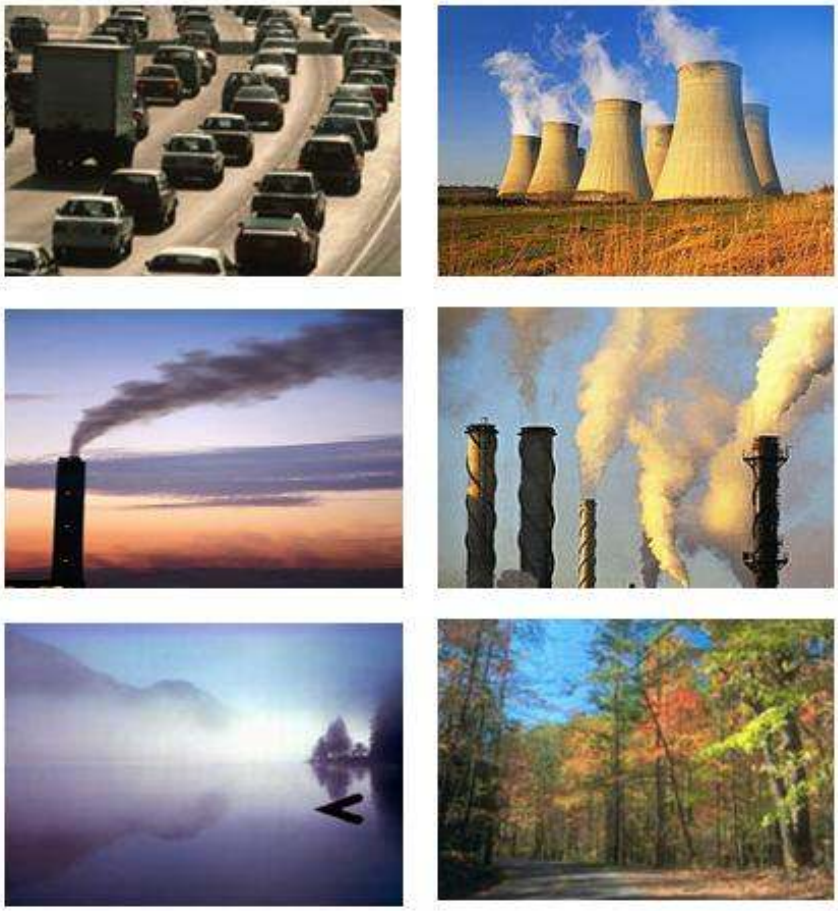
An update on cost-benefit analysis of the CAFE programme



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Service Contract for Carrying out Cost-Benefit Analysis of Air Quality Related Issues, in particular in the Clean Air for Europe (CAFE) Programme

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Executive Summary

This report considers various issues raised since publication of the last report in the CAFE-CBA series relating to the benefits of the Thematic Strategy on Air Pollution. These concern:

1. The reliability of the marginal damage estimates made using the CAFE methodology and included in the IPPC Bureau's BREF note on Economics and Cross Media Effects.[1] A comparison is made here between results for a variety of scenarios calculated using these marginal figures with results calculated using the CAFE scenario based approach as applied in the work on the Thematic Strategy. Totals for the EU show good agreement.

   It is not to be expected that national damage estimates so calculated would show good agreement as they describe different things – the CAFE scenario analysis quantifies damage occurring in each country whilst the marginal damage analysis estimates damage caused by each country.

2. Non-linearities in ozone benefits relative to emission reductions. It is found that the effect of reductions in ozone on deaths over the period 2000-2020 is offset by ageing of the population. Another important factor concerns non-linearities in the atmospheric chemistry of ozone.

3. A number of questions on valuation were raised at a stakeholder meeting of the DIEM project in Brussels in December 2005.[2] Here, we consider the extent to which these issues could affect the conclusions drawn on the CBA of the Thematic Strategy. It is found that the overall conclusion, that there is a very high probability (>90%) of benefits exceeding costs for the Strategy, is very unlikely to be affected.

[1] The IPPC Directive 96/61/EC lays down a framework requiring Member States to issue operating permits for certain installations carrying on industrial activities. Best available techniques (BAT) reference documents (BREFs) provide information which Member States are required to take into account when determining best available techniques generally or in specific cases in the permitting process.

