5 - CBA under the microscope

CONCAWE's assessment of latest scientific information on valuation of benefits from aspects influencing mortality and morbidity factors reveals that proposed benefit numbers applied in recent Cost Benefit Analysis (CBA) studies supporting the current Air Policy review process are significantly overestimated.

Recalculating the health costs related to morbidity (in particular Reduced Activity Days (RAD) and chronic bronchitis) and mortality effects (i.e. mortality from chronic exposure to PM) of air pollution based on updated values from the scientific literature, results in a reduction of total health costs due to air pollution by a factor 4 (approximately b€ 90 per year compared to b€ 366 per year stated in IIASA Report #10 (IIASA, 2013)). Figure 15[15] provides a useful insight how a more robust calculation of chronic mortality and morbidity impacts of air pollution significantly changes the marginal benefits of air pollution control and thereby the optimal gap closure[16]. Updated health benefit figures shift the optimal gap closure to a significantly lower PM gap closure than the 75% used as central ambition level for health impacts from PM in IIASA report #10 (IIASA, 2013).

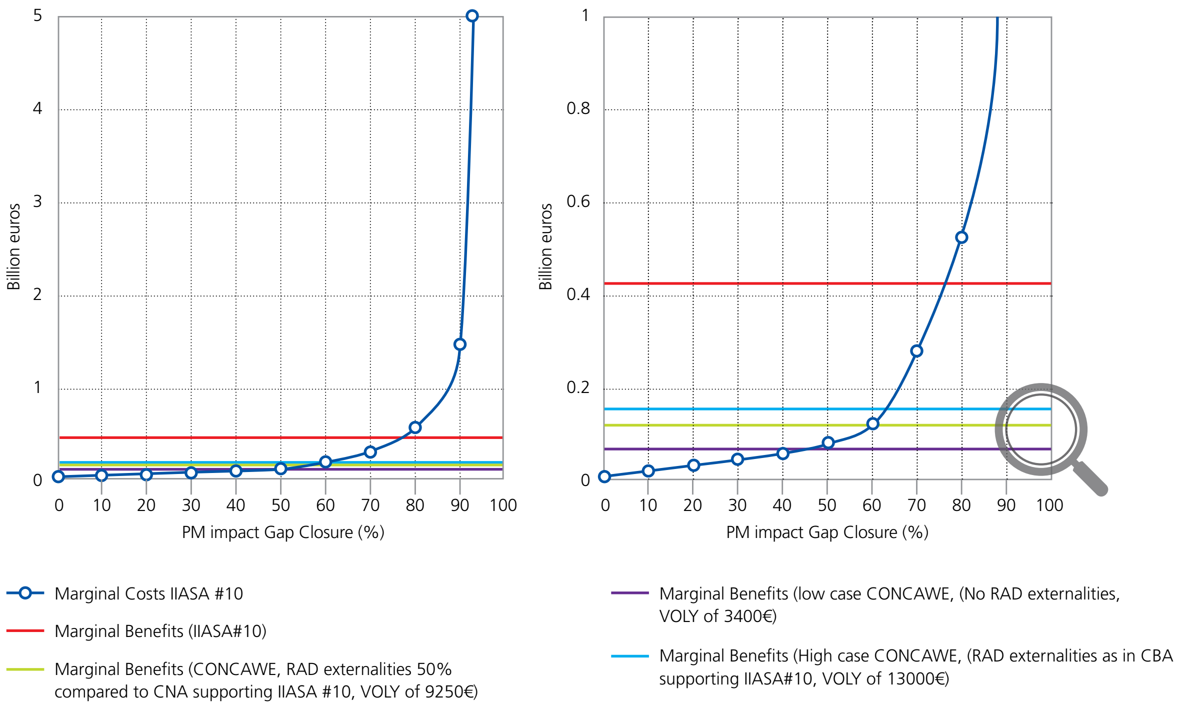
It is important to note that IIASA Report #10 (IIASA, 2013) follows a very different approach compared to the CAFE study. In the CAFE study, costs and benefits of different scenarios were compared, but in IIASA Report #10 marginal costs and benefits are compared in order to find the optimal gap closure. With this change in approach the concern is that the uncertainties in the benefit figures are very high, and the costs curves are very steep for high policy ambition levels. This means that small uncertainties in costs or benefits can significantly change the point of optimal gap closure, as demonstrated in this section.

In IIASA Report #10 (IIASA, 2013), the comparison of marginal cost and benefits excludes from the benefits all non-health related benefits, e.g., for ecosystems, agricultural crops and materials. Ecosystem services were also excluded in the CAFE study. It is important to note that including the contributions from ecosystem services do not necessarily increase the net marginal benefit. Ecosystem services are discussed in section 6 of this Review.

