# Emission projections 2008-2012 versus NAPs II[1]

26.9.2006

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[1] We are grateful for extensive help and discussions from Terry Barker, Stephan Schleicher (Austria), Felix Matthes (Germany), Luis Olmos (Spain), Jos Sijm (Netherlands), Michal Sobotka (Poland) and Misato Sato. Financial support from the UK research council grant TSEC 2 is gratefully acknowledged.

We compare the publicly available national allocation plans (NAPs) for the period 2008-2012 with a best estimate for $CO_2$ emissions by the installations covered by these NAPs. Our key findings are:

1. The collective allocations proposed under Phase II NAPs exceed the historic trend of emissions extrapolated forward, but are below model-based ‘business-as-usual’ forecasts.

2. The gap (potential demand) is very small in the case of ‘favourable to gas’ fuel prices, a few percent in the case of ‘favourable to coal’ fuel prices.

3. Even in the high case, the potential demand is smaller than most estimates of the volume of CDM/JI credits available to ETS.

4. Based on an ensemble of emission projections under uncertainty in fuel prices, economic growth rates, performance of the non-power sector and CDM/JI availability we find:
a. Taking no account of CDM/JI, there is c.15% chance of a ‘dead market’ (emissions below cap even at zero price), and a roughly 50:50 chance of the market sustaining 20€/tCO2.
b. However, with an expected inflow of committed CDM/JI credits (100 MtCO2/year) into ETS the allowance supply will exceed demand in 50% of cases without any carbon price, and in 80% of our 20€/t$CO_2$ scenarios
c. At the high end of CDM/JI inflows into ETS (200 Mt/yr), there would be excess supply in more than 80% of scenarios in both cases.

5. Consequently, we conclude that if currently proposed Phase II NAPs were approved, prices would tend to be very low and only small volumes of CDM/JI would enter the EU ETS

6. Current proposed NAP allocation would therefore result in CDM/JI being almost exclusively public sector funded, placing the cost of Kyoto compliance entirely upon government Treasuries, and exacerbating the cost by removing any significant incentive to abate in the EU ETS sectors

## I. Introduction

The aim of this paper is to assess the implications of the National Allocation Plans proposed for the second phase of the EU ETS, 2008-12. As of mid September, almost all Member States had plans either submitted for approval to the European Commission, or published for consultation. Our aim is to assess the collective implications of these plans for the operation of the EU ETS in Phase II, if they were to be approved.

Apart from collating the information in the NAPs – itself a complex exercise given some of the special provisions – this requires projection of emissions under different scenarios. We first set the context by comparing allocations against extrapolation of past trends, and explore the implications of different price and growth scenarios using detailed model analyses.

## II. Methodology and assumptions

To project future $CO_2$ emissions, we treat the power sector separately from other sectors covered by the ETS. For the power sector we examine emissions using the Integrated Planning Model (IPM®) of ICF International which simulates every European power station and investment decisions in new power stations. For the remaining sectors we use two approaches. First, we start from the verified emissions from 2005, adjust for the coverage of the ETS and then apply sector specific growth rates from a recent DTI BAU study combined with country specific $CO_2$ growth rates from OECD projections. The second approach to project emissions of the non-power sectors involves applying country and sector specific $CO_2$ growth rate as determined by the E3ME model of Cambridge Econometrics and calibrated for the Matisse FP6 project assuming $CO_2$ prices around 20 €/t$CO_2$. The detailed assumptions and our treatment of missing data are explained in Appendix I and II.

To explore sensitivity to prices, we use four different fuel price assumptions from a recent UK Department of Trade and Industry study (DTI 2006c) (Appendix III).

To determine the total cap, we use the publicly available data from NAPs, assuming in the following figures that all new entrant reserves will be issued. Some NAPs [2] envisage that New Entrant Reserves will be cancelled if not issued to new entrants. Without any new build in these countries, the total EU cap would be reduced by 40 Mt $CO_2$/year.

We furthermore assume an inflow of allowances into ETS from CDM and JI projects. Following a more detailed discussion in Grubb and Neuhoff (2006), we assume between 0 and 1000 Mt$CO_2$ international project credits and allowances could be available to enter the ETS during the period 2008-2012. The upper level is one third lower than the total projected availability of CDM and JI for Europe, assuming that at least some of the inflow would be taken by government inflow in all cases; it is also roughly consistent with the 'supplementarity' constraint that many MS have built into their plans, representing even at this maximum level an inflow of less than 10% of allocated allowances. Table 1 gives the range that we assume for cap and inflow (Appendix IV).

| | |
|---|---|
| CAP | 2089 |
| CAP with NER | 2202 |
| CAP with NER, low CDM/JI inflow | 2402 |

**Table 1 depicts our estimations on CAP including inflows from JI and CDM projects (Mt$CO_2$/year).**

## III. Emission projections in relation to historic trend

To verify our emission projections we first compared them to historic emissions from 1990-2004 using data from the Euroepean Community GHG Inventory (EEA 2006)

[2] The NAPs specify that Cyprus, Germany, Denmark, Spain, Lithuania, Latvia, Malta, Portugal should not to sell the excess NER back to the market. In the French NAP it is not decided whether to cancel the excess NER or auction it, but for the purpose of calculating the maximum possible reduction of the Cap we assume that it will be cancelled.

(Figures 1 and 2). As the Inventory only provides data on the total national GHG emissions, for the purposes of these figures we assume that the share of emissions associated with ETS stays constant (Georgopoulou et al. 2005). Applying a linear trend to this historic emission from 1990-2004 (later start for accession countries), we extrapolated the BAU development of emissions for 2005-2012 (Appendix V).

