Appendix 2: CBA Under the Microscope

Cost Benefit Analysis under the Microscope

CONCAWE Comments on the Key Submissions Associated with 5th Stakeholder Expert Group of the Air Quality Policy Review held in Brussels, 3rd April 2013

General points

Cost benefit analysis (CBA) seems to be increasingly referred to as a basis to support target setting for air quality policies when in the past (CAFE 2005 program) its function was to provide an ex-post perspective on costs and potential benefits associated with the delivery of the policy ambition levels. With CBA the societal costs and benefits of different ambition levels can be compared, provided that both costs and benefits are expressed in a monetary unit. Recent CBAs conducted in support of European air quality policies have focussed on comparing costs and benefits of 5 specific scenario's (CIAM, 2011), each comprising a mix of targets for reducing the ambient concentrations of PM, ozone, acidifying and eutrophying substances. These studies suggest that the monetised benefits of air pollution control exceed the costs of emission reduction, for all of these five scenario's. The benefits are driven by the particular value given to the statistical improvements in average life expectancy arising from reduced exposure to fine particulates.

Since CBA is having an increasing role in the target setting process of the current Air Quality Policy review, it is crucial that it is applied in a scientifically robust manner. CONCAWE sees that there are at present several important flaws and limitations in the way CBA is applied in the Air Quality Policy review process. This paper describes the main limitations and proposes a more robust approach for VOLY calculation from a given Willingness to Pay (WTP) survey. Three of the limitations are specific methodological inaccuracies in the CBAs conducted in support of the EU air quality policy formulation process. All three aspects have very significant implications for the outcomes of the CBAs of air policy targets and should be addressed as part of the current policy formulation process. Two additional limitations are fundamental to CBA. They cannot be addressed through specific methodological upgrades, but they need to be kept in mind in the interpretation of CBAs.

Important issues related to CBA that should be addressed in the current phase of air quality target setting

In CONCAWE's view, the major shortcomings in recent CBAs (AEA, 2011; EC4MACS, 2011; EEA, 2011) conducted in support of the Air Policy review process that prevent the work from providing robust policy input are: values for monetising (i) mortality and (ii) morbidity effects, and (iii) an insufficient uncertainty analysis to analyse the repercussions of these uncertainties on the costs and benefits of different policy targets. Regarding point (i) CONCAWE proposes a more robust approach to express a single value to represent the results of a given WTP survey. This is outlined below.

(i) Improved statistical life expectancy – Use of a more robust VOLY value

Estimating the monetary value of a life year in a given population is not an easy thing to do. The chosen method is to survey people for their WTP to achieve a small increase in statistical life expectancy (see CONCAWE, 2012b). It must be kept in mind that the responses represent 'virtual' rather than 'real' money, are very varied and depend on the size of the risk reduction assessed. The highly skewed distribution of responses (ranging by over three orders of magnitude and highly skewed towards the low end (Figure 1) should be used directly in Monte-Carlo analysis of cost-benefit after rescaling to represent one life year increments. However policy-makers prefer a single reference "VOLY" for ease of communication. The CBAs conducted for the Air Quality Policy review (AQPR) uses the median value from the NewExt study (2004), updated for inflation (to match costs) and without regard to whether attitude has changed in the ten years since the survey was carried out. We note that the median does not respect individual WTP choices; it just marks the dividing price for the risk reduction where 50% say they are not willing to pay more for the statistical benefit.

As stated above it was acknowledged by the CBA community during the Clean Air For Europe (CAFE) program that the most representative CBA results could be obtained by statistical analysis using the full distribution of WTP survey results and distribution of abatement costs together as discussed in detail in the CONCAWE report 4/06. The challenge in shortening this process to use a single representative value is to find a means of respecting individual choices. CONCAWE's recent work is a response to this challenge (CONCAWE, 2012a). This alternative approach defines a VOLY that Maximises Societal Revenue (MSR), while respecting individual expressions of WTP of all the individuals surveyed. This is achieved by a simple flat fee analysis to determine VOLY from a WTP survey, it assumes a pay/no pay threshold and sets the threshold (fee) to maximise the sum that can be raised from the survey population. This is a technically and methodologically more robust approach compared to using median or mean values of a survey. The biggest advantage is that this flat fee approach reflects the full distribution of expressed WTP values and is less sensitive to the very highest and lowest choices. How the MSR values relate to the median and mean values is shown in Table 1 and Figure 2 for a number of elicited WTP studies. It is worth noting that the MSR values correspond more closely to the median and are far away from the mean VOLY values of each of the surveys.