It is also important to recognise that generally such CBA assessments do not tell the policy maker whether the expenditure on this 'societal risk' if spent on another 'risk' would return a greater societal benefit. The need to spend proportionally across a range of policy areas is often lost in CBA.

[15] The data presented in Figure 15 are derived from digitised points taken from Figure 5.2 from IIASA TSAP report #10 (IIASA, 2013) since the source data was unavailable.
[16] GAP CLOSURE: the reduction in impacts, expressed as a percentage, of the maximum further impact reduction achievable in moving from Current Legislation scenario to Maximum Technical Feasible Reduction.

Figure 15
Comparison of marginal costs vs. marginal benefits according to IIASA calculations and CONCAWE assessments of actual health benefits. CONCAWE estimates include uncertainty assessment (low and high cases)



The justification for selecting a specific Gap Closure target is based on the monetisation of human health impacts. These are proportional to PM concentration and so the marginal benefit (the rate of change of benefit with concentration (gap closure) is a straight line. Abatement costs increase exponentially with PM reduction and so the marginal cost increases with increasing Gap Closure ambition. This figure shows on two scales how the valuation given to health impacts drives the policy ambition which should not go past the point where the marginal cost of measures equals the marginal benefits.

The sensitivity interval for the gap closure ambition ranges from 45% (low case CONCAWE) to 63% (high case CONCAWE) based on elements around valuation of health benefits in a CBA. The variables in this sensitivity analysis are twofold: a) the VOLY value applied (€ 13,000, € 9,250 or € 3400) and b) the value of Restricted Activity Days (RAD) reduction compared to IIASA Report #10 (ranging from unchanged to total exclusion due to attached major uncertainties; (IIASA, 2013)). This more robust valuation of health benefits results from a consequent application of latest scientific health data from peer-reviewed literature, most applicable methodology to determine a VOLY value for the valuation of chronic mortality impacts, and more robust valuation of morbidity (Chronic bronchitis and RADs) and chronic mortality impacts.

Table 5
Comparison of mortality and morbidity benefits stated in IIASA report 10 and CONCAWE recalculation

	IIASA report #10 data billion€/year, 2005 prices	CONCAWE estimation billion€/year, 2005 prices
Mortality from Chronic Exposure to PM	261	42
Chronic Bronchitis	42	6
Reduced Activity Days	35	17
Other Morbidity benefits	28	28[17]
Total	**366**	**93**

[17] CONCAWE did not recalculate "other morbidity costs", the study focused on Reduced Activity Days, chronic bronchitis and mortality from chronic exposure to PM.

Cost-benefit analysis (CBA) is increasingly referred to as a basis to support target setting for air quality policies. 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 (AEA, 2011; EC4MACS, 2011; EEA, 2011a) conducted in support of European air quality policies have focused on comparing costs and benefits, each comprising a mix of targets for reducing the ambient concentrations of PM, ozone, acidifying and eutrophying substances. The benefits are mainly 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 Policy review, it is crucial that it is applied in a scientifically robust manner. However, CONCAWE sees that there are at present several important flaws and limitations in the way CBA is applied in the Air Policy review process.

This section of the special issue summarises a set of CONCAWE Review articles, CONCAWE submissions to the Stakeholder Expert Group (SEG) engagement process and some more recent assessments by CONCAWE to address the difficulties and improvement opportunities in evaluating health effects in environmental CBAs.

The limitations, in the CBAs cited above, are specific methodological inaccuracies regarding the valuation of the benefits associated with improvement of human health, and uncertainties of scientific data underlying the valuation process and conceptual limitations in the interpretation of CBA outcomes for policy-making:

(i) Basics principles for valuating health impacts in a cost-benefit analysis
(ii) Values for monetising chronic mortality effects
(iii) Values for monetising morbidity effects
(iv) Quality and uncertainty of morbidity health effects of air pollution
(v) Insufficient uncertainty analysis to analyse the repercussions on the costs and benefits of different policy targets.
(vi) Fundamental limitations of applying CBA for policy formulation

Figure 15. and the box above summarise the key findings of CONCAWE's assessments, while the sections 5.1 to 5.6 provide more of the rationale behind these outcomes.

5.1. Basics for evaluating health impacts in an environmental cost benefit analysis

Estimating the monetary benefits to society of health improvements is a complex endeavour. To start with, it is essential to select the correct metric. In the context of air pollution CONCAWE strongly believes that VOLY is the only appropriate metric to assess chronic mortality effects caused by air pollution, where health effects are hugely dominated by PM.

