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Air Quality Appraisal –
Valuing Environmental Limits

Interdepartmental Group on Costs and Benefits,
Air Quality Subject Group

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Contents

Executive Summary

1. This paper describes the Interdepartmental Group on the Costs and Benefits - air quality subject group (IGCB(A)) supplementary methodology to monetise changes in air quality. This methodology supplements the IGCB(A) central methodology which is recommended as best practice for the appraisal of changes in air quality. The central IGCB(A) methodology follows Green Book guidelines to set out how a Social Cost Benefit Analysis (SCBA) can be applied to the valuation of air quality. More information on this methodology is available from www.defra.gov.uk/evidence/economics/igcb/

2. There are limited circumstances when the central IGCB approach to valuing air pollution is not appropriate as it does not reflect environmental limits. This paper outlines the abatement cost methodology which should be used in these specific circumstances when it would be appropriate and proportionate to do so.

3. The new methodology builds on existing approaches, and will only apply in cases where a policy is expected to result in limit values being exceeded. In such cases, the new methodology involves estimating the abatement action required, and its cost, to keep emissions within the limit value, in order that these costs can be factored into the economic appraisal. This new methodology helps to ensure that the costs of exceeding limit values are properly reflected in the analysis. It will also help prevent future exceedences as any abatement required will have been considered in the appraisal.

4. This methodology marks the first stage of a process of improving the appraisal guidance in this area. The second stage of the process will be to produce a clear guidance document outlining how the methodology should be used in practice. Also as each Government Department has its own appraisal structure, the IGCB(A) will work together with Government Departments to help tailor this guidance so that it can be integrated, where it is feasible to do so, with current Departmental appraisal guidelines. This process will involve further work: (a) to test out its application and to seek views from expert practitioners on the practicalities of applying this methodology; and (b) to develop guidance and tools for the specific needs of practitioners so that the new methodology can be applied in a proportionate and transparent way.[1]

Policy context

5. Air pollution has an adverse effect upon human health and the natural and man-made environment. These spill-over impacts (externalities) are not fully incorporated into the decision making process of private firms and individuals. This can lead to levels of pollution which are sub-optimal to society. This creates a strong driver for government intervention to protect air quality both by controlling the emission of harmful airborne pollutants and setting minimum air quality standards.

[1] Consistent with the Green Book it is the responsibility of the decision maker to ensure they have the required information and therefore judge what would be proportionate to the decision. Where practitioners require further advice on proportionality they should contact the relevant Department.

6. Policy on air quality is set based on two key drivers[2]:

- Economic efficiency - intervening where the market cannot be expected to deliver the socially optimal outcome[3]; and

- Equity - where the market outcome is distributed in an undesirable way.

7. To deliver on both of these drivers, in principle, the best solution would be to undertake a comprehensive analysis that reflected all the outcomes and their distribution. In a world of perfect information this analysis would set the level of pollution up to the point at which the social cost of the marginal unit of pollution (appropriately weighting both efficiency and equity) would be equal to or less than the cost of abatement (such as through technological or behavioural changes) and therefore any further improvements in air quality would not be justified.

8. However, as we operate in a world of imperfect information it is not possible to deliver this first best solution. Therefore two broad approaches to the control of air pollution are required. These two broad approaches can be described as marginal policies and aggregate policies.

9. Marginal policies usually target a specific source of pollution. These policies will consider the impacts of a range of emissions to the air from a source to judge if additional emission controls are justified. Justification for additional abatement is then usually assessed by valuing the marginal benefits against the marginal costs using the most comprehensive available analysis. Thereby assessing whether the benefit of reducing air pollution is greater than the associated cost.

10. Aggregate policies however address the total level of air pollution within an area irrespective of the sources. Aggregate levels reflect environmental limits which may be set through a range of considerations including, the protection of the natural capital, managing uncertainties on the impacts of air pollution, the distribution of pollutants across the population and across time and thus help address the equity driver above. Controls usually target a specific type of pollution e.g. NO_X and set a maximum concentration. Therefore these controls set the minimum standards for air quality which can be seen to act as a safety net.

11. To inform the development of either type of policy it is well recognised that robust evidence is fundamental. It is also noted that to ensure the optimality of decisions across areas a consistent approach is required.

[2] HM Treasury Green Book Annex 1 http://www.hm-treasury.gov.uk/d/green_book_complete.pdf
[3] Economic efficiency (otherwise known as Pareto optimality) is defined as the situation where it is not potentially possible to make one or more individuals better off without necessarily making one or more other individuals worse off. This definition of efficiency is generally seen to be true where there are positive net benefits from an action.

The IGCB(A)

12. The core objective of the Interdepartmental Group on Costs and Benefits – air quality subject group (IGCB(A)) is to develop, maintain and disseminate a methodology for producing evidence to inform decisions which impact on air quality. Substantial progress has been made on this remit with the development of the impact-pathway approach and through it the estimation of damage costs (relating impacts to volumes of emissions) and activity costs (relating impacts to different activities such as driving). The IGCB(A) aims to continually refine and improve its methodology to reflect the latest developments in evidence, economic appraisal and the policy needs.

13. The central methodology of the IGCB(A) to assess changes in air quality is the impact-pathway approach (hereafter referred to as the IGCB(A) central guidance). This methodology is aimed primarily to inform marginal decisions. The IGCB(A) central methodology follows Green Book guidelines and describes how a Social Cost Benefit Analysis (SCBA) can be applied to the valuation of air quality.

14. The impact pathway approach follows the logical progression from the location of the emission through dispersion and consequent exposure to a range of outcomes that can then be valued. These values are then placed into the relevant SCBA to provide a value for the net benefit (or cost) of policy measures. An advantage of SCBA is that it allows comparison between different policy measures on a consistent metric e.g. money. This method continues to be the best available approach to air quality appraisal in nearly all circumstances.

Limitations of the impact pathway approach

15. However there are limitations to this approach as it is not able to provide concentration limits required to remain within environmental limits. The limitations can be summarized into three broad groups:

1) **Efficiency** - measures to constrain emission rates may not lead to optimal (efficient) ambient levels of pollution. This is because concentrations depend on both emission rates and usage and the scale of impacts are location specific[4].

2) **Uncertainty** – there are considerable uncertainties around the available evidence and therefore the precautionary principle requires some minimum standards.

3) **Equity –** the current analysis is not able to fully reflect equity factors, such as:

    i) racial equality

    ii) age distributions and

    iii) intergenerational issues

16. The above reasons mean there may be circumstances when the current methodology may need to be supplemented to reflect the impact on the overall level of air quality. From this point on we term such a holistic approach as an aggregate analysis. The three limitations are discussed in more detail later in Chapter 2 of this document.

[4] In principle a marginal approach applied at an aggregate level could deliver the efficient outcomes however to enable a pragmatic application this may not occur given the existing evidence.

Abatement cost approach

17. The limitations of the marginal analysis are part of the motivation for setting aggregate objectives such as maximum acceptable concentrations. Particularly with respect to uncertainty where aggregate objectives such as limit values can be seen as providing a ‘safety net’ for the level of air quality.

18. Over time demand for continual improvements in ambient air quality combined with growing evidence of a wider range of impacts has meant that these minimum standards have started to become increasingly binding constraints. A notable example being the recent application for a time extension for the achievement of the legally binding EU limit value on Particulate Matter (PM) which was exceeded in 2005.[5]

19. When a policy decision leads to an increase in a pollutant above these aggregate objectives, such that future abatement will be required, a cost of abatement approach should be used to value changes in air quality.

20. This approach uses cost effectiveness analysis to identify the least costly approach to undertake such abatement. In doing so a range of abatement options are considered with the least costly approach used to value the required improvements in air quality. This abatement cost represents the real resource cost or price of an extra unit of pollution (the cost of removing it). This is then used to inform policy decisions as it can be compared against the benefit which accrues from allowing pollution to increase and incorporates the consequential costs of abatement into decision making.

When to use the supplementary methodology

21. The IGCB(A) only recommends the use of the approach set out in this paper when decisions are expected to result in concentrations that exceed government objectives such that future abatement will be required, and where it would be proportionate to undertake the assessment. In all other situations the IGCB(A) recommends the use of its central guidance to apply the impact-pathway approach to evaluate changes in air quality.

22. To help with the decision on when it is appropriate to use this approach IGCB(A) have developed a decision tree outlined in Chapter 4 of this document.

23. In order to help facilitate this change the IGCB(A) is working to develop and publish marginal abatement cost curves (MAC Curves). The intention being to develop tools to produce area specific MAC Curves that relate to both levels of NO_X emissions (in volume terms) and NO_2concentrations (as measured in $\mu g.m^{-3}$). It is expected that a similar analysis will also be developed for other air pollutants, such as Particulate Matter (PM_{10} and $PM_{2.5}$), if ambient concentrations get to levels where a similar approach to appraisal is likely to be required. However it is noted that any such tools are only intended to compliment analysis by the decision maker in identifying the least cost abatement technologies. The responsibility to produce robust evidence to estimate abatement cost will remain with the party evaluating the decision.

