ANNEX C

Planning and Environmental Policy Group

Local Air Quality Management

Practice Guidance 1

Economic Principles for the Assessment of Local Measures to improve Air Quality

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Executive Summary

i. The objectives of this guidance are to provide advice on the general economic principles, and economic appraisal methods, which can be applied for the assessment of local air quality measures and schemes. It thereby provides a means to aid improvements in Local Air Quality Management practice and local action plan performance.

ii. Consistent with the Government's environmental goals, this guidance has been developed with a consideration of all the impacts of air pollutants including impacts on human health, climate change and the environment. Where practicable and sensible, synergistic policies beneficial to both air quality and climate change should be pursued.

iii. The guidance is advisory (not mandatory). It is consistent with government principles and appraisal approaches. However, if as guidance changes inconsistencies do arise, primacy should be given to national UK Government guidance (the Green Book). This guidance is intended for action plan assessments, but also more general policies and plans for improving air quality. It has two key elements:

- **economic instruments** look to effect the behavioural choices of agents by altering the estimated costs and benefits of different actions. There are a wide range of potential economic instruments including changes in taxes and subsidies, trading schemes, voluntary agreements and publicity campaigns; and
- **economic appraisal** is the key decision-making approach recommended by Government, and considers the overall value for money of a proposal, considering the wider costs and benefits to society.

iv. The guidance is also accompanied by a set of specific guidance notes for scheme types. Each of these schemes has been highlighted from the Air Quality Strategy 2007 as potentially having benefits in excess of their associated costs.

- Practice Guidance 2 on designating low emission zones.
- Practice Guidance 3 on encouraging the uptake of low emission vehicles.
- Practice Guidance 4 on encouraging the uptake of retrofitted abatement equipment on vehicles.

v. The guidance is set out to inform an iterative development process, in distinct stages as set out in Figure 1 below, with repeated rounds moving from a scoping assessment through to more detailed analysis. This is consistent with the development of policy proposals, and requires different levels of detail and knowledge at the scoping and detailed stages. The guidance first outlines a scoping stage which would, for example, be appropriate for use in early analysis of air quality proposals or plans, and which could be undertaken by a wide range of practitioners, even without specialist economic knowledge. This stage is used

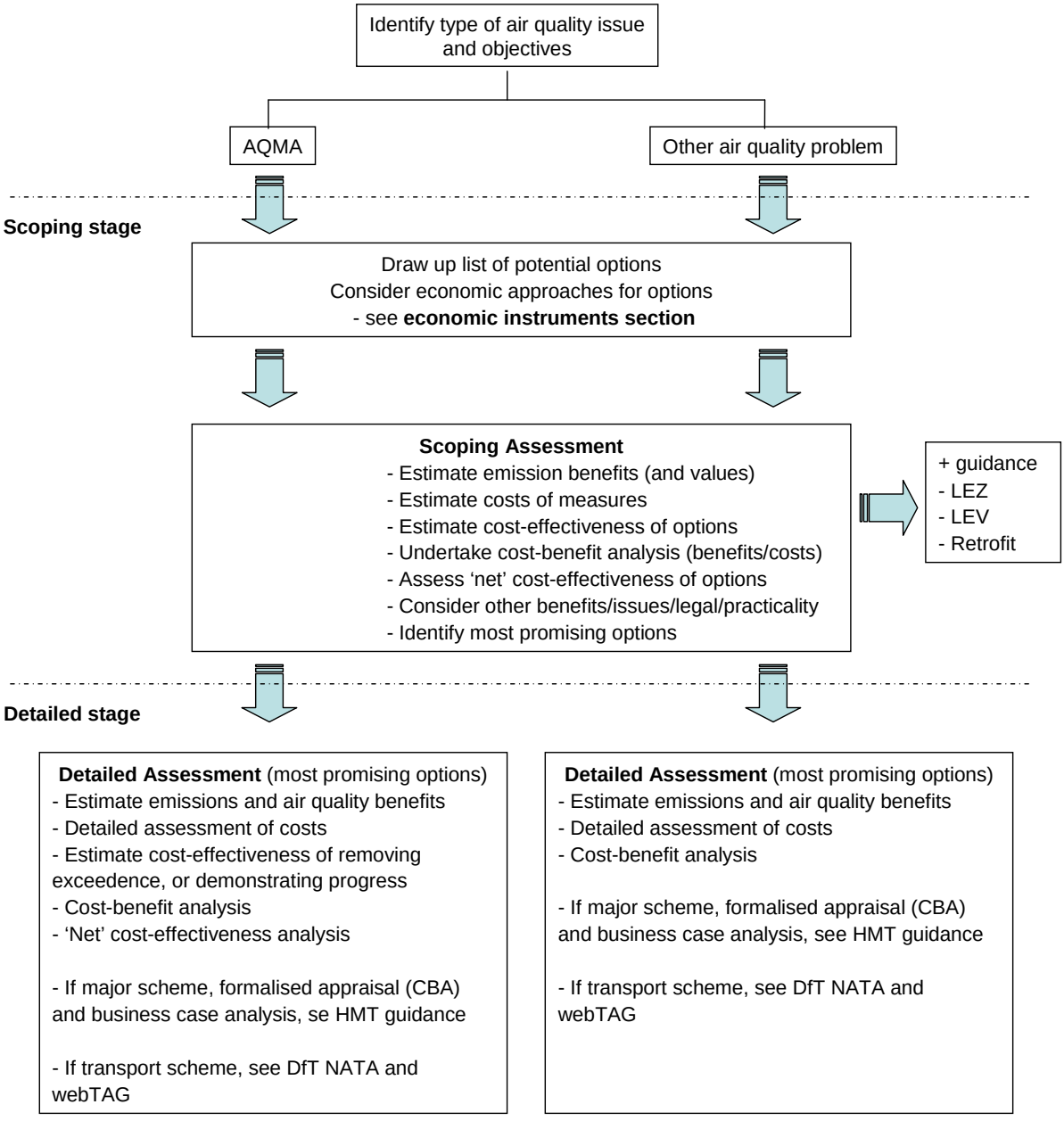
to filter down a range of options to a short-list for the second stage of more detailed analysis. Following this stage, more detailed guidance may be required for more substantial proposals (or transport projects), using existing Government guidance. This note therefore focuses on the scoping analysis only.

vi. The guidance provides advice on:

- identifying options and design of policy;
- estimating benefits, including how to estimate the monetary benefits of proposals;
- estimating costs, including which cost elements to consider; and
- comparing costs and benefits, including using cost-effectiveness and cost-benefit analysis, and how to express costs and benefits in equivalent terms.

vii. The overall process is shown in Figure 1 below. This has a slightly different route according to whether the analysis is considering an Air Quality Management Area or not. In general the approach is consistent however, there may be a slightly different emphasis or focus in cases where an Air Quality Management Area has been declared. The level of detail of the analysis, particularly in later stage, will be determined by the size of the scheme (a larger scheme will require a more in-depth appraisal). Note also that if a transport based scheme is identified initially, this should be assessed through formalised transport appraisal.

Figure 1: Policy proposal development process.



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1 Introduction

1.1. Background and Objectives of the Guidance

1.1. The objectives of this guidance are to establish general economic principles and economic appraisal methods which can be applied for the assessment of local air quality measures and schemes, and provide a means to improve Local Air Quality Management (LAQM) practice and local action plan performance.

1.2. This guidance may be used by local authorities in Northern Ireland in regard to carrying out their local air quality management duties under Part III of the Environment (Northern Ireland) Order 2002. It is intended to enable local authorities to improve on the service they already provide in tackling poor air quality by specifically providing relevant policy and technical guidance

1.3. The guidance is advisory not mandatory. Local authorities that have declared Air Quality Management Areas (AQMA) must have regard to the guidance when developing their Air Quality Action Plans. However, the guidance is also suitable and recommended for those other local authorities that are considering implementing measures to improve local air quality. It provides guidance on the selection of options, and on how to assess these options.

1.4. Consistent with the Government's environmental goals, this guidance has been developed with a consideration of all the impact of air pollutants including impacts on human health, climate change and the environment. Where practicable and sensible, synergistic policies beneficial to both air quality and climate change should be pursued.

1.5. The guidance focus on two economic aspects:

- **economic instruments** look to effect the behavioural choices of agents by altering the estimated costs and benefits of different actions. There are a wide range of potential economic instruments including changes in taxes and subsidies, trading schemes, voluntary agreements and publicity campaigns; and
- **economic appraisal** is the key decision-making approach recommended by Government, and considers the overall value for money of a proposal, considering the wider costs and benefits to society.

1.6. The information in this guidance is consistent with Government recommendations. It provides the means to demonstrate that air quality proposals are cost-effective, and to justify scheme implementation.

1.6. This general economic guidance is accompanied by a set of more specific guidance for scheme types for improving local air quality.

- Practice Guidance 2 on designating low emission zones (LEZ).

- Practice Guidance 3 on encouraging the uptake of low emission vehicles (LEV).
- Practice Guidance 4 on encouraging the uptake of retrofitted abatement equipment on vehicles.

1.8. It is stressed that these specific measures, however, are not the only measures that local authorities should examine when considering how to improve local air quality. There are also a wide range of alternate transport, residential and industrial measures.

1.9. The guidance is set out to allow iterative development of proposals, in two separate stages. This is consistent with the development of policy proposals, and requires different levels of detail and knowledge.

- It has initial scoping guidance, which would for example be appropriate for use in early scoping analysis of plans, and which could be undertaken by a wide range of practitioners, even without specialist economic knowledge. This can help to filter down a range of options to a short-list for more detailed analysis.
- It has advice and worked examples on considering specific scheme types for improving local air quality (incentivising LEV, designating LEZ, incentivising retrofitting of existing fleets) – though again it is stressed that these are not the only measures that local authorities should examine when considering how to improve local air quality.
- It has some specific notes on additional issues that will be needed in detailed guidance (planning and detailed phases) and highlights the existing Government guidance for detailed appraisal (some of which is mandatory). The application of these more detailed steps is likely to require more economic knowledge.

1.10. Local authorities should have regard to the guidance here in conjunction with other relevant guidance with regard to LAQM duties. These guidance documents are:

- Local Air Quality Management Technical Guidance 2009.
- Local Air Quality Management Policy Guidance 2009.

1.11. The guidance builds on, and links through, to existing national UK Government guidance (the Green Book) and specific transport appraisal guidance from the Department for Transport (DfT), notably the New Approach for Appraisal (NATA), and the transport analysis guidance at webTAG (www.webtag.org.uk/). It is therefore consistent with appraisal undertaken by local authorities in other areas of policy. In some cases, local authorities will need to have regard directly to these other guidance sources, for example for many scheme developments, or for transport proposals.

1.12. Further help on the guidance can be obtained from Defra (air.quality@defra.gsi.gov.uk), or by contacting the Local Authority Air Quality Action Plan Helpdesk (Telephone:0870 190 6050 Email: lasupport@aeat.co.uk). In many cases, such as for transport based schemes, there will also be wider local authority expertise (in other departments), that should be drawn upon.

1.13. This first guidance note provides the overall economic principles and approaches for economic appraisal. The contents of the guidance are set out as follows:

- an outline of how to use the guidance;
- guidance on economic principles, and the benefits of such approaches;
- information on scoping analysis, with estimation of benefits and costs, and appraisal (cost-effectiveness and cost-benefit analysis);
- information on where to find more detailed guidance.

1.2. Essential issues and key definitions

1.14. In reading this guidance, a number of essential issues and key definitions are highlighted. It is important for readers of this guidance to be aware of these before consulting this guidance.

Economics. Economics is the study of choice and decision-making in a world with limited resources.

Decision-making and appraisal. Good policy making considers a range of potential options prior to introduction of any proposal, and applies decision making techniques to select the best and most relevant options. This process is known as appraisal (also sometimes called ex ante analysis). Economics has a key part in this process. After policy implementation, there should also be a process of review and monitoring after introduction, known as evaluation (or ex post analysis).

Financial appraisal. A financial appraisal looks at the affordability of a proposal, and works within a typically budgetary framework, with financial costs and accounts.

Economic appraisal. An economic appraisal looks at the wider costs and benefits to society as a whole, of a proposal. This is not the same as a financial appraisal. This requires consideration of all costs and benefits, including those elements not valued directly by markets. An economic appraisal therefore provides a basis for assessing value for money.

Many practitioners confuse financial and economic appraisal. They are different because they consider different elements: a financial appraisal only considers budgetary elements, whereas economic appraisal considers wider societal elements. They also work with different frameworks, which include or exclude different elements. As an example, VAT is relevant to a financial proposal, but

not an economic one. Note that both economic and financial appraisal will need to be undertaken for a detailed scheme, in order to justify that the proposal is both financially affordable (for example in relation to local budgets) and that it presents value for money (for example in terms of societal benefits being greater than costs).

Cost-effectiveness analysis and Cost-benefit analysis are both methods for economic appraisal, though they have very important differences.

Cost-effectiveness analysis (CEA) compares the costs of different ways of achieving the same objective. It is relevant for air quality when looking to achieve (or to make progress towards) the reduction of air quality exceedences, i.e. legally binding concentrations that must not be exceeded. The benefit of cost-effectiveness analysis is that it allows the relative attractiveness of different options or combinations of measures to be assessed, in order to achieve the overall objective (the removal of the exceedence) in the most cost-effective way, i.e. economically efficiently. However, the traditional application of cost-effectiveness analysis only considers one environmental objective at a time, rather than all environmental objectives.