It is a complex exercise to assign a monetary value to changes in human health impacts due to air pollution. For the first time this has been done in the Clean Air For Europe (CAFE) Cost Benefit Analysis (CBA). Two aspects are of specific relevance:

- The choice of the right metric (or 'unit of measurement') to express the health impacts that will be discussed in this section,
- The monetary valuation of this metric, as outlined in section 5.2.

Two concepts are often used to assign a monetary value to changes in human mortality. A metric that is often used is called the Value of a Statistical Life (VSL) or the Value of a Prevented Fatality (VPF). The VPF is the amount of money that a community of people is willing to pay to lower the risk of one anonymous instantaneous premature death within that community (e.g. by certain traffic safety measures). Whereas to save a specific individual in danger usually no means are spared the VPF is about lowering the risk of premature death in the statistical sense. This leads to a finite value for VPF. VPF is the correct metric within a context of observable deaths, e.g. in traffic accidents.

However, in the context of air pollution, as set forth in the CAFE methodology (2005), the health impact especially of particulate matter (PM), can be described much more adequately in terms of a shortening of the life expectancy of people (often called chronic mortality) rather than by attributable deaths.

"Consistent with WHO guidance, our own established practice, and a wider emerging consensus in favour of using life table methods, the analysis will express health impacts in terms of years of life lost from air pollution. The study team also recommends years of life lost as the most relevant metric for valuation..."

AEA, 2005

Therefore, the so called Value of a Life Year (VOLY) is the only appropriate metric. The VOLY is the amount of money associated with an increase in statistical life expectancy of one year.

More details, including all references, can be found in CONCAWE 2006a and CONCAWE 2012b as well as in a CONCAWE report (CONCAWE, 2006b).

5.2. More robust monetisation of Chronic Mortality impacts

CONCAWE proposes to use a more robust way to calculate a "Value of a Life Year" (VOLY) from a given Willingness to Pay (WTP) survey, this is the so called "Maximising Societal Revenue" (MSR) that respects the WTP choices of the whole population included in the survey. CONCAWE believes that the data of the more advanced WTP studies should be used to derive the VOLY value and has done so in this assessment. As a consequence, the monetised benefits for chronic mortality aspects would decrease by a factor of 6.2 (VOLY value of NewExt[18] study adjusted to 57,700 € vs. 9250 € of CONCAWE's MSR value).

The effect of long-term exposure to fine particulate matter has emerged as the most important health issue resulting in reduction in life-expectancy. The monetisation or valuation of mortality impacts of air pollution, and therefore of the benefits of its reduction, is carried out by calculating the so called "Value Of a Life Year" (VOLY), which is the amount of money associated with an increased statistical life expectancy of one year. VOLYs are generally derived via execution of Willingness to Pay (WTP) surveys. In such WTP surveys people are interviewed for their WTP to achieve a small increase in statistical life expectancy (see CONCAWE, 2012b).

The method followed in the cost-benefit analysis used in the Air Policy review presents a set of issues summarised in the boxes below.

The different valuation of the mortality impacts in the benefits calculation of air pollution reduction measures. This is because the mortality aspect (i.e. reduced statistical life expectancy from exposure to PM) driven by the CAFE[19] VOLY value represents around 70 to 75% of the total health benefits and hence dominates the benefits associated with CBA. That is why it is important to apply the most robust methodology to determine a reliable / realistic VOLY value. In CONCAWE's view the MSR method combined with the data derived from more advanced WTP studies reflects current best practice. CONCAWE supports the weighted average VOLY range from €3,400 to €13,000 with a mid VOLY value of €9.250 (all values are not corrected for inflation; see section D in the box below). Consequently, the benefits for mortality aspects would decrease by a factor of 6.2 (VOLY value of NewExt study 57,700 € (NewExt, 2004) vs. 9250 € of CONCAWE's MSR value; the NewExt values are still being applied in the current Air Policy review process) and the overall health benefits by a factor of 4. The more robust valuation of morbidity impacts is discussed in Section 5.3 and 5.4, which represents the biggest part (20 to 25%) of the remaining overall health benefits.