[5] More information on this situation is provided in Annex B.

Chapter 1: Introduction

Issue

24. The central objective of the Interdepartmental Group on Costs and Benefits – air quality subject group (IGCB(A)) is to develop, maintain and disseminate the best practice methodology to produce evidence that informs decisions which impact upon air quality. A challenge to the current methodology has been that it does not fully reflect the aggregate impacts of decisions on air quality. Therefore it may not deliver the minimum standards of air quality universally demanded by the general public. This paper sets out the supplementary methodology to be applied, in the rare circumstances where as a result of a current policy decision additional abatement would be required to deliver these standards and when it would be appropriate and proportionate to do so.

Background

25. Air quality has improved substantially over the past decade. However, even at the prevailing levels of air pollution can lead to a range of serious adverse outcomes. Exposure to air pollution has both long-term and short-term effects. The long-term effect on health relates to premature mortality due to cardiopulmonary (heart and lung) effects. In the short-term, high pollution episodes can trigger increased admissions to hospital and contribute to the premature death of people who are more vulnerable to daily changes in levels of air pollutants. Air pollution also has negative impacts on the environment, both in terms of direct effects of pollutants on ecosystems, and indirectly through effects on the acid and nutrient status of soils and waters.

26. In 2008 air pollution in the form of anthropogenic particulate matter (PM) alone was estimated to reduce average life expectancy in the UK by around 6 months. Thereby imposing an estimated equivalent health cost of £19 billion in 2008.[6, 7] However, it has been argued that this estimate is conservative as it only reflects the long term chronic impact on life expectancy from fine particles and does not include a range of other health impacts, such as acute mortality, morbidity or indirect health impacts.

27. It is more difficult to value the impacts on ecosystems and therefore these are usually considered relative to the estimated level at which harmful effects are expected to occur, commonly known as critical loads. Modelling undertaken for the Air Quality Strategy 2007 suggested that by 2010, 47 per cent of habitats would exceed the acidity critical loads and 49 per cent would exceed the nutrient nitrogen critical loads.

28. The negative impacts of air pollution are not fully reflected in market signals and therefore, in the absence of government interventions, we would not expect these impacts to fully inform decisions. The exclusion of the health and environmental spill-overs (externalities) results in levels of air pollution above the social optimum.

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[6] This figure equates to a value of £17 billion in 2005 prices as quoted in the Air Pollution: Action in a Changing Climate.

[7] "Valuing the overall impact of air pollution" available from www.defra.gov.uk/evidence/economics/igcb/

Air quality policy

29. To address this challenge there is a strong rationale for government interventions to manage air quality. As with all government interventions air quality policy is driven by two key considerations[8]:

- Economic efficiency - intervening where the market cannot be expected to deliver the socially optimal outcome[9]; and
- Equity - intervening where the impacts would be distributed in an undesirable way.

30. To deliver on these objectives policy decisions are informed by the use of a marginal social cost benefit analysis (SCBA). The potential abatement costs of a given emissions standard are compared against the associated air quality benefits. Where the benefits are estimated to be greater than the costs there is a strong case for government intervention. This is a marginal analysis which compares the cost of a unit reduction of pollution against the benefits of this unit reduction.

31. An illustrative example would be the introduction of more stringent emission standard for a single source. To evaluate such a proposal a key consideration will relate to the additional marginal cost of achieving the proposed emission standard relative to the value of the associated air quality improvements. If for example the emission control technology at a national level had an estimated total cost of £50 million then justification would be shown on efficiency grounds if it has an associated air quality benefit significantly in excess of £50million.[10]

32. There are a wide range of air quality regulations focusing on individual sources that have been informed by this type of analysis. These interventions can be split into broad groups according to the source of the emissions, such as EU vehicle emission standards (EURO standards), industrial emissions, including the local authority pollution prevention and control (LAPPC) regime, and domestic emissions, including the Clean Air Act. More information on all of these interventions is available from the Defra website (http://www.defra.gov.uk/environment/quality/air/airquality/index.htm)

33. However there may be occasions when this marginal analysis needs to be supplemented by an analysis that reflects both the marginal changes and any environmental limits. From this point on we term such a holistic approach as an aggregate analysis. For example, the above example did not consider the distributional impacts i.e. who would face the £50 million emission controls and who would benefit from the improved air quality.

[8] HM Treasury Green Book, Annex 1 http://www.hm-treasury.gov.uk/d/green_book_complete.pdf

[9] Economic efficiency (otherwise known as Pareto optimality) is defined as the situation where it is not possible to make one or more individuals better off without necessarily making one or more other individuals worse off. This definition of efficiency is generally seen to be true where there are positive net benefits from an action.

[10] However, due to the fact that equity considerations are not always possible to monetise it is not necessarily the case that a benefit of less than £50 would necessarily mean that the proposal was not justified. This example also abstracts from the range of potential ancillary impacts therefore implicitly it is assuming that all other impacts are represented by the total cost.

34. Government equity objectives cover equity between all groups including different income groups, ethnic groups, religions, ages, genders, sexual orientation and across generations. Such objectives are primarily addressed in relation to air pollution through controls of ambient concentrations of air pollution. To deliver these outcomes a key role has been established for the use of objectives at local, regional, national and international levels. These objectives explicitly set the maximum level of air pollution which is deemed acceptable. This level reflects the distribution of impacts of air pollution on human health and the natural and manmade environment. Such aggregate objectives also have a 'safety-net' role given the large uncertainties in the marginal analysis.

35. Air quality objectives can take a wide range of forms, the four key types being:

- EU limit values - legally binding EU parameters that must not be exceeded. Generally limit values are set for individual pollutants over a given period, which may allow a number of incidents of exceedences per year, and an achievement date.
- Target values - are defined in the same manner as limit values but are not legally binding. These values are to be attained as far as possible without incurring disproportionate cost.
- Critical loads - provide a quantitative estimate of the level of exposure to a pollutant at which significant adverse impacts on the environment are expected.
- Critical levels - refer to gaseous concentrations above which direct adverse effects on vegetation or ecosystems are likely to occur.

36. Depending upon the type of objective the strength of the obligation can vary. Clearly compliance is mandatory for legally binding requirements, such as EU limit values, while aspirational objectives, such as target values, must only be achieved where they do not impose a disproportionate cost. Given the imperative to meet legal requirements, the focus of this paper is on such objectives, however this should not be taken to downplay the importance of the other obligations. Table 1 below identifies some of the key limit values and the date for compliance.

Table 1: European limit-values

Pollutant	Concentration measured as	European obligation	Date to be achieved
PM_{10}	24 hour mean	50µg.m^{-3} not to be exceeded more than 35 times a year	1st January 2005
PM_{10}	Annual mean	40µg.m^{-3}	1st January 2005
NO_2	1 hour mean	200µg.m^{-3} not to be exceeded more than18 times a year	1st January 2010
NO_2	Annual mean	40µg.m^{-3}	1st January 2010

37. It is important to highlight the process by which the above limit values are agreed by EU Member States. These limits are set based on a number of criteria only one of which is economic efficiency. There are a number of considerations for Member States when agreeing EU air quality standards, including distributional issues, uncertainty, and aversion to risk, amongst others. Box 1 provides a brief overview of the process by which European air quality targets are established.

Box 1: Setting of Air Quality Objectives

There is a need to manage air quality at a supranational level due to the trans-boundary characteristics of air pollution. The key international objectives joined by the UK are set in the EU Air Quality Directive. In setting these objectives a range of factors are considered and a number of checks and balances are in place to ensure that any obligations are justified. This box briefly outlines these procedures and the considerations that have informed the existing limit values.

The four institutions playing the chief parts in the EU legislative process are the European Commission, the Council of Ministers, the European Parliament, and the European Court of Justice. Depending on the nature of the proposed legislation, various decision making processes can be applied. In the case of environmental issues, that most commonly used is the co-decision procedure, operating principally as follows:[a]

1. Commission presents a proposal
2. Parliament adopts an opinion, usually including proposals for amendments
3. On the basis of the Commission's proposal, the Parliament's opinion, and the views of member states, the Council adopts a Common Position (CP)
4. Commission presents its view on the CP
5. The second reading in Parliament, then
   a) Parliament approves the CP and the legislation is eventually adopted by the Council.
   b) Parliament proposes amendments to CP and Council has to react
6. Council has to reject or approve within three months. Then
   a) Council approves; legislation will – after consultation with the Commission – be adopted by the Council.
   b) Council does not approve of (all) amendments. Conciliation procedure starts.
7. A Conciliation Committee is formed, involving in practice representatives of the Council, the Parliament, and the Commission, with the aim to agreeing on a compromise text within six weeks. Then either
   a) Agreement on a joint text and after approval by Parliament and Council legislation is adopted. Or
   b) No agreement – no legislation.

