.5
PULP&PAPER									
EU23	38,635,691	30,628,002	795	771,988	2.0	8,485,611	22.0	−7,713,623	−20.0
EU15	35,629,925	28,734,717	720	762,395	2.1	7,387,681	20.7	−6,625,286	−18.6
EE8	3,005,766	1,893,285	75	9,593	0.3	1,097,930	36.5	−1,088,337	−36.2
CEMENT&LIME									
EU23	174,663,015	161,419,401	462	7,534,377	4.3	19,873,806	11.4	−12,339,429	−7.1
EU15	155,051,883	147,237,414	399	7,464,191	4.8	14,374,475	9.3	−6,910,284	−4.5
EE8	19,611,132	14,181,987	63	70,186	0.4	5,499,331	28.0	−5,429,145	−27.7
GLASS									
EU23	19,315,789	17,112,080	344	464,039	2.4	2,462,392	12.7	−1,998,353	−10.3
EU15	17,127,707	15,407,853	297	450,383	2.6	1,934,143	11.3	−1,483,760	−8.7
EE8	2,188,082	1,704,227	47	13,656	0.6	528,249	24.1	−514,593	−23.5
CERAMICS, BRICKS&TILES									
EU23	16,430,329	13,257,432	1035	475,507	2.9	3,401,801	20.7	−2,922,327	−17.8
EU15	13,662,675	11,090,958	868	427,983	3.1	2,721,570	19.9	−2,293,587	−16.8
EE8	2,767,654	2,166,474	167	47,524	1.7	680,231	24.6	−628,740	−22.7

Appendix IIIa. An overview on the data used to derive GDP trends in each member state.

	Gross domestic product at constant market prices (Billions, National currency)						
	1995	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Austria	182.0	210.4	212.1	214.0	216.3	221.6	226.1
Belgium	220.8	251.5	254.5	258.2	260.6	266.8	270.9
Denmark	1124.1	1294.0	1303.1	1309.2	1318.2	1342.9	1386.2
Finland	104.8	132.3	135.8	138.0	140.4	145.4	149.6
France	1263.3	1442.5	1468.7	1485.0	1501.8	1532.3	1550.6
Germany	1873.8	2062.5	2088.1	2088.3	2083.2	2109.2	2127.5
Greece	79.9	94.7	99.5	103.3	108.2	113.3	117.4
Ireland	76.2	121.0	127.9	135.6	141.5	147.6	155.7
Italy	1083.8	1191.1	1212.4	1216.6	1217.0	1230.0	1229.6
Luxembourg	16.3	22.0	22.6	23.4	23.9	24.9	25.9
Netherlands	367.4	441.4	447.7	448.1	449.6	458.4	465.4
Portugal	100.1	122.3	124.7	125.7	124.3	125.7	126.2
Spain	515.4	630.3	652.6	670.1	690.2	711.5	735.9
Sweden	1891.3	2217.3	2241.0	2285.7	2324.4	2411.5	2476.6
UK	884.7	1035.3	1059.6	1081.5	1110.3	1146.5	1167.8
Cz Republic	2031.1	2189.2	2242.9	2285.5	2367.8	2467.6	2617.8
Estonia	70.9	92.9	98.9	106.1	113.2	122.0	134.0
Hungary	10820.8	13272.2	13846.9	14375.4	14861.6	15637.1	16280.7
Latvia	3.6	4.8	5.1	5.5	5.9	6.4	7.0
Lithuania	37.1	45.8	48.8	52.1	57.6	61.6	66.2
Poland	337.2	438.6	443.5	449.8	467.0	491.6	508.3
Slovakia	785.6	941.3	971.7	1011.7	1053.8	1110.8	1178.8
Slovenia	2404.6	2981.0	3060.2	3165.9	3249.8	3385.2	3516.2

Source: International Monetary Fund, World Economic Outlook Database, September 2006.
Notes: Estimates start after 2005, except for Belgium, Finland, Hungary, Latvia and Poland where estimates start after 2004

Appendix IIIb. An overview on the data used to calculate GDP based on IMF data weighted at 2004 PPP values.