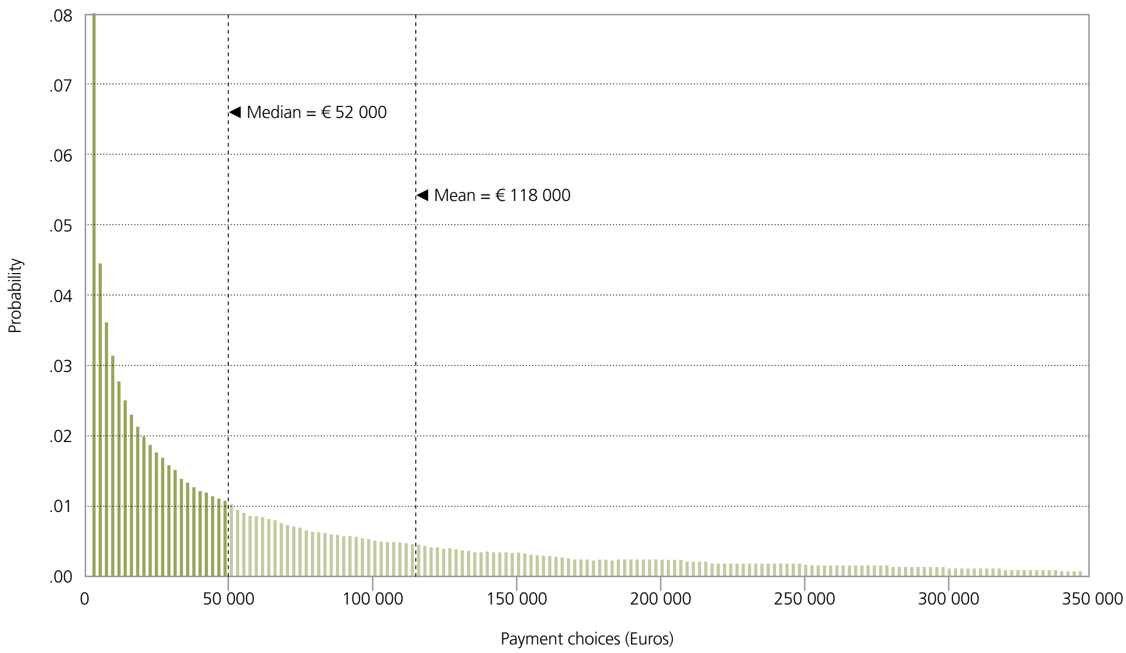
[18] The NewExt study assessed external costs of energy technologies. Its findings were used in the Cost Benefit Analysis supporting the CAFE program during the previous revision of air policy in Europe (NewExt,2004)
[19] CAFE: Clean Air For Europe programme 2005.

Issues Deriving the Value Of Life Year (VOLY)

A) Variance in Willingness to Pay choices:

- The responses from interviewed participants represent 'virtual' rather than 'real' money,
- The responses are very varied and particular highly skewed at one end (towards zero) (Figure 16).
- Formulation of survey questions has an important effect on made choices:
  - In particular the responses (scaled up to a year) are not proportional to the risk reduction, but depend on the size of the risk reduction assessed; it appears that longer life expectancy is disfavoured relatively speaking as it can be seen in Figure 17 for the results of the subsets of the NEEDS study, where WTP for 3 and 6 months increase in life-expectancy were elicited (Desaigues et al. 2007 & 2011) and the DEFRA study where WTP for 1, 3 and 6 months increase in life-expectancy were elicited (Chilton et al. 2004).
  - If it is suggested respondents will not be in good health then lower values are obtained.

Figure 16
Highly skewed distribution of WTP values as forecasted from the Weibull distribution parameters of the NewExt survey in 2004 (CONCAWE, 2006a), adjusted for inflation and used as a basis for the 57,700€ value used in the Air Policy review CBA



B) Variance among Willingness to Pay studies:

- Derived VOLY values are very different across a number of elicited WTP studies (Figure 17).

C) Challenges in determination of the most appropriate VOLY value:

- The CBA community acknowledged during the Clean Air For Europe (CAFE) program that the most representative VOLY could be obtained by statistical analysis using the full distribution range instead of median or mean values as these do 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. However policy-makers prefer a single reference VOLY (median or mean) for ease of communication.
- Assessing the available WTP surveys (Figure 17), the NewExt study is the least appropriate WTP study due to the following restrictions:
  - NewExt was designed to develop data for prevented fatality (VPF); to derive a VOLY value an inappropriate methodology was applied by back-calculating from VPF/VOSL.
  - Its inappropriateness is evident considering NewExt results deviate strongly from those of other WTP studies (Figure 17; Table 6).

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 policy rounds. Instead CONCAWE proposes to use an advanced methodology, which is briefly summarised below (see section D in this box).