Figure 1 and Figure 2 illustrate that the emissions under this linear trend are lower than projected in either of our two base case scenarios. The fundamental reasons why emissions resume growth in the modeling projections, after a decade of decline or stability, is probably due to an assumed slowdown in the rate of energy efficiency improvements and a slowdown in the historic shift from coal towards natural gas, in the light of higher natural gas prices. We do however note a general tendency that models have previously projected growth that has not materialized, and to this extent our results may be conservative.– the excess allocation that we find under the currently envisaged NAPIIs might be even higher in practice.

To set this in the context of Phase II allocations, the total Phase II CAP with NER implied in the present NAPs is slightly above the average emissions levels over the past 10 years.

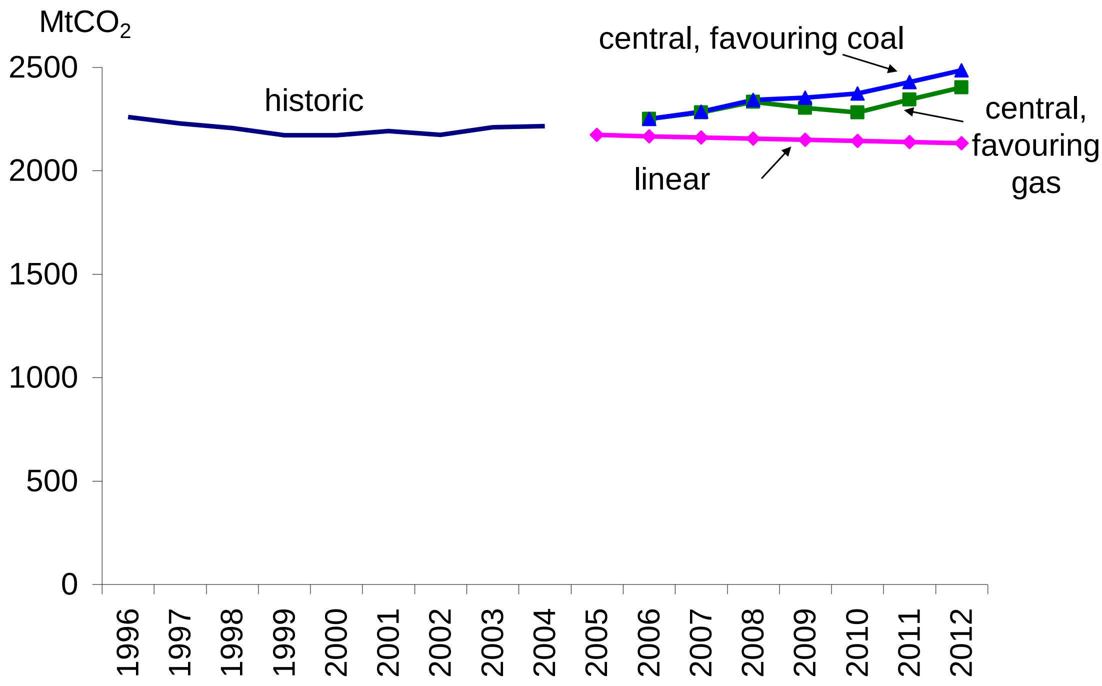


**Figure 1 Linear trend of ETS emissions compared to base case simulation results for the case of 0 $CO_2$ price.**

Figure 2 illustrates that, with a price of €20/tCO2, emissions from the ETS sectors are projected to be roughly stable at current levels, still slightly above the historic trend.

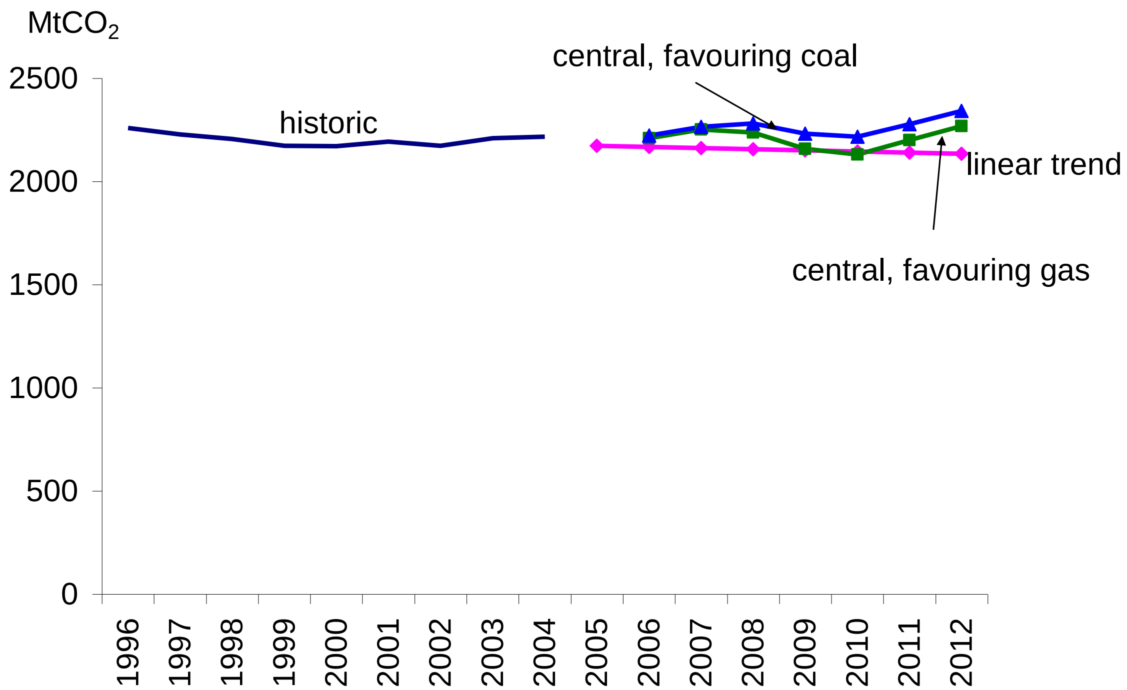


**Figure 2 Linear trend of ETS emissions compared to base case simulation results for the case of 20 €/t$CO_2$ price.**

## IV. **Numerical results from simulations under uncertainty**

Figure 3 compares the total NAP II allocation (the horizontal line spanning 2008-12) against most recent emissions, the Phase I cap, and our range of projections for emissions over the period if there were no EU ETS. With the blue vertical bars we also show the the range of potential inflow from JI and CDM credits into ETS.

