Title: **A Low Emissions Zone framework for inclusion in the Time Extension Notification for compliance with the EU limit value for NO2** **Lead department or agency:** Defra **Other departments or agencies:**	**Impact Assessment (IA)** **IA No:** Defra1341 **Date:** 13/01/2011 **Stage:** Development/Options **Source of intervention:** EU **Type of measure:** Other **Contact for enquiries:** Robert Vaughan

Summary: Intervention and Options

What is the problem under consideration? Why is government intervention necessary?

Nitrogen dioxide (NO2) is a harmful air pollutant which has adverse effects on health and the environment. Directive 2008/50/EC sets limits for concentrations of NO2 in air, setting the minimum standard of air quality. By acting as a safety net on exposure to air pollution they manage uncertainties around the impact of air pollution, protect vulnerable groups and irreparable damage. The UK (like many other Member States) is not predicted to achieve compliance when the limit comes into effect in 2010 but the above Directive does allow postponement to 2015 subject to submission by September 2011 of plans setting out how compliance will be delivered by 2015. Normal fleet improvements would deliver slower progress than if Government intervened.

What are the policy objectives and the intended effects?

The policy objective is to put into place justifiable measures that reduce air pollution as quickly as possible in order to make progress in delivering the minimum standards, reduce the impacts of poor air quality on health and the environment and to improve prospects of compliance with EU limit values for NO2 by 2015. This action will support the UK's plans for progressing towards compliance with this limit value and our application for additional time until 2015 to meet this limit value.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

1) Submit plans on the basis of current and planned measures.

2) Submit plans which include consideration of a national framework to facilitate low emission zones in those local authorities (LAs) with the highest exceedences of the limit value by restricting access of heavy goods vejhicles (HGVs) and buses to at least Euro IV emission standards.

Option 2 is the preferred option. A national framework of low emission zones will enable significant progress in improving air quality and signal to the EC out commitment to achieveing the limits set, thereby improve our prospects for being granted a time extension to deliver full compliance.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** 12/2016
What is the basis for this review? Not applicable. **If applicable, set sunset clause date:** Month/Year

Are there arrangements in place that will allow a systematic collection of monitoring information for future policy review?	Yes

SELECT SIGNATORY Sign-off For consultation stage Impact Assessments:

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible SELECT SIGNATORY: .... Date: ....

Summary: Analysis and Evidence

Policy Option 1

Description:

Low Emission Zone Framework

Price Base Year 2010	**PV Base Year** 2010	**Time Period Years** 5	**Net Benefit (Present Value (PV)) (£m)**		
			Low: Optional	**High:** Optional	**Best Estimate: £155**

COSTS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Cost** (Present Value)
Low	£65	1	£2	**£75**
High	£267		£2	**£277**
Best Estimate	£267		£2	**£277**

Description and scale of key monetised costs by 'main affected groups'

The majority of the monetised costs occur to vehicle operators through the cleaning up of the HGV fleet, at a cost of £267 million. These costs are expected to occur through either replacement of the existing or retrofitment of abatement technologies.
Other costs are incurred by Local Autorities that choose to establish a low emissions zone and to central government in setting up a certification scheme for vehicles which demonstrate compliance.

Other key non-monetised costs by 'main affected groups'

Other costs of establishing low emission zones which have not been valued include the potential change in behaviours of operators of HGVs and buses, owing to changing costs between areas with and without an LEZ, the cost if increased costs resulting from the policy were to force vehicle operators to leave the sector and the impact on the second hand market for older 'dirty' vehicles.

BENEFITS (£m)	**Total Transition** (Constant Price)	Years	**Average Annual** (excl. Transition) (Constant Price)	**Total Benefit** (Present Value)
Low	Optional		£21	**£98**
High	Optional		£180	**£842**
Best Estimate	0		£92	**£432**

Description and scale of key monetised benefits by 'main affected groups'

The two monetised benefits are: a) progress towards the NO2 limit values; and b) improved public health from reductions in particulate matter (PM). This introduction of LEZs is modelled to significantly reduce the number and length of road links which exceed the NO2 limit value. It also substantially reduces a range of adverse health effects associated with air pollution both in the areas directly introducing a LEZ and more widely.