However, all recent CBAs (AEA, 2011; EC4MACS, 2011; EEA, 2011a) supporting the Air Policy reviews continue to use the median VOLY value of the NewExt study (2004). The CBAs simply adjusted 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), despite better insights from more recent studies.

D) Advanced methodology "Maximising Societal Revenue" to derive a robust VOLY value

- CONCAWE proposes to use a more robust way to calculate a VOLY from a given Willingness to Pay (WTP) survey, which respects 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 6 and Figure 17 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.
- More detail can be found in (CONCAWE 2012a).

Figure 17
The (forecasted) VOLY distributions (20 to 80 percentiles) according to three studies, also indicating the location of the median, mean and MSR value

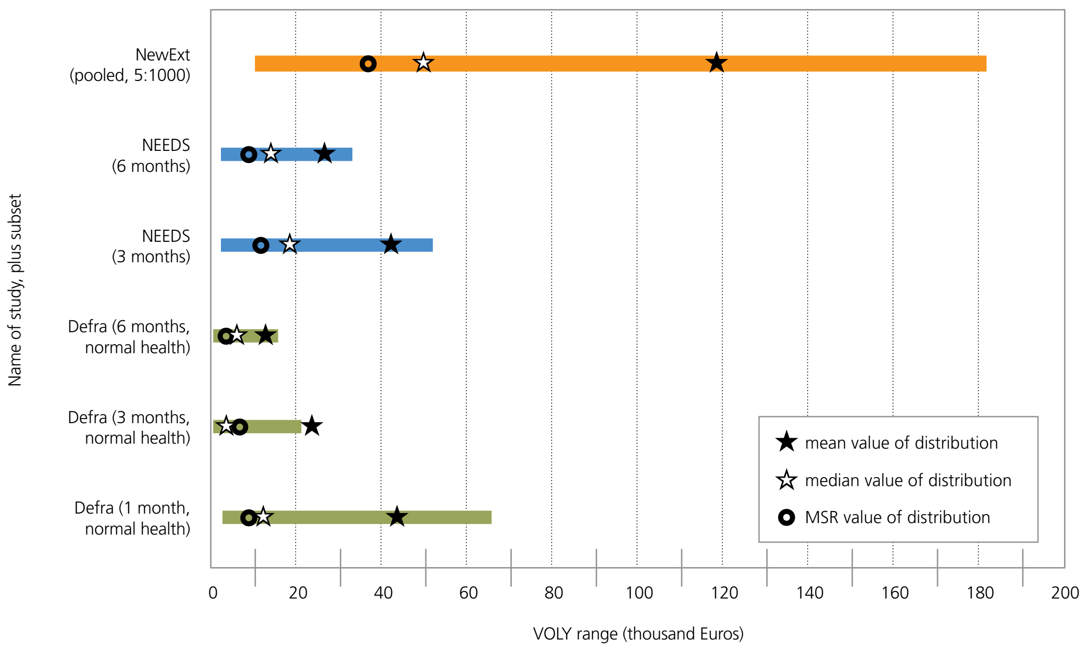


Table 6
. Derived VOLY (€ per statistical life year lost) of more advanced WTP studies (no correction for inflation applied)

WTP study	VOLY Median	VOLY Mean	VOLY based on MSR[20]
NEEDS - 6 months[21]	14,000	27,000	9,100
NEEDS - 3 months[5]	19,000	42,000	13,000
DEFRA - 6 month[22]	2,700	13,000	3,400
DEFRA - 3 months[6]	2,200	23,000	5,500
DEFRA - 1 month[6]	15,000	45,000	13,000
Weighted average VOLY of all studies	**11,600**	**31,000**	**9,250**

[20] CONCAWE, 2012a.
[21] Chilton et al. 2004.
[22] 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.

5.3. More robust monetisation of Morbidity impacts

The results of the recent studies indicate that the value range of chronic bronchitis is approximately 7 times lower than considered in the CBA studies. And as the uncertainties around monetising Restricted Activity Days (RAD) are substantial, CONCAWE has strong reservations about the monetisation of RAD. Therefore in CONCAWE's valuation it was assumed as base case that the health cost of RAD would be halved, representing a more conservative estimate which is in line with the only recent study on RAD by Maca et al. (2011). In this more realistic valuation, the benefits associated with morbidity are halved.

The morbidity impact is also valued and considered as part of the total economic benefits of the improvement in the air quality. The costs of morbidity typically account for 20-25% of the costs of air pollution in Europe as calculated for the Air Policy review but will be proportionally higher if the cost of chronic mortality is given a more realistic value (see Section 5.2). Hence, it is important to ensure that the morbidity impacts and the monetary values of these effects are robust

The morbidity impacts of air pollution are calculated from two main components: the new chronic bronchitis cases and the restricted activity days (RADs).