Figure 1
Highly skewed distribution of WTP values as forecasted from the Weibull distribution parameters of the NewExt survey in 2004 (CONCAWE, 2006a)

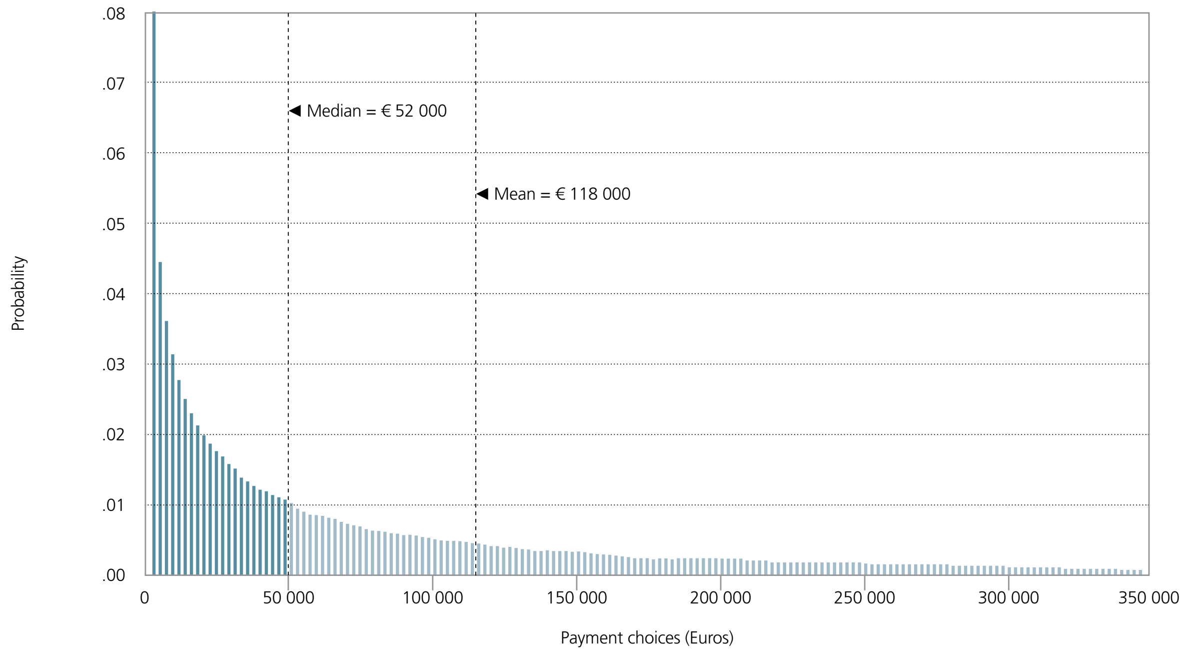

Table 1
VOLY values (€ per statistical life year lost) for a number of elicited WTP studies

Study	VOLY Median	VOLY Mean	VOLY based on MSR/4
AEA (2011)/1	57,700	138,700	37,000
EC4MACS (2011) / EEA (2011)/1	54,000	125,000	37,000
Desaigues et al. (2011) - 6 months/2	15,200	24,700	9,100
Desaigues et al. (2011) – 3 months/2	19,400	38,400	13,000
DEFRA - 6 months/3	2,700	13,000	3,400
DEFRA - 3 months/3	2,200	23,000	5,500
DEFRA - 1 month/3	15,000	45,000	13,000

Note /1: based on the NewExt (2004) study but corrected for inflation.
Note /2: based on the NEEDS study (equation 1; Desaigues et al., 2007) but corrected for inflation (population weighted average for 18 EU countries plus Switzerland).
Note /3: Note that '1 month', '3 months' and '6 months' refer to the different risk-reduction choices in these WTP studies. The values represent averages of assessments for normal health for each risk-reduction choice and are not corrected for inflation; Chilton et al., 2004.
Note /4: CONCAWE, 2012a.