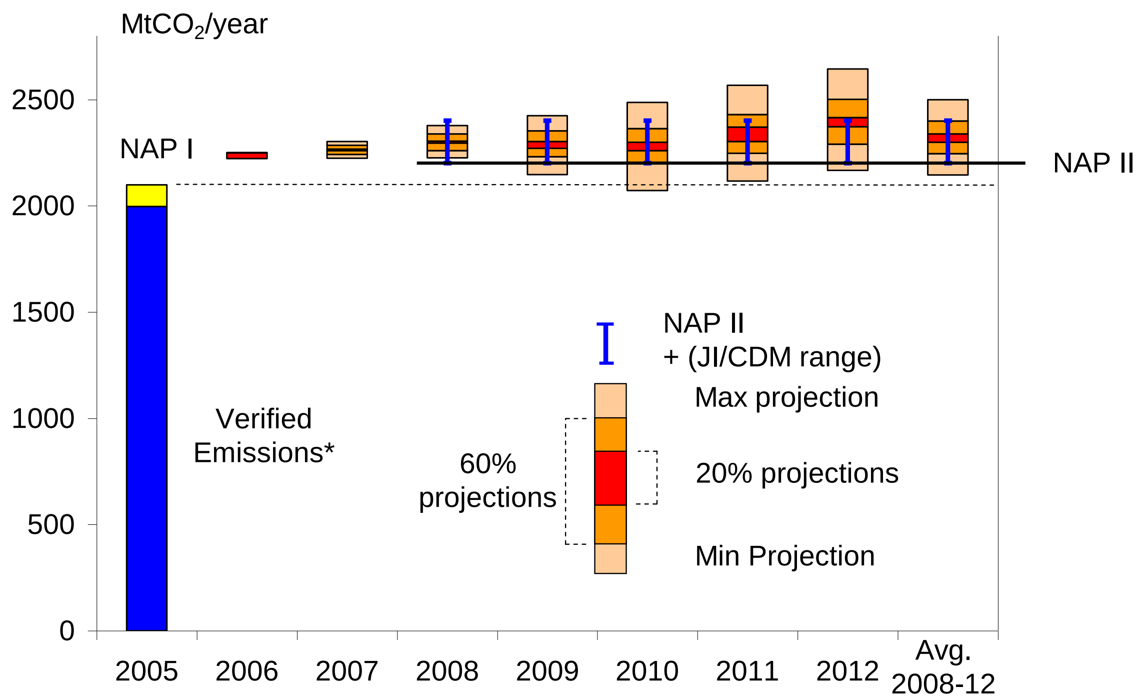


**Figure 3 Projected $CO_2$ emissions versus Cap for the BAU (assuming zero $CO_2$ price)**

Note that the Phase I cap was significantly above the 2005 verified emissions, and the NAP II allocations in turn represent a significant increase over Phase I.

Our model estimates of emissions for 2006 exceed the 2005 verified emissions, for four reasons. First, in the electricity modeling we do not reflect that some gas generation is operated despite being more expensive than coal, because it is supplied under take-or-pay gas contracts. This would have increased $CO_2$ emissions by 100 Mt. Second, the electricity model calculates aggregate $CO_2$ emissions that exceed verified emissions by 25 Mt. Third, with GDP growth emissions of the non-power sector are expected to grow by 25 Mt. Fourth, 55.1 Mt of additional installations are covered under NAP II, that either opted out of NAP I, or where the coverage is extended.

The results for 2008-12 illustrate that emission projections are subject to considerable uncertainty. Across our range of assumptions, the Figure illustrates the distribution in term of five probability bands, with the central red illustrating the central 20% of scenario outcomes. The results show that even with a ‘zero carbon price’ (a ‘no EU ETS’ scenario):

- without any inflow of CDM and JI credits, allowance supply will exceed demand in 20% of our scenarios. In other words, based on the current NAPs and range of other input assumptions, there is a one-in-five risk that the EU ETS would be unable to sustain any carbon market or incentive to abate, at home or abroad. We could only expect a positive price if banking moves a significant share of the allowances towards post-2012.

- if inflows from JI and CDM projects are high (200 $MtCO_2$/year), 80% of the projections result in excess supply. Obviously, there is a certain paradox in a combination of high emission credit imports with an overall surplus market, but it illustrates that current Phase II allocations are extremely unlikely to support private purchase of emission credits on the scale that suppliers may be hoping for even at very low carbon prices.

Figure 4 illustrates the equivalent results if the power sector adjusts investment and operational decisions to reflect a Carbon price of 20 €/$tCO_2$ (we do not explicitly model the response of non-power sector, hence again our results are likely to be conservative). Obviously, this reduces the total emissions in our 24 model scenarios, as depicted.