Other key non-monetised benefits by 'main affected groups'

These include the benefits to the vehicle operators from updating the fleet with newer vehicles which would be expected to reduce fuel costs. As a consequence this would also reduce the level of carbon emissions presenting a potentially significant climate change benefit. Monetised air quality impacts also exclude the impacts on the natural environment and ecosystems. Reputational benefit to the UK in Europe by demonstrating all justifiable action had been taken to comply with the legislation.

Key assumptions/sensitivities/risks **Discount rate (%)** 3.5

The central assumption is that the UK values the safety net provided by limit values. If it did not, and ignored infraction risk, the benefits of this option would be reduced to the direct health effects valued at £98m. Using the EU methodology it would be in the range of £92 - £267m. The value of the shadow price of NOx abatement can also vary significantly depending on the marginal technology, ranging betweeen £328 - £842m. Impacts on participation and market for used vehicles is insignificant. The effectiveness of the emission control technologies is a notable risk with evidence of previous standards have underperformed. Reaction to an LEZ framework is also uncertain both by LAs and by vehicle operators. If no LAs decide to take introduce a LEZ the impact would be zero.

Direct impact on business (Equivalent Annual) £m):			**In scope of OIOO?**	**Measure qualifies as**
Costs: £57	**Benefits:** unvalued	**Net:** (£57)	No	NA

Enforcement, Implementation and Wider Impacts

What is the geographic coverage of the policy/option?	Options				
From what date will the policy be implemented?	01/01/2015				
Which organisation(s) will enforce the policy?	Local Authorities				
What is the annual change in enforcement cost (£m)?					
Does enforcement comply with Hampton principles?	Yes				
Does implementation go beyond minimum EU requirements?	No				
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)	**Traded:**	**Non-traded:**			
Does the proposal have an impact on competition?	No				
What proportion (%) of Total PV costs/benefits is directly attributable to primary legislation, if applicable?	**Costs:**	**Benefits:**			
Distribution of annual cost (%) by organisation size (excl. Transition) (Constant Price)	**Micro**	**< 20**	**Small**	**Medium**	**Large**
Are any of these organisations exempt?	No	No	No	No	No

Specific Impact Tests: Checklist

Set out in the table below where information on any SITs undertaken as part of the analysis of the policy options can be found in the evidence base. For guidance on how to complete each test, double-click on the link for the guidance provided by the relevant department.

Please note this checklist is not intended to list each and every statutory consideration that departments should take into account when deciding which policy option to follow. It is the responsibility of departments to make sure that their duties are complied with.

Does your policy option/proposal have an impact on…?	**Impact**	**Page ref within IA**
Statutory equality duties[1] Statutory Equality Duties Impact Test guidance	No	
Economic impacts		
Competition Competition Assessment Impact Test guidance	No	
Small firms Small Firms Impact Test guidance	No	
Environmental impacts		
Greenhouse gas assessment Greenhouse Gas Assessment Impact Test guidance	Yes	44
Wider environmental issues Wider Environmental Issues Impact Test guidance	Yes	39
Social impacts		
Health and well-being Health and Well-being Impact Test guidance	Yes	39
Human rights Human Rights Impact Test guidance	No	
Justice system Justice Impact Test guidance	No	
Rural proofing Rural Proofing Impact Test guidance	No	
Sustainable development Sustainable Development Impact Test guidance	No	

[1] Public bodies including Whitehall departments are required to consider the impact of their policies and measures on race, disability and gender. It is intended to extend this consideration requirement under the Equality Act 2010 to cover age, sexual orientation, religion or belief and gender reassignment from April 2011 (to Great Britain only). The Toolkit provides advice on statutory equality duties for public authorities with a remit in Northern Ireland.

Evidence Base (for summary sheets) – Notes

Use this space to set out the relevant references, evidence, analysis and detailed narrative from which you have generated your policy options or proposal. Please fill in **References** section.

References

Include the links to relevant legislation and publications, such as public impact assessments of earlier stages (e.g. Consultation, Final, Enactment) and those of the matching IN or OUTs measures.

No.	Legislation or publication
1	
2	
3	
4	

+ Add another row

Evidence Base

Ensure that the information in this section provides clear evidence of the information provided in the summary pages of this form (recommended maximum of 30 pages). Complete the **Annual profile of monetised costs and benefits** (transition and recurring) below over the life of the preferred policy (use the spreadsheet attached if the period is longer than 10 years).