	2004 GDP based on PPP valuation of country GDP (Billions, current intern. dollar)	**2004 weights**		**Country-specific indices at constant prices**			
		Region	**EU23**	**2002**	**2003**	**2004**	**2005**
EU 23	-	-	-	***100.0***	***101.4***	***103.9***	***105.8***
EU 15	-	***1.0000***	***0.9145***	***100.0***	***101.1***	***103.3***	***104.9***
EE 8	-	***1.0000***	***0.0855***	***100.0***	***104.1***	***109.6***	***114.8***
Austria	263.3	0.0242	0.0221	100.0	101.1	103.6	105.7
Belgium	313.5	0.0288	0.0263	100.0	100.9	103.3	104.9
Denmark	179.4	0.0165	0.0151	100.0	100.7	102.6	105.9
Finland	156.3	0.0144	0.0131	100.0	101.8	105.3	108.4
France	1758.9	0.1616	0.1478	100.0	101.1	103.2	104.4
Germany	2440.4	0.2242	0.2050	100.0	99.8	101.0	101.9
Greece	234.9	0.0216	0.0197	100.0	104.8	109.7	113.7
Ireland	155.9	0.0143	0.0131	100.0	104.3	108.8	114.8
Italy	1627.0	0.1495	0.1367	100.0	100.0	101.1	101.1
Luxembourg	30.1	0.0028	0.0025	100.0	102.0	106.4	110.7
Netherlands	487.6	0.0448	0.0410	100.0	100.3	102.3	103.9
Portugal	197.4	0.0181	0.0166	100.0	98.9	100.0	100.4
Spain	1028.8	0.0945	0.0864	100.0	103.0	106.2	109.8
Sweden	257.0	0.0236	0.0216	100.0	101.7	105.5	108.4
UK	1753.3	0.1611	0.1473	100.0	102.7	106.0	108.0
Cz Republic	175.8	0.1727	0.0148	100.0	103.6	108.0	114.5
Estonia	20.2	0.0198	0.0017	100.0	106.7	115.0	126.3
Hungary	160.2	0.1574	0.0135	100.0	103.4	108.8	113.3
Latvia	26.4	0.0260	0.0022	100.0	107.2	116.5	128.4
Lithuania	44.3	0.0435	0.0037	100.0	110.5	118.2	127.0
Poland	469.4	0.4611	0.0394	100.0	103.8	109.3	113.0
Slovakia	80.6	0.0791	0.0068	100.0	104.2	109.8	116.5
Slovenia	41.0	0.0403	0.0034	100.0	102.7	106.9	111.1

Source: Derived from the authors from IMF.

Appendix IV: CO_2 emissions excluding net CO_2 from LULUCF (CO_2 equivalent, Gg).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
EU23	***3,935,715***	***4,041,282***	***3,978,984***	***3,982,571***	***3,939,944***	***3,950,391***	***4,024,554***	***4,001,167***	***4,089,716***	***4,106,598***
EU15	***3,283,298***	***3,361,793***	***3,310,521***	***3,354,289***	***3,331,210***	***3,355,237***	***3,420,438***	***3,415,643***	***3,484,853***	***3,505,887***
EE8	***652,417***	***679,489***	***668,463***	***628,283***	***608,734***	***595,154***	***604,116***	***585,524***	***604,863***	***600,711***
Austria	63,655	67,321	67,146	66,828	65,435	66,178	70,171	71,935	77,553	77,077
Belgium	123,632	127,762	122,272	127,933	122,911	123,986	124,110	123,311	126,974	126,907
Denmark	60,450	73,967	64,464	60,403	57,532	53,070	54,669	54,262	59,454	53,941
Finland	58,105	63,916	62,609	59,233	58,845	57,113	62,563	65,043	73,099	69,115
France	392,983	406,682	400,834	421,272	411,141	405,647	409,263	404,706	412,090	417,353
Germany	920,155	943,608	914,700	906,672	881,685	886,258	899,301	886,480	892,545	885,854
Greece	87,426	89,623	94,361	98,966	98,141	103,963	106,210	105,905	109,914	110,280
Ireland	34,783	36,081	38,504	40,306	42,136	44,241	46,704	45,701	44,519	45,266
Italy	445,384	438,843	443,056	454,031	459,051	463,311	469,062	470,821	486,126	489,590
Luxembourg	9,276	9,390	8,681	7,705	8,437	8,952	9,227	10,226	10,702	11,997
Netherlands	170,694	178,100	171,627	173,100	167,779	169,680	175,113	174,853	178,178	180,675
Portugal	53,131	50,258	53,543	58,234	64,894	63,762	65,018	69,250	64,600	65,705
Spain	255,724	242,993	262,655	270,747	296,302	307,673	311,552	330,551	333,837	354,562
Sweden	58,206	61,713	57,127	57,624	54,771	53,503	54,245	55,401	56,469	55,360
UK	549,695	571,537	548,942	551,236	542,151	547,901	563,230	547,198	558,792	562,204
Cz Republic	132,125	133,863	138,389	129,188	122,099	129,017	129,033	124,040	128,075	127,297
Estonia	19,315	20,264	20,225	18,318	16,771	16,849	17,103	17,312	19,106	19,232
Hungary	60,870	62,220	60,478	60,139	60,015	57,803	59,360	57,703	60,461	59,149
Latvia	8,802	9,081	8,535	8,157	7,550	6,907	7,410	7,331	7,477	7,485
Lithuania	24,384	21,477	18,570	15,663	14,884	14,105	13,326	12,704	12,287	13,350
Poland	348,172	372,530	361,626	337,448	329,697	314,373	317,844	308,277	319,082	315,234
Slovakia	14,908	15,666	15,978	15,722	15,088	15,177	16,145	16,212	16,012	16,464
Slovenia	43,841	44,389	44,662	43,649	42,630	40,924	43,896	41,945	42,362	42,498

Source: European Environmental Agency (2006), Annual European Community greenhouse gas inventory 1990–2004 and inventory report 2006, EEA Technical report No. 6/2006, Copenhagen.