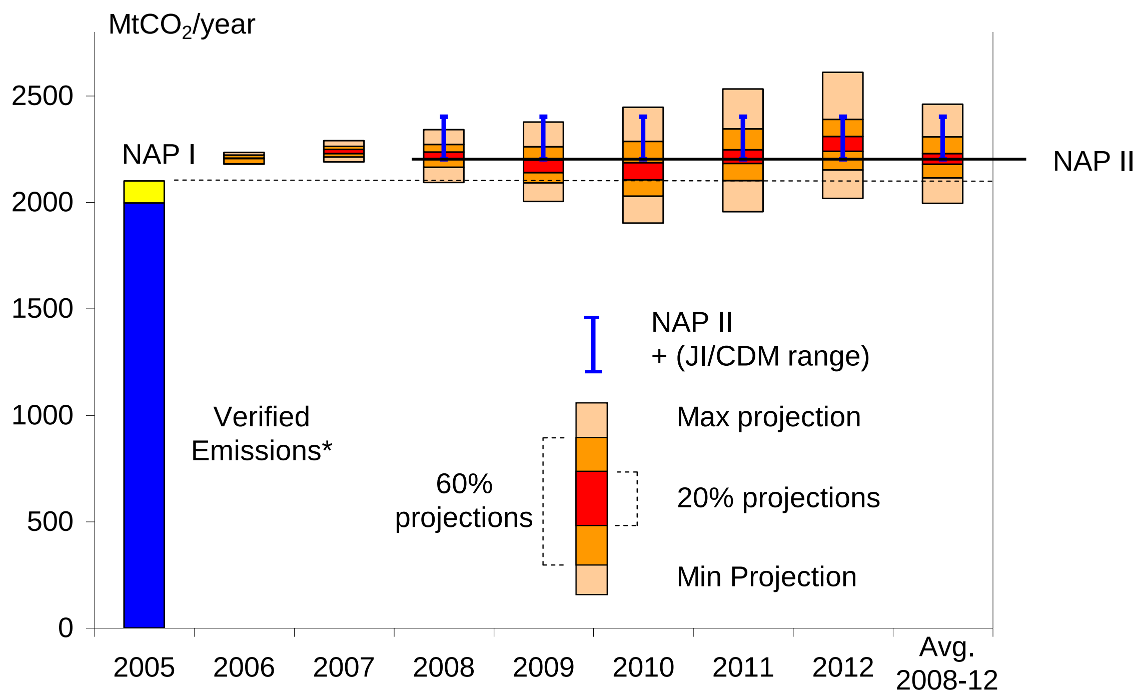


**Figure 4 Projected emissions and Cap, when the power sector is exposed to 20 €/$tCO_2$ price.**

The Figure illustrates that:

- in 50% of the scenarios assuming an allowance price of 20 €/$tCO_2$, emissions would fall below the European cap even without *any* inflows of JI and CDM credits into the EU ETS.
- At the high level of credit inflow, the probability of sustaining a 20€/t price is very small, and even on our central case (100MtC/yr), there is only a 20% chance of the market sustaining a price of €20/t.

This suggests that the currently published allocation levels of NAPs II are simply not consistent with sustaining $CO_2$ prices at any like the levels seen to date.

The level of the $CO_2$ emissions in this projection suggests that if the European countries want to ensure $CO_2$ prices close to 20 €/$tCO_2$ then they have to significantly reduce the aggregated EU Cap. The implication based on our projections is that if a 200Mt tightening were associated with a similar level of JI/CDM imports (200Mt/yr), there would then be a roughly 50% chance of the market sustaining a price of around €20/t – before taking account of responses outside the power sector.

## V. Discussion

### V,a. Implications for the NAP approval process

Our analysis implies that the currently proposed allocations are unlikely to support a viable $CO_2$ market. If other analyses confirm this, this conclusion obviously puts a spotlight on the approval process. The Commission has to evaluate each NAP on its own merits, in relation to the criteria laid out in the Directive. Nevertheless, given the relative ambition of some of the NAPs (eg. Spain, Italy, UK) our collective result must imply that many other NAPs contain overallocation based on emission projections which, at least when considered collectively, are implausible. This would contravene relevant terms of the Directive.

A further basis on which the Commission might critically assess the national allocation plans are state aid considerations. Johnsten (2006) argues that free allowance allocation does constitute state aid, which has to be notified according to the Directive. One relevant provision for the assessment of such state aid could be the proportionality principle – the benefits from the free allocation should be proportional to the transition cost for companies from the introduction of emission trading.

Moreover, the weak allocations raise questions about the consistency of plans with national Kyoto targets, which is another criteria relevant to Commission assessment. In principle, countries could 'fill the gap' with purchases of JI/CDM, to which we now turn.

### V.b. Implications for CDM / JI credits and government purchase

Weak allocations in the EU ETS do not necessarily imply a weak market for CDM/JI credits. As long as countries comply with Kyoto, the total demand for CDM/JI (or equivalent transfers of AAUs under Green Investment Schemes – an option not open to ETS private sector participants) is set by the difference between national emissions and Kyoto targets over 2008-12. The real implication of weak EU ETS allocations is what it does to the cost of compliance to governments, specifically Finance ministries and taxpayers, through three factors:

- *Substitution:* more allocations to ETS sectors mean the private sector will have less need to purchase CDM/JI credits that would contribute to national compliance; governments must pay for these directly.
- *Increased total need*: a weak EU ETS price means that EU ETS sectors undertake less abatement, resulting in higher national emissions, and in aggregate a greater *total* need for CDM/JI credits. National governments could also decide to acquire

additional AAUs from countries like Russia and the Ukraine. It is currently unclear to what extent that is politically acceptable and what level of 'greening' would be desired.
- *Price escalation*: the greater aggregate demand for CDM/JI credits might reasonably be assumed to have some impact on the overall CDM/JI market, increasing the price.