Cost-benefit analysis (CBA) assesses whether the total benefits and costs of a project or policy, thereby allowing their direct comparison to see if the benefit exceed the costs. It is therefore an absolute measure and can assess value for money. It quantifies costs and benefits in monetary terms, including values not captured by markets (i.e. the full costs and benefits to society). The technique allows consideration of multiple environmental goals. The UK Government, in its guidance for economic appraisal, favours the use of cost-benefit analysis. This is also the main part of the approach used in local transport appraisal – and has been the case for many years. Cost benefit analysis is relevant for all air quality proposals, but especially those which are not specifically addressing an existing exceedence.

Note that these two techniques can be complementary. The cost assessment is part of both techniques, but in cost-benefit analysis, the analysis is extended to compare directly to the benefits of the proposals. Related to this, the results of a cost-benefit analysis can be used to undertake a '**Net cost-effectiveness'** analysis, which has the advantage of considering all environmental objectives. A 'net' cost effectiveness analysis considers costs, but also takes into account the monetary benefits of environmental improvements when comparing the relative attractiveness of options, and so provides a more holistic approach for achieving the overall objective efficiently.

Exceedences. UK air quality objectives are policy targets often expressed as a maximum ambient concentration not to be exceeded, either without exception or with a permitted number of exceedences, within a specified timescale. EU Limit values are legally binding EU parameters that must not be exceeded. Limit values are set for individual pollutants and are made up of a concentration

value, an averaging time over which it is to be measured, the number of exceedences allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times.

2. How to use this guidance

2.1. This guidance is set out to allow an iterative development, in distinct stages, based on different user needs or stages of analysis. It is consistent with the business case guidance from UK Treasury for proposals, which outline a three stage approach:

Stage 1 – The Strategic Outline Case or scoping stage.
Stage 2 – The Outline Business Case or detailed planning phase.
Stage 3 – The Full Business Case or detailed final phase.

Note that the different levels will involve different levels of expertise and resources. The business case develops iteratively over time, with more detail being provided at each stage. **This document is primarily concerned with the first of these stages, i.e. the scoping stage.**

2.2. The **strategic outline case** or **scoping stage** is appropriate for use in early analysis of plans, and could be undertaken by a wide group of practitioners, even without specialist economic knowledge. As the guidance moves to the **business case** or **detailed phase**, a greater focus on in depth analysis including economic expertise will be required. This will require more detailed analysis using other formalised guidance (see below). For this reason, the detailed planning phase and detailed final phases above are not included in detail in this document. Note that for some very small air quality proposals, it may not be proportionate to undertake significant more detailed phases. However, for major schemes, especially transport related schemes, these latter detailed stages are likely to be mandatory (linked with DfT guidance).

2.3. In progressing proposals, there is a typical series of steps that are good practice in design and implementation of policy. These are:

- set objectives for the proposals (for example to reduce health effects of air pollution);
- identify options for achieving the objectives;
- appraise the range of options identified;
- prioritise most promising options and select the favoured option;
- develop and implement the favoured option; and
- put in place the necessary steps and monitoring for later evaluation.

2.4. The first key step in your approach should be to set out the objectives of your plans. This should be mindful of the Government's objectives as part of the Air Quality Strategy and wider Governmental objectives such as on climate change. The objectives are likely to be:

- to achieve or progress towards the limit values in cases where an exceedence is declared; or

- to improve air quality (and local public health) in cases where there are no exceedences.

2.5. Following the setting of objectives, it is necessary to identify the potential options to achieve the objective. This should include:

- consideration of a case without any policies or plans, i.e. the 'do minimum' scenario.
- a wide ranging list of all the potential options available.

2.6. A shortlist of options can be created, to keep the appraisal process manageable. This is usually undertaken at the scoping stage of a policy appraisal, but the short-list should always include a 'do minimum' scenario.

2.7. In drawing up the list of options, it is important to consider **economic instruments** as outlined in chapter 3 of this guidance. This would consider a range of approaches for any given objective. In cases where an action plan has been produced, you may already have a set of options, but the consideration should also include the actual instruments that might need to be introduced to implement your plan or project, for example for introducing cleaner vehicles, whether this would be through regulation, taxes, charges or voluntary schemes. Note that it is also important to consult widely, as this is often the best way of creating an appropriate set of options.

2.8. The next step is to appraise the options and progress the most favourable proposals. Initially this will involve a scoping analysis, considering many options. In more detailed stages it is likely to focus down and assess a few options in detail. This appraisal should draw on the guidance on **economic appraisal set out in chapters 5 to 7 of this guidance.**

2.9. The economic appraisal will need to consider the **benefits** of options. This will involve the estimation of emissions and air quality benefits consistent with the other technical air quality guidance. However, for economic appraisal, it is also necessary to extend this to analysis of the monetary benefits of options. This is set out in detail in chapter 5.

2.10. The economic appraisal will need to consider the **costs** of options. Guidance on assessing the costs of air quality proposals is not included in the other technical air quality guidance, and this document provides voluntary guidance and good practice on how to compare the costs of proposals. This is set out in detail in chapter 6.

2.11. Based on these building blocks, the appraisal process can then **compare different options** and provide important information to help prioritise them. This can be through a cost-effectiveness analysis, which compares how effective different options are in terms of the emissions or air quality benefit improvement that they achieve, relative to their costs (or a 'net' cost effectiveness analysis

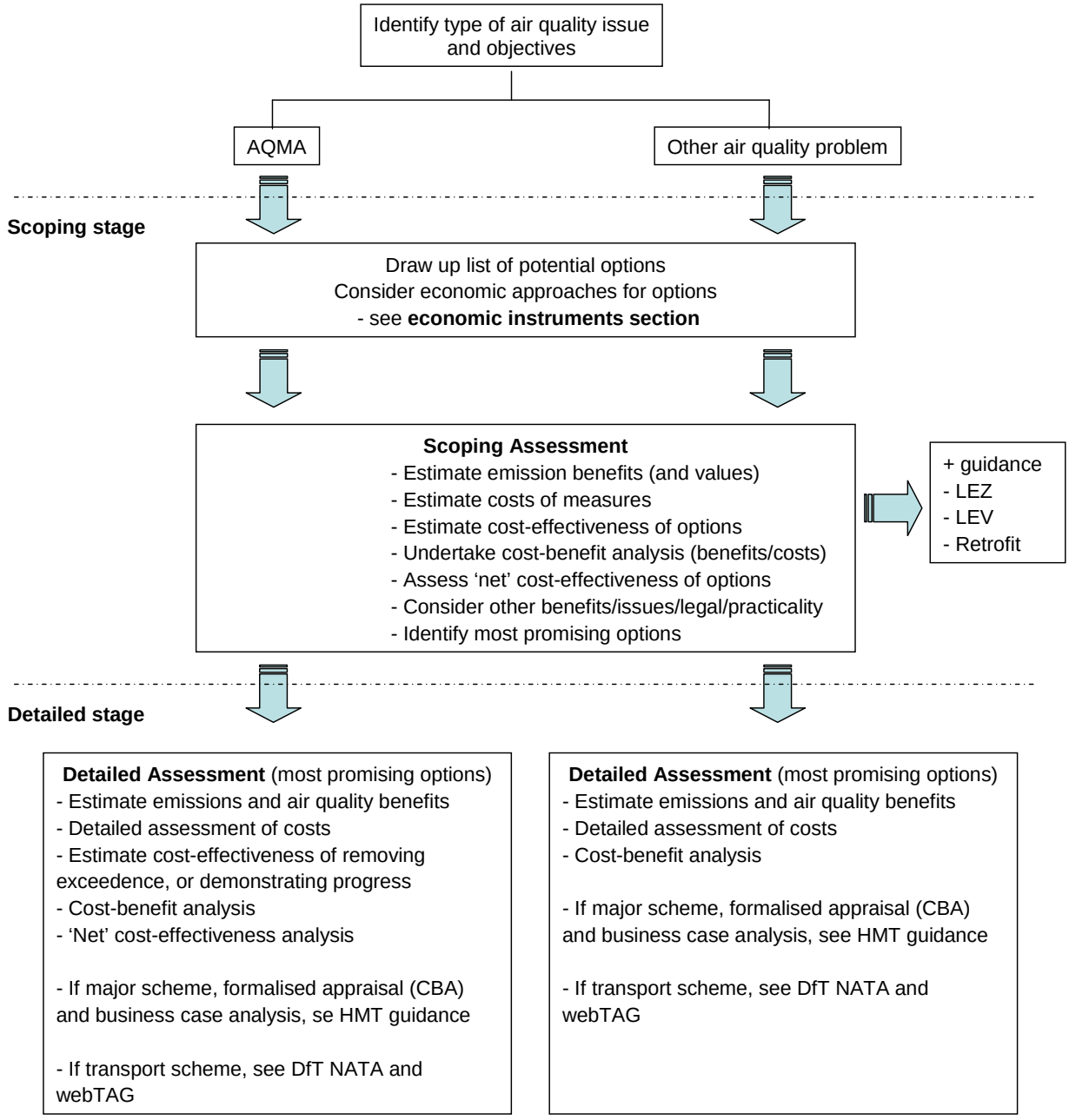
which also takes into account the monetary benefits of environmental improvements when comparing the relative attractiveness of options). It can also be through a cost-benefit analysis, which directly compares the economic benefits of options against their costs, and can therefore identify the most effective options and judge the economic case for action. The process of appraisal should also consider the extent to which the options have synergies or trade-offs with other economic and social objectives and the extent to which these are acceptable. It is also important to consider how the options would be introduced in practice, and potential legal or practical issues. At the end of this stage, you should have a short-list of potential options. Further guidance on this is set out in chapter 7.

2.12. This approach to benefits and costs can be built upon in the detailed phase, working to appraise this short-list in more detail. As with the previous phase, it is good practice to consider the role of economics in your options in terms of the actual policy implementation, and to include economic appraisal to assess and compare options.

2.13. A schematic of the different stages in the guidance is presented below in Figure 2. Note that in general the approach is common. However, there may be a slightly different emphasis on focus in cases where an AQMA has been declared, and the level of detail particularly in later stage will be determined by the size of the scheme (a larger scheme will require, proportionally, a more in-depth appraisal), and whether the short-list includes a transport based scheme, which should be assessed through a formalised transport appraisal.

2.14. In general Government recommends the use of cost-benefit analysis for appraisal. In the case of improving air quality to improve health, this would allow delivery of the largest health benefit for least cost (efficiency). However, in the case of a legally binding target, as for air quality, there is also a role for cost-effectiveness analysis. The existing legislation seeks to ensure health and environmental protection by setting limits for air quality concentrations. It is therefore also appropriate to undertake cost-effectiveness to analyse how to achieve these binding set targets, however, to take into account other environmental objectives (other air quality pollutants, greenhouse gas emissions), it is recommended that ‘net’ cost-effectiveness analysis is used. For the guidance here, there is a potential separation between cases for action where there is a potential infringement, i.e. an AQMA, and where there is not, in the type of approach we recommend, though we recommend a common approach that addresses cost-benefit analysis as good practice.

Figure 2: Policy proposal development process.



2.15. While the focus in this guidance is on economic instruments and appraisal, it is highlighted that there are other important aspects to consider in the research and analysis needed to support decisions. Guidance is presented in the HMT Business Case guidance, available at (http://www.hm-treasury.gov.uk/data_greenbook_index.htm which breaks down the case into five different aspects: the strategic, economic, financial, commercial and management aspects, to enable stakeholders to ascertain that proposals are:

- applicable, i.e. are supported by a robust Case for Change – the Strategic Case;
- appropriate, i.e. optimise Value for Money – the Economic Case;
- attractive, i.e. are commercially viable – the Commercial Case;
- affordable, i.e. are financially affordable – the Financial Case; and,
- achievable, i.e. can be delivered successfully – the Management Case.

These will be most relevant when moving to the detailed part of the analysis, especially for larger schemes that require significant investment.

2.16. Similarly, if the initial options analysis identifies transport schemes, particularly larger schemes or those that involve changes in transport demand, there will a need to adopt the DfT's webTAG, available at www.webtag.org.uk/. This transport analysis guidance should be seen as a requirement for all projects/studies that require government approval. For projects/studies that do not require government approval the transport analysis guidance should serve as a best practice guide. In many cases, guidance and practical experience of applying these transport appraisal techniques will be within Local Authority Transport Departments.

3. Economic Instruments and appraisal

3.1. Economic Instruments

3.1. Economic analysis forms a key part of the evidence for policy development. Economic evidence can be used to consider if and where actions may be required, identifying potential options to achieve a desired objective, choosing between the options and ultimately the evaluation of any policies. This is true across all policy development including air quality.

3.2. This section is concerned with the first of these aspects, i.e. identifying potential options. The role of economics in appraisal is outlined in the next section. A final section outlines the benefits of considering economics in both areas.

3.3. Economic analysis and evidence suggest that, in general, markets provide an efficient means of allocating an economy's resources. There are however particular problems for the market in allocating environmental resources that lead to a misallocation of resources or "market failure". The key environmental cause of market failure for environmental goods is externalities as discussed below.

3.4. Economic instruments look to use markets to correct such market failures by altering the incentives faced by economic agents. Evidence has shown that such instruments can influence the behaviour of consumers and manufacturers in more subtle, yet potentially more powerful ways, than conventional regulatory controls. For example establishing property rights in the form of tradable permits for air pollution emissions in the USA was seen to deliver higher emission reductions at a lower cost than conventional regulation.

3.5. This is important in looking at the design of policies for improving air quality, and in the selection of the initial list of options (as outlined in the previous chapter). It is often possible to use economic instruments on existing markets to achieve environmental objectives. It is also possible (where appropriate) to create new markets to tackle environmental problems such as by establishing tradable permits.

Externalities and Economic instruments

3.6. Markets are sometimes subject to imperfections or market failures. This is particularly the case for markets involving the environment. Correcting these market failures helps to make the market deliver more efficient outcomes.