Figure 2
The (forecasted) VOLY distributions (20 to 80 percentiles) according to three studies, also indicating the location of the median, mean and MSR value

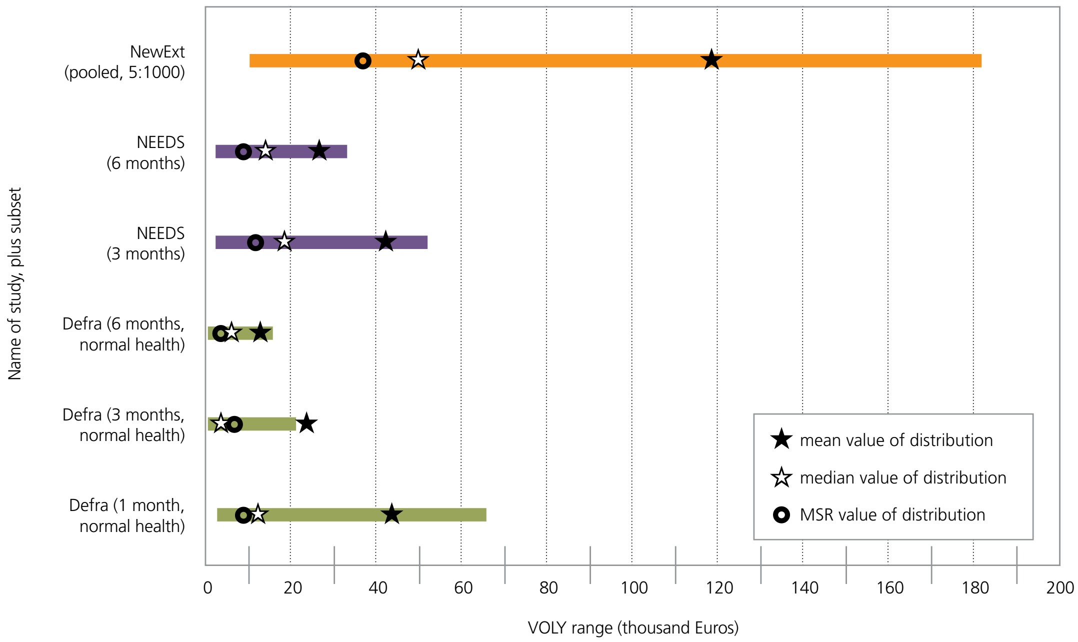

Table 1 and Figure 2 clearly show that VOLY values across a number of elicited WTP studies are very different and that they are dependent on the risk reduction discussed as shown by the variation in annualised values between the one month, three or six months increase in life expectancy (Desaigues et al. and DEFRA).

All of the analysed recent CBAs (AEA, 2011; EC4MACS, 2011; EEA, 2011) that were conducted in support of the Air Policy review process on behalf of the European Commission are based on a single VOLY estimate prepared by the NewExt project that was used during the CBA work for the Clean Air For Europe (CAFE) process. The NewExt study (2004) resulted in a median VOLY of €52,000 and a mean value of €118,000. It must be noted that the NewExt developed data for prevented fatality (VPF), i.e. analysing the Value of a Statistical Life (VOSL), to derive a VOLY value an inappropriate methodology was applied by back-calculating from VPF/VOSL, rather than estimating the value of VOLY directly based on WTP surveys. This is fully elaborated in earlier CONCAWE work (2006a & b).

Since the NewExt study was conducted a decade ago there are a number of new insights in the field. As recognised in the NEEDS study, which was a follow-up to NewExt, the VOLY should be derived directly from survey questionnaires rather than be derived from the VOSL (see also CONCAWE, 2006a & b). In addition, there is increasing experience with the design of questionnaires used to elicit WTP. These new insights were reflected in the NEEDS study, that was published in 2011 in the scientific literature (Desaigues et al., 2011). It is notable that some of the researchers involved in NewExt were also involved in the NEEDS study. The NEEDS study points to much lower median and mean VOLY values, of €15,200 and €24,700, respectively (Table 1, Figure 2; published in Desaigues et al., 2011). These recent findings are much more in line with other research studies (e.g. the DEFRA study conducted in the UK).