In short, the weak EU ETS allocations mean that governments have to take up the slack, and substitute for less domestic abatement by funding additional abatement abroad at a higher unit cost to the taxpayer. If the price of CDM/JI credits exceeds the EU ETS price, the Kyoto credits market will become a largely public-sector funded operation, rather than leveraging the private investment that many had originally envisaged.

As it is frequently assumed that the installations of the covered sector, especially the power sector, have easier accessible emission reduction options one could have expected that the ETS share of the national emission budget should have declined, rather than increased as some current plans seem to envisage. Preliminary estimates suggest that the cost of weak allocations to governments, in aggregate, could be several billion Euros, but distributed very unequally between the different countries.

### V.c. Implications for auctioning and other mechanisms

As noted, if the EU ETS is to be an effective market during the Kyoto period, the process from hereon must reduce the currently proposed volume of total free allocations, probably by a couple of hundred $MtCO_2$ per year. However, our analysis has emphasized the irreducible uncertainty associated with emission projections. This suggests that Member States should consider carefully measures to increase price stability and thus provide investment certainty.

One option would be increased use of auctions. Auctions in themselves could in principle provide a source of revenue for government purchase of Kyoto credits. In addition, if all MS were to auction allowances within the 10% limit of the Directive (200 Mt/yr) and the auctions where implemented with a price floor, then this would cover the range of uncertainty in the projections (Hepburn e.a. 2006). This could ensure that in the case of low emissions a reduced inflow from the auctions would maintain prices, without distorting the demand/supply balance in the case of higher demand.

Banking of allowances to the period post-2012 could also help to support the price, if participants believe that the future allowance price will be higher. Banking has worked effectively in $SO_2$ and $NO_X$ programs in the US (Ellerman 2004). However, the same mechanism in the EU ETS would subject to high degree of uncertainty due to its iterative allocation approach and the complexity of post-2012 negotiations. These added uncertainties could subject the EU ETS to greater price volatility, and may thus reduce the effectiveness of banking as a mechanism to reduce investment risk.[3]

[3] Note also that in the longer term governments could issue option contracts for $CO_2$, also ensuring a price floor (Ismer and Neuhoff 2006). European governments could thus guarantee buying back allowances until the scarcity of allowances is increased to the strike price of the option contracts.

## VI. Caveats and Sensitivities

It is important to note that this study does not calculate the impact of $CO_2$ prices on the $CO_2$ emissions of the non-power sector. It relies on (a) a DTI study, which assumes $CO_2$ emissions under 0 $CO_2$ price and then gives aggregate figures on the price response of the covered sector to allowance prices, and (b) the E3ME study, which assumes a positive allowance price (increasing from 18 to 25 €/t$CO_2$ during phase II). Using data from the E3ME study, our emission projections for the non-power ETS sectors decrease by 85 Mt relative to our simulations based on DTI data. As both approaches differ in various dimensions, it is not clear to what extent this difference can be attributed to the emission reductions or due to $CO_2$ prices. Therefore we did not differentiate between both approaches, and depicted the results both for the 0 and 20 €/t$CO_2$ case as a component of the prediction uncertainty.

Table 2 illustrates how different assumptions affect the projected $CO_2$ emissions from the EU ETS sectors. As basis for the previous two Figures we had calculated the impact of combining all these scenarios.

| (Average 2008-12) | 0 $CO_2$ price | | 20 €/t$CO_2$ | |
|---|---|---|---|---|
| | Mt$CO_2$/year | Change | Mt$CO_2$/year | change |
| Base case favouring gas, DTI | **2333** | | **2199** | |
| Matisse study with E3ME for non power | 2248 | -3,7% | 2114 | -3,9% |
| Fuel price scenario central favouring coal | 2397 | 2,7% | 2270 | 3,2% |
| Fuel price scenario low fuel price | 2297 | -1,6% | 2141 | -2,6% |
| Fuel price scenario high fuel price | 2425 | 3,9% | 2388 | 8,6% |
| GDP growth 0.75% higher/a (= $CO_2$ growth) | 2404 | 3,1% | 2266 | 3,0% |
| GDP growth 0.75% lower/a (= $CO_2$ growth) | 2264 | -3,0% | 2134 | -3,0% |

**Table 2 Sensitivity of projected CO2 emissions to model parameters**

## VI Conclusion

We combined a detailed power sector model for all European countries with two approaches to project emissions of the non power sector emissions covered by ETS and simulated $CO_2$ emissions until 2012. We used the data from currently available national allocation plans and extrapolated to the outstanding plans to determine the currently envisaged emission cap under ETS for the period 2008-2012. We also made assumptions about the possible inflows of JI and CDM project credits into the ETS.

The result suggests that it is possible that emissions will fall short of the allowances in the scheme in a scenario where we assumed 0 $CO_2$ prices and it is very likely that emissions will fall short of allowances in the scheme in a scenario with 20 Euro t/$CO_2$. Thus very low CO2 prices are likely to result from the currently envisaged NAPs. In the current arrangement only extensive banking into the period post 2012 could ensure a significant positive $CO_2$ price. However, given the uncertainty about post 2012 arrangements such banking is unlikely to attribute very high values to allowances, and given the complexity of political negotiations, such banking is likely to introduce large volatilities in the prices of ETS allowances throughout the period 2008-2012.

The range of $CO_2$ emission we simulated for the year 2008-2012 illustrates how sensitive emissions can be to changing GDP growth rates, fuel prices and to energy intensity and technology development in all sectors. To increase the predictability of $CO_2$ prices in the light of this uncertainty one might consider using the flexibility of the EU Directive and reducing free allocation to sectors that are not exposed to competition outside of the EU (e.g. power sector). The allowances not issued for free could then be auctioned, e.g. 10% of the allowances issued per country. If a harmonised European price floor were to be used in these auctions, then this could help to manage the volatility inherent in any system in which cutbacks are modest compared to the intrinsic uncertainties in emission trends, and create confidence that the price will not drop below the price floor. This would facilitate investment in low Carbon technologies and energy efficiency.