This process provides a number of opportunities for the discussion and scrutiny of any proposal. Then only if agreement can be met is the new legislation adopted.

The following extracts from the Europa website show the thinking behind the setting of limit values.

> "to reduce pollution to levels which minimise harmful effects on human health"
>
> "emissions of harmful air pollutants should be avoided, prevented or reduced and appropriate objectives set for ambient air quality taking into account relevant World Health Organization standards, guidelines and programmes" [b]

These extracts show that the main consideration is the protection of human health and the environment as a whole.

The following extract shows the WHO advice for NO_2

> "The current WHO guideline value of 40 µg/m^3 (annual mean) set to protect the public from the health effects of gaseous NO_2 remains unchanged from the level recommended in the previous AQGs".[c]

[a] Source: http://www.airclim.org/factsheets/EU_fact202.PDF
[b] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe
[c] Fact sheet N°313 Air quality and health (www.who.int/mediacentre/factsheets/fs313/en/index.html)

The Interdepartmental Group on Costs and Benefits

38. The Interdepartmental Group on Costs and Benefits – air quality subject group (IGCB(A))[11] is a Defra led interdisciplinary group of government economists and other experts that provides economic analysis and advice relating to the control of air pollution. The remit of the group is to develop, maintain and disseminate the best practice approached to air quality appraisal.

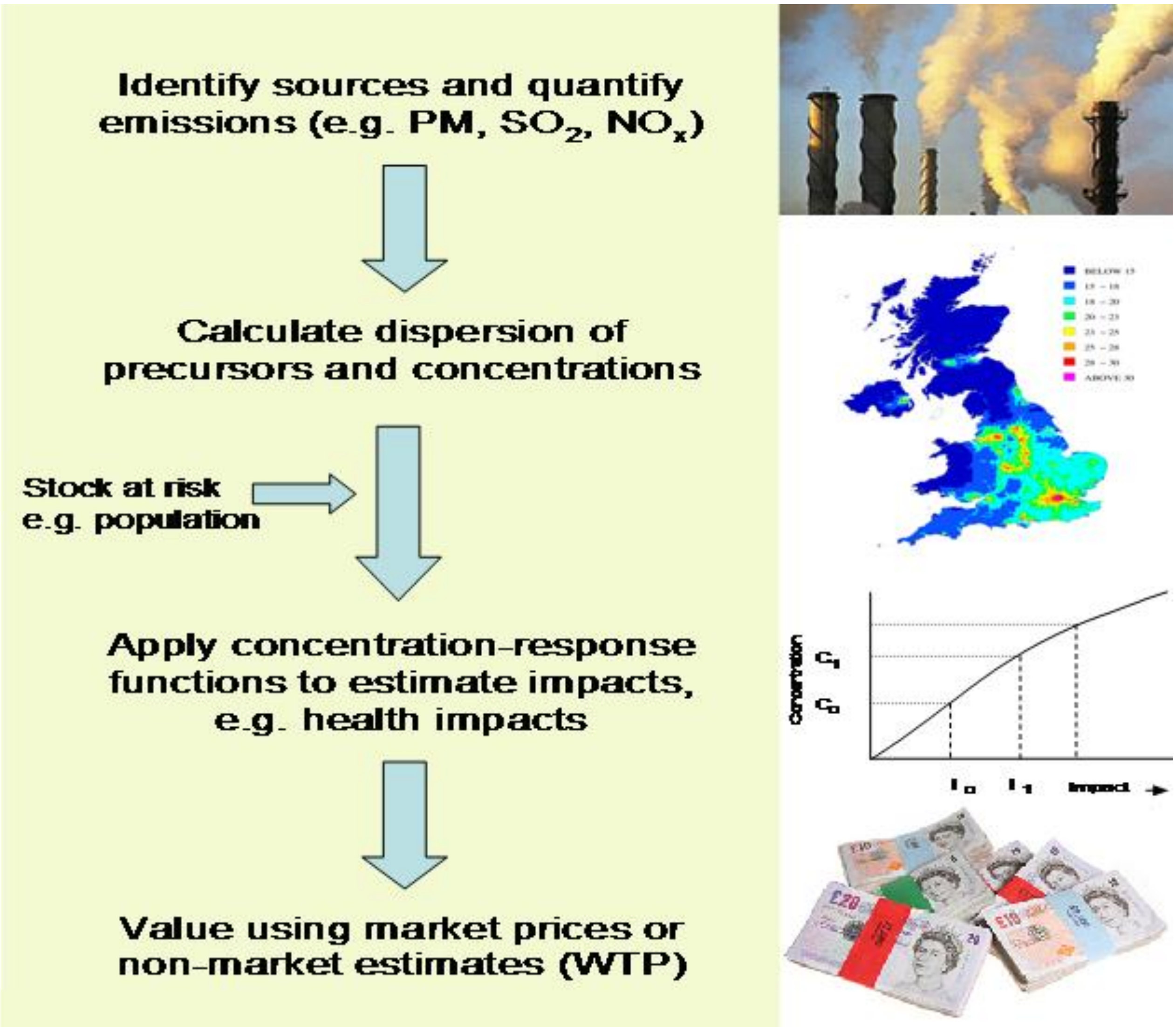
39. Through this role it plays an important part in helping the government develop its objective to deliver the "air with minimum practicable harmful levels of pollutants". It seeks to develop and improve the appraisal methodology for policies that have air quality impacts.

40. IGCB(A) consists of government economists and other experts from relevant government Departments and associated institutions. Annex A gives details of the current members of the group. The membership changes over time to reflect institutional change and there is a continual desire to include all government departments.

41. A major achievement of the IGCB(A) has been the establishment of a consistent and robust methodology to monetise air quality changes (the IGCB methodology). This approach looks to estimate the social costs of air pollution by estimating and valuing the measurable outcomes of air pollution. To do so it applies the impact-pathway approach which follows the logical progression from the emission of the pollutant through dispersion to a range of outcomes which are then valued. This methodology is outlined in Diagram 1 below.

[11] In addition to the air quality subject group there is also a noise subject group. For more information on this group and its activities please visit www.defra.gov.uk/evidence/igcb/.

Diagram 1: Impact pathway approach[12]



[12] Willingness to Pay (WTP) is used where there is no market price for a good. WTP estimates are derived from survey responses i.e. no actual transaction is required. They show the amount which an individual is willing to pay for a good or service.

42. Diagram 1, above provides an illustration of the process undertaken in the impact-pathway approach. The main steps are:

- Quantification of emissions for both the baseline and scenario under consideration;
- Conversion of estimated emissions into relevant exposures for all scenarios;
- Estimation of marginal impacts from the policy option relative to the base case;
- Valuation of the impacts associated with the scenario relative to the base case;
- Comparison of the air quality and other impacts on a consistent basis; and
- Description of the uncertainties, risks and consequently any sensitivities.

43. More detail on the impact pathway approach is available on the IGCB website www.defra.gov.uk/evidence/economics/igcb/index.htm.

44. Through this methodology it is possible to explicitly estimate and value a range of outcomes from changes in air quality. Therefore it can be used to consider the marginal impacts of a proposal by demonstrating the trade off between the change in air quality and the full range of other impacts. This approach has been effective in informing decisions on the improvement of economic efficiency.

45. There are specific situations when this approach is not appropriate, particularly where changes in emissions would lead to a requirement for compensatory abatement. The need for subsequent abatement can arise for a number of reasons. These reasons are described further in the next chapter. In such rare circumstances IGCB(A) has produced this supplementary methodology to outline how appraisal should be undertaken. Further detailed guidance will be published to help policy analysts to carry out the approach in practice.

Chapter 2: Challenges with the existing appraisal approach

46. This chapter provides an overview of the challenges that have been faced in applying the existing IGCB methodology to appraising air quality. In doing so it explains why this approach does not always provide appropriate information for policy decisions. This is most commonly seen in situations where a decision is expected to create a need for consequential abatement.