[2] DIEM (Dissemination and Discussion of the ExternE Methodology and Results) project, http://www.externe.info/diem.html

Contents

Introduction

This report addresses a series of questions and issues raised concerning previous reports published from the cost-benefit analysis of the CAFE (Clean Air For Europe) Programme relating to:

1. The reliability of the marginal benefit estimates made by Holland et al (2005a).

2. Change in emissions of ozone precursors and corresponding effects on ozone related health impacts.

3. Various issues on valuation, primarily concerned with mortality.

Reliability of marginal damage estimates

It has been noted that there are significant differences between the damage figures generated by the CAFE scenario-based approach as used in the work on the Thematic Strategy (Holland et al, 2005a, b), and those calculated by combining the marginal damage figures from the report by Holland et al (2005c) with emissions for the scenarios considered under CAFE. The reason for this is simple – at the national level the CAFE scenario results indicate damage occurring in each country, whilst the marginal figures applied to scenario emissions generate estimates of the damage caused by each country. There is thus no reason why the two sets of results should generate outputs that are closely comparable at the national level, though it is to be expected that total damages so calculated for the whole of Europe will be similar. Note that the marginal damage estimates have been used more widely, noteably in the IPPC Bureau's BREF note on Economics and Cross Media Effects (EIPPCB 2006).

A request was recently received to quantify the ancillary benefits of changes in emissions of the CAFE pollutants (NH_3, NOx, $PM_{2.5}$, SO_2 and VOCs) arising from different levels of climate policy. An initial assessment was made using the marginal damage estimates of Holland et al (2005c) applied directly to emissions for a number of scenarios. This was followed up using the CAFE scenario approach defined by Holland et al (2005d, e) as used for assessment of the Thematic Strategy. Full results of the latter approach are given elsewhere (Holland and Pye, 2006), though here a comparison is made of the results estimated by the two approaches.

Data inputs to the benefits analysis

The PRIMES model has estimated fuel use (by type and quantity) in the EU in 2020 with shadow prices for carbon of €0, €20 and €90/t CO_2[3]. These results were used by the RAINS model to estimate emissions in 2020 of NH_3, NOx, $PM_{2.5}$, SO_2 and VOCs (IIASA, 2004, 2005) under current legislation (CLE) and under the maximum feasible reduction (MFR) in emissions according to the measures contained in the RAINS mode, for each carbon price. Total emissions are given in Table 1 and Table 2, the breakdown by country is provided in the Appendix to Holland and Pye (2006). Emissions data were then used in the EMEP model to generate a pan-European concentration field of various pollutants on a 50x50 km grid.

Table 1. Total emissions (kt) under the scenarios investigated.

Pollutant	CLE, €0/t CO_2	CLE, €20/t CO_2	CLE, €90/t CO_2	MFR, €20/t CO_2	MFR, €90/t CO_2
NH_3	3,687	3,687	3,677	2,219	2,203
NOx	12,114	11,837	11,377	6,582	6,329
$PM_{2.5}$	1,364	1,321	1,283	958	935
SO_2	6,729	6,332	5,914	2,257	2,111
VOCs	6,135	6,139	6,107	4,449	4,425

[3] Past analysis of the benefits of abating the CAFE pollutants has started from a baseline scenario with an estimated shadow price for CO_2 control of €20/t.

Table 2. Change in emissions (kt) with increased CO_2 price

Pollutant	CLE, €0 to €20/t CO_2	CLE, €20 to €90/t CO_2	MFR, €20 to €90/t CO_2
NH_3	0	10	16
NOx	277	460	253
$PM_{2.5}$	43	38	23
SO_2	397	418	146
VOCs	-4 (increase)	32	24

Methods

CAFE scenario analysis

The 'CAFE scenario analysis' combined the EMEP-derived concentration fields with the CAFE methodology defined in Holland et al (2005d, e) and Hurley et al (2005) to quantify the health impacts arising from emissions of each pollutant, mediated through exposure to primary and secondary particles. Effects on both mortality and morbidity were quantified. Sensitivity analysis on mortality characterisation and valuation provides a range of estimates, as follows:

- CAFE-low: Quantifies mortality as years of life lost (YOLL) and applies the median estimate of the value of a life year (VOLY)[4].
- CAFE-low/mid: Quantifies mortality as deaths and applies the median estimate of the value of a statistical life (VSL).
- CAFE-high/mid: Quantifies mortality as YOLL and values it using the mean estimate of the VOLY.
- CAFE-high: Quantifies mortality in terms of deaths and values it using the mean estimate of the VSL.