However, all recent CBA studies (EC4MACS, 2011; EEA, 2011; AEA, 2011; IIASA (TSAP report #7), 2012) have continued to use the inappropriate VOLY from the NewExt study, simply adjusting its values for inflation in the geographical zone of the individual study (inflation corrector differs as a function of different geographical scope of the studies because of different inflation rates for each country). This is reflected in median and mean VOLY values of €54,000 or €57,700 and €125,000 or €138,000, respectively (see Table 1). This has far reaching consequences for the benefits calculation of air pollution reduction measures as the VOLY dominates the benefits associated with CBA, i.e. reduced statistical life expectancy from exposure to PM represents around 70 to 75% of the total benefits.

CONCAWE strongly believes that the VOLY values derived from the NewExt are inappropriate and should not be considered in CBA analyses for the ongoing or any future air quality policy rounds. Instead we would propose that an (weighted equally across the NEEDS and DEFRA surveys) averaged VOLY value, based on both the NEEDS and DEFRA surveys be used. Based on the more robust MSR methodology, a value of €9,250 (Table 2) should be considered the reference value given that it represents the most up-to-date and more scientifically robust estimate for a VOLY. The range of MSR VOLY values from €3,400 to €13,000 (Table 2) should be used for a sensitivity analysis for further verification of the robustness of the CBA of the current TSAP review process.

Table 2
Appropriate VOLY expression (€ per statistical life year lost) of more suitable WTP studies (no correction for inflation applied)

WTP study	VOLY Median	VOLY Mean	VOLY based on MSR/3
NEEDS - 6 months/1	14,000	27,000	9,100
NEEDS - 3 months/1	19,000	42,000	13,000
DEFRA - 6 month/2	2,700	13,000	3,400
DEFRA - 3 months/2	2,200	23,000	5,500
DEFRA - 1 month/2	15,000	45,000	13,000
Weighted average VOLY of all studies	**11,600**	**31,000**	**9,250**

Note /1: Chilton et al., 2004.
Note /2: Desaigues et al., 2007. Note that '1 month', '3 months' and '6 months' refer to the different risk-reduction choices in these WTP studies. The values represent averages of assessments for normal health for each risk-reduction choice.
Note /3: CONCAWE, 2012a.

Recommendation: If a single value is adopted to describe such WTP surveys, then MSR is a more robust approach as it respects individual expressions of WTP of all respondents to the survey. As such it reflects the full distribution of WTP survey results and reduces the dominance of more extreme values. Disregarding the VOLY values of the NewExt study as this WTP survey was not designed to derive a VOLY value in first place, the MSR approach gives an (weighted) average VOLY value of €9,250 (not corrected for inflation), based on the NEEDS and DEFRA WTP studies. This value is considerably less than the €54,000 to €57,700 used in current policy developments. When applying a sensitivity analysis the (weighted average) range from €3,400 to €13,000 (not corrected for inflation) should be tested.

In light of the above, CONCAWE believes that there is a strong case for adopting a MSR VOLY averaged over all suitable WTP studies (i.e. €9,250). This compares to a median VOLY averaged over all suitable WTP studies of €11,600.

(ii) Realistic and sound reflection of morbidity effects

There is a need to re-assess the dose-response relations for morbidity effects and the monetary values of these effects. In all the recent CBA studies the dominating component of overall benefits has been the reduced statistical life expectancy associated with exposure to particular matter (PM; i.e. around 75%). Therefore, there has been little attention to the uncertainties associated with other elements of monetised benefits, such as morbidity effects. However, the valuation of these effects may also be overestimated (IIASA, 2012), in particular for chronic morbidity and restricted activity days (RAD)[29], as an analysis by CONCAWE indicates (see Attachment 1 "Technical Note. An Assessment of the Valuation Methods for and Costs of Morbidity" for details).