3.7. In the case of the environment, and air quality, market failures exist principally because the costs of environmental damage are not reflected in the prices of goods and services. These are known as environmental externalities as the costs are external to the decision makers directly involved in the transaction. Correcting these externalities can improve overall economic efficiency by

delivering better environmental outcomes. It is worth noting that other market failures may also exist, for example information failures may prevent public group action against emitters that could in theory lead to an efficient outcome.

3.8. One way to address market failures is through economic instruments. Economic instruments are broadly defined by the OECD as “instruments that seek to address the market failures either by incorporating the external cost of production or consumption activities or by creating property rights and facilitating the establishment of a proxy market”. In this way they can provide incentives for behaviour that protects or improves the environment, and deter actions that are damaging to the environment.

3.9. For both consumers and business, economic instruments can enable environmental goals to be achieved in the most efficient way and may even set the optimal level of environmental protection. By internalising environmental costs into prices, they help to signal the changes needed to move to a more sustainable economy. They can encourage innovation and the development of new technology. The behavioural changes are then chosen by economic agents to reflect the full costs of their decisions.

3.10. It is also worth noting that environmental taxes can also provide a “double dividend” in that revenues can be used to reduce the level of other taxes.

3.11. A range of economic instruments can be considered. These might include taxes or other economic instruments such as tradable permit schemes, spending programmes, tax incentives, or voluntary agreements. Each of these instruments can be used independently or as part of a package with other measures.

3.12. The Government has implemented a range of economic instruments in the environmental area over the past decade. These include measures such as the climate change levy and the aggregates levy, changes to existing taxes such as the landfill tax, and fuel duty differentials to favour cleaner fuels and graduated vehicle excise duty (VED) to favour less polluting cars. Examples are presented in Figure 3 below.

3.13. Note, however, that in the case of air quality, there may also be instances where economic instruments are not an appropriate option. The HM Treasury Tax and the Environment document identifies such cases particularly where local quantities of emissions are important or where it is essential that emissions do not exceed specified limits in any individual area. Further, that in these cases, the problem will probably need to be addressed through regulation. Regulations may also be more appropriate where there is a large number of small polluters, as the costs of setting up a scheme based on an economic instrument may outweigh the benefits.

3.14. Local authorities have some potential to introduce economic instruments. However, the options for tackling sources of emissions with economic instruments may be more limited for local authorities. In these cases, it is important to consider economic principles in the design of policy, as outlined below.

Figure 3: Examples of Government policies to address market failures.

Market failure	Tax	Trading schemes	Tax credits/ public spending	Voluntary agreements	Publicity campaigns	Regulation
Negative externalities	• Aggregates levy • Climate change levy • Landfill tax • Fuel duty	• Emissions trading scheme • Landfill permits • Acid gas trading (proposed)	• Reduced rate of VAT on grant-funded installation of central heating and heating appliances	• Pesticides • EU CO_2 from cars agreement		• Integrated pollution prevention and control • Water quality legislation
Positive externalities or public good			• Tax relief for cleaning up contaminated land • Public space • Agri-environment schemes			• Habitats and species protection legislation
Information failures	• Differential rates of fuel duty				• 'Are you doing your bit?' • Car labelling scheme • EU eco-label scheme and energy labelling	• Environmental impact assessment directive

Note: Measures such as fuel duty can help to address information failures as well as external environmental effects.

Source: Tax and the Environment. HMT, 2002[1].

The type of regulation and the route of implementation

3.15. Historically many have commented that regulatory proposals have been too quick to move to 'classic' prescriptive regulations that stipulate objectives and how they should be achieved. While this type of 'classic command and control regulation' can work well – a good example being the Euro standards[2] – it can impose unnecessary burdens and costs, and reduce innovation. It should not be the automatic first choice and other approaches should be considered (as alternatives, or in combination), as they may be quicker, more flexible, cheaper and more effective. This is part of the Government's Better Regulation Agenda,

[1] www.hm-treasury.gov.uk./documents/taxation_work_and_welfare/tax_and_the_environment/tax_environ_index.cfm
[2] See the Defra Air Quality Evaluation, www.defra.gov.uk/environment/airquality/publications/stratevaluation/index.htm

which is about achieving policy objectives in the most in efficient and effective ways.

3.16. If those being regulated can devise their own ways of achieving an objective, they will find the most efficient way to do so. It is in their interest to meet targets while minimising bureaucracy and costs. Flexible, non-prescriptive regulation can also encourage businesses to innovate, as they are not restricted in how they can achieve regulatory targets. Using alternatives instead of classic regulation also has advantages that alternatives are generally quicker to implement, especially where the organisations and businesses likely to be affected are involved.

3.17. Guidance on these alternatives was provided by the Better Regulation Task Force, in its 'Routes to Better Regulation' document[3]. This outlines the factors that will affect the attractiveness of different options. These alternative approaches include:

- the use of market based instruments (otherwise known as economic instruments);
- providing information or guidance;
- co-regulation or self regulation (including) voluntary approaches;
- partner agreements;
- issuing recommendations; and
- new and flexible approaches.

The discussion of market based instruments was included above. The other approaches are briefly described in Box 1.

3.18. The guidance also identifies certain factors that influence whether or not the use of the above alternatives are likely to be successful.

[3] http://archive.cabinetoffice.gov.uk/brc/upload/assets/www.brc.gov.uk/routes.pdf

Box 1. Alternative Approaches for Better Regulation

Market based instruments (MBIs) seek to influence the behaviour of a market by using either positive or negative incentives. They can include trading schemes, competition policy or fiscal measures.

Providing information or guidance can be a relatively inexpensive and effective method of influencing people's behaviour. Information can be provided by the EU itself or it can demand that industry or other bodies provide information to their customers. Such information can include publicity campaigns, training, guidance or rating systems. This option can be used independently to influence behaviour although campaigns are often combined with other legislative and non-legislative options, so that stakeholders know what is expected of them.

Co-regulation involves a mechanism whereby the attainment of the objectives defined by the legislative authority is entrusted to parties which are recognised in the field (such as economic operators, the social partners, non-governmental organisations, or associations).

Self-regulation requires markets to regulate their own activities, without the requirements or agreements being underpinned by legislation. EU involvement is usually limited to encouraging or facilitating the process, perhaps with the threat of legislation should it not be successful.

Partner agreements give partners (stakeholders) an opportunity to try to reach agreement without the need for legislation. If legislation is necessary, the partners can negotiate its content and they are trusted to reach the most practical solution.

Recommendations are (official) instruments produced that do not have legal force but set out suggested courses of action. They can be used to encourage action in a particular sector and can be used as part of self-regulatory schemes.

Source: Better Regulation Unit, (now Better Regulation Executive)
http://archive.cabinetoffice.gov.uk/brc/upload/assets/www.brc.gov.uk/routes.pdf

General economic principles in policy design

3.19. An important economic principle is that options and policies are often best advanced by providing as much flexibility as possibly through technology neutrality, thus policies or measures are based on the desired outcomes, rather than an approach that would look to establish a specific technology. This is important as it allows greater flexibility for those who are affected by the policy, incentivising innovation, reducing the risk of distorting competition and reducing the opportunity for perverse incentives.

3.20. It is also good practice to consider the design of options such that they have most effect in driving behavioural change. One of the important aspects here is to consider a marginal approach to effect marginal decisions, i.e. targeting options that will affect additional marginal (additional) journeys. In economic pricing, this is usually approached by setting taxes or charges so that they reflect the external costs of additional (marginal) journeys. The logic behind this

is that higher average costs do not alter driving behaviour in the intended way; in fact the cost per journey can be reduced in this case by increasing the number of journeys made. Instead, the objectives are more likely to be met by incentivising the reduction in marginal trips (i.e. on a marginal cost basis). For example, a marginal cost-based instrument will give a direct incentive for owners to drive less. For example, discounted parking for LEVs at parking meters is a much better instrument than a discount given on annual parking permits. Similarly, in considering options that do not involve charges directly, focusing on the options that are most likely to affect marginal trips is likely to achieve greater levels of compliance and be more effective.

3.2. Economic Appraisal

3.21. The UK government publishes guidance on undertaking economic appraisal in the HM Treasury Green Book[4]. This is the main guidance on how to undertake economic assessment of spending and investment related guidance for the public sector.

3.22. At the centre of this guidance is the recommendation that all new policies, projects and regulation should be subject to comprehensive but proportionate assessment, so as best to promote the public interest. This assessment should answer the two following questions.

- Are there better ways to achieve this objective?
- Are there better uses for these resources?

3.23. By answering the questions, the guidance aims to promote efficient policy development and resource allocation, and emphasises the need to take account of the wider social costs and benefits (including environmental benefits) of proposals. It sets out three key aims.

- To Identify other possible approaches which may achieve similar results.
- Wherever feasible, to attribute monetary values to effects of the proposed policy or project.
- To assess the costs and benefits for relevant options.

3.24. The Green Book presents the techniques and issues that should be considered when carrying out assessments before implementation (known as **appraisal**), as well as the monitoring and assessment of the success of the scheme after implementation (known as **evaluation**). Economic tools can be used to appraise the costs and benefits of actions, and to identify the most efficient methods of government intervention. The Government aims to use these techniques as effectively as possible to ensure that intervention is effective and efficient, and proportionate to the problem being addressed.

[4] www.hm-treasury.gov.uk/economic_data_and_tools/greenbook/data_greenbook_index.cfm
Note there is also guidance on policy impact assessment (regulatory impact assessment)

3.24. The key steps recommended are:

- to set objectives;
- to develop a list of potential options.
- to appraise options;
- to develop and implement a solution;
- to put in place the necessary steps and monitoring for later evaluation.

3.25. For the first of these, to justify action, the Green Book raises two key questions.

- Is the rationale for intervention clear?
- Is it reasonable to assume that intervention will be cost-effective: i.e. that the benefits of intervention will exceed the costs?

3.27. As highlighted in the previous section on economic principles, the rationale for intervention is often linked to efficiency concerns in cases where there are market failures. The previous section outlined the strong general rationale for improving air quality, because of the existing environmental externalities. In the case of air quality where there is an existing exceedence, there is clearly a strong policy justification for action because of a legally binding commitment. However, there is also a strong justification for action when the aim is for improving air quality (without an exceedence) due to the non-market nature of air pollution.

3.28. The technique recommended to assess if the benefits of intervention will exceed the costs is cost-benefit analysis (more details are given in the later sections). In cost-benefit analysis, all relevant costs and benefits to government and society of all options are valued, and the net benefits or costs calculated[5]. Cost-benefit analysis differs from cost-effectiveness analysis, where a goal is set and the most cost-effective way to meet it is determined, or other approaches such as multi-criteria analysis (also below), where benefits are not (solely) expressed in monetary terms. In the case of air quality, especially where there are AQMAs, both are relevant, see chapter 2.

3.29. Note that the Green Book recommends that the economic assessment undertaken should be proportionate. This is important in formulating how much detail you will need to undertake for your scheme. A more extensive (and expensive) scheme will need a greater level of in depth analysis. This is reflected in the staged approach in this guidance. There is no formalised advice on the level of detail and scale and the level of appraisal necessary.

[5] though note it is usually difficult to value all the costs and benefits of a particular project.

3.3. What are the Benefits of Using this Guidance

3.30. It is important to recognise what the benefits to local authorities and the public will be from applying this guidance.

3.31. Economics lies at the heart of recommended Government appraisal and decision making. It has been applied routinely at national level, and local level, for many decades. It can help in providing a framework to help make decisions, and to ensure that implementation is achieved efficiently.

3.32. Even in cases where a local authority is working towards a pre-defined level of ambition, i.e. towards achievement of an objective, there are still economic principles that can be applied to ensure that target is achieved efficiently. The guidance here presents an approach to achieve the limit value (or progress towards the limit value) in the most efficient or least cost way. This could significantly reduce the costs of your proposals, increasing their acceptability, and also reducing the level of local authority funds needed (allowing more resource for other local authority activities). Using these approaches will also demonstrate that your proposal is following the principle of cost-effectiveness. Such a technique will help the presentation of the business case for your proposals, and also help the discussion within the local authority and to external stakeholders.

3.33. In cases where there is not an existing exceedence, but there is a policy to improve air quality, the guidance here can provide a sound demonstration that the benefits of the proposals outweigh the costs, and ensure that the policy aims are being progressed in an efficient and effective way. This is particularly important in ensuring that public funds are spent on activities that provide the greatest benefits to society, and that they are spent in the most efficient way. It also provides similar justification to above in relation to discussion within the local authority and to external stakeholders.

3.34. In particular this guidance illustrates that this approach can be useful in helping local authorities to assess the costs and impacts of measures they may be considering as part of their LAQM, local transport planning or land-use planning duties. For example, the economic guidance should be helpful in relation to:

- providing justification for Government funding;
- providing evidence for all decision makers, at different levels of local government, to external stakeholders;
- to help provide information for budget planning;
- to provide wider information for discussion with stakeholders;
- to enhance the success of successful Air Quality Grant bids;
- to help inform central government on the progress towards the air quality objectives that is possible from local action.

4. Scoping Phase

4.1. The first key step is to set out the objective(s) of the actions. The objectives are likely to be either: to achieve or progress towards the limit values; or improve air quality (and local public health). The next second step is then to identify a range of options to achieve the objective.

4.2. Guidance on how to identify options is included in general terms in the Green Book (Chapter 5). It is likely to include a range of approaches, including using existing reports, information from practitioners and experts, research, and drawing on other examples (including international examples).

4.3. It is highlighted that in choosing this list of options, you should have regard for the economic instruments and principles and the possible range of approaches that could be used as set out in Box 1 on page 12. The list of options should include a range of policy instruments, and should span different sorts of interventions, for example regulatory and non-regulatory approaches, including economic incentives (see chapter 3).