Appendix Va. Energy intensity of the economy (Gross inland consumption of energy divided by GDP at constant prices, 1995; kgoe per 1000 Euro).

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
EU 25	***230.4***	***235.0***	***227.6***	***224.2***	***214.9***	***208.8***	***209.7***	***206.5***	***207.6***	***204.9***
EU 15	***205.4***	***209.4***	***202.7***	***201.0***	***195.7***	***190.5***	***191.4***	***188.4***	***189.5***	***187.5***
Austria	145.8	151.0	148.2	144.8	139.6	134.4	142.8	139.9	149.0	146.1
Belgium	238.6	252.3	249.0	248.8	244.0	236.1	228.1	213.6	217.4	208.2
Denmark	146.9	161.7	146.5	140.7	132.1	125.0	126.6	123.8	126.1	120.3
Finland	290.6	302.4	299.1	288.9	276.0	260.1	263.8	272.2	280.1	272.1
France	199.7	209.3	198.6	197.7	191.0	186.6	188.3	186.1	188.5	185.5
Germany	175.2	179.2	174.2	170.2	163.9	159.7	162.5	158.7	161.0	158.8
Greece	268.5	276.1	268.3	272.7	262.5	263.6	260.6	258.0	247.8	240.4
Ireland	217.0	213.4	201.7	196.8	187.7	175.1	172.5	166.1	155.2	156.9
Italy	192.4	190.1	189.0	191.4	190.9	186.9	184.0	184.1	189.2	189.1
Luxembourg	241.2	238.0	216.5	197.9	192.9	186.6	190.7	196.7	181.8	194.3
Netherlands	231.2	233.2	221.3	211.7	202.1	198.5	200.7	201.1	202.2	203.2
Portugal	237.3	228.6	233.2	239.2	247.4	241.5	243.9	254.7	234.7	239.6
Spain	228.7	220.3	222.7	223.6	227.0	227.0	225.4	226.3	219.7	222.5
Sweden	265.5	268.4	255.4	248.5	238.2	215.0	228.9	224.3	217.1	217.5
UK	251.5	256.1	242.0	242.7	234.3	227.3	223.7	214.5	212.1	207.2
Cz Republic	965.8	952.1	969.5	946.5	868.4	888.4	883.9	875.8	891.2	851.8
Estonia	1835.2	1863.4	1659.2	1495.3	1398.1	1214.8	1273.0	1153.2	1179.1	1140.2
Hungary	740.6	747.5	700.5	661.9	642.0	600.5	588.6	579.6	566.6	534.1
Latvia	994.4	921.3	793.3	740.5	840.9	756.0	816.5	750.3	725.1	696.3
Lithuania	1691.7	1735.2	1531.8	1592.4	1372.2	1208.4	1256.8	1272.7	1194.8	1135.6
Poland	962.8	972.9	878.5	792.3	730.2	680.2	673.5	654.2	623.1	596.6
Slovakia	1155.4	1051.8	1055.8	997.6	976.5	955.9	1015.8	976.0	929.6	854.3
Slovenia	397.3	402.0	388.4	371.8	348.1	341.7	349.6	344.6	341.1	329.2

Source: Eurostat.

Appendix Vb. Energy intensity of industry (index 1995 = 100).