Introduction

47. In assessing air quality it is important to reflect both the marginal change and the aggregate level (ambient concentration). As with any evaluation methodologies there are some particular circumstances where a single approach may not be appropriate. The aggregate levels of air pollution can require additional controls due to three limitations of the marginal analysis. These three limitations relate to:

1) **Efficiency** - marginal measures may not in all instances lead to optimal (efficient) ambient levels of pollution

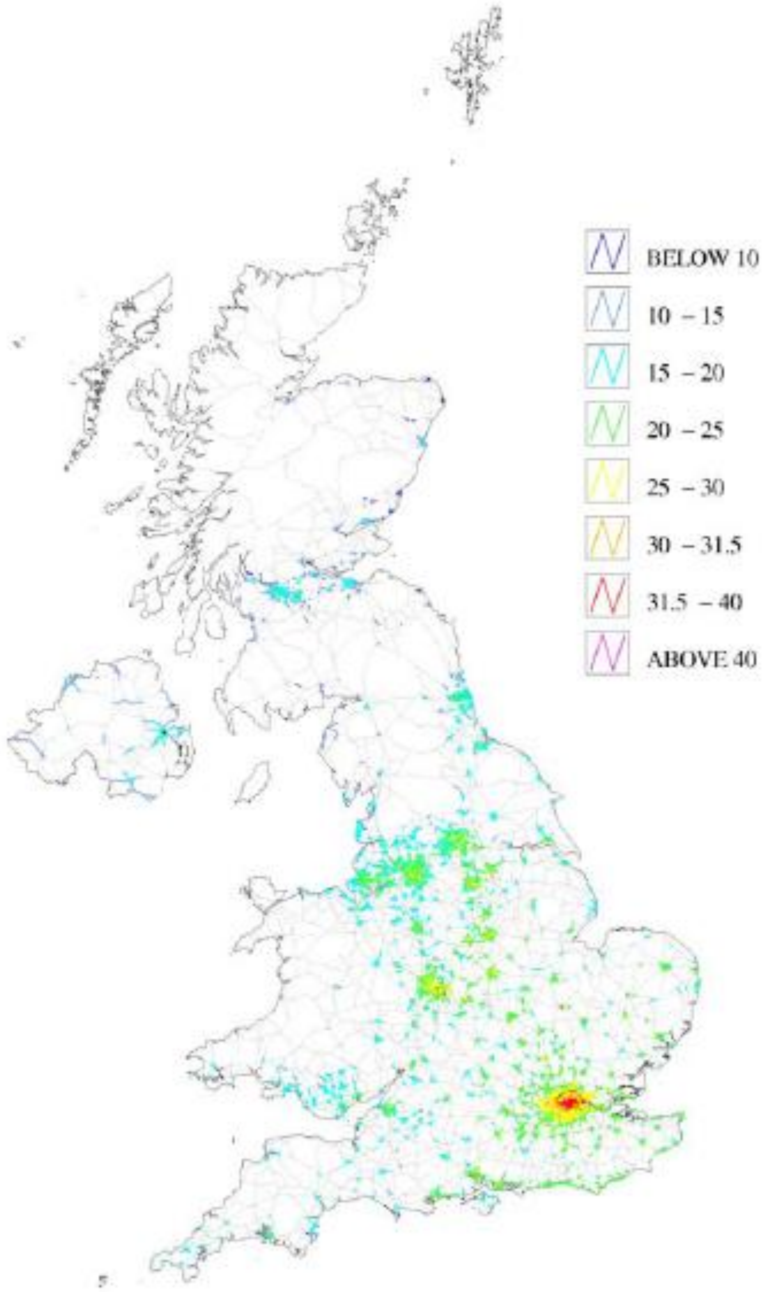
2) **Uncertainty** – there are considerable uncertainties around the results of the marginal analysis

3) **Equity –** the current analysis does not consider equity factors, such as distributional impacts or intergenerational issues.

Efficiency

48. The impacts of emissions are location specific. The link from emissions to concentrations depends on other conditions such as the ambient level of pollution within an area. This means that a single national marginal analysis is not appropriate, rather each location with different characteristics should have its own marginal analysis. The following map shows the large variation in PM_{10} across the country.

Diagram 2: Ambient PM10 concentrations across the UK (μg/m3 2005)



49. The map shows that the concentrations of PM_{10} vary across the country. The largest concentrations are centred in urban areas.

50. The abstract graphs below consider the social costs of air pollution in a city and a rural location. The damage costs in each case are non-linear, although each pollutant is different, in general this is because the chemical reactions in the atmosphere are non-linear i.e. higher ambient concentrations may lead to the formation of more damaging pollutants, and because the health impacts may be non-linear, i.e. at higher concentrations additional health impacts are observed, above those predicted from a linear relationship.

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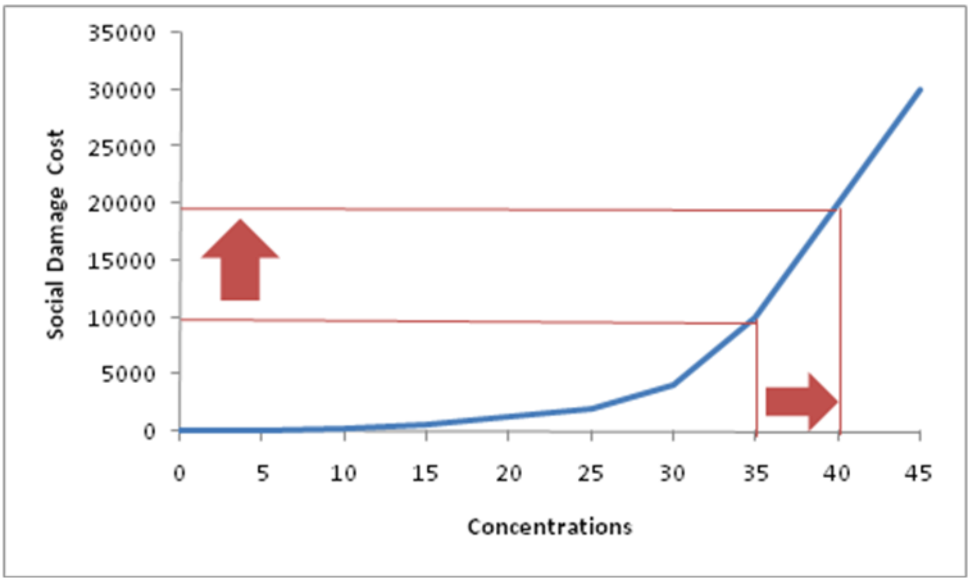
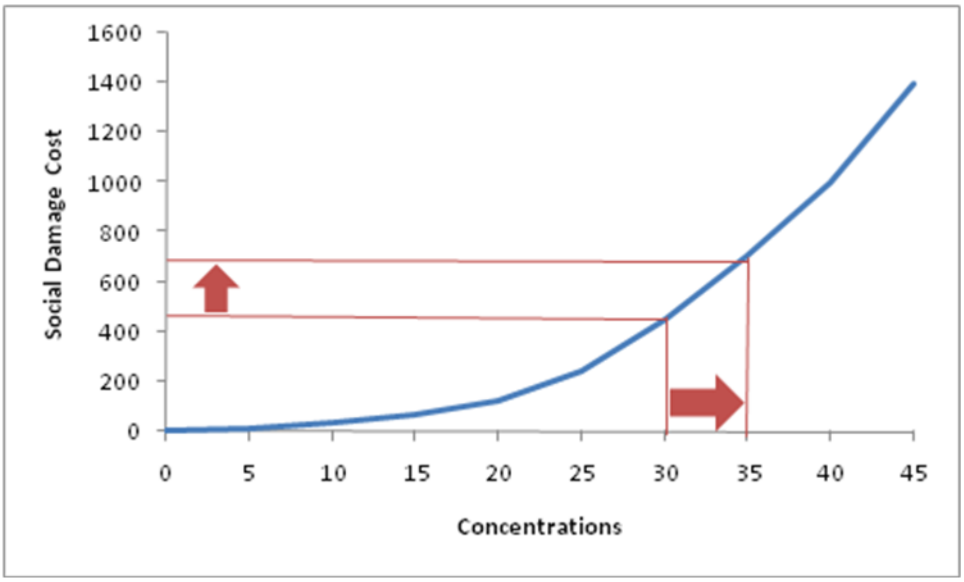
Figure 1: Social damage costs for a city from an increase in concentrations



51. In the city social damage costs are very high. This could be due to higher background concentrations of pollutants or due to a larger population exposure. A rise in the pollutant from 35 to 40 in the city increases the social costs from £10,000 to £20,000; an increase of £10,000.

Figure 2: Damage cost for rural location from an increase in concentrations



52. In the rural location the social costs are lower than the city due to a lower population and lower ambient levels of pollution. A rise in the pollutant from 30 to 35 in the rural location increases damage costs from £450 to £700; an increase of £250.

Table 2: Damage costs from an increase in an air pollutant

Location	City	Rural
Increase in pollutant ($\mu g/m^3$)	5	5
Increase in social damage	£10,000	£250

53. The average social damage cost across the two locations is therefore £5,125. However, using this average value would not deliver efficient outcomes in either the city or rural location. In the city location air pollution would be seen to be too high as options to reduce pollution costing over £5,125 would be justified but not pursued. Conversely in the rural location the level of air pollution would be too low as options costing up to £5,125 would be pursued but only where the cost was below £250 would they be economically efficient. While the full impact pathway approach would be able to reflect this differential commonly used tools such as damage costs would not fully reflect them.