4.4. The scheme specific guidance released alongside this document provides information on possible options, low emission zones, incentivising low emission vehicles, incentivising retrofitting of existing fleets, that might be appropriate in drawing up your list of options. It is highlighted that the specific measures in the practice guidance documents are not the only measures that local authorities should examine when considering how to improve local air quality. The relevant policy guidance is clear that local authorities should be prepared to consider all possible measures if relevant. However, there is now an increasing amount of experience in implementing these particular measures in the UK and in other countries. Where possible this guidance document therefore presents relevant details of this experience in order to highlight good and bad practice in implementing schemes.

4.5. Once a list of potential options has been identified, the next step is to assess and prioritise these. To do this, a series of steps are required, set out in the following sections.

- The estimation of benefits is first outlined. This includes consideration of the potential economic benefits of emissions and air quality improvements.
- The estimation of cost is then explained.
- The methods for appraisal. Cost-effectiveness and cost-benefit analysis are then explained.
- These considerations must then be weighed against other relevant issues such as practicality, including legal, technical and social barriers.

5. Estimating benefits

5.1 Introduction

5.1. This section outlines the approaches for estimating the benefits of potential schemes, both as emissions and ambient concentrations. It then goes onto outline how these can be assessed in monetary terms using easily usable summary information from the Defra web-site on damage costs.

5.2. Consistent with the Government's environmental policies, the guidance has been developed with a consideration of air pollutants range of impacts on human health, climate change and the environment. The guidance here therefore also provides easily usable summary information from the Defra web-site on how to estimate greenhouse gas emissions in monetary terms as well.

5.3. For many other schemes, there may also be wider benefits, particularly for transport schemes. These also need to be considered, and there is guidance from the DfT on these wider effects.

5.2 Health, Environmental and Other Benefits

5.4. Air pollution has a number of important impacts on human health, as well as on the natural and man-made environment. These include impacts of short-term and long-term exposure to air pollution on health, damage to building materials, effects on crops and impacts on natural and semi-natural ecosystems (both terrestrial and aquatic). These impacts also have a number of important economic or social costs, known as external costs or externalities, as they are not included in the price of goods or services.

5.5. Air quality improvements will therefore lead to health and environmental benefits. It is highlighted, however, that the benefits vary with the type of pollutant and the location of emission.

5.6. The analysis of these impacts and external costs has focused on health and environmental impacts. In the UK, this has been taken forward through the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP)[6], which advises on health of outdoor and indoor air pollutants on the basis of data currently available, and has published reports on the quantification of health effects of air pollution in the UK, and the Interdepartmental Group on Costs and Benefits (IGCB)[7], which develops understanding of the costs and benefits of reducing air pollution, and appraisal methods used for policies that reduce air pollution and provides economic analysis and advice on the Air Quality Strategy.

[6] www.advisorybodies.doh.gov.uk/comeap/
[7] www.defra.gov.uk/environment/airquality/panels/igcb/index.htm

5.7. In considering the estimation of benefits, a number of key points are highlighted below.

- Different types and levels of health impacts are attributed to different pollutants. Currently the greatest health concerns are associated with particulate matter (PM), followed by sulphur dioxide (SO_2), ozone and nitrogen dioxide (NO_2).
- A number of important issues are highlighted for particulate matter:
  - Health effects are associated with primary particulates (for example from vehicle exhaust) and also from secondary particulates. These secondary particulates are formed from (amongst other things) sulphur oxides (SO_x) and nitrogen oxides (NO_x) emissions. Therefore reducing NO_x (as an example) has both direct (NO_2) and indirect (secondary particulate) benefits. Note, however, that NO_2 effects are local, whilst secondary particulates are more regional.
  - The health effects of primary particulates will vary with the location of the emission, because of the different population exposure. An emission reduction in a major urban area will therefore have a greater relative health benefit (for example per tonne of pollution reduced) than in a rural area. Note for this reason, the later benefits analysis recommends the use of different damage costs for primary PM according to location.
  - Europe is moving strongly towards a focus on $PM_{2.5}$, reflecting much of the health based evidence and also the advice received from the scientific community such as the World Health Organisation[8].
- A number of important issues are highlighted for NO_2 and SO_2, in relation to the current limit values.
  - COMEAP did not quantify direct impacts of NO_2 (as a gas) at ambient UK levels in its quantification analysis. The Air Quality Strategy identifies that at relatively high concentrations, NO_2 causes inflammation of the airways. There is evidence to show that long-term exposure to NO_2 may affect lung functions and that exposure to NO_2 enhances the response to allergens in sensitised individuals. However, COMEAP did not provide functions for quantification of NO_2 in view of the difficulties and doubts about the relationships between exposure to NO_2 and effects on health (i.e. that apparent NO_2 effects on health at ambient levels may be due to particles; or at least, are highly dependent on background particle levels). However, a possible relationship for the effects of the pollutant on respiratory hospital admissions was included for sensitivity analysis. The recent Air Quality Strategy Review (and also the European legislation) reviewed the evidence on NO_2, and decided not to remove the NO_2 objectives, not least because the achievement of the NO_2 objectives should ensure that risk to vulnerable individuals is reduced.
  - Note that as above, NO_x does affect health indirectly through the formation of secondary particulates, which are quantified in COMEAP,

[8] See the Clean Air for Europe (CAFE) documents at http://ec.europa.eu/environment/archives/cafe/general/keydocs.htm

assuming similar impacts as primary particulates. Nitrogen oxides also have complex relationships on ozone formation, which also affects health.

- o Sulphur dioxide has some direct effects as a gas, and COMEAP quantified direct impacts of SO_2 (as a gas). Sulphur dioxide also affects health indirectly through the formation of secondary particulates (see above) which are quantified in COMEAP, assuming similar impacts as primary particulates.

5.8. As well as air quality benefits, it is important that you take account of other environmental issues in your appraisal, and also wider effects. Two key issues are.

- The need to consider greenhouse gas emissions. Many local air quality schemes can also affect greenhouse gas emissions, including carbon dioxide (CO_2). These need to be assessed in your appraisal. There is guidance on how to estimate these emissions changes, and now also guidance on how to value these changes provided by Defra.
- For schemes affecting transport movements, there is a need to consider the wider issues of transport in relation to congestion, accidents and noise. Whilst this guidance has an air quality focus, these other effects must be taken into account in any scheme which is likely to have an effect on transport demand or activity. There is already comprehensive guidance available on these benefits (see later).

5.9. As an example, for the additional practice guidance documents which look at specific schemes, there are other important benefits to consider, shown in the table below. It is highlighted that these measures are not the only measures that local authorities should examine when considering how to improve local air quality.

Table 1: Benefits of Low Emission Zones, Low Emission Vehicles and retrofitting

Scheme	AQ	CO_2	Noise	Congestion	Accidents
Low emission vehicles (LEV)	✓	Variable *			
Low emission zones (LEZ)	✓	Variable *	✓**		
Retrofitting	✓	Variable *			

* The effects on CO_2 depend on the types of vehicles or retrofit technology. Some newer vehicles have lower CO_2 emissions, however, it varies with Euro standard and vehicle type. Some retrofit technologies, whether applied as a policy, or as a response by operators to say a LEZ, can increase CO_2 emissions.

** A LEZ can have noise benefits if it replaces older vehicles. Changes in vehicle noise legislation have not in general been concurrent with those for exhaust emissions, and the noise certification test does not represent urban driving conditions. Nonetheless, Euro II/III vehicles are likely to be quieter than older vehicles. However, traffic noise has two main sources: tyre/road noise, which is determined by vehicle speed and size (but not necessarily age), and engine noise which considers the age and size of the vehicles. An LEZ will only affect the latter, unless changes in vehicles numbers also occur.

5.3 Estimating Emissions and Air Quality Improvements

5.10. The underlying principle for emissions or air quality impact assessment is to firstly define the baseline or business as usual emissions or air quality. This is the case that currently applies and would apply in future years if no additional action is taken, i.e. the business as usual case should include consideration of:

- the impacts of national policies such as Euro standards for vehicle emissions;
- the impacts of local transport policy on traffic growth; and
- all actions to which the local authority is already committed including transport policies and new developments.

5.11. Once the baseline case has been defined the effects on baseline emissions and or air quality from new policies can be assessed. Emissions and air quality assessments are technical tasks. Therefore local authorities are referred to the guidance document Local Air Quality Management Technical Guidance 2009 for additional information.

Emissions

5.12. In simple terms emissions are calculated as the product of activity of relevant emission sources and appropriate emission factors for that activity. For example, heavy goods vehicle (HGV) NO_x emissions can be estimated as the product of the total distance travelled by the vehicles of interest and the most appropriate emission factor (NO_x g/km) for the vehicle weight, speed and age.

5.13. Therefore, emissions reductions may be assessed for a reduction either in source activity (distance travelled) or in the emission factor (for example by replacing a Euro II heavy duty vehicle (HDV) with a Euro III or better vehicle).

5.14. From this description it follows that a key tool to assess the baseline case and impacts of new policies is a sufficiently detailed emission inventory. Such an inventory allows the impacts of a range of potential policies to be assessed.

5.15. A detailed emission inventory allows baseline and with-policy emissions to be calculated that account for the following.

- Road transport activity potentially disaggregated by zone and vehicle type. This allows the effects of policies that reduce activity, move its location or switch from one transport mode to another to be assessed.
- The contribution from stationary traffic. This allows policies that reduce congestion to be assessed.
- Fleet numbers and ages for key vehicle types. This allows the effects of policies to promote the uptake of newer vehicles to be assessed.
- The effects of policies being implemented in future years. This allows the trend in reducing road transport emission factors to be accounted for.

5.16. By assessing the impacts of measures on the baseline emissions the local authority can then more accurately assess the potential cost-effectiveness and air quality health benefits associated with the measures.

5.17. Potential sources of data from which to develop emission inventories are summarised below.

Source activity: Road transport models can provide average speed and annual average daily flow data disaggregated by road link and usually split between light and heavy-duty vehicles. More detailed surveys have been used to disaggregate HDV types between buses and HGVs. Furthermore, some traffic models also provide link specific data on the daily average time that traffic is stationary at junctions and the average length of these queues. These data are necessary to estimate the potential contribution from congestion.

Vehicle emission factors: The Air Quality Archive local authority emissions toolkit (www.airquality.co.uk/archive/laqm/tools.php?tool=emission) has tools that allow calculation of road traffic exhaust emissions for different vehicle categories and splits, at various speeds, and on different road types. This tool also calculates emission factors in future years.

Local authorities may also consider using the tool Defra has developed to be used by local authorities in calculating emissions of NO_x and PM_{10} under the new performance indicator framework (i.e. NI 194: Air quality – % reduction in NO_x and primary PM_{10} emissions through local authority's estate and operations). This is available at www.defra.gov.uk/environment/airquality/local/indicator.htm. This tool can be used to indicate the potential difference in emissions due to replacement by one vehicle type with another or due to a reduction in annual mileage.

Specific fleet inventories: In the case of specific and relatively small fleets (such as the local authorities own fleet or commercially operating bus fleets) it is recommended that a specific fleet inventory is developed. A key reason for this is that the distribution of vehicle ages within these fleets can typically vary quite significantly from the national average age distribution. For example, the local bus fleet may be significantly older or younger than the national average. For better accuracy it is therefore recommended to list the age and abatement equipment of each vehicle. In these cases local authorities should attempt to work in partnership with commercial and other fleet operators to obtain the relevant data.

5.18. Other key factors in the inventory: To be useful as a policy assessment tool, local authorities are advised to consider including the following additional capabilities in their local inventories.

- Inventory breakdown by geographical area. In cases where controlled zones are being considered as a local measure the local authority may need to

calculate the effect on emissions both inside and outside of the zone or zones. This will require road link and vehicle activity data to be disaggregated.

- Compliance rates. Depending on the range of regulatory approaches being considered to enforce a local measure (strong or weak) then a greater or lesser rate of compliance may be expected. If this is a significant factor then local authorities should include the capability within their inventory for assessing the emissions impact of compliance rates less than 100%.
- Compliance year (or year that the measure under consideration would come into force): Natural vehicle replacement rates mean that on average the national fleet unit emission factors decrease over time. If the compliance year is in the future then local authorities are advised to include these effects in their inventory. Otherwise the inventory is likely to overestimate the potential emissions impact of a local measure.

Air Quality Assessment

5.19. Air quality assessments use monitoring, dispersion model and Geographical Information Systems (GIS) data to assess a) where the air quality objectives are exceeded and b) whether there is relevant exposure at these locations. The methods to be used in these assessments are provided in detail in Local Air Quality Management Technical Guidance 2009 and local authorities are recommended to have regard to this guidance.

5.20. For assessing the effects of local measures it is most appropriate to consider the exercise as a formal Further Assessment, i.e. this is the most detailed of review and assessment technical activities and is designed to estimate the contribution of different sources to the local air quality (source apportionment).

5.21. An appropriate further assessment allows air quality arising from baseline and with-policy cases to be calculated that account for the following.

- Road transport activity potentially disaggregated by zone and vehicle type. This allows the effects of policies that reduce activity, move its location or switch from one transport mode to another to be assessed.
- The contribution from stationary traffic. This allows policies that reduce congestion to be assessed.
- Fleet numbers and ages for key vehicle types. This allows the effects of policies to promote the uptake of newer vehicles to be assessed.
- The effects of policies being implemented in future years. This allows the trend in reducing road transport emission factors to be accounted for.

5.22. By assessing the impacts of measures on the baseline air quality the local authority can then more accurately assess the potential effect on compliance with the air quality objectives associated with the measures.

5.4 Estimating the Economic Benefits of Air Quality Improvements

5.23. As highlighted above, air quality improvements have health and environmental benefits. Some of these improvements can then be valued using economic evidence to produce monetary estimates (such as through health or environmental improvements).