	1995	1996	1997	1998	1999	2000	2001	2002	2003
EU 25	***100***	***100.2***	***98.5***	***94.9***	***91.6***	***91.8***	***91.4***	***90.2***	***91.6***
EU 15	***100***	***99.9***	***98.8***	***96.6***	***95***	***95.2***	***95.4***	***94.2***	***95.9***
Austria	100	100.7	109.4	105.9	97.1	97.5	95.5	100	102.7
Belgium	100	95.5	97.2	98.6	100.7	98.5	97.8	91.9	97.3
Denmark	100	100.7	95.9	93.4	90.7	85.3	87.6	87.1	86
Finland	100	98	98	94.8	95.6	88.2	84.6	86.5	86.3
Germany	100	100.3	94.4	92.8	90.2	92.8	90.5	90.1	92.1
Greece	100	102.6	104.6	99.3	91.3	92.4	87.8	85.3	77.7
Italy	100	99	101.3	98.6	105.2	105.6	100.8	101.2	104.7
Luxembourg	100	95.1	80.9	66.3	68.8	67.2	62.7	58.7	57
Netherlands	100	102.4	101.6	99	94.3	97.7	96.6	96.5	102.7
Portugal	100	97	101.7	105.4	105.9	107.5	121.4	114.3	114.2
Spain	100	95	99.4	98.2	92.5	100.3	102.6	103.6	105.9
Sweden	100	99.9	95.6	90.9	84.8	82.5	76.8	74.6	73.1
UK	100	100.9	100.1	96.1	97.6	93.7	97.3	92.2	95.4
Cz Republic	100	90.4	93.2	91.6	72.6	74.6	74.3	68.9	65.8
Estonia	100	106	84.1	70	55.4	51.8	53.1	41.7	42.7
Hungary	100	102.5	86	79.7	71.5	66.6	67.6	68.7	62
Latvia	100	156.2	144.3	101.9	93.8	81.1	77.8	74.5	70.3
Lithuania	100	89	86.5	76	66.8	62.1	56.8	58.1	60.4
Poland	100	99.7	89.6	75.6	64.2	62.6	58.7	57.1	55.6
Slovakia	100	86.1	89.4	82.6	79.7	88.6	91	93.1	89.6
Slovenia	100	95.7	92.3	85.8	85.3	95.9	85.4	80.4	92.4

Source: Eurostat.

Appendix VI. An overview of the data relevant for member state abatement.

	Base period emissions (Mt CO_2)	Observed annual GDP growth rate of 2002–2005	Assumed annual rate of change of carbon intensity 2000–2004	Implied annual rate of increase of CO_2	Counterfactual 2005 BAU emissions (Mt CO_2)	Verified emissions 2005 (Mt CO_2)	Difference BAU–2005 emissions (Mt CO_2)	Difference BAU–2005 emissions (%)
EU23	***2,078.0***	–	–	***1.1%***	***2150.1***	***2006.6***	***–143.5***	***–6.7***
EU15	***1676.6***	–	–	***1.0%***	***1729.3***	***1636.6***	***–92.7***	***–5.4***
EE8	***401.4***	–	–	***1.6%***	***420.7***	***370.0***	***–50.8***	***–12.1***
Austria	30.2	1.9%	+2.2%	4.0%	34.0	33.4	–0.7	–2.0
Belgium	63.0	1.6%	–0.9%	0.7%	64.4	55.4	–9.0	–14.0
Denmark	30.9	2.0%	–0.5%	1.4%	32.2	26.5	–5.8	–17.9
Finland	36.2	2.8%	+1.8%	4.6%	41.5	33.1	–8.4	–20.2
France	141.1	1.5%	–0.8%	0.6%	143.8	131.3	–12.5	–8.7
Germany	501.0	0.6%	–0.6%	0.1%	501.8	474.0	–27.8	–5.5
Greece	70.1	4.6%	–3.3%	1.2%	72.7	71.3	–1.5	–2.0
Ireland	20.9	4.9%	–4.7%	0.3%	21.1	22.4	+1.3	+6.3
Italy	224.0	0.4%	+0.5%	0.9%	229.9	225.3	–4.6	–2.0
Luxembourg	2.9	3.6%	+3.0%	6.5%	3.5	2.6	–0.9	–25.8
Netherlands	89.5	1.3%	+0.6%	1.8%	94.5	80.4	–14.2	–15.0
Portugal	36.6	0.1%	+0.0%	0.2%	36.8	36.4	–0.4	–1.0
Spain	164.1	3.3%	+0.1%	3.3%	181.2	182.9	+1.7	+0.9
Sweden	20.2	2.8%	–1.3%	1.4%	21.1	19.3	–1.8	–8.5
UK	245.9	2.7%	–2.0%	0.7%	250.8	242.5	–8.4	–3.3
Cz Republic	89.0	4.8%	–3.4%	1.4%	92.9	82.5	–10.4	–11.2
Estonia	12.4	8.8%	–4.4%	4.3%	14.1	12.6	–1.5	–10.5
Hungary	32.0	4.4%	–3.7%	0.7%	32.7	26.0	–6.6	–20.3
Latvia	3.7	9.5%	–6.0%	3.4%	4.1	2.9	–1.2	–30.3
Lithuania	9.0	9.0%	–9.2%	–0.2%	8.9	6.6	–2.3	–26.2
Poland	219.8	4.3%	–2.9%	1.5%	229.6	205.4	–24.2	–10.5
Slovakia	26.5	5.5%	–2.4%	3.0%	29.0	25.2	–3.8	–13.0
Slovenia	9.0	3.7%	–2.4%	1.3%	9.4	8.7	–0.6	–6.8

Notes: Polish data assumed according to footnote 3. Base period data from DEHSt (2005); GDP growth rate based on own calculations of weighted GDP; carbon intensity figures derived from EEA data on CO_2.

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