The analysis presented here did not include quantification of various other impacts. The most significant omissions are likely to be:

1. Effects of acidification and eutrophication following emission of nitrogen and sulphur on ecosystems.
2. Effects of ozone on health, crops and ecosystems linked to emissions of NOx and VOCs. Following from the CAFE analysis it is very likely that these effects are small compared to the health impacts of exposure to PM. Note that effects on health and crops from ozone are usually included in the CAFE analysis.
3. Damage to materials.

Marginal damage analysis

In this case, emissions at the national level were simply multiplied by the national average damage per tonne estimates derived by Holland et al (2005c), and summed to give total damage for the EU25. In addition to the $PM_{2.5}$ health impacts this analysis also includes consideration of ozone effects on health and crops.

Results

The results shown in Table 3 demonstrate that the marginal damage analysis returns a result within a band of -22% to +8% of the results obtained from the CAFE scenario analysis.

[4] More complete discussion of mortality valuation is given in Volume 2 of the CAFE-CBA methodology report (Hurley et al, 2005), and in the CAFE-CBA scenario analyses (Holland et al, 2005d, e).

Marginal damage analysis results for the CLE scenarios are consistently lower than those of the CAFE scenario assessment. For the MFR scenario results are slightly lower when mortality is characterised as deaths, and slightly higher when characterised as years of life lost. Several factors are likely to be involved:

1. The marginal assessment omits water bound into particles. This is one reason for underestimation for the CLE scenario.
2. The marginal assessment is based on population and dispersion data for 2010 (although the emission scenarios are of course for 2020), a time when death rates are forecast to be lower than in 2020, the year for which all data are taken for the CAFE scenario assessment. Again, this will bias to underestimation.
3. Non-linearities in dispersion as emissions change is the most likely reason for the gap between simplified and detailed assessment results closing from CLE to MFR.

Table 3. Comparison of results generated using the two approaches – scenario totals.

Scenario/ sensitivity case	CAFE scenario analysis	Marginal damage analysis	Ratio
CLE €0/t			
CAFE-low	183,000	162,000	0.88
CAFE-low/mid	313,000	247,000	0.79
CAFE-high/mid	345,000	316,000	0.92
CAFE-high	587,000	461,000	0.78
CLE €20/t			
CAFE-low	175,000	155,000	0.89
CAFE-low/mid	298,000	238,000	0.80
CAFE-high/mid	329,000	304,000	0.92
CAFE-high	560,000	443,000	0.79
CLE €90/t			
CAFE-low	168,000	149,000	0.88
CAFE-low/mid	287,000	228,000	0.79
CAFE-high/mid	318,000	292,000	0.92
CAFE-high	539,000	425,000	0.79
MFR €20/t			
CAFE-low	90,000	93,000	1.04
CAFE-low/mid	153,000	143,000	0.93
CAFE-high/mid	170,000	183,000	1.08
CAFE-high	287,000	266,000	0.93
MFR €90/t			
CAFE-low	88,000	90,000	1.02
CAFE-low/mid	149,000	138,000	0.92
CAFE-high/mid	166,000	176,000	1.06
CAFE-high	280,000	257,000	0.92

Comparison of the estimated change in damage between scenarios is made in Table 4. This demonstrates a higher level of variation between the two approaches than in the total results for the set of scenarios considered, though results are still broadly consistent. The largest discrepancy arises for the MFR €20 to €90/t CO_2 increment. This is not surprising as it is the scenario furthest from the conditions used by Holland et al (2005c) for the marginal damage calculations. However, even in this case there is substantial overlap in the ranges so derived

(€1.9 to 6.6 billion for the CAFE scenario analysis and €3.3 to 9.2 billion for the marginal damage analysis).