5.24. As an example, improved air quality leads to health benefits, reducing the numbers of cases of respiratory hospital admissions from high pollution episodes, and this has benefits through reducing health care costs, lost time at work, and the pain and suffering of individuals. These benefits can then be valued using economic evidence on resource savings, health valuations, productivity losses etc.

5.25. Detailed methods have been developed to quantify and value the health and environmental benefits of air pollution improvements. As outlined earlier, in the UK, this has been advanced by the Department of Health's COMEAP group and IGCB. The methods were used in the economic analysis to inform the review of the Air Quality Strategy[9]. Similar methods have also been adopted in the European Commission proposals on air quality, as part of the Clean Air For Europe (CAFE) project and the Thematic Strategy on Air Quality.

5.26. The approach taken by the IGCB for the Air Quality Strategy was very detailed, and used modelling with the 'impact pathway approach', following an estimation of emissions, dispersion and pollution modelling, calculation of receptor exposure, quantification of impacts and valuation.

5.27. However, the group also provided summary values that can be used in appraisal. These are known as '**damage costs'** and provide the benefits of marginal air quality improvements, in **benefits (£) per tonne of pollutant reduced**. These damage costs are presented on the Defra web-site (www.defra.gov.uk) and are recommended for use in cost-benefit analysis (see later section). Examples are included in Box 2.

Box 2. Examples of the Damage Costs

Examples of the damage costs are presented below, for a 2005 emission in 2005 prices, for the central high estimate.

- SO_2 has a central high damage cost value of £1,735 per tonne.
- NO_x has a central high damage cost value of £1,061 per tonne.
- PM_{10} (transport average) has a central high damage cost value of £53,391 per tonne.

[9] www.defra.gov.uk/environment/airquality/publications/stratreview-analysis/index.htm

It can be seen that there is a different scale of effect between PM and other pollutants. Note also that the PM values vary with the location – such that values in rural areas are much lower - because of the lower population density.

5.28. These damage costs are based on values for a range of health impacts, including mortality and morbidity effects, and non-health impacts, such as damage to buildings and effects on crop yields, and also take account of both primary and secondary air pollution changes. It should be noted that there are important caveats with application [10].

5.29. Inter-Departmental Group on Costs and Benefits damage costs are given for primary PM_{10}, SO_2 and NO_x. Note that multiple values are given for PM, reflecting the sector and location of emission. This reflects the fact that the benefits of primary PM improvements are strongly related to local population weighted exposure[11], [12].

5.30. It is highlighted that not all potential benefits of air quality have been quantified / valued in these damage costs, because quantification is not possible or highly uncertain. Amongst the most important of the effects excluded are impacts on ecosystems. The values also only include the benefits that occur in the UK (i.e. they do not include benefits from reductions in trans-boundary pollution).

5.31. It is important to highlight that the economic benefits of air quality improvements change over time. It is important not use the same value for each year! These effects can be taken account of by directly using the damage cost calculator on the Defra web site.

5.32. An example on the use of the calculator is included in Box 3. The results are presented as a central value, and also a central range (a low and high). The central range reflects the uncertainty in a small number of key parameters, and is not a measure of statistical uncertainty.

[10] The damage cost approach is intended for use across government, such as for project appraisals (project cost-benefit analysis) and Regulatory Impact Assessments (policy cost-benefit analysis). It is not, however, considered a replacement for detailed modelling and analysis. The use of damage costs is therefore only recommended for policies with a pollution reduction over a period of less than 20 years and: as part of a filtering mechanism to narrow down a wide range of policy options into a smaller number that are then taken forward for more comprehensive assessment; or where air quality impacts are expected to be ancillary to the primary objectives or are relatively small.

[11] For some secondary pollutants (secondary particulates from NO_x and SO_2), one uniform value has been derived for the UK in the IGCB damage costs. This reflects the fact that local issues are less important for these pollutants. These secondary pollutants form in the atmosphere over time, and so the immediate local environment is less important in determining damage costs.

[12] At present the IGCB damage costs do not capture the effects of ozone formation. The use of a single value for ozone (i.e. for precursor emissions of NO_x and volatile organic compounds (VOC)) is more uncertain than other pollutants, especially in relation to NO_x, i.e. strongly non-linear due to the titration effects in urban sites. However, ozone damages (when expressed in £) are small compared to secondary PM effects, and so have little effect on the results for NO_x.

Box 3. Valuation of Air Quality Benefits

The damage cost calculator allows estimation of the monetary benefits of air quality improvements. The analysis needs inputs of emissions over time. For the example here, we have a scheme for five years, **starting in 2007** (and for a 2007 base year) which leads to improvements in PM_{10} and NO_x over time as follows.

Year	2007	2008	2009	2010	2011	2012
PM_{10} reduction (tonnes)	1	0.8	0.6	0.4	0.2	0
NO_x reduction (tonnes)	5	4	3	2	1	0

The time period, start date, and emission values are entered into the spreadsheet, for example for NO_x.

1. What length (in years) is your policy appraisal?	5
2. When is the first year of your appraisal?	2007
3. What pollutant are you assessing? (click box to select from drop-down menu)	*1*
4. Input the annual changes in emissions below (in tonnes)	

Year	*2007*	*2008*	*2009*	*2010*	*2011*		
Change in emissions (tonnes)	5	4	3	2	1		

CALCULATED RESULTS		
Central Estimate Present Value	£ 0.01	Million
	£ *13,513*	

Note that the damage cost calculator automatically estimates the value of the damage costs in future years and then discounts the values of the benefits, as **present** values, so there is no need to do this calculation separately.

One important aspect is that when there are PM_{10} improvements, different values are provided according to the sector (for example transport, waste, etc), and for road transport, different values for the specific area.

- Central London (Existing Congestion Charge Scheme (CCS) area)
- Inner London (within North South Circular)
- Outer London (within GLA boundary)
- Inner Conurbation
- Outer Conurbation
- Urban Big
- Urban Large
- Urban Medium
- Urban Small
- Rural

5.33. The damage costs are based on a number of assumptions. These should be noted, along with a number of caveats, in any application of the values. These are as follows.

- External costs of air pollution vary according to a variety of environmental factors, including overall levels of pollution, geographic location of emission sources, height of emission source, local and regional population density, meteorology and so on. The damage cost numbers take these issues into account to a certain degree only.
- The values are based on national level analysis (and national averages). They are therefore potentially more relevant for national policies than specific local analysis.

5.34. It is also stressed that the values exclude a number of important effects.

- The values do not currently take into account ozone formation and effects, from either NO_x and do not have VOC damage costs (another ozone precursor).
- The numbers only include costs that occur in the UK - all transboundary pollution and impacts are excluded.
- The numbers exclude effects on ecosystems (acidification, eutrophication, etc) and effects on cultural or historic buildings from air pollution.
- A number of potential additional morbidity or mortality aspects are not included. For discussion, see the damage cost guidance documents.

5.5 How to estimate carbon dioxide emissions

5.35. Local authorities should have regard to the section above on assessing the effects of measures on NO_x and PM_{10} emissions. They are advised to consider using the tool Defra has developed to be used by local authorities in calculating emissions of CO_2 under the new performance indicator framework (i.e. NI 185) for this purpose. This can be accessed at www.defra.gov.uk/environment/airquality/local/indicator.htm

5.6 How to Estimate the Economic Benefits of carbon dioxide emissions

5.36. As well as Government values on the benefits of air quality improvements, there are also value for benefits from reducing greenhouse gas emissions. These value the wider social benefits of reductions, rather than the costs of measures and policies needed to reduce greenhouse gas emissions[13].

5.37. The values, and guidance on use, can be found on the Defra web-site, under the section on the Shadow Price of Carbon (SPC) www.defra.gov.uk/environment/climatechange/research/carboncost/step1.htm.

[13] Strictly speaking, the value is the marginal global damage cost of climate change from emissions.

5.38. As with the damage costs for air quality above, the SPC is expressed as the economic benefit for a reduction of 1 tonne of CO_2 emission (or carbon dioxide equivalent (CO_2e)). An example is included in Box 4 below.

Box 4. Valuation of carbon dioxide benefits

The SPC guidance presents values for estimation of the monetary benefits of CO_2 in appraisal. The 2007 base year values are below, as the monetary value per tonne of CO_2.

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Value	25.5	26.0	26.5	27.0	27.6	28.1	28.7	29.2	29.8	30.4	31.0	31.6

(2007 prices, with 2% pa increase)

It is important to highlight that the economic benefits of carbon benefits change over time, i.e. they increase in each future year. The values are increased at 2% a year, as in the table above. The values are then discounted in appraisal to give present values, as for the analysis of costs (see later sections). Note that for air quality pollutants, the damage cost calculator (Box 3) does these steps automatically.

As an example, we assume the scheme in Box 3 (for air quality improvements) also leads to emission reductions in CO_2. Using the SPC guidance, the benefits of these improvements can also be monetised. The analysis needs inputs of emissions over time. As with the example above, we have a scheme for five years, **starting in 2007** which leads to improvements in CO_2 over time as follows.

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
CO_2 reduction (tonnes)	100	80	60	40	20	0

Going to step 2 of the SPC guidance, the monetary values for CO_2 improvements (shown at the top of this box) are multiplied by the quantity of greenhouse gas emissions abated/emitted in each (expressed in CO_2e) (step 3 of the guidance) to give total benefits in each year.

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
£ value	2550	2080	1590	1080	552	0

These values must then be **discounted**. Guidance on discounting is given in the later sections. As an example here, we are using 2007 start date and base year, so the values are discounted back to this year.

Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
£ value	2550	2080	1590	1080	552	0
Discount factor	1.00	0.97	0.93	0.90	0.87	0.84
Discounted value	2550	2010	1484	974	481	0
Present Value (sum)	7499					

Note that if a different base year to 2007 is chosen – adjustments are needed to the set of shadow prices (to above), and the values will need to be discounted in relation to this different base year.

5.7 How to estimate other benefits

5.39. For some schemes, there will be additional effects. For transport schemes, this will potentially include aspects of noise, accidents, and congestion. For other schemes, it will also include additional aspects.

5.40. These additional elements should be captured in the assessment of options. For transport schemes, further guidance on these aspects is provided at the DfT's webTAG website www.webtag.org.uk/. In many cases, guidance and practical experience of applying these transport appraisal techniques will be within Local Authority Transport Departments.

6. Estimating Costs

6.1 Introduction

6.1. This section outlines the approaches for estimating costs. It focuses on the initial scoping of cost estimates.

6.2. The first stage in a cost assessment is to gather the information on costs. There are a number of sources of information that are likely to be useful to local authorities in undertaking this task. While no centralised database exists of the costs of potential measures for improving air quality, a number of reference sources may be of use. These include.

- Information from previous schemes, introduced in the UK or Europe.
- Information from recent national assessments, such as the Air Quality Strategy and supporting economic analysis (IGCB).
- Information from other government organisations, such as the Energy Saving Trust and its vehicle replacement schemes.

6.3. In collecting these costs, you should be mindful of a number of issues related to the analysis of cost information in appraisal. These are set out below.

6.2 Estimating Costs of Options

6.4. A key building block of an economic appraisal is the estimation of costs. In undertaking cost assessments of air quality options and schemes, it is important to recognise that the analysis of costs in economic appraisal differs from financial budgeting and accounting. This means it may be necessary to collect additional data and that the subsequent analysis requires the consideration of costs in a different way (that is often non-intuitive to conventional financial or budgeting procedures). There are two key issues to note.

- First, it is necessary to capture the full costs of a project or proposal (to society), rather than just the costs of setting up or introducing a scheme to the local authority. This may involve, for example, the costs of capturing the costs to vehicle operators from any scheme that is introduced to improve air quality. Related to this, costs have to be considered in terms of the impact to society as a whole and therefore do not take account of transfers between different sectors (for example taxes and subsidies) or accounting costs such as depreciation. This means there are significant differences between a financial analysis and economic analysis, though for major schemes, both are required.
- Second, it is necessary to present all cost information in equivalent terms. This involves some adjustments to costs (historic or future) to ensure they can all be compared directly.

The sections below outline some of the issues.

6.5. In the subsequent guidance that follows, a simplified (rule of thumb) approach is proposed, which simplifies lots of the following information, but this will be important for subsequent detailed analysis.

6.3 Economic vs. Financial Appraisal

6.6. Many practitioners confuse financial and economic appraisal. They are different because they have different objectives.

- An economic appraisal (economic case) focuses on wider value to money for society as a whole, taking into account all costs and benefits, even those that don't normally have monetary values.
- A financial appraisal looks at the affordability of a proposal. This is more likely to be similar to the sorts of local budgetary framework, financial costs and accounts, that many practitioners will be familiar with, i.e. they are similar to an accountancy based perspective.

6.7. For any scheme, **both the economic and financial case for a proposal will be important**, as it will be necessary to show the wider value for money of a proposal, but also ensure that from the local authority perspective, it is affordable.

6.8. At the simplest level, there are two sets of costs that are likely to be relevant in any option or scheme. These are capital costs and operating costs.

- **Capital costs**, also known as 'up front' or 'investment expenditure' costs, are the costs associated with, for example, the costs of purchase of a retrofit technology, or a new vehicle.
- **Operating costs,** also known as 'maintenance costs', are the costs associated with, for example, the running and maintaining the retrofit technology over the lifetime. These will include the costs of regular maintenance, but should also include the costs of any associated effects, for example on fuel economy.

6.9. In considering the economic costs of any option or scheme, it is important to take account of the capital and operating costs that accrue to all affected individuals, i.e. to society as a whole, rather than to the local authority alone. As an example, the costs of any scheme, such as a LEZ, involves costs to the local authority to set-up, run and enforce the scheme. However, it also includes costs to operators who have to comply with the scheme, and take action for example to upgrade their vehicles with retrofit technology to comply with the scheme.