**Appendix I Verified Emissions**

We started with verified emission data (EU Commission 2006a) differentiated into iron and steel, cement, lime, glass, pulp and paper, ceramics, others and primary aluminium. Based on WIFO (2006) we separated the classification combustion installations into power and non-power related combustion installations. Since we could not allocate the non-power combustion installations to specific sectors we included them in the category 'others'.

For Poland only data on 284 installations was available as of 21st of September 2006, representing allocated allowances for 110.7 $MtCO_2$ out of a total NAP I of 239.1 $MtCO_2$. We assumed that the installations not reported in the CITL will have the same ratio to allocated emissions as the installations for which already reported data is available. Thus we assumed 189.4 $MtCO_2$ emissions for Polish installations covered by ETS in 2005 (implying a total national surplus of 49.6 $MtCO_2$). In our simulations of the European power sector, we calculated 132 $MtCO_2$ emissions for Polish power installations covered by ETS, and used this figure to separate between power and non-power related emissions.

For Cyprus and Malta no data was available and we assumed that they have the same ratio between verified emissions and NAP I allocation as the Member States for which full data was available. We did not have data available that allowed us for a differentiation between power and non-power installations and thus applied general emission growth trend to all emissions.

We added to these verified emissions the volume of new installations covered under NAP II that either opted out or were not covered under NAP I (17 Mt in Germany, 32 Mt in the UK, 6.6 MtCO2 in Netherlands, 5.5 in France).

**Appendix II Projections for non-power sector**

To project the $CO_2$ emissions for the non-power sector, we first used an approach based on a recent DTI study (2006 a,b) and then an approach based on a European model of Cambridge Econometrics.

For the first approach we applied to the verified emissions per sector and country the sector specific emission growth rates used by the UK DTI (2006 a,b), scaled by the differences in the expected national growth rates (Table 3). For example the Spanish GDP is expected to grow 0.6 % faster in 2006 than the UK GDP, thus we also assumed that emissions across the sectors increase by 0.6% faster in Spain than in the UK. GDP growth projections for the period 2006-2007 are based on Eurostat (2006) and for the period 2008-2012 based on OECD (2006) and IMF (2006).

| | 2006 | 2007 | 2008-2012 |
|---|---|---|---|
| **AT** | 2,5% | 2,2% | 2,4% |
| **BE** | 2,3% | 2,1% | 1,9% |
| **CY** | 3,8% | 3,8% | 2,8% |

| | | | |
|---|---|---|---|
| **CZ** | 5,3% | 4,7% | 3,8% |
| **DE** | 1,7% | 1,0% | 2,0% |
| **DK** | 3,2% | 2,3% | 1,1% |
| **EE** | 8,9% | 7,9% | 4,6% |
| **ES** | 3,1% | 2,8% | 2,5% |
| **FI** | 3,6% | 2,9% | 1,5% |
| **FR** | 1,9% | 2,0% | 2,1% |
| **GR** | 3,5% | 3,4% | 3,1% |
| **HU** | 4,6% | 4,2% | 3,0% |
| **IE** | 4,9% | 5,1% | 3,6% |
| **IT** | 1,3% | 1,2% | 1,4% |
| **LT** | 6,5% | 6,2% | 4,6% |
| **LU** | 4,4% | 4,5% | 4,0% |
| **LV** | 8,5% | 7,6% | 4,6% |
| **MT** | 1,7% | 1,9% | 4,6% |
| **NL** | 2,6% | 2,6% | 2,1% |
| **PL** | 4,5% | 4,6% | 4,5% |
| **PT** | 0,9% | 1,1% | 2,0% |
| **SE** | 3,4% | 3,0% | 1,8% |
| **SI** | 4,3% | 4,1% | 4,6% |
| **SK** | 6,1% | 6,5% | 5,5% |
| **UK** | 2,4% | 2,8% | 2,5% |

Sources:
2006-2007 data from Eurostat (2006)
2008-2012 data from OECD (2006), except for CY, EE, LT, LV, MT and SI from IMF (2006).

**Table 3 Assumed GDP growth rates.**

The second approach uses sector and country specific growth rate computed from Cambridge Econometrics modelling. They represent those of the baseline scenario for the FP6 project Matisse using the E3ME model, covering the 2005-2010 period (Matisse 2006). For the purpose of this paper we assume that the sector specific growth rates are constant in 2011 and 2012. As the definitions of sectors under E3ME did not exactly match the classifications of verified emissions, we matched these sectors as described in Table 4.

| CITL | Matisse/E3ME |
|---|---|
| Refineries | 2 - Other energy own use and transformation |
| Cement and Lime | 6 - Non metallic nes |
| Ceramics | 6 - Non metallic nes |
| Glass | 6 - Non metallic nes |
| Pulp and Paper | 10 - Pulp and Paper |
| Iron and Steel | 3 - Iron and Steel |
| Other | 12 - Other industry |

**Table 4 Mapping of E3ME model results to classification used for verified emissions**

**Appendix III Projections for power sector**

For our analysis of the European power sector, we use the Integrated Planning Model (IPM®) developed by ICF International. The Integrated Planning Model (IPM®) is a linear programming model that selects generating and investment options to meet overall electricity demand today and on an ongoing and forward looking basis over the chosen planning horizon at minimum cost. Further details about the model are available from the EPA website (http://www.epa.gov/airmarkets/epa-ipm/).