- Valuation of chronic bronchitis: this is done by taking into account the costs of medication and the willingness to pay studies to avoid the symptoms of chronic bronchitis.
- Valuation of Restricted Activity Days: this is done by taking into account the results of the willingness to pay studies to avoid a day of restricted activity.

CONCAWE has analysed the various approaches used in the scientific literature to value the costs of chronic bronchitis and RADs and how these values are included in recent CBAs considered in the development of European air policies. The assessment shows that there is an urgent need to reconsider the cost values currently attributed to morbidity effects in the European CBAs on air pollution control.

Issues Deriving the Morbidity Impacts

Values of chronic bronchitis and RADs are based on very few valuation studies using the Willingness-to-Pay (WTP) principle (see also Section 5.2), based on limited sample surveys, and with inconsistent results for some of the studies.

Chronic Bronchitis

Based on an analysis by CONCAWE of recent studies available in the literature[23], the analysis 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 (e.g. IIASA GAINS model, EEA 2011a). The complete analysis, which was also made available during the SEG process, can be found in Appendix 2. CBA under the Microscope of this issue.
The results of the recent studies indicate that the value range of chronic bronchitis is approximately 7 times lower than considered in the CBA studies. If this new values were considered the benefits associated with morbidity would decrease by a factor of 1.5.

Restricted Activity Days (RADs)

There are important uncertainties in relation to the assumed monetised value used in the CBA studies.
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 WTP of Spanish and Portuguese to avoid a RAD far exceeds that of northern Europeans, and the WTP to avoid a minor RAD exceeds the WTP to avoid a 'regular' RAD in Spain. This may be related to an incorrect application of the survey.
A more recent and thorough study (Maca et al., 2011), presents estimates for the costs of RAD that are around a factor 2 lower than the value by Ready et al, 2004.
Considering these uncertainties CONCAWE has strong reservations about the monetisation of RAD. Therefore, in CONCAWE's valuation it was assumed as base case that the health cost of RAD would be halved, representing a more conservative estimate which is in line with the only recent study on RAD by Maca et al. (2011).

[23] 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

5.4. Quality and uncertainty of morbidity health effects of air pollution

CONCAWE has not only concerns regarding the monetisation of the health effects of air pollution, but also on the soundness of certain underlying morbidity health data.

Studies on chronic bronchitis and Restricted Activity Days (RADs) used to quantify morbidity health impacts of air pollution have severe shortcomings that should limit their application in the policy formulation process.

In CONCAWE's view, the studies proposed for use in the CBA, Abbey et al. (1995) for bronchitis, and Ostro et al. (1987) and Ostro and Rothchild (1989) for RADs, are not of sufficient quality for use in a CBA. CONCAWE's scientific concerns with these studies are summarised in the note on Concentration-Response Functions for Morbidity Endpoints under the Project HRAPIE)[24]. The complete note can be found in Appendix 3: CONCAWE comments to the HRAPIE project.

Chronic Bronchitis study (Abbey et al. 1995) – Summary of CONCAWE concerns:

- Use of the imprecise exposure metric of PM_{10} estimates derive from measurement of total suspended particulates and airport visibility data.
- PM_{10} risk estimates have been converted to $PM_{2.5}$ estimates for purposes of the CBA. Since bronchitis is primarily a disease of the upper respiratory tract, it is inappropriate to attribute bronchitis to $PM_{2.5}$, a pollutant that distributes in the lower respiratory tract. In CONCAWE's view the exposure response functions (ERFs) are inflated as they are based on high levels of air pollution in California 20-30 years ago, and hence are not applicable to evaluation of air pollution in Europe today. Results of the study are confounded by lack of control for smoking, a well-known risk factor for development of bronchitis. In our view, a single study reporting a non-statistically significant result should not be used in a CBA.

Reduced Activity Days studies, RAD, (Ostro et al. (1987) and Ostro and Rothchild (1989)) – Summary of CONCAWE concerns

- $PM_{2.5}$ levels were not measured. Rather, $PM_{2.5}$ levels were estimated from PM_{10} measurements and visibility data from airports.
- The air pollution data evaluated were high levels in existence in California over 30 years ago are not applicable to Europe today.
- The health endpoint of RAD is highly subject to socioeconomic confounding. Significant city to city differences in RAD rates were observed in the studies used to derive the exposure response factors.