Table 4. Comparison of results generated using the two approaches – increments between scenarios.

Scenario/ sensitivity case	CAFE scenario analysis	Marginal damage analysis	Ratio
CLE €0 to €20/t			
CAFE-low	8,400	6,100	0.72
CAFE-low/mid	15,000	9,300	0.61
CAFE-high/mid	16,000	12,000	0.75
CAFE-high	27,000	17,000	0.63
CLE €0 to €90/t			
CAFE-low	15,000	13,000	0.86
CAFE-low/mid	26,000	19,000	0.74
CAFE-high/mid	27,000	24,000	0.88
CAFE-high	48,000	35,000	0.74
CLE €20 to €90/t			
CAFE-low	6,200	6,500	1.04
CAFE-low/mid	11,000	9,900	0.91
CAFE-high/mid	12,000	12,000	1.07
CAFE-high	20,000	18,000	0.89
MFR €20 to €90/t			
CAFE-low	1,900	3,300	1.69
CAFE-low/mid	3,700	6,300	1.73
CAFE-high/mid	3,500	5,000	1.43
CAFE-high	6,600	9,200	1.39

Discussion

Results indicate that climate policy is likely to generate ancillary benefits through reductions in regional air pollutants of several €billion each year. To illustrate, the incremental benefit through reduction in regional air pollutant emissions of moving from CLE €20/t CO_2 to CLE €90/t CO_2, is estimated at between €6 and €20 billion.

Overall, it is very encouraging that results from the two methods are broadly similar across the full range of scenarios likely to be considered in the near future. The following should be considered as priorities for improvements to the marginal damage estimates:

1. Recalculation using the latest EMEP results and for different scenarios.
2. Generation of results for different years, accounting for population changes.

It is not suggested that the marginal damage approach should replace the CAFE scenario methodology in its current role for quantification of damage on a full European scenario basis. However, the consistency in results between the two scenarios demonstrates that the marginal approach can be applied with an acceptable level of reliability in, for example, CBA of individual measures.

Changes in NOx, VOCs and ozone health indicators according to the CAFE analysis

Ozone health impacts, as reported in the CAFE Thematic Strategy communication, do not correlate well with reductions in VOC emissions. The problem is summed up in the following table:

Table 5. Changes in VOC and NOx emissions and ozone health indicators, 2000 – 2020 as published in the Thematic Strategy documentation

	Baseline	Thematic strategy	TS improvement
VOC reduction 2000 to 2020	45%	51%	6%
NOx reduction 2000 to 2020	49%	60%	11%
O_3 health indicator improvement 2000 to 2020	3%	10%	7%

It has been asked, why, in % terms, does more benefit derive from the relatively small reduction in VOCs and NOx in going from 2020 baseline to the Thematic Strategy, than from the bigger reduction from 2000 to 2020?

Part of the answer lies in the pattern of ageing of the population over time. In Europe there have been 2 major events that make a difference to death rates for the population as a whole in the 2000 – 2020 period:

1. The Second World War caused the death of many who would otherwise be dying now, meaning that the death rate for 2000 is lower than it would otherwise have been. This effect will have largely passed through by 2020
2. The baby boomers of the post war period are reaching old age in 2020, meaning that the death rate at that time goes up.

The effect of these changes partly (there are no doubt some other issues as well, such as health care improvements) explains why the annual death rate that we use (from UN data and forecasts) goes up from 1.03% in 2000 to 1.17% in 2020[5].

It is therefore apparent that the comparison made in the table above deals with changes not only in air pollution but also in population structure. It is of course possible to adjust inputs to factor out the population and death rate changes – this gives a better guide to the improvements arising from current legislation. On this basis we compare the effects of 2000 and 2020 pollution on the 2020 population[6]. This shows that if the ozone levels of 2000 were to remain unchanged to 2020, the annual number of ozone related deaths would be 24,300 rather than the 20,800 of the CAFE 2020 baseline. Then, rather than a 3% improvement in the health indicator from 2000 to 2020, a 14.4% improvement arises when going to the 2020 baseline, and a 6.6% improvement going further to the Thematic Strategy:

[5] The death rate for each age group in the population changes very little: the increase in the overall death rate comes about simply because there are more elderly people than before, and as a group they naturally have a higher death rate.