6.10. It is also necessary to consider all costs and benefits, irrespective of boundaries, in economic appraisal. This will include the costs that occur within the local authority area, for example local fleets, but also other operators who maybe

affected by the schemes, i.e. those travelling into the area that will have to comply.

6.11. All sets of costs need be assessed for any option. However, it is good practice to keep these cost elements separate, as this separation is likely to be needed for subsequent financial appraisal, for example to look at scheme affordability to the local authority.

6.12. Some of the cost categories for the examples here are summarised in the table below for a retrofit scheme as an example. More specific examples are presented in the worked examples for the practice guidance.

Table 2: Cost categories for a retrofit scheme

Scheme	Capital Costs	Operating Costs
Cost to the local authority	Capital costs associated with infrastructure for the scheme.	Annual operating costs for the scheme, including staff resource.
Retrofit of a vehicle, for example for Diesel particulate filter (DPF)	Additional costs of purchase and operation of the retrofit technology.	Annual maintenance cost of retrofit technology, for example cleaning. Change in fuel efficiency.

6.13. Note that there are additional costs that are also potentially relevant, especially for larger schemes. These are particularly important for measures that affect transport demand (vehicle km) or travel time, rather than just transport technology and emissions, where there are a much wider set of costs that potentially need to be considered. These would include the wider costs (or benefits) of changes in travel time, accidents, etc.

6.14. There are additional levels of detail that are likely to be needed when undertaking a detailed appraisal, especially of a major scheme or a large transport based schemes. These include the following.

- Operating costs maybe comprised of fixed and variable elements. Some costs will remain fixed over time (for example the same cost each year), whilst some costs will be variable, and may vary with the volume of activity (for example related to annual mileage). Some costs may have elements of both, for example maintenance is an example, where there is usually a set planned programme, as well as a responsive regime whose costs vary in proportion to activity, i.e. the number of call-outs). Note that staff resources (such as those associated with setting up and running any scheme) are also a cost and these should be factored into the analysis.
- The assessment of transport-related costs will need to take account of the costs of new technology, the costs due to a change in fuel use. However, it

will also need to take into account the wider welfare effects due to any change in kilometres travelled.

- Traditionally, cost data availability will be at market prices. For example, the costs of equipment as provided by suppliers of low emission abatement equipment. However, when Government undertakes cost assessment, a different accounting concept is used, based on the '**technology costs'** of the measures (as in the Air Quality Strategy Review). This is the cost of the technology that the producers have to face when manufacturing equipment (or new vehicles) and is, of course, lower than the market cost. It is the estimated technology costs assuming mass production.
- For some schemes, there are likely to be wider indirect costs from introduction. As an example, in addition to the costs of implementation and the costs to operators, there maybe wider effects in the local economy from the scheme.

Assessing these effects in detail is more challenging, but these potential effects should be highlighted in your detailed considerations.

6.15. In collecting and analysing cost data, it is also important to recognise that the two appraisal approaches (economic and financial) work with different accounting principles, consistent with their objectives. As an example:

- an **economic appraisal will exclude** VAT and capital charges (including depreciation) because these are not relevant in the wider societal costs as they are effectively transfers,
- a **financial appraisal has to include** these because they have a direct bearing on the affordability of the options.

6.16. Similarly, this principle applies to revenues (taxes and charges) which are raised by scheme options, such as parking charges. In economic appraisals, costs are presented in terms of the impact to society as a whole and therefore do not take account of these transfers between different sectors (for example taxes and subsidies). However, in financial terms, they are strongly related to the affordability of the proposals, for example in relation to revenues that are likely to be important for the local authority.

6.17. Equally, in economic appraisal, it is necessary to consider all costs and benefits, whether or not they fall within local authority boundaries. For financial appraisal, it will be important to the costs and benefits that fall within and outside your area.

6.18. The key differences between economic and financial appraisals can be summarised in Table 3.

6.19. Separating out these issues can be complex, and require detailed input. It is not required for the scoping analysis, but it will be important to be mindful of these issues even in earlier rule of thumb analysis.

Table 3: Comparison of Economic Appraisal and Financial Appraisal

	Economic appraisal	**Financial appraisal**
Focus	Value for Money (measured as net present value)	Affordability (cash flow)
Coverage (boundary)	Wider cover – Government and society ('UK ltd')	Relevant organisation (for example local authority)
Analysis / Accounting standards	HMT Green Book on government appraisal	Organisation accounting rules
Transfers (for example VAT)	Excludes all transfer payments such as VAT	Includes all transfer payments such as VAT
Depreciation	Excludes depreciation and capital charges	Includes depreciation and capital charges
Inflation	Excludes general future inflation	Includes inflation
Benefits	Includes all benefits, including those that are not expressed in monetary terms, for example environmental benefits, such as health or air pollution benefits	Only considers cash releasing benefits
Costs	Includes all quantifiable costs, including indirect and attributable costs (costs of others), and environmental costs	
Prices	Constant (real) prices	Current (nominal) prices
Other	Includes opportunity cost Applies Government discount rate Excludes sunk costs	

Source: Adapted slightly from HMT, Business Case guidance.

6.4 Assessing costs in equivalent terms

6.20. In economic appraisal, all historic and future cost estimates need to be expressed in equivalent terms, so they can be directly compared. At first, this might seem rather simple, as all costs can be expressed in £ sterling. However, it is important to note that costs are not constant over time.

6.21. To address this, economic appraisal requires some adjustments to historic costs, for example, to account for effects such as inflation. It also requires adjustments for future costs to allow comparison and direct equivalence to cost that occur today. Note that these adjustments are different to the approaches used in financial appraisal (accountancy).

6.22. For the scoping phase, it is likely indicative costs should suffice. Nonetheless, it is important even in the scoping phase to try and ensure that current and future

costs are expressed in equivalent terms. This requires all cost estimates to be expressed in current prices using a common base year.

6.23. This base year provides a common point in time. Note that this base year can vary. Sometimes it is the most recent year. Sometimes it is a common starting point (the same year that the scheme is planned for introduction). Sometimes it is a historic base year (as in transport appraisal). The base year chosen does not really matter, as long as all cost estimates are expressed in this year consistently. As an example, older data should be expressed in this base year. For example, a study from the year 2002 may quote the cost of a piece of pollution control equipment for vehicles at £1000, but these costs will not be representative of current prices. Using this value (from an earlier year, without adjusting for inflation) will underestimate costs. There are approaches for expressing such data in current prices.

6.24. Similarly, it is also necessary to adjust costs that occur in the future. For most proposals, costs include operating costs that occur over the time period of the option or scheme. These might include annual maintenance, or scheme running costs that run over a period of five or more years.

6.25. In economic appraisal, it is necessary to adjust these costs in the future. In order to do this, and directly compare economic costs and benefits at different times, a technique called **discounting** is usually used.

6.26. Discounting is different to inflation, and is based on the principle that individuals (and society) prefer to receive goods and services now rather than later (known as time preference), and also that costs and benefits in the future count less because they affect a larger expected future income.

6.27. In economic appraisal, a **discount rate** is used to convert future economic costs to ‘present values’, so that everything can be compared on a common basis. In Government, a standard discount rate (strictly speaking, a social time preference rate (STPR), representing the rate at which society values the present compared to the future. Note this social rate is much lower than the private investment discount rate used in industry, reflecting that in economic appraisal we are assessing social preferences.

6.28. The recommended Government discount rate is 3.5%. A simple example of how this is applied is presented in Box 5, showing how £1000 changes over a period of five years. This can be related to, for example, running operating costs over time for a scheme.

Box 5. Discounting

Based on the recommended discount rate, an equation is applied to estimate the discount factor. This is applied to future costs to express them as 'present values'. The equation is:

$$D_n = \frac{1}{(1 + r)^n}$$

where r is the discount rate (3.5% in the UK, i.e. 0.035) and n is the year.

As an example, the discount factor that should be applied to derive the present value of £1000 in five years time can be calculated as Discount Factor = 1/(1 + 0.035)^5 = 1/(1.1876) = 0.842.

This discount factor is applied to the £1000 to estimate the present value, for example £1000 * 0.842 = £842.

The appropriate discount factors are published in the Treasury Green Book, shown below, though these can be calculated directly for each year using the equation above. **They are included in the guidance cost estimation spreadsheet.**

Year	Long Term Discount Factor
0	1.0000
1	0.9662
2	0.9335
3	0.9019
4	0.8714
5	0.8420
6	0.8135
7	0.7860
8	0.7594
9	0.7337
10	0.7089

The schedule over five years is shown below, showing how the value of £1000 falls with time when expressed in present values, i.e. the discounted value.

Year	0	1	2	3	4	5
Value	£1000	£1000	£1000	£1000	£1000	£1000
Discount factor	1.00	0.966	0.934	0.902	0.871	0.842
Present Value	£1000	£966	£934	£902	£871	£842

Note for later analysis (for example in cost-benefit analysis), the total present value of the scheme is obtained by summing these individual present values over time, so rather than a total of £6000 (6 * £1000), the present value is £1000 + £966+£934+£902+£871 + £842 = £5515.

6.29. Importantly, such an analysis, with all costs expressed in equivalent terms, allows the stream of capital and operating costs in different time periods to be expressed in a single value, called the **present value**. This then allows comparison of options, with different costs in different time periods in a directly equivalent way. This is important in, for example, comparing an option that has a large up-front capital costs versus one that has high operating costs that extend over time. An example is given in Box 6 below, showing the present value for two alternative options. The one with the lowest present value has the lowest economic costs. Note that the approach also allows comparison of schemes that have different operating lifetimes. The same principle is applied to the estimation of benefits (to derive present values) see later section, to allow a direct comparison of the costs and benefits to prioritise options.

Box 6. An example of Present Value

Two alternative options, A and B, are being considered for improving air quality.

- Option A involves a high level of initial capital expenditure to set up (£50,000), but has low operating costs (£1,000 per year) for the six years of the option.
- Option B has much lower initial capital expenditure (£10,000) but has high operating costs (£10,000 per year) for the six years of the option.

The costs in each year are added, and the discount factors are applied to estimate the sum of the values, i.e. the present value.

Option A	**0**	**1**	**2**	**3**	**4**	**5**
Capital costs	£50,000					
Operating costs	£1,000	£1,000	£1,000	£1,000	£1,000	£1,000
Total (cap + op)	£51,000	£1,000	£1,000	£1,000	£1,000	£1,000
Discount factor	1.00	0.97	0.93	0.90	0.87	0.84
Present value	£51,000	£966	£934	£902	£871	£842
Total PV (sum)	£55,515					

Option B	**0**	**1**	**2**	**3**	**4**	**5**
Capital costs	£10,000					
Operating costs	£10,000	£10,000	£10,000	£10,000	£10,000	£10,000
Total (cap + op)	£20,000	£10,000	£10,000	£10,000	£10,000	£10,000
Discount factor	1.00	0.97	0.93	0.90	0.87	0.84
Present value	£20,000	£9660	£9340	£9020	£8710	£8420
Total PV (sum)	£65,151					

In this case, even though option A has larger capital costs, the present value of costs is lower than B, because option B has higher operating costs over time.

6.30. Further details and worked examples are given in the later cost-effectiveness analysis and cost-benefit analysis and in the guidance spreadsheet. Both cost-effectiveness analysis and cost-benefit analysis use the same approach in terms of deriving present values as in the box above. However, for cost-effectiveness analysis, an additional calculation is usually carried out to express the present value in an annual metric, to allow direct comparison with annual benefits.

7. Appraisal: Cost-Effectiveness and Cost-Benefit Analysis

7.1 Introduction

7.1. The next stage in the appraisal process is to compare options. This section sets out the main approaches to do this. It is best practice in Government appraisal to use cost-benefit analysis for appraisal. However, in the case of a legally binding target, as for air quality exceedences, there is also a role for cost-effectiveness analysis. Both techniques use the same building blocks on estimating benefits and costs from the previous chapters. They differ in that cost-effectiveness provides a method for looking at the relative attractiveness of options, usually with a particular focus on a single year, i.e. for a legally binding target date, whilst cost-benefit analysis looks at the absolute costs and benefits of options over time and can assess their full societal benefits and value for money.

7.2 Cost-effectiveness analysis

7.2. In any area, there are a potentially large number of different measures that can be implemented to improve air quality. An important component of developing an action plan or air quality strategy is to compare these options against each other to allow selection of the most appropriate measure or combination of measures to achieve the necessary air quality improvements.

7.3. The existing Guidance highlights that one of the key criteria recommended for action planning is to assess measures in terms of their cost-effectiveness. Undertaking a cost-effectiveness analysis will allow a prioritisation of options according to the physical benefits that they achieve (for example emissions or air quality improvement) for the level of investment (costs). When used in an overall action plan, it can ensure that the achievement of the air quality objective is undertaken in the most economically efficient way. This is important in reducing the costs of proposals.

7.4. To assess the cost-effectiveness of a measure, two elements are involved.

- The first assesses the likely reductions in emissions or air quality concentration improvement, as calculated in the earlier benefits section, for example, how many tonnes of emissions an option achieves in a given year.
- The second assesses the economic costs of implementing the measure, i.e. as estimated in the previous section on cost analysis. This includes all cost elements, with costs expressed in directly equivalent terms as a present value. In the case of air pollution improvements with a given target date, it is usual to express these costs in an annual term, to provide an equivalent annual cost that can be compared against the environmental benefit above.