54. This example shows that attempts to address information gaps by aggregating across areas will not necessarily deliver an optimal outcome.

Uncertainty

55. The appraisal of air quality is complex and inherently uncertain. Therefore setting minimum standards might be justified on the grounds that it provides some management of the unknown or uncertain risks of air pollution. Some of the key uncertainties with respect to air quality are around:

- Modelling the baseline situation for example the effect of different meteorology;
- Quantifying the link between emissions and concentrations;
- Estimating health and non-health impacts of changes in air quality; and
- Valuation of the estimated outcomes.

56. Uncertainties are usually handled by providing a range. The following stylised example uses just three uncertainties to demonstrate how these ranges can stack up to give unworkably large ranges. The first key uncertainty is around the level of emission from a given activity. For modelling a central value is applied but the actual emissions may vary substantially. This can be seen in the figures used in the Renewable Energy Strategy where boiler emissions were seen to vary by a factor of two between the low and central values and almost two again from the central to the high value. Focusing specifically on the effects of long-term exposure to air pollution and mortality, the Committee on the Medical Effects of Air Pollutants (COMEAP) recommends sensitivities around the central increase in hazard rate of a 'typical low' 1% and a 'typical high' 12% increase in hazard rate per 10 $\mu g/m^3$ increase in $PM_{2.5}$, creating a 12 fold difference. Finally, the valuation of health impacts can also vary notably between studies. For example the IGCB use a value of around £30,000 per life year lost however analysis for the EU Clean Air For Europe (CAFE) uses a value of up to £120,000 for a same life year. The variances in these figures are then multiplied up in Table 3 to show the scale of the difference based on these figures.

Table 3: Relative scale of uncertainties in valuing health impacts of air pollution

	Ratio		
	Low	:	High
Emissions (Tonnes)	1	:	4
Hazard rate	1	:	12
Valuation of health outcomes	1	:	4
Total Range	**1**	**:**	**192**

57. Table 3 shows that the combination of these three uncertainty ranges creates a total range between the high and low values of 192 to 1. Therefore using this range might make a policy have a benefit in the range of £10 million to £1.9 billion. The width of this range creates potentially major issues in policy appraisal particularly if the costs were within this range. It should be noted that the probability of the total range being this large is small as we have chosen the end points of the probability distributions at each stage. However, it should also be noted that there are a number of other uncertainties in estimating the health impacts of pollution, only three categories are presented above.

58. The presence of limit values acting as a 'safety net' on air quality has allowed the assumptions made within the impact-pathway approach to be relatively conservative. For example the value of health outcomes used by IGCB is around a quarter of that used in the EU. However, without these effective backstops it would be challenging to maintain these conservative assumptions.

Equity

59. There are also notable equity considerations when managing air quality:

i. Distributional grounds - as noted above efficiency considerations do not necessarily prevent the impacts being distributed in a way that is seen to be socially unacceptable. One particular example might be if the adverse impacts were substantial but focused on one small specific group (eg. significant adverse health effects for a small group of people) while the social benefits were small but spread across a wider group.

ii. Intergenerational issues - changes in air quality may impose non-transitory impacts on natural capital. Therefore controls may be justified on the grounds of sustainable development.

60. Given this range of considerations it is believed that there are reasonable grounds to set some controls to address the aggregate level of air quality. To deliver such objectives the most common approach has been to set minimum ambient air quality standards as discussed in Box 1 above.

61. Also, it should be noted that these minimum standards do not necessarily represent the "optimal" level of air pollution. Limit values are introduced to protect a minimum standard of air quality. However, in many instances it is desirable to abate below these levels to achieve the additional benefits of improved air quality.

Box 2: Challenges of only applying a marginal analysis

The application of marginal analysis to inform policy decisions ignoring strong other drivers can impose significant unnecessary costs on the public. This box outlines a hypothetical example to illustrate how such adverse impacts can occur.

Table I sets out the results of a thorough social cost benefit analysis on the hypothetical example. This analysis suggests that it is shown to be economically justified.

Table I: Ex ante project assessment

	Impact (£ per annum)
Net Social benefit of new project (excluding air quality impact)	£1,300,000
Monetised IGCB Air Quality Cost (increase in PM from 40 µg.m^{-3} to 50 µg.m^{-3})	£1,000,000
Net Benefit	£300,000

The analysis presented in table I suggests that the new project is economically efficient, even when including the adverse impacts of increased air pollution. While the inclusion of the air quality impacts is seen to reduce the net benefit of the project there remains a notable net benefit from this proposal. As is best practice it is also noted that the new project will increase concentrations from 40 µg.m^{-3} to 50 µg.m^{-3}. This change is seen to result in concentrations that exceed the limit value of 40 µg.m^{-3}.

It is assumed that while noting the modelled exceedences it is felt that the positive social net benefit including an air quality assessment justified the pursuit of the project.

Having committed to the project it would then be identified as an area where the aggregate controls were not going to be met. Therefore in order to achieve this obligation the delivery body (at a national, regional or local level) would look to undertake abatement. To do so it would consider a range of potential abatement options and select the option, or package of options, that was seen to minimise the abatement cost.

This example assumes that the lowest average abatement cost is twice the value of the social cost of air quality, as currently valued. This cost will however be offset to some degree by the improvement in air quality. Given the definition of the efficient concentration, set out above, we would necessarily expect this abatement cost to exceed the estimated cost of the adverse impacts.

As the lowest cost abatement option this is undertaken to achieve the obligation imposing a total net cost of £2,000,000. Table II, below, evaluates the social outcomes of this project including the impacts of the necessary abatement.

Table II Ex post policy evaluation.

	Impact (£ per annum)
Net Social benefit of new project (excluding air quality impact)	£1,300,000
Abatement Cost (associated with lowering concentrations from 50 µg.m^{-3} to 40 µg.m^{-3})	£2,000,000
Net Cost	£700,000

Table II shows that in this example overall the net impact of the project is to impose a net social cost of £700,000. This is because while the benefits associated with the hypothetical example would outweigh the monetised marginal monetised costs of increased air pollution it is not large enough to outweigh the consequential abatement cost.

Chapter 3: Valuing environmental limits.

62. The previous chapters have shown the possible limitations to a strictly marginal approach to valuing air quality in the context where legally defined air quality limits are at risk of being breached. Maintenance of air quality within the environmental limits has allowed significant progress in placing monetary values on air quality however such values have in some instances challenged the delivery of the natural limits, as set out in limit values. **Where policy decisions will lead to increases in pollutants above the levels set in these objectives the cost of abatement should be used to value changes in air quality.** This chapter sets out this new abatement cost approach and the following chapter then provides guidance on when the different approaches should be used.

Valuing aggregate impacts

63. Generally there are two potential approaches to value the impacts of air pollution that are not currently included in the appraisal methodology:

- Comprehensive analysis – this approach would quantitatively reflect every aspect of the consequences of a decision including impacts on efficiency and equity; or

- Restoration Cost – when air quality objectives are not met use the cost of abatement to value changes in air quality

64. It has always been IGCB(A)'s objective to pursue a comprehensive analysis and this will always remain as its key objective. However, as set out in chapter 2, there are many reasons for controlling ambient air quality that are not currently fully reflected including morality, intergenerational transfers, attitudes to risk and racial distribution and so on. Therefore it will take a long time for this goal to be achieved, if it is possible. To in the intervening period a pragmatic approach is required in the short to medium term where such considerations are important.

65. The IGCB(A) is therefore introducing the use of abatement costs of air pollutants where appropriate. The decision on when to use abatement costs is discussed in the next chapter.

Abatement cost

66. When air quality objectives are not met or where a decision is expected to exceed an air quality objective the IGCB(A) identifies the use of marginal abatement costs to identify the least costly path back to compliance as best practice approach to appraisal.

67. The cost of abatement may vary substantially depending upon the location, scale of the abatement necessary and the relevant sources. For example in one location a minor change in activity, such as managing traffic flows, might be able to deliver the necessary abatement while in another location it might require major new controls on industrial or domestic sources. Therefore, to provide an estimate of this cost, it is necessary to undertake a location specific assessment of the available abatement options identifying the potential level of abatement and the associated cost.

68. In addition to considering the local factors it is also necessary to consider a range of options to improve air quality. Broadly abatement options vary between new technology (such as additional filtration equipment) and behavioural changes (such as reduced activity). Abatement should also be considered across a range of causes of air pollution such as transport, industrial and domestic sources. This is further complicated as there may be a range of levers by which the desired change in technology or behaviour could be achieved such as regulation, direct provision, trading schemes and fiscal instruments.

69. The geographically specific nature of pollution and the differing availability of abatement opportunities throughout the nation will result in different abatement costs for different areas. However, these different prices are required to inform policy setting and to address the three limitations identified with marginal analysis.