For instance, the costs of chronic bronchitis have been estimated at €208,000 per case (IIASA, 2012). This cost figure applied during the CAFE program is based on two studies: Viscusi et al. (1991) and Krupnick and Cropper (1992). This value is also cited in several recent European CBAs on morbidity impacts, while there is a set of more recent studies available in the scientific literature and despite the fact that already in the CAFE program it was noted that the two studies (Viscusi et al. 1991 and Krupnick and Cropper 1992) use a definition of chronic bronchitis that is not in line with the epidemiological literature. An assessment by CONCAWE of the more recent studies that consider both the costs of medication and the WTP to avoid the symptoms of chronic bronchitis reveals much lower values (Menn et al., 2012; Maca et al., 2011; Chapman et al., 2006; Stavem, 2002; Wilson et al., 2000; Priez and Jeanrenaud, 1999; O'Conor and Blomquist, 1997). A reasonable approximation of the value of chronic bronchitis may be in the order of € 28,000 to € 38,000 per case. This is approximately 1/6th to 1/7th the value used in the most recent European assessments of the costs of air pollution, such as IIASA (2012). It is clear that there is an urgent need for verifying the morbidity costs of the recent CBAs and that the values currently used should be interpreted with caution.

[29] According to the CAFE methodology, RAD include (i) days when a person needs to stay in bed and (ii) days when a person stays off work. Days including other, less serious, restrictions on normal activity are called minor RADs, and are valued separately

With regards to Restricted Activity Day (RAD), there are important uncertainties in relation to the assumed monetised value as acknowledged in Ready et al. (2004) but not in CAFE or the follow-up CBAs. As based on CONCAWE's preliminary assessment, these uncertainties are:

1 - The value is based upon just one study (Ready et al., 2004)
2 - The results of this one study (Ready et al., 2004) are internally inconsistent, specifically the outcomes that the WTP of Spanish and Portuguese to avoid a RAD far exceeds that of northern Europeans, and that the WTP to avoid a minor RAD exceeds that the WTP to avoid a 'regular' RAD in Spain. This may be related to an incorrect application of the survey.

While it is clear that the monetised RAD values used in CAFE are likely to be overstated, it is difficult to say how much the costs of RAD would be overestimated as data are missing. It seems highly questionable if it is justifiable to use monetary values with such a high degree of uncertainty as a basis for decision making and hence we suggest to remove this from the benefits analysis until a proper sensitivity analysis has been performed.

Recommendation: As expressed by CONCAWE's preliminary analysis it is clear that there is an urgent need for verifying the morbidity costs of the recent CBAs and that the values currently used should be interpreted with caution. In particular, values of chronic bronchitis and RADs are based on very few valuation studies, based on limited sample surveys, and with inconsistent results for some of the studies. Based on the recent studies the analysis also reveals a more up-to-date value range for monetising new cases of chronic bronchitis from €25,000 to €28,000 per case rather than the €208,000 currently applied in CBAs. Furthermore given the uncertainties around monetising RADs this end point should be removed from the benefit analysis until a proper sensitivity analysis has been performed.

(iii) Conduct proper uncertainty analysis

Furthermore, an issue of concern is that there is at present insufficient understanding of the effects of the various sources of uncertainty on the outcomes of the CBAs. These uncertainties pertain to: uncertainties in future baseline emissions as a function of economic developments, uncertainties in future energy prices and impacts on future emissions, uncertainties on ambient concentrations as a function of emission reductions and other factors (including weather patterns and wind directions that may be influenced by climate change), uncertainties in exposure levels of people as a function of human behaviour, and uncertainties on the monetary value of health and environmental effects. CONCAWE has earlier provided input to the TSAP review process with regards to this discussion (CONCAWE, 2012c).

Relatively minor changes in each of these factors could have significant repercussions for the cost benefit ratio of different emission control strategies. In order to ensure the selection of no-regret policy measures, there needs to be an understanding of how robust the cost and benefit assessments are prior to air quality policy setting.

Recommendation: In addition to using an updated VOLY figure (i.e. €9,250), there should be a proper uncertainty analysis, for instance using Monte Carlo analysis with full distributions of both benefit and cost in order to analyse the repercussions of these uncertainties on the overall costs and benefits of different policy targets.

Two fundamental aspect to keep in mind when using CBA for policy formulation

In addition to these three key issues that need immediate attention as part of the current policy formulation process, there are two aspects that need to be kept in mind when interpreting and using CBA outcomes in the context of EU air policy. Each of these two aspects needs further consideration in the near future, and at presents limits the applicability of CBAs.