7.5. Cost-effectiveness simply combines these two metrics, so that an option can be assessed in terms of either the:

economic cost (£) to reduce one tonne of emissions, or

economic cost (£) to improve air quality by 1 µg m^{-3}

7.6. The cost-effectiveness of an option represents the air quality benefits it achieves, relative to its costs, i.e. it provides a ranking of the economic effectiveness of different options. Usually this is reported as a £ cost per tonne, i.e. as an equivalent annualised cost per emission reduced/year (though it can also be expressed by swapping the terms around, i.e. expressed as tonnes reduced per £). Note that in the case of an AQMA, the relevant metric is likely to be the emissions abated in the area of the exceedence, though more accurately it is the cost per level of air quality improvement (µg m^{-3}).

7.7. Expressing different measures in this way allows a method for directly comparing options. By undertaking a scoping analysis, and estimating the indicative cost per tonne, the cost-effectiveness of different options can be compared. This allows one element in the prioritisation and selection of options. The individual cost-effectiveness of measures can also be used to draw up an overall action plan, i.e. by implementing the most cost-effective measures first, it is possible to estimate how to reduce an exceedence, or achieve a given level of air quality improvement, in the most cost-effective way. This is outlined in more detail in a later section.

7.8. The starting point for any scoping cost-effectiveness analysis is the emission improvement and cost data. For the latter, as highlighted in Chapter 6, this must be collected in equivalent terms, and should be based on an economic appraisal method in relation to boundaries, taxes and charges, etc. However, the present values (as in Chapter 6) are expressed as annualised costs. The annualised cost is equivalent to the constant annual payment that is required over a fixed number of years to produce the same present value at a given discount rate.

7.9. However, this type of traditional cost-effectiveness analysis focuses only on one objective, and does not consider other Government environmental goals. To address this, it is good practice to assess the 'net cost-effectiveness' of options. This extends the cost-effectiveness analysis to a net cost metric (annualised costs less annualised benefits) before comparing against the reduction in tonnes of pollutant (or µg m^{-3}). The advantage of this 'net' assessment is it builds in other environmental objectives directly to the relative ranking of options, i.e. so that reductions of other air quality pollutants or changes in greenhouse gas emissions are also considered.

7.10. Undertaking a full cost-effectiveness assessment can be a detailed and time-consuming activity. In a scoping phase, precise calculations of cost-effectiveness will not, in all cases, be possible or needed. The aim is to identify which options merit further consideration. In most cases, a simple cost-effectiveness scoping study based around emissions benefits will very quickly

identify those options that achieve good emissions improvements at low cost, which should be taken forward to a more detailed assessment, though a check should be made to see how these vary when ‘net’ cost-effectiveness is considered (to bring in other environmental objectives). For detailed studies, especially of major schemes and specifically for transport schemes, it is likely that additional expertise will need to be brought in for detailed appraisal, and a more in-depth analysis of cost and benefits will be needed.

7.11. As highlighted earlier, the application of this scoping cost-effectiveness is not mandatory, but is good practice. It will demonstrate that local authorities have considered a range of options and the cost-effectiveness information provides an extremely valuable input in ranking and prioritising different options. By using the cost-effectiveness analysis, a local authority is able to demonstrate that cost and efficiency considerations have been considered, (important for internal and external stakeholders). Note, however, that cost-effectiveness is not the sole output for prioritising measures for inclusion in an action plan, and other criteria are important and should be assessed alongside costs. These include, but are not confined to, other environmental effects (which can be assessed with a ‘net cost-effectiveness analysis), social impacts, acceptability of options, and secondary economic effects. It is also important that the distributional implications of each option are considered during appraisal. This type of analysis enhances the understanding of the fairness of proposals, their social impacts and their scale.

7.12. A simplistic worked example is shown in Box 7. Specific examples for each of the schemes are included in the additional practice guidance on LEZ, LEV and retrofitting.

Box 7. Estimating the cost-effectiveness of a measure

The present value of the options A and B was presented in Box 6.

- Option A involves a high level of initial capital expenditure to set up (£50,000), but has low operating costs (£1,000 per year) for the six years of the option. The present value of these costs was £55,515 (see Box 6).
- Option B has much lower initial capital expenditure (£10,000) but has high operating costs (£10,000 per year) for the six years of the option. The present value of these costs was £65,151 (see Box 6).

The two options both reduce annual emissions of NO_x, for example,

- Option A reduces emissions by 10 tonnes of NO_x a year in the area.
- Option B reduces emissions by 14 tonnes of NO_x a year in the area.

To estimate the cost-effectiveness, one additional calculation is needed to convert the present value of costs (from above) into an annual term, an annualisation. This is often known as the equivalent annual cost. This uses an equation which is multiplied by the present values as follows. **There is an excel function which can estimate equivalent annualised costs. This is included in the example sheet.**

Equivalent annualised cost = Present value multiplied by $\left[\frac{r(1+r)^n}{(1+r)^n-1}\right]$

where again r is the discount rate (3.5% in the UK, i.e. 0.035) and n is the length in years.

This is applied to give [0.035*(1+0.035)^year]/[((1+0.035)^year)-1]. In the case of the six years here, [0.035*(1+0.035)^6]/[((1+0.035)^6)-1] = 0.188.

Therefore, the equivalent annual costs for two options are:

- Option A = £55,515* 0.188 = £10,418
- Option B = £65,151* 0.188 = £12,227

The cost-effectiveness is then the annual emission reduction divided by the equivalent annual cost, as follows

- Option A = 10 tonnes/ £10,418 = £1,042 per tonne reduced.
- Option B = 14 tonnes/ £12,227 = £873 per tonne reduced

So option B is the more cost-effective option, as it achieves a reduction in NO_x for a lower cost per tonne. This type of analysis can also be undertaken for air quality improvement, i.e. cost per micro gram.

Note that if the options had different lifetimes, it would be necessary to annualise them over different periods – so for example – if option B had a longer lifetime by two years, we would need to adjust this in the annualisation equation, so that the costs were spread over the appropriate lifetime.

The cost spreadsheet has a function for estimating the equivalent annualised cost.

However, the analysis above only considers one objective (NO_x improvement), and does not consider other Government environmental goals or benefits of the options, for example PM_{10} reduction, or greenhouse gas emission reductions. To address this, it is necessary to assess the 'net cost-effectiveness' of the options. An example for these options is given in Box 9.

7.13. There are additional levels of detail that are likely to be needed when undertaking a detailed appraisal, especially of a major scheme or a large transport based schemes. These include the following.

- If the study is aiming to reduce a specific hot-spot or achieve a target in a given exceedence area, then the cost-effectiveness will need to target the cost-effectiveness to the emissions benefits that will directly affect the air quality in this area, i.e. very localised benefits, rather than say the benefits across the wider area. In more detailed analysis, this can be investigated in more specific detail by assessing cost-effectiveness for improving air quality concentrations, for example ($\mu g\ m^{-3}$) rather than in emissions.
- In many cases, the emissions benefits of a scheme will change over time. For the scoping assessment above, it is enough to estimate the emission savings in the first year, and compare to annualised costs. In more detailed analysis, it will be necessary to consider how the emissions savings change over the lifetime of the scheme. This is important otherwise the benefits of measures that have high initial benefits which fall off over time may be overestimated.
- It should be noted that the cost-effectiveness methodology assigns all costs to abatement of a single pollutant, for example to PM_{10} or NO_x. Some technologies abate both PM_{10} or NO_x, or lead to positive or negative changes in greenhouse gas emissions for example. Care must be taken not to underestimate the benefits of these measures (i.e. by concentrating on one pollutant at a time). It is possible to take these effects into account by undertaking a 'net' cost-effectiveness analysis (see Box 10), rather than using a simple methodology for ranking options in terms of cost-effectiveness for a single pollutant. Note that cost-benefit analysis also addresses these multi-pollutant issues.
- Other factors will be important in determining the overall ranking of measures, including the wider assessment (see 5As in 2.15) and other legal and technical issues, as well as acceptability.

7.14. Existing data on the cost-effectiveness of different options is not provided in the guidance. However, previous studies do indicate some broad general trends, which are summarised below. The case studies provide more specific examples of this. As very broad considerations, the following is highlighted.

- For transport, the introduction of the Euro standards means that there are strong differences in emissions between older and more modern vehicles. It

is therefore usually more cost-effective to target the older, higher polluting vehicles.

- Heavier vehicles, such as lorries, buses and coaches, have much higher emissions than cars per vehicle kilometre driven. These vehicles therefore tend to be more cost-effective to target, because it is possible to have a large impact in reducing emissions by tackling a relatively small number of vehicles. However, note the following bullet.
- In cases where the priority is a LAQM area or hot-spot, it is usually much more cost-effective to tackle those vehicles which have highest annual vehicle km in the area, rather than those that only spend a small proportion of annual distance in the actual area. This often means that it is much more cost-effective to tackle local fleets with high area km, such as buses, local authority fleets or the taxi fleet.

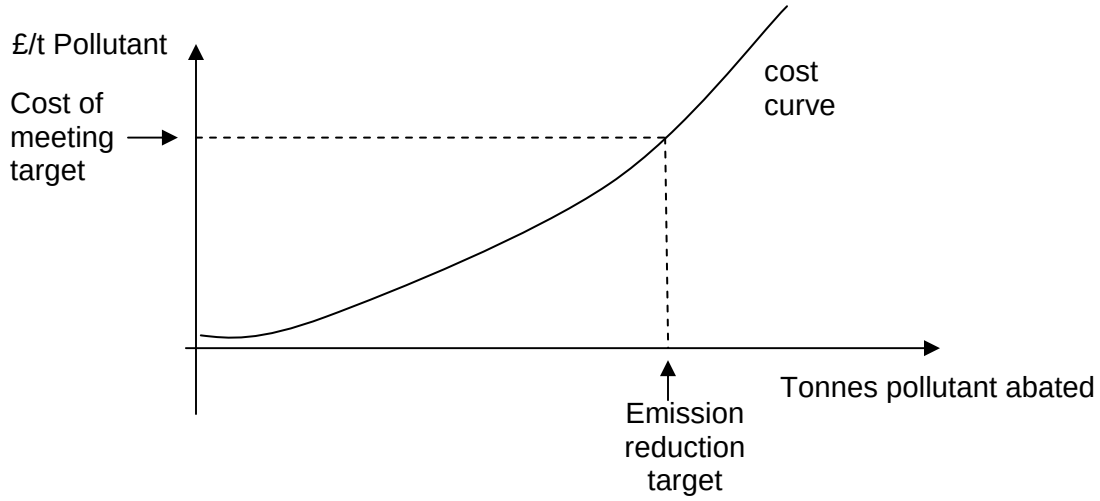
Building up a Cost-Effective Action Plan (Cost Curves)

7.15. The information from a cost-effectiveness analysis above can be used to look at the overall economic costs of hitting an air quality target, and to ensure that the target is achieved in the most cost-effective way.

7.16. In many cases, a combination of options may be needed to achieve, or demonstrate progress towards an air quality target. The cost-effectiveness analysis (previous section) allows prioritisation of a range of different measures and should provide the basis for developing a cost-effective action plan. Those measures that are most cost-effective, i.e. that achieve greatest air quality improvements for least cost should be included first in the plan. Progressively less cost-effective options are then added until the target air quality improvement is achieved, or until proportional progress towards the target can be demonstrated. Undertaking analysis in this way will also provide a total cost of compliance.

7.17. Arranging options in order of cost-effectiveness, and building them up to achieve a given target, can be plotted in a figure, known as a cost curve. An illustration is shown in Figure 4. It plots the cumulative emission reduction potential against the costs, and shows the rising costs of options up the vertical axis with increasing emission reductions. The cost curve thus gives the total cumulative emissions reduction, and the total cumulative costs. If there is a target level, for example associated with achieving an air quality level, it is possible to ‘read off’ the curve by drawing a horizontal line, as indicated in the schematic below, to assess the measures needed, and the total costs, of achieving the target.

Figure 4: A Cost Curve for Emission Reductions.



7.18. As outlined above, a traditional cost-effectiveness analysis will only consider one objective in drawing up this cost curve. In order to take account of other environmental objectives, for example multiple air pollutants, and greenhouse gas emissions, the 'net' cost-effectiveness analysis of options should be assessed, and this used to build up the cost curve in order of the ranking of options, so as to provide a more holistic ranking approach.

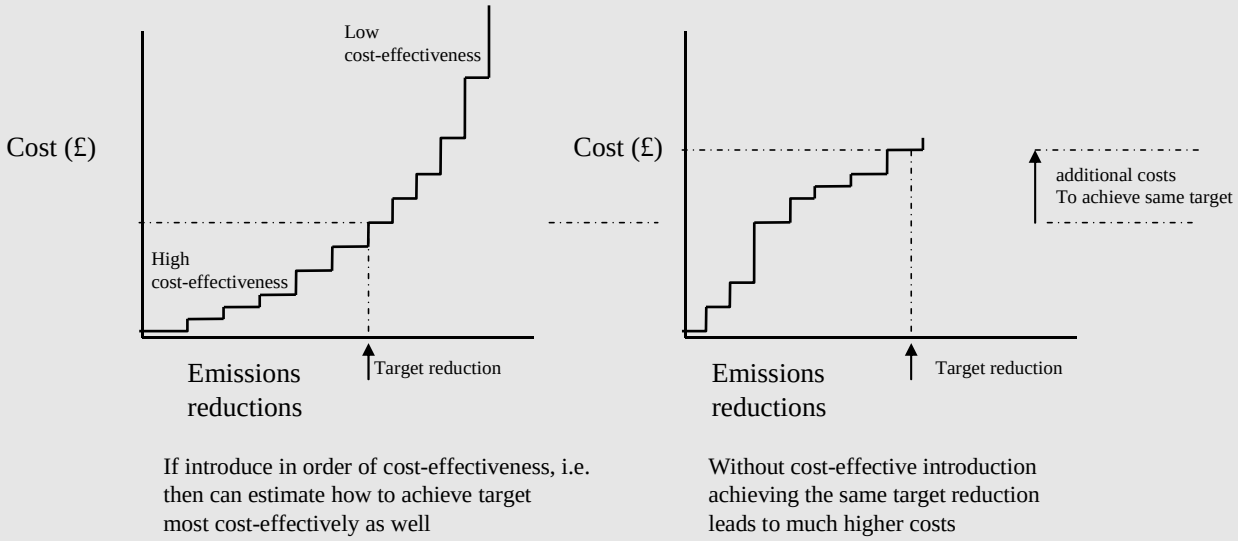
7.19. The advantage of the cost-effectiveness analysis and cost-curve is it demonstrates how to hit a particular target most cost-effectively, as the options are arranged with the most cost-effective ones implemented first (or most cost-effective in 'net' terms). It therefore provides a way to figure out how to achieve a given target at least cost. More description is given in Box 8.