[6] This forms the basis for various past analyses investigating the costs and benefits of current legislation. For CAFE, however, we were interested in going beyond the 2020 baseline, not assessing how worthwhile current legislation was.

Table 6. Changes in VOC and NOx emissions and ozone health indicators, 2000 – 2020 after adjustment to remove differences in death rate

	Baseline	Thematic strategy	TS improvement
VOC reduction 2000 to 2020	45%	51%	6%
NOx reduction 2000 to 2020	49%	60%	11%
O3 health indicator improvement 2000 to 2020	14.4%	21%	6.6%

Now, instead of the baseline improvement being less than half of the Thematic Strategy improvement, it is more than double. However, per unit emission reduction, the move to the Thematic Strategy still appears more efficient than the preceding move to the 2020 baseline. The likely reason for this is the non-linearity of ozone processes in the atmosphere, particularly with respect to ozone and NOx emissions.

Issues relating to valuation

A number of concerns about uncertainties in externalities assessment, and on mortality valuation in particular, were raised at the DIEM Project seminar in Brussels in December 2005[7]:

1. Variation in estimates of the VSL of between €1 million and $6 million as used by USEPA.
2. Roughly factor 2 variation in VSL and VOLY according to the use of either median or mean estimates.
3. Availability of alternative methods for valuing environmental goods – willingness to pay, willingness to accept, hedonic pricing, 'avoided damage costs'.
4. Public understanding of risk and probability when assessing their willingness to pay.
5. Anchoring of environmental valuations.
6. Concepts of public goods and free riders.
7. Monetisation needs to be extended to other areas, such as ecosystems.
8. There is a lack of consensus regarding the use of VOLY and VOSL.
9. There are uncertainties present in the analysis, and hence results have to be used with caution in CBA.

It is necessary to ask how well these issues have been addressed by the CAFE-CBA. It should be noted that these concerns were expressed against the general subject of externalities evaluation – neither was directed specifically at CAFE, so it is unclear what the commentators thought of the robustness of the CAFE outputs, including the uncertainty analysis carried out there. Table 7 reviews the way that each issue was addressed in the CBA of the Thematic Strategy, and considers possible effects on the outcome of the analysis.

[7] http://www.externe.info/brussels/br1120.pdf

Table 7. Consideration of general concerns expressed on external costs analysis by EC DGs in relation to work done on the CAFE programme.

Concern	Addressed in CAFE?	Effect on CAFE outcome? [1]
VSL or VOLY	Yes – both used in sensitivity analyses.	None – net benefit arises with high probability whichever one is used.
VSL = €1 or 6 million?	Partly through use of median and mean estimates (€1 – 2 million). €6 million is not supported by European research.	None – higher figures would simply raise the already high probabilities of a net benefit further.
Median or mean for VSL and VOLY?	Yes – both used in sensitivity analyses.	None – net benefit arises with high probability whichever one is used.
Public understanding of risk and probability	No – results of costing work taken as given. However, there is reasonable consistency in the results of different studies that have been undertaken recently in different parts of the world, indicating consistency in interpretation of information provided during surveys.	Error could go either way. However, effect on the TS outcome could well be small, given the results for the other sensitivities that have been examined.
Anchoring of valuations	No – results of costing work taken as given. May be of little concern given availability of several studies giving similar results.	Limited?
Public goods, free riders	Partially – results of costing work taken as given, but VOLY/VSL estimates based on inclusion of non-protest zeroes.	Limited?
Extension of monetisation to areas not currently addressed, e.g. ecosystems	To some degree through the extended CBA.	None – the already very high probability of a net benefit would have further increased.
Existence of uncertainties	Yes, systematically addressed.	As above.

Note 1) The CAFE outcome referred to is the conclusion that benefits of the Thematic Strategy (TS) would exceed costs.

It is therefore concluded that these concerns, such as they affect the CAFE work, have largely been addressed through the work done in CAFE-CBA on uncertainty, in such a way that there has been effective communication of uncertainties to decision makers. It is also concluded that these uncertainties have little effect on the outcome of the analysis for the Thematic Strategy, given the existing very high probability that benefits would exceed costs.

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