This was likely due to socioeconomic factors and other factors that were not adequately controlled in the selected studies:

- Time spent outdoors, building construction, health practices including how such days are recorded, age of the population, sex, race, education, income, marital status, temperature, employment conditions and rates, smoking rates, and many other factors. Even greater differences would be expected when extrapolating the results of these studies for use in Europe.

[24] During the development of the CBA methodology for the CAFE program, CONCAWE provided detailed comments on these studies which have been so far not appropriately addressed, and are once again used for the latest CBA reports in the current air policy review process.

5.5. Appropriate uncertainty analysis on CBA

There are considerable uncertainties accompanied with CBA for the air policy development. The understanding of the extent of and the effect of these uncertainties is insufficient. Relatively small changes in each source of uncertainty could have significant effect on the cost-benefit ratio of different emission control strategies. A better understanding of these uncertainties and/or careful consideration of the uncertainties is required to achieve a robust (revision of the) air policy package.

At present there is insufficient understanding of the effects of the various sources of uncertainty on the outcomes of the CBAs. These uncertainties pertain to:

- Future baseline emissions as a function of economic developments may affect the marginal cost/benefit ratio of different air policy ambition levels or may lead to technically unattainable ambition levels. (see also Section 4)
- Future energy prices and impacts on future emissions can affect the marginal cost/benefit ratio of air pollution control ambition levels. (see also Section 4)
- Future ambient concentrations as a function of emission reductions and other factors (including weather patterns and wind directions that may be influenced by climate change)
- Exposure levels of people as a function of human behaviour
- Monetary valuation of health and environmental effects.

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 deriving any ambition level in the air policy.

It is also relevant to note that care needs to be taken in applying singular CBAs as a basis for policy-setting (See section 5.6).

A proper uncertainty analysis of the valuation of health benefit needs to consider a range of valuation studies including a sensitivity analysis of critical assumptions. This approach has not been taken in recent CBA studies (AEA, 2011; EC4MACS, 2011; EEA, 2011a) undertaken in support of the Air Policy review process. Moreover, these CBAs did not account for the more recently available studies in the field of mortality and morbidity valuation.

Besides uncertainties related to the methodology and execution of CBAs, this special issue of a CONCAWE Review addresses also other uncertainties that refer to aspects beyond or outside CBA, such as anticipated energy scenarios, multiple time horizons for policy formulation (see Section 4).

5.6. Fundamental limitations to keep in mind when using CBA for policy formulation

In addition to the methodological inaccuracies in current CBAs (see sections 5.1, 5.2, 5.3, 5.4 and 5.5), there are two aspects that need to be kept in mind when interpreting and using CBA outcomes in the context of EU air policy:

- Firstly, 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.
  - Emission control measures have been implemented over many decades to successfully reduce national pollutant emissions. Taking further reduction actions 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.
  - Integration of Climate and Air Policy measures: include the short lived climate forcers effect as a factor in the cost-benefit analysis (see also Section 4.5).

- Secondly, only health benefits and ozone damage to some 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; EC4MACS, 2011; EEA, 2011a). Acidification and eutrophication affect ecosystems and the benefits provided by ecosystems to people ('ecosystem services', see Section 6), and eutrophication may lead to increases in some ecosystem services (for instance timber production in nitrogen limited forests) and decreases in the supply of other services (for instance biodiversity). However, it is important to note that including these contributions do not necessarily increase the net marginal benefit.

  Even if these costs and benefits are not quantified, ambitious targets for eutrophication and acidification control are included in the policy scenarios for air pollution control (A1-A6) presented in IIASA Report #10 (IIASA, 2013). The ambition levels for eutrophication and acidification have been established by association with the anticipated health benefits following PM emission reduction instead of on the basis of an analysis of the costs and benefits associated with the reduction of eutrophication and acidification themselves. 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. Each of these two aspects needs further consideration and evaluation/assessment in the near future in order to allow a more robust policy formulation. Until a better resolution is achieved, these aspects limit the applicability of CBAs.

Some more information is available in Appendix 2. CBA under the Microscope.