70. Once a range of options have been considered it is then necessary to rank the options in terms of favourability. One key factor used to undertake such a ranking is the estimated marginal cost of abatement either by levels of emission (per tonne) or by change in ambient concentration (per $\mu g.m^{-3}$). Such an approach is commonly illustrated using a marginal abatement cost curve (MAC Curve).

71. It must however be stressed that appraisal of such options for implementation will also require a range of further considerations, such as feasibility, social acceptance, and potential. Therefore while MAC Curves are useful to inform identification of policies it does not necessarily mean that the recommendations will always be the optimal route to achieve the desired objectives. Any approaches identified to deliver the desired abatement must however be seen to be realistic and implementable otherwise alternate abatement should be identified and assessed.

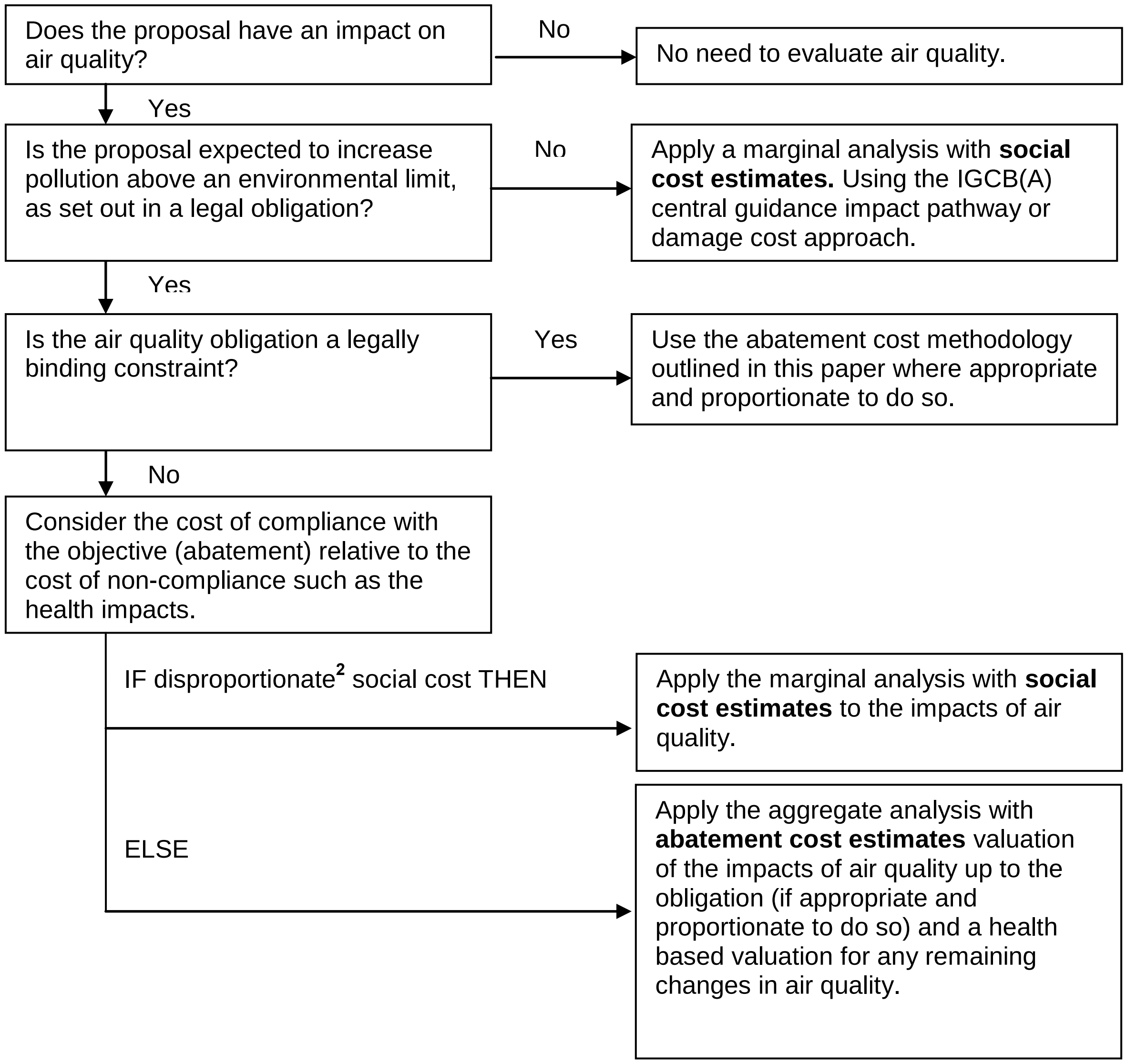
Chapter 4: Selecting an approach to evaluate air quality.

72. In most instances proposals that impact on air quality will not create a tension between the efficiency and equity considerations. For 10 of the 12 different pollutants controlled by air quality objectives there is no evidence that the UK will exceed the minimum air quality obligations and targets. Therefore in most circumstances the current IGCB(A) central guidance should be used. For the two pollutants where potential exists for such a tension it should also be noted that this tension would only be in limited geographic areas. However, on such occasions where proposals are expected to contravene the minimum standards it is necessary to have a well defined approach to evaluate them.

73. Identifying the appropriate approach to value air pollution will need to be undertaken on a case by case basis. In making such a decision it is necessary to balance the efficiency impacts against the equity considerations. Or put differently to balance the cost of compliance (the abatement costs) with the costs of non-compliance (the health costs and possibly infraction costs).

74. When the obligations are legally binding, such as EU limit values (discussed in Chapter 1) the abatement valuation should be used where it is proportionate to do so. This approach reflects the binding constraint that is imposed by such obligations. Figure 3 sets out the decision tree for selecting how to value changes in air quality.

Figure 3: Air Quality appraisal methodology decision tree



[1] In some extreme cases there may be options that span a limit value or are consistently above a limit value. Changes which span a limit value are discussed in Annex C and areas consistently above are discussed in Annex D.
[2] Target values by definition should be achieved in all instances except where achievement would be disproportionately costly.

75. When using the above decision tree it is important to consider the level of the ambient concentration as it may change the recommended approach to appraisal. In most cases it is expected that concentrations will start below the target concentration and therefore only a part of the increase will be above the target. In such an instance it is important to recognise when the abatement will reach the desired level as below this the appraisal should revert to the central approach. Such a situation is discussed in more detail in Annex C. In the more simple situation where the concentration begins above the target and increases further then abatement should only be valued for the expected increase, i.e. not back to the target value. Annex D provides further guidance for such situations.

76. The decision tree is provided as best practice guidance for policy makers; it does not however provide a prescriptive approach on how each of the stages is completed. This is intended to allow some flexibility in its application to be tailored to particular situations. It is the responsibility of the policy maker to weigh-up the scale of the intervention, as well as the relevant importance of the efficiency and equity drivers of policy and implement a proportionate approach.

77. Therefore, as noted above further work will be undertaken by IGCB(A) to produce a clear guidance document outlining how the methodology should be used in practice. Also as each Government Department has its own appraisal structure, the IGCB(A) will work together with Government Departments to help tailor this guidance so that it can be integrated, where it is feasible to do so, with current Departmental appraisal guidelines. This process will involve further work: (a) to test out its application and to seek views from expert practitioners on the practicalities of applying this methodology; and (b) to develop guidance and tools for the specific needs of practitioners so that the new methodology can be applied in a proportionate and transparent way.

78. In summary, SCBA remains the first best solution to valuing changes in air quality. However, when a policy decision leads to an increase in a pollutant to levels that exceed legal obligation requiring future abatement, a cost of abatement approach should be used where it is proportionate to do so.

Chapter 5: Conclusions

79. Air pollution has an adverse impact upon human health, as well as the natural and manmade environment. As these spill-overs are not automatically reflected in market prices it would not be expected that they would be reflected in market choices. This provides a robust rationale for the government intervention to manage air quality.

80. In managing air quality, the two key levels for appraisal are at the margin and reviewing the aggregate level to meet legal requirements on air quality. The former relates to specific policy considerations whereas the latter places the decisions into the wider context. IGCB(A) support the use of marginal analysis within a social costs benefit analysis and so have produced a range of tools to aid such appraisal. However, in certain circumstances these tools may not provide the full information for policy decisions. This is most commonly seen in situations where a decision is expected to create a need for consequential abatement to keep within prescribed air quality limits.

81. To inform how to address such situations this supplementary methodology establishes a principled, consistent approach to ensure decisions are made on a transparent and equitable basis. To aid and inform such decisions it provides the following key recommendations:

- Any policies that impact on air quality should be considered on their own merits reflecting potential cost, benefit and distributional effects. Figure 3 provides a decision tree to aid such considerations.
- Where the impact on air quality is positive then the IGCB(A) recommend the use of their central guidance to evaluate changes in air quality. It is only when proposals will worsen air quality, and when this will lead to a requirement for future abatement, that the methodology describes in this paper should be used.