Table 5 gives the fuel price assumptions for which we followed the July study of the Department of Trade and Industry in the UK (DTI 2006c). These prices were also applied to other European countries, correcting for location/transport costs and adjusting the differing intra annual price profile for gas between the UK and continental Europe. Demand projections are based on the UCTE forecasts for all Member States except the UK (based on DTI projections).

| | Central - Favouring GAS | | | Central - Favouring COAL | | |
|---|---|---|---|---|---|---|
| | Oil ($/bbl) | Gas (p/therm) | Coal (£/t) | Oil ($/bbl) | Gas (p/therm) | Coal (£/t) |
| **2005** | 55 | 41 | 33,6 | 55 | 41 | 33,6 |
| **2010** | 40 | 25,8 | 27,2 | 40 | 33,5 | 27,2 |
| **2015** | 42,5 | 27,3 | 26,1 | 42,5 | 35 | 26,1 |
| **2020** | 45 | 28,8 | 25 | 45 | 36,5 | 25 |

| | High prices | | | Low prices | | |
|---|---|---|---|---|---|---|
| | Oil ($/bbl) | Gas (p/therm) | Coal (£/t) | Oil ($/bbl) | Gas (p/therm) | Coal (£/t) |
| **2005** | 55 | 41 | 33,6 | 55 | 41 | 33,6 |
| **2010** | 67 | 49,9 | 36,5 | 20 | 18 | 19 |
| **2015** | 69,5 | 51,4 | 36,5 | 20 | 19,5 | 16,8 |
| **2020** | 72 | 53 | 36,5 | 20 | 21 | 14,6 |

**Table 5 Fossil fuel price assumptions from DTI (2006c)**

We assumed that the EU renewables target is satisfied. The model calculates the emissions for all power stations. For one base case we determined the volume of emissions that results from installations with less than 20 MW thermal capacity (56.4 $MtCO_2$/year). As these installations are mainly heat driven we assumed the emissions to stay constant across the time frame considered and across fuel price scenarios.

For the simulations, we constrained newbuild CCGT and coal plants to those already commissioned until 2013. The only plants coming on before 2013 are firm builds, unplanned CT units and unplanned wind installations (this reflects the idea that CCGT or coal plant to become operational by 2012 already have to be commissioned today). This might understate the potential for emissions reductions from a more rapid shift to gas through additional investment in gas generation. However, given that we already observe an increase of gas demand for power generation in Europe in the low fuel price scenario with ETS price (from 6700 TBtu to 11300 TBtu coverage exceeding ETS), it is reasonable to assume caution with additional shifts to gas generation.

Table 6 presents the aggregate $CO_2$ emissions for the European power sector (including the small installations with less than 20 MW thermal capacity).

| $CO_2$ price | Fossil fuel price scenario | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
|---|---|---|---|---|---|---|---|---|
| *0 €/t$CO_2$* | *Central - Fav GAS* | *2251* | *2281* | *2333* | *2303* | *2282* | *2344* | *2403* |
| | *Central - Fav COAL* | *2250* | *2285* | *2343* | *2354* | *2373* | *2429* | *2485* |
| | *High Prices* | *2250* | *2283* | *2337* | *2370* | *2414* | *2474* | *2529* |
| | *Low Prices* | *2251* | *2284* | *2334* | *2268* | *2221* | *2295* | *2368* |
| *20 €/t$CO_2$* | *Central - Fav GAS* | *2210* | *2251* | *2237* | *2158* | *2130* | *2201* | *2269* |
| | *Central - Fav COAL* | *2222* | *2265* | *2281* | *2232* | *2217* | *2278* | *2342* |
| | *High Prices* | *2234* | *2273* | *2307* | *2324* | *2375* | *2439* | *2496* |
| | *Low Prices* | *2208* | *2245* | *2197* | *2122* | *2045* | *2128* | *2212* |
| *20 €/t$CO_2$* | *Central – Fav gas, minimum gas constraint* | *2110* | | | | | | |

**Table 6 EU emission projections for power sector using IPM® model (Mt$CO_2$)**

When comparing the model results in 2006 with the 2005 verified power sector emissions we observed that we exceeded these emissions. This is what we expected as many gas power stations have long-term take-or-pay contracts and were thus operating despite the high 2005 gas prices. To test our model, we implemented a minimum run requirement on gas. On a country by country level the same amount of gas had to be used in the power sector in the 2006 as observed in 2003. Using this constraint our 2006 simulated data for all countries excluding Poland, Malta and Cyprus exceeded the verified emission data for the power sector of these countries by only 2%. Most deviations on a per country level could be explained by the specific climatic conditions in the year 2005. Thus we were content to use the model for emission projections.

For our long-term projections we did not apply the minimum gas consumption constraint. We assume that the take-or-pay contracts for gas that we reflected in this constraint will be resolved as part of the European liberalisation or that new gas powered stations are exposed to the market price for gas.

## Appendix IV NAPs II

We used information on the second phase cap from the National Allocation Plans submitted to the European Commission (2006b), and from the NAP II drafts published for public debate by those countries that had not officially approved them yet, as they represent the most up to date data available.

As the NAPs for DK and HU have not been published (as of 24.9.2006) we assumed the same ratio between their cap 2005-2007 and 2008-2012 as applicable to average of the other member states.

We included the entire New Entrant Reserve in the cap and also included the emissions that are currently envisaged for auctions (7 %UK, 1.22% Austria, 0.29% Belgium, 2.6 Mt$CO_2$ Poland, 2.32 Mt$CO_2$ Lithuania, 0.5 Mt$CO_2$ Ireland, 0.19 Mt$CO_2$ Luxembourg).