First, care needs to be taken in applying singular CBAs as a basis for policy setting. To ensure that policy development is robust, it is important that the policy does not focus on a single issue/value. For example, measures have been implemented over many decades to successfully reduce national pollutant emissions. Taking further reduction measures will soon result in diminishing returns and escalating costs. This implies that there may be more cost effective ways to achieve certain health or environmental benefits compared to reducing air pollution.

Second, the scenario's developed to support the air quality policy formulation process comprise a mix of health and environmental benefits (including particulate matter, ozone, eutrophying and acidifying substances). Only health benefits and ozone damage to crops are quantified in the monetary analyses. The costs and benefits of eutrophication and acidification control are not quantified and therefore not included in the CBA models constructed to date (AEA, 2011; EEA, 2011; EC4MACS, 2011). Nevertheless, ambitious targets for eutrophication and acidification control are included in the policy scenario's for air pollution control (A1-A6) presented in IIASA Report #10 and the 5 policy scenario's (LOW, low*, Mid, High* and HIGH) analysed in the aforementioned CBAs (gap closure compared to MTFR ranging from 25% in the LOW to 75% in the HIGH scenario's). The ambition levels for eutrophication and acidification have been established by association with the anticipated health benefits following PM emission reduction.

In order for CBA to properly play its role in informing the ambition setting process for meeting multiple targets in the most cost effective way (and provide transparency in the final impact assessment) it needs to be in a position to correctly attribute the incremental benefits and associated incremental costs for meeting each individual target. This is vital to ensure that benefits derived from achieving one target (e.g. PM health impact reduction) are not used to 'subsidise' the limited monetised benefits or lack of monetised benefits for meeting the additional target(s) (e.g. ozone health impact reduction). Therefore, eutrophication and acidification targets should be subject to a specific incremental CBA rather than be included in policy scenario's where the monetary benefits are driven by health impacts.

This need was highlighted by CONCAWE in its follow-up comments to SEG-4. However, in IIASA Report #10, the additional cost versus impact reductions in the step out scenarios from A3 (a high ambition PM only gap closure scenario) to A4-A6 does not develop such data but just asserts that the cost involved enables the capture of additional 'low hanging fruit'.

CONCAWE has undertaken a first assessment[30] of the additional marginal cost versus additional marginal benefits of the move from the A3 to A5 scenario using the CAFE approach for the valuation of ozone health benefits and an 'ecosystem services' approach to eutrophication and acidification.

As in CAFE, for ozone, the marginal costs exceed the marginal health benefits around a gap closure of 25%. Such a gap closure for ozone is already achieved as a 'come along' consequence of the high PM ambition scenario of A3 (see Figure 5.3 in Report #10). Any further incremental expenditure on reducing ozone impacts would therefore exceed the incremental benefit for this endpoint.

The expenditure to achieve the 25% ozone impacts gap closure is some 200M€/y; by subtracting this from the 894M€/y cost of A5 over A3, we obtain the necessary benefit figure for ecosystem services improvements (from reduced areas of eutrophication and acidification) required to justify the move from A3 to A5 scenarios, i.e. 694M€/y. The estimated (see footnote 2) increase in the area of ecosystem protected in moving from A3 to A5 is 3,500 km^2 for acidification and 3,500 km^2 for eutrophication. This would imply an improvement in ecosystem services value of about €1000/hectare/y to support the additional expenditure of 694M€/y. This is substantially higher than recent values for the average level of ecosystem services provided by European forests published in the literature (e.g. Matero et al., 2007; Zanderson et al., 2009; TEEB, 2010; Ding et al., 2010).

Without prejudice to earlier comments on the lack of justification for the A3 scenario, this clearly indicates the incremental costs in moving from A3 to A5 are also not supported by the incremental benefits.

Conclusions

This note shows that there are a number of points that should be addressed before the presently available CBAs of air quality targets can be used as a basis for robust policy formulation. In particular, there is an urgent need to use VOLY figures and monetised morbidity values that are in line with recent scientific insights, and to conduct proper uncertainty analysis to show the robustness of the cost benefit figures. In addition, there is a need to further examine alternative approaches to CBA for revealing the economic justification for policy setting and to conduct dedicated CBAs for the specific types of air pollutants (ozone, PM, eutrophying and acidifying substances).

[30] A more complete assessment can only be undertaken when the additional details on all the scenarios are released by IIASA; in particular scenarios A1 through A4.

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