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)

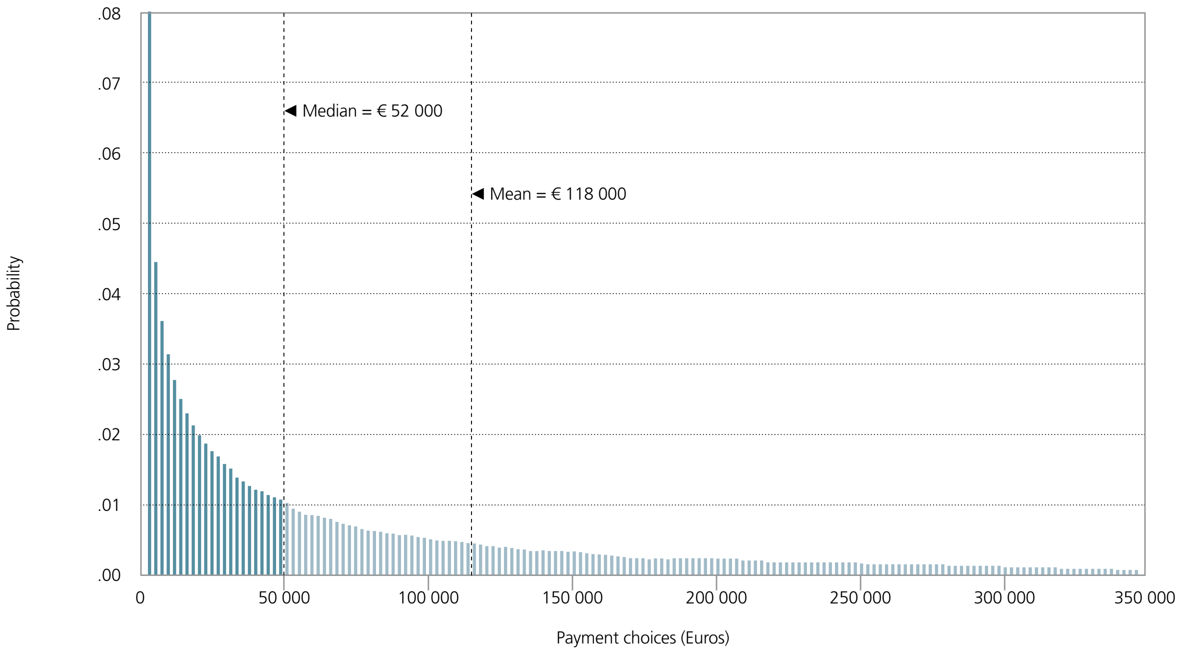


Table 1
VOLY values (€ per statistical life year lost) for a number of elicited WTP studies

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

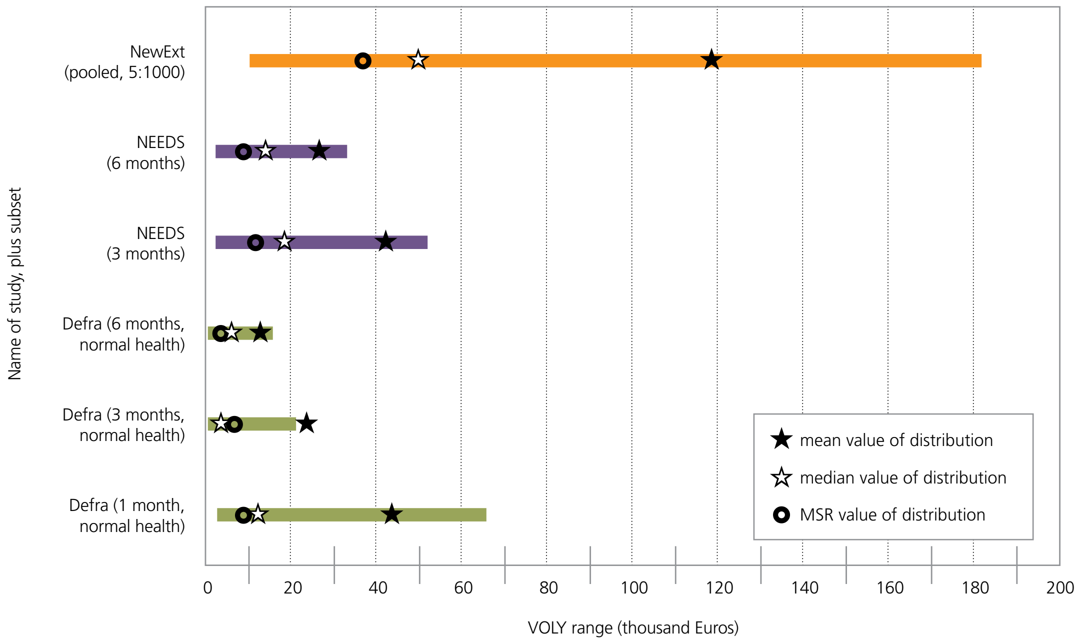


Table 1 and Figure 2 clearly show that VOLY values across a number of elicited WTP studies are very different and that they are dependent on the risk reduction discussed as shown by the variation in annualised values between the one month, three or six months increase in life expectancy (Desaigues et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