82. To enable the implementation of these recommendations the IGCB(A) is undertaking further work in this area to:

- Publish further guidance with practical advice and tools around the application of the methodology described in this paper in a proportionate and transparent way;
- Work with government departments to integrate this guidance into their current appraisal structure. This will include testing out the application of this methodology and to seek views from expert practitioners on the practicalities of applying this methodology;
- Develop tools to support practitioners to apply the new methodology such as the Marginal Abatement Cost Curve which provides evidence on the marginal cost to abate NO_X per tonne and to reduce ambient concentrations of NO_2;
- Consider the scope to build a Marginal Abatement Cost Curve in relation to emissions and ambient concentrations of other pollutants such as PM_{10} and $PM_{2.5}$; and
- Investigate further challenges and potential advice in applying these recommendations. One particular challenge is co-ordinating the use of abatement technologies across a range of demands.

Annex A: List of IGCB(A) members

The member organisations of the Interdepartmental Group on Costs and Benefits are:

- Department for Environment, Food and Rural Affairs (Defra)
- Better Regulation Executive (BRE)
- Cabinet Office
- Department for Business, Innovation and Skills (BIS)
- Department for Communities and Local Government (DCLG)
- Department for the Energy and Climate Change (DECC)
- Department for Transport (DfT)
- Department of Environment for Northern Ireland (DOENI)
- Department of Health (DH)
- Environment Agency for England and Wales (EA)
- Foreign and Commonwealth Office (FCO)
- Health Protection Agency (HPA)
- HM Revenue & Customs (HMRC)
- HM Treasury
- Home Office
- National Assembly for Wales
- Scottish Environment Protection Agency (SEPA)
- Scottish Government

Annex B: Current challenge around PM

This annex provides an overview of the Time Extension Notification (TEN) which was submitted to the European Commission (EC) in January 2009. The TEN permits Member States to defer compliance with legally-binding limit-values.

The UK is legally obligated to comply with a number of regulations and directives as set by the EC (in addition to national obligations). This annex focuses specifically on the EU limit-value placed on Particulate Matter (PM_{10}) to be achieved by 1st January 2005. In that calendar year, the UK is required to achieve two limit-values;

- An annual mean ambient concentration below 40 $\mu g.m^{-3}$ in urban background locations.
- A 24-hour mean concentration not to exceed 50 $\mu g.m^{-3}$ on more than 35 occasions per calendar year.

The application for the TEN will permit the UK to defer the original PM_{10} compliance date from 1st January 2005 to 11th June 2011.

To be accepted for the time extension and avoid infraction proceedings, the TEN must outline the measures taken at a national, regional and local level that are to be implemented to achieve full compliance by the deferred deadline, but also to highlight which of the following are the key cause of the non-compliance with the limit value by the original deadline date;

- Site-Specific dispersion characteristics,
- Adverse climatic conditions,
- Transboundary contributions.

The UK achieved full compliance with the limit-values by the 2005 deadline throughout most zones and agglomerations. However, the UK did not achieve compliance in a number of densely populated zones and agglomerations, these are outlined below:

- Greater London Urban Area
- West Midlands Urban Area
- West Yorkshire Urban Area
- Glasgow Urban Area
- Brighton/Worthing/Littlehampton
- Swansea Urban Area
- Eastern (England)
- Yorkshire and Humberside

The key reasons for not achieving compliance in these locations are meteorology (and impacts on local dispersion) as well as transboundary impacts from outside the UK. These factors have resulted in hotspot pockets of high ambient PM concentrations in the zones and agglomerations outlined above.

Under best estimates of future emissions and concentrations, it is expected the UK will be fully compliant by 2011. Therefore if the time extension is granted, it is expected the UK will not need to implement beyond business-as-usual measures to achieve compliance with the deferred deadline.

Annex C: Valuation of air quality across limit values

In instances where changes in air quality will move from within the minimum standards to exceedences, and it is proportionate to do so, to inform a decision on such a proposal it is necessary to estimate the total potential cost of this change in air quality. This cost will be made up of both the abatement cost and the cost of an increase in air pollution. Figure C.1 illustrates how air quality impacts are to be valued where abatement would be necessary.

Figure C.1: Valuation of air quality with abatement

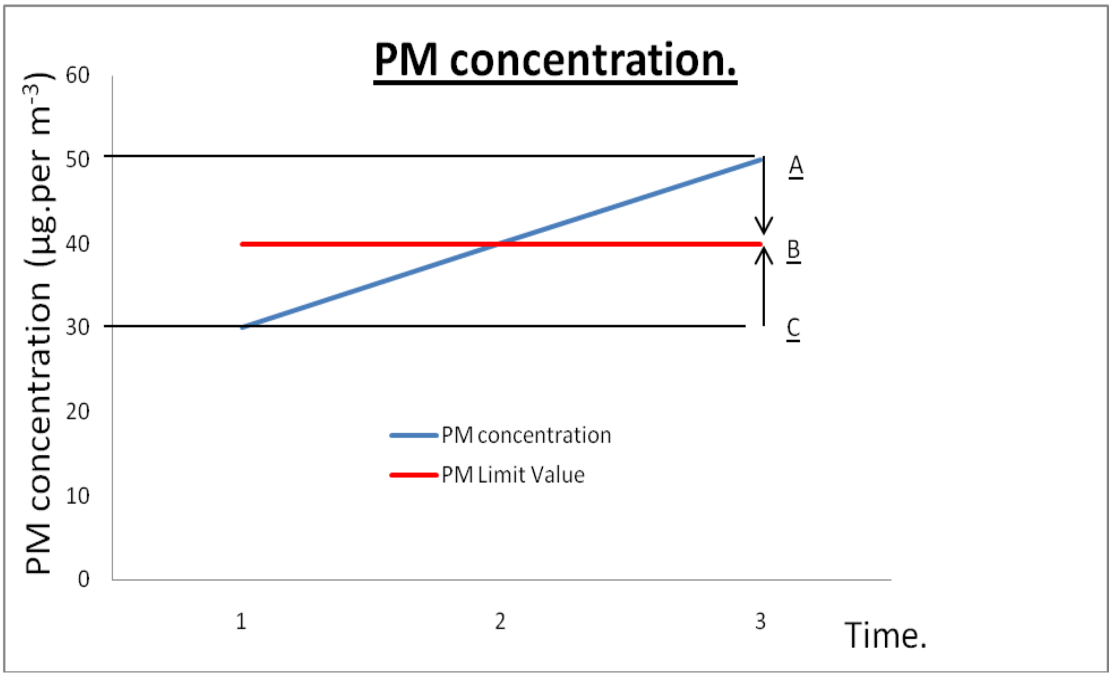


Figure C.1 shows the appraisal of a proposal that is expected to increase the PM concentration from 30 µg.m^{-3} to 50 µg.m^{-3}. The presence of a limit value of 40 µg.m^{-3} means that such a change would require abatement of 10 µg.m^{-3}. The abatement cost is applied to all the emissions above the limit value i.e. from the modelled level 50 µg.m^{-3} (marked A) to the limit value of 40 µg.m^{-3} (marked B). In addition there will also be an impact from the outcomes owing to reduced air quality, shown as the increase from the current concentration of 30 µg.m^{-3} (marked C) to the limit value of 40 µg.m^{-3} (marked B). The social cost of air quality should be used to value this change between 30 µg.m^{-3} to 40 µg.m^{-3} (points C to B).

Annex D: Valuation of air quality above limit values

This Annex provides an example of a policy option that results in an increase in ambient concentrations of PM_{10} when concentrations are already exceeding a limit-value. In this example, the level of abatement that the government is obliged to meet is increased, meaning that the government is required to implement additional – and less cost-effective – abatement options. This forces the government to move up the Marginal Abatement Cost Curve (MAC Curve).

In this example, government is considering a new project which will increase ambient concentrations of PM_{10} from 55 $µg.m^{-3}$ to 65 $µg.m^{-3}$. The completion of the project has a net benefit (excluding air quality impacts) of £2,000,000.