7.20. In some cases, the costs of achieving a target may be considered dis-proportionately high. The cost curve can provide an important demonstration of this, as it will show if there is a disproportionate increase in the relative cost-effectiveness of options at some point, i.e. a step change or discontinuity in the cost curve.

Box 8. Developing a Cost-effective Air Quality Plan

Once a cost-effectiveness analysis has been undertaken, it is possible to rank different options in order of their cost-effectiveness. Under such an analysis (though considering other elements), the most attractive measure is the most cost-effective option, i.e. the one that gives the greatest emissions improvement at least cost. In some cases, however, more than one measure may be needed to meet the necessary air quality target and so the next most cost-effective option must also be added. This process can be continued until the target level is reached (note, checking that measures can be implemented simultaneously). The resulting plan will mean that target levels are achieved at lowest (least) total cost. The approach is shown in the left hand figure below. An approach that does not address cost-effectiveness has the potential to significantly increase the costs of hitting a target. The graph below on the right shows what happens if the cost-effectiveness order is reversed. By reading off to the cost axis, it can be seen that this significantly increases (moves upwards) the costs of achieving the target.

Figure 5: Cost-effective Air Quality Plans



Note that to take account of multiple air quality pollutants, and greenhouse gas emissions, a 'net' cost curve can be produced, which also takes these other environmental objectives into account in the ranking and ordering of different options.

7.21. In practice there are additional complexities in cost curve analysis as part of action plans. Many of these relate to the more detailed issues with cost analysis and cost-effectiveness highlighted in the previous cost section. In addition:

- A key issue is that different measures often affect similar activities, or one option may preclude the introduction of another, and so in practice, it is necessary to check synergies and conflicts between options in drawing up a plan.

- Other factors will be important in determining the overall ranking of measures, including the wider assessment (see 5As in 2.15) and other legal and technical issues, as well as acceptability.

7.3 Cost benefit analysis

7.22. Cost-benefit analysis is an alternative economic appraisal technique. In cost-benefit analysis, all relevant costs and benefits to government and society of all options are valued, and the net benefits or costs calculated. Cost-benefit analysis differs from cost-effectiveness analysis, as it works with monetary values for emissions benefits, and because it does not have to work with a pre-defined goal, i.e. it provides a method for investigation the justification for air quality improvements irrespective of AQMAs. Cost-benefit analysis is relevant for all air quality proposals, but especially those which are not specifically addressing an existing exceedence, or those that are related to larger transport projects.

7.23. Cost-benefit analysis is the preferred approach for economic appraisal in Government. It is also the main basis of the transport appraisal guidance (NATA and the guidance in webTAG).

7.24. The building blocks for a cost-benefit analysis are the monetary estimation of benefits, described earlier in chapter 5 using the Defra Damage Cost Calculator, downloadable as an excel sheet (www.defra.gov.uk/environment/airquality/panels/igcb/guidance/index.htm), and the estimation of the present value of costs, from chapter 6.

7.25. Note that consistent with Government objectives, it is good practice to include any significant effects on greenhouse gas emissions as part of your estimates (positive or negative) and to include these in your analysis. Chapter 5 set out the approach for estimating the monetary benefits of greenhouse gas emissions improvements, using the Government SPC guidance, downloadable at www.defra.gov.uk/environment/climatechange/research/carboncost/step1.htm.

7.26. A cost-benefit analysis simply compares the present value of all benefits against the present value of all costs. Calculating the differences between the streams of costs and benefits provides the overall **net present value** (NPV) of an option. The NPV is the primary criterion for deciding whether government action can be justified, i.e. if the benefits are higher than the costs.

7.27. Note that unlike cost-effectiveness, cost-benefit analysis looks at the benefits over time, rather than the benefits in a single year. This requires analysis of future benefits. As with future costs, these are discounted using the same Government recommended discount rate.

7.28. Also different to cost-effectiveness, cost-benefit analysis can work with multiple pollutants, so it can estimate the combined benefits of PM and NO_x emission

reductions. It can also include wider benefits such as CO_2 emission reductions (and as part of wider appraisal, other elements as well).

7.29. A scheme that has a positive net present value, shows a positive scheme. An example is shown in Box 9 below. Additional examples are given in the worked examples document accompanying this practice guidance case study guidance documents.

Box 9. Example of a Cost-Benefit Analysis

The present value of costs of the options A and B was presented in Box 6.

- Option A involves a high level of initial capital expenditure to set up (£50,000), but has low operating costs (£1,000 per year) for the six years of the option. The present value was £55,515 (see Box 6).
- Option B has much lower initial capital expenditure (£10,000) but has high operating costs (£10,000 per year) for the six years of the option. The present value was £65,151 (see Box 6).

These costs need to be assessed against the economic benefits of the options. As outlined in Box 6, the two options both reduce annual emissions of NO_x. As examples:

- Option A reduces emissions by 10 tonnes of NO_x a year in the area.
- Option B reduces emissions by 14 tonnes of NO_x a year in the area.

In order to estimate the monetary benefits of these emissions, it is necessary to use the Defra damage cost guidance to provide estimates. It is also necessary to increase the value of benefits in future years, and the discount these benefits, to derive a present value of benefits to compare to costs above. Note that the damage cost calculator does these steps automatically. As an example, the value for NO_x for option A are entered into the damage cost calculator spreadsheet, as below.

The present value of NO_x benefits for option A are estimated at £53,318 (see central value above). For option B (not shown) the present value of benefits is £74,407.

1. What length (in years) is your policy appraisal?	6
2. When is the first year of your appraisal?	2007
3. What pollutant are you assessing? (click box to select from drop-down menu)	*1*
4. Input the annual changes in emissions below (in tonnes)	

Year	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Change in emissions (tonnes)	10	10	10	10	10	10	

CALCULATED RESULTS		
Central Estimate Present Value	*£* 0.05	Million
	£ *53,148*	

These benefits can be compared against the present value of costs, to estimate the **net present value** of each option. The findings are:

- Option A has a present value of benefits of £53,148, and present value of costs of £55,515, so it has a negative net present value.
- Option B has a present value of benefits of £74,407, and present value of costs of £65,151, so it has a positive net present value of £9,257.

Therefore Project B is preferable in cost-benefit terms.

Note that if the options above had additional PM emission improvements, **the economic benefits of these other pollutants should be added to the values above** in the cost-benefit analysis (as should CO_2 emissions using the SCP, if these were relevant as well), for example if:

- Option A reduces emissions by 0.1 tonnes of PM_{10} a year in the area.
- Option B reduces emissions by 0.05 tonnes of PM_{10} a year in the area.

In this example, the damage cost calculator is used again. Note that for PM_{10}, it is necessary to specify the sector, and for transport, the location of the emission reductions. In this case, we select inner conurbation. Using the calculator, the present value of PM_{10} benefits for option A are estimated at £65,602, and for option B at £32,801. Therefore:

- Option A has a present value of NO_x benefits of £53,148 and PM_{10} benefits of £65,602, making a total of £118,750 compared to a present value of costs of £55,515, so it now has a positive net present value (compared to the assessment of NO_x alone).
- Option B has a present value of NO_x benefits of £74,407 and PM_{10} benefits of £32,801, making a total of £107,208 compared to a present value of costs of £65,151, so it also has a positive net present value, though the NPV it is now lower than option A.

Option	Present Value Benefits	Present Value Costs	Net Present Value
A	£118,750	£55,515	£63,235
B	£107,208	£65,151	£42,058

With both pollutants considered, option A is now preferable. This highlights the value of cost-benefit analysis in considering the overall benefits.

7.30. The information from a cost-benefit analysis can also be used to consider other environmental objectives in a cost-effectiveness analysis, as part of a 'net' cost-effectiveness analysis[14]. For the case of air pollution, where we are concerned with achieving air pollution targets in a given year, this is estimated from the estimation of annualised costs less annualised benefits / by reduction in tonnes pollutant (or μg m^{-3}). The advantage of this 'net' cost-effectiveness assessment is it allows consideration of other air quality pollutants, and greenhouse gas

[14] Note the Defra Greenhouse Gas Policy Evaluation and Appraisal in Government Departments. April 2006, defines cost-effectiveness analysis = NPV costs less NPV benefits divided by carbon saved. In the Defra greenhouse gas programme, cost-effectiveness is similarly defined, as the resource costs, i.e. the costs to society and other ancillary benefits (for example air quality) are also added to the equation. However, the latter document also refers to this being the net cost per tonne saved. This definition of 'net' cost-effectiveness is used here, to refer to resource cost-effectiveness analysis.

emissions, in the cost-effectiveness ranking (outlined in earlier sections) and so provides a more holistic overall ranking method. An example is given in Box 10 below.

Box 10. Example of 'Net' Cost-Effectiveness Analysis

The equivalent annual costs of the options A and B were presented in Box 7. When just the cost effectiveness against NO_x improvements were considered, option B was found to be more cost-effective, as shown by the annual emission reduction divided by the equivalent annual cost:

- Option A = 10 tonnes NO_x/ £10,418 = £1,042 per tonne reduced.
- Option B = 14 tonnes NO_x/ £12,227 = £873 per tonne reduced

However, in a 'net' cost-effectiveness analysis, other environmental objectives are considered, using the information from the cost-benefit analysis (Box 9) for NO_x + PM_{10} benefits:

- Option A has a present value for NO_x + PM_{10} benefits of £118,750.
- Option B has a present value for NO_x + PM_{10} benefits of £107,208.

These values must be expressed in an equivalent annual value, to compare to costs. This uses the same equation as in Box 7.

- Option A has an equivalent annual NO_x + PM_{10} benefit of +£22,286.
- Option B has an equivalent annual NO_x + PM_{10} benefit of +£20,120.

A 'net' cost-effectiveness analysis is estimated by (annualised costs less annualised benefits) / reduction in tonnes pollutant – in this case towards a NO_x objective. This gives

- Option A = (£10,418 - +£22,286)/10 tonnes NO_x = -£1,187 per tonne reduced
- Option B = (12,227 - +£20,120)/14 tonnes NO_x = -£564 per tonne reduced

When these other environmental aspects are included, the 'net' cost-effectiveness changes the ranking, and option A is now most favourable. This highlights the importance of considering these other factors. If either option led to changes in greenhouse gases, these would also be considered by estimating the annualised values.

7.31. Note that other factors will be important in determining the overall ranking of measures, including the wider assessment (see 5As in 2.15) and other legal and technical issues, as well as acceptability. Examples of some of these issues are presented in the worked examples document accompanying this practice guidance case study guidance notes.

7.32. In practice there are additional complexities in cost-benefit analysis. Many of these relate to the more detailed issues with cost analysis highlighted in the earlier cost section. There will, however, be other aspects that need to be covered, especially in any more detailed analysis (beyond the scoping stage). Information on detailed cost-benefit analysis is available in the guidance available for major schemes as follows.

- If your options have identified the potential for a major transport scheme, or any scheme that involves transport demand changes, you should consult the DfT's webTAG available at www.webtag.org.uk/), which follows a cost-benefit approach and provides detailed guidance. This should be seen as a requirement for all projects/studies that require government approval. For projects/studies that do not require government approval the transport analysis guidance should serve as a best practice guide. In many cases, guidance and practical experience of applying these transport appraisal techniques will be within Local Authority Transport Departments.
- If your options have identified a major non-transport scheme, that is likely to require significant public investment, then you should use the Treasury '5 Case Model' which has been in widespread use across the public sector for some years. It complies with both the Green Book guidance on assessment and the OGC Gateway process for project assurance. The Business Case keeps together and summarises the results of all the necessary research and analysis needed to support decision making in a transparent way. It breaks down the case into five different aspects: the strategic, economic, financial, commercial and management aspects (www.hm-treasury.gov.uk/media/C/B/greenbook_businesscase_shortguide.pdf)

Appendix 1: Glossary

AQMA	Air Quality Management Area
CAFE	Clean Air For Europe
CBA	Cost-benefit analysis
CCS	Congestion Charge Scheme
CEA	Cost-effectiveness analysis
CO_2	Carbon dioxide
COMEAP	Department of Health's Committee on the Medical Effects of Air Pollutants
Defra	Department for Environment Food and Rural Affairs
DfT	Department for Transport
GIS	Geographical Information System
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicle
IGCB	Interdepartmental group on costs and benefits
LAQM	Local air quality management
LEV	Low Emission Vehicle
LEZ	Low Emission Zone
NATA	New Approach to Transport Appraisal
NO_x	Oxides of nitrogen or nitrogen oxides
NO_2	Nitrogen dioxide
PM_{10}	Particulate matter smaller than 10 microns
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SPC	Shadow Price for Carbon
VED	Vehicle Excise Duty
VOC	Volatile organic compounds
WebTAG	Web-based Transport Analysis Guidance