We assume total available CDM and JI credits for the period 2008-2012 are between 800 and 2200 Mt$CO_2$ while Japanese demand could range between 250 and 1000 Mt$CO_2$ (Grubb and Neuhoff, 2006). Very high availability is unlikely to coincide with very low Japanese demand and vice versa. We also have to allow for demand from governments to cover excess emissions in the non-covered sector. Thus we assume that inflows into ETS in the period 2008-2012 could range between 0 and 1000 Mt$CO_2$. Table 1 summarises our assumptions about the cap.

## Appendix VI Historical emissions and linear trend

We used data on the total per country green house gas emissions for the period 1990-2004 from the annual European Community GHG Inventory (EEA 2006).

Projections for 2005-2012 have been obtained by linear regression of the available sample of total GHG emissions for each country. The initial analysis on a country by country level pointed to the well known strong decline of emissions in accession countries during their early transformation in the 1990$^{th}$, and therefore we subsequently excluded data for Czech Republic, Estonia, Hungary, Lithuania, Latvia and Slovakia for the years until 1992, 1993, 1992, 1998, 1995 and 1993 for the estimation of the linear trend.

We then used data on the ETS share of $CO_2$ emissions relative to the total GHG emissions from Georgopoulou et al. (2005) based on 2003 data and thus were able to derive the a linear trend for EU ETS BaU emissions projections.

By adopting this procedure the implicit assumption has been made that the proportion of greenhouse gases from “trading” and “non-trading” sectors would remain unchanged. As emissions from some of the non-trading sectors such as transports are expected in fact to increase significantly, it is likely that our approach overstates the $CO_2$ emissions of the covered sector.

## Appendix VII CITL classifications

An analysis of the CITL raw data performed by Entec highlighted the existence of ‘some fundamental errors with regards to classification in the EC database of sites by sector/activity’, although the cause is ‘not yet known’ (Entec 2006: p4). Some of the problems of miss-classification are addressed in our projections:

a) An analysis of the CITL classification compared to that of NAP I for Spain, Italy and UK illustrates some differences, which are however not persistent across countries and sectors. For Italy the discrepancy is minimal (with the maximum around 2%), while although it is more relevant for UK and Spain, it is not in the same sectors. Therefore on aggregate they might to some extent average out.

b) Thanks to more accurate aggregate country data for the power sector (including CHP) provided by WIFO it has been possible to correctly distinguish non-power verified emissions from the CITL "Combustion" class, thus substantially reducing the possible distortion scope to only 44% of the total cap in terms of allocations.

c) If remaining errors are in the order of 5% and imply misspecification between sectors that have different projected $CO_2$ growth rates of 2% then the aggregate error ($1.02^7$ after 7 years, e.g. 15%) is 0.3%.

**Appendix VIII Analysis: Allocated versus verified**

Based on the data available in the Community Independent Transaction Log we could compare for every installation the verified emissions with the allocated allowances for the year 2005 (EU Commission 2006a). We grouped all installations where over/under allocation fall within ranges of ± 2.5% under/over allocation. The intervals are then labelled according to the middle value of the interval. The remaining installations were summarised in the +100% and -100% categories.

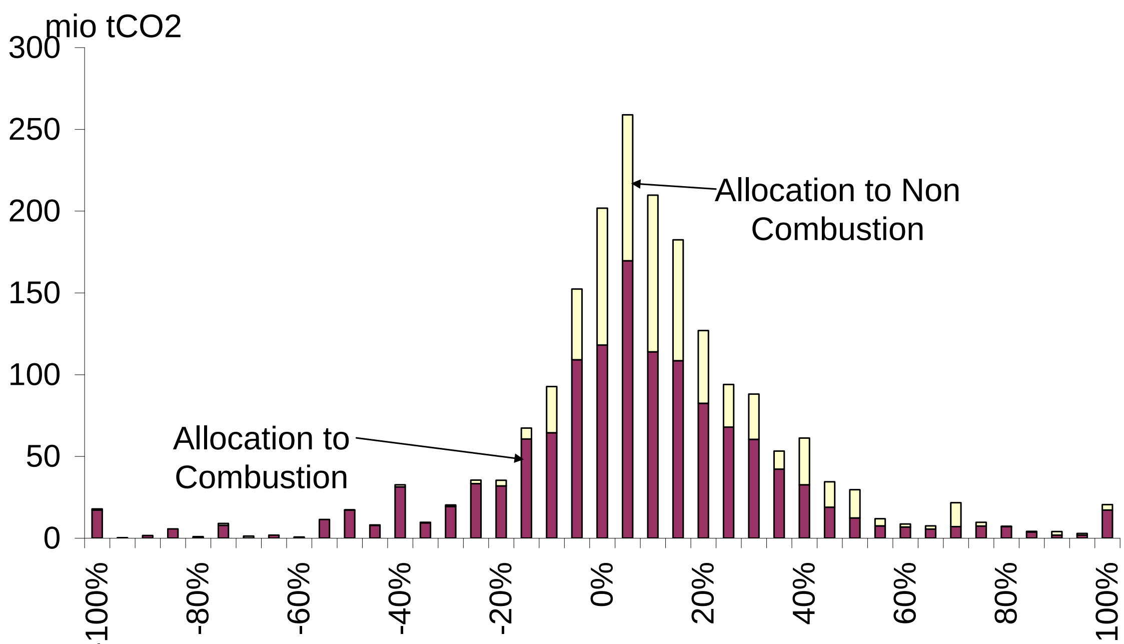


**Figure 5 Relationship between verified emissions and allowances allocated to installations in 2005.**

Figure 5 shows the distribution of total emission permits according to the extent of under/over allocation at installation level as a fraction of the allocation received. The distribution is bell shaped with a mean higher than zero, reflecting the overall long position of the EU ETS. According to the CITL classification, Non Combustion installations in general received more allowances compared to the needs than Combustion, although the latter includes both Power and non-power sector installations, thus distorting the analysis adding over allocated installations to the category.

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