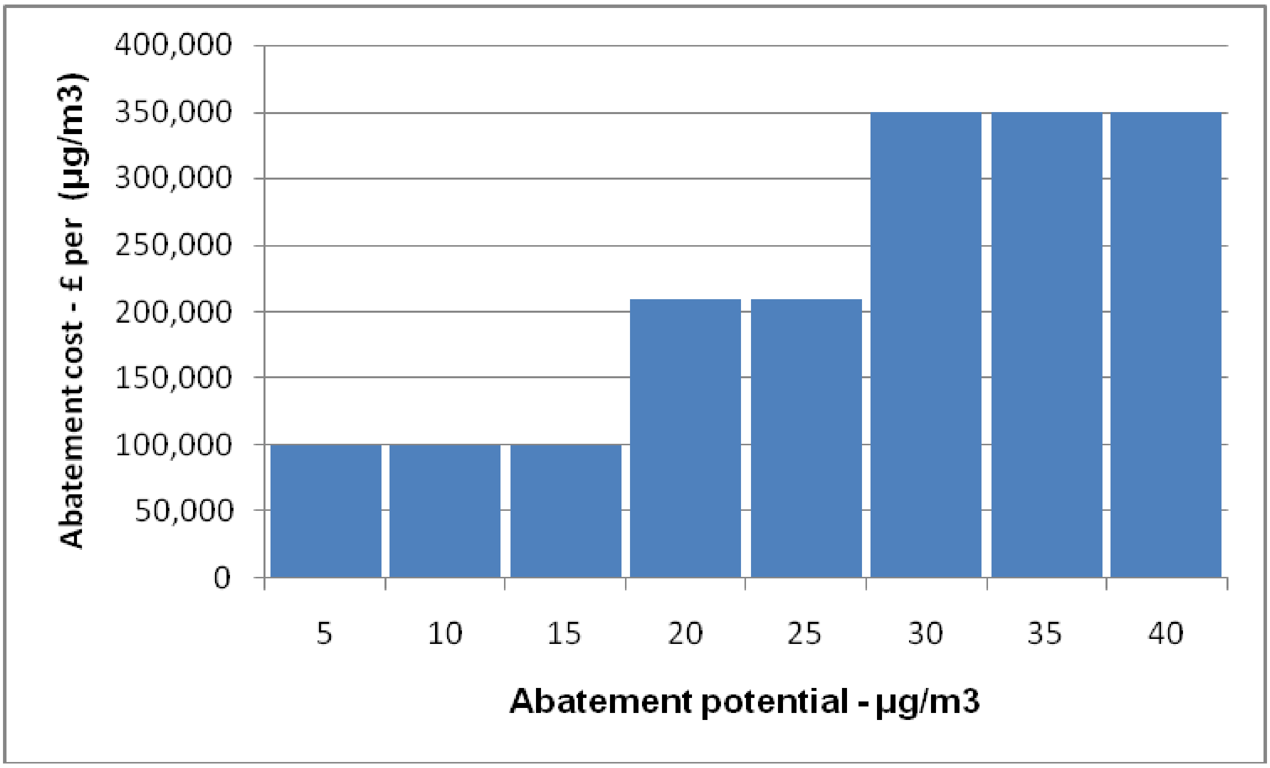
Before we value the air quality costs of this option, it is important to highlight exactly what the costs consist of when this policy increases concentrations by 10 $µg.m^{-3}$ from 55 $µg.m^{-3}$ to 65 $µg.m^{-3}$, but where the government is obligated to lower concentrations back to 40 $µg.m^{-3}$ to comply with the limit-value.

- First, because ambient concentrations are above the limit-value, and must be abated to the limit value there are no health costs associated with the completion of the project because emissions of PM_{10} must be offset elsewhere in the economy.

- There are technological abatement costs associated with the final completion of the project. Because concentrations increase by 10 $µg.m^{-3}$, the abatement cost is equal to the cost associated with most cost effective abatement option available. However, given that government is obligated to abate 15 $µg.m^{-3}$ of PM_{10} irrespective of whether this additional abatement option is adopted, the most cost-effective abatement options associated with the first 15 $µg.m^{-3}$ of abatement potential are already being implemented, or are planned to be implemented. Therefore, the cost-effectiveness of offsetting the increased ambient concentrations associated with this policy option equate to the cost of abating from 15 $µg.m^{-3}$ to 25 $µg.m^{-3}$ of abatement capacity in the MAC Curve (Figure D.1. below).

The fact that a less cost-effective abatement option is being implemented can be significant. If the policy option increased concentration levels from 40 $µg.m^{-3}$ to 50 $µg.m^{-3}$ then the marginal abatement cost would be £100,000 per 1 $µg.m^{-3}$ (from Figure D.1), which would equate to a total cost of £1,000,000 for the 10 $µg.m^{-3}$ abatement required. However, because the government is obligated to abate 10 $µg.m^{-3}$ using the abatement options for the 15 $µg.m^{-3}$ to the 25 $µg.m^{-3}$ in Figure D.1, then the marginal abatement cost is £210,000 per 1 $µg.m^{-3}$, which would equate to a total abatement cost of £2,100,000.

Figure D.1: A stylised MAC



Given that the abatement costs associated with the project are £2,100,000, and that the net benefit of the policy (excluding air quality impacts) equates to £2,000,000, this equates to a net cost of £100,000. This means that on efficiency grounds the policy option should not be adopted given that the government is forced to offset the concentrations using abatement options higher up the MAC Curve.

However, if the government did not face a limit-value it would be economically efficient for the government to complete the project. In this instance, there would be no abatement costs associated with the policy option, but there would be health costs associated with the increase in ambient concentrations from 55 $\mu g.m^{-3}$ to 65 $\mu g.m^{-3}$. In this example, health costs are assumed at a rate of £500,000 per 10 $\mu g.m^{-3}$. Therefore, it can be concluded that the total air quality cost (i.e. the health cost) are £500,000, which in turn means that the project has a net benefit if £1,500,000.

This example (as with the example in Chapter 2) highlights a situation where the limitations of the marginal analysis lead to a level of pollution which the aggregate analysis shows to be damaging to society.

Annex E: Glossary

Abatement Costs – The technological or behavioural costs associated with abating ambient concentrations of air pollution.

Anthropogenic – Relates to the study of human beings. In this context it refers to pollution which is attributable to human activity.

CAFE – Clean Air for Europe

COMEAP – Committee on the Medical Effects of Air Pollutants

Cost-Benefit Analysis (CBA) - method of economic analysis that assesses both costs and benefits of an intervention, service, or program, estimating both costs and benefits in monetary terms, and determining whether the benefits of an intervention exceed the costs.

Cost-Effectiveness Analysis (CEA) – method of economic analysis that compares alternative interventions in which costs are measured in monetary units and outcomes are measured in non-monetary units (i.e. abatement of ambient concentrations), In relation to air quality, cost-effectiveness analysis informs on policies which minimise the costs of achieving a given level of air pollution abatement.

Economic Appraisal – values the economic costs and benefit of a given level of abatement. This analysis does not account for taxes and transfer payments because they reflect a transfer of wealth from one group of people to another grouo of people with no associated net increase in societal wealth. Further economic analysis has the objective of placing a monetised valuation on goods that have no market price to inform optiomal policy settin.

Efficiency (Pareto) – A situation in which no feasible change can raise anybody's welfare without lowering that of somebody else (Compare with equity).

Equity – There are two concepts of equity; vertical equity concerns relative impacts on the poor or more vulnerable; and horizontal equity concerns relative impacts on anyone else, irrespective of their relative vulnerability. Government equity objectives cover both these concepts of equity between different groups. This therefore does not only include equity between different income groups but also includes all other forms of equity between different ethnic groups, religions, ages, genders, sexual orientation and across generations (Compare with efficiency).

IGCB – Interdepartmental Group on Costs and Benefits

IGCB(A) – Interdepartmental Group on Costs and Benefits - air quality subject group

IGCB(A) central guidance – The central IGCB(A) guidance refers to the impact pathway methodology to estimate and value the impacts of changes in air quality. This guidance also includes the tools based on this approach including damage costs, which link tonnes of emissions to monetary value, and activity costs, linking specific activities to monetised air quality impacts.

Limit Value – An air quality standard periodically agreed by member states setting a legally binding ceiling on ambient concentrations of air pollution.

Marginal impact - a policy that does not result in a permanent impact upon the natural asset of air quality (measured for this paper in terms of Limit Values).

Marginal Abatement Cost Curve (MAC Curve) – A method of informing on the most cost-effective method of achieving a given level of air pollution abatement. The method outlines the costs (financial and economic) of an additional unit of abatement and the abatement capacity of a portfolio of abatement options.

Micro Grammes per cubic meter ($\mu g.m^{-3}$) – the metric for which ambient concentrations are measured, and through which limit values are set.

Micrometers (µm) – The metric used to distinguish between the size of fine and coarse particulates.

Non-marginal (Aggregate) impact - a policy that does result in a permanent impact upon the natural asset of air quality (measured for this paper in terms of Limit Values).

Particulate Matter ($PM_{2.5}$) – Fine particulates, particulates with a gravimetric diameter of less than 2.5 micrometers (2.5 µm).

Particulate Matter (PM_{10}) – Coarse particulates, particulates with a gravimetric diameter of less than 10 micro maters (10 µm).

Social Costs – Represent the economic costs (as calculated using the IGCB methodology) for a given incremental change in emissions of ambient concentrations of air pollution. These reflect the adverse impacts that air pollution has upon human health, as well as the natural and manmade environment.