The spreadsheet also contains an emission changes table that you will need to fill in if your measure has an impact on greenhouse gas emissions.

Annual profile of monetised costs and benefits* - (£m) constant prices

	Y_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9
Transition costs	0	0	0	0	0	-	-	-	-	-
Annual recurring cost	2	2	2	2	2	-	-	-	-	-
Total annual costs	269	2	2	2	2	-	-	-	-	-
Transition benefits	0	0	0	0	0	0	-	-	-	-
Annual recurring benefits	144	110	84	59	35	-	-	-	-	-
Total annual benefits	144	110	84	59	35	-	-	-	-	-

* For non-monetised benefits please see summary pages and main evidence base section

Microsoft Office Excel Worksheet

Evidence Base (for summary sheets)

There is discretion for departments and regulators as to how to set out the evidence base. However, it is desirable that the following points are covered:

- Problem under consideration;
- Rationale for intervention;
- Policy objective;
- Description of options considered (including do nothing);
- Costs and benefits of each option (including administrative burden);
- Risks and assumptions;
- Direct costs and benefits to business calculations (following OIOO methodology);
- Wider impacts;
- Summary and preferred option with description of implementation plan.

These sections are expanded below.

List of explanatory boxes, tables and figures

Problem under consideration

Background to the Nitrogen Dioxide limit value and why additional time to meet the limit value must be sought

1. Nitrogen Dioxide (NO_2) is an air pollutant which is harmful to human health and the environment. Directive 2008/50/EC sets out hourly and annual limits for the concentration of NO_2 in ambient air, set out in Box 1. These limits had to be met by all Member States by 2010. The Directive allows Member States to extend this deadline until 2015 upon the acceptance by the European Commission of plans to achieve that deadline. The options considered within this document focus on how progress can be made towards achieving our NO_2 limit value obligations by 2015. Therefore the impacts are a subset of the total impact of Directive 2008/50/EC.

Box 1: The limit values for NO_2

The limit values for NO_2 are as follows:

- An hourly limit value of 200µg/m^3 for outdoor air not to be exceeded more than 18 days each year.
- An annual limit value of an average of 40µg/m^3 for outdoor air.

These limit values are based on World Health Organisation guidelines and were first introduced by Directive 1996/62/EC (consolidated by Directive 2008/50/EC).

2. All combustion processes produce air-borne oxides of nitrogen (NO_X). Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen, which together are referred to as NO_X. Road transport is the most significant source of these emissions, in areas exceeding the NO_2 limit value, followed by the electricity supply industry and other industrial and commercial sectors. NO_2 is associated with adverse effects on human health, and at high levels causes inflammation of the airways. Long-term exposure may affect lung function and cause adverse respiratory symptoms. NO_2 also exacerbates the response to allergens in sensitive individuals. High levels of NO_X can have an adverse effect on vegetation, including leaf or needle damage and reduced growth. Deposition of pollutants derived from NO_X emissions contribute to acidification and/or eutrophication of sensitive habitats, which in turn can lead to loss of biodiversity. Impacts can arise at locations far removed from the original source of emissions. NO_X also contributes to the formation of secondary particles and ground-level ozone, both of which are associated with ill-health effects. Ground-level ozone also damages vegetation.

3. Assessment of compliance with NO_2 and other EU limit values is done on the basis of air quality data from a network of monitoring sites across the UK (called the Automatic Urban and Rural Network or AURN), supplemented by modelling of pollutants using a GIS-based Pollution Climate Mapping model (PCM) which is underpinned by data from the National Atmospheric Emissions Inventory and ambient monitoring data from national monitoring networks[1]. The AURN network meets siting and other requirements set out in Directive 2008/50/EC and assessment is carried out in accordance with requirements in the Directive and with guidance issued by the European Commission. Assessment is carried out during the year immediately following data collection and must be submitted to the European Commission by the end of September of the following year. The UK will therefore submit its assessment of compliance with EU limit values for 2010 in September 2011. For the purpose of assessment, the UK is split into 43 zones and agglomerations. There are 28 agglomerations (contiguous urban areas with a population greater than 250,000) and 15 other zones.

4. The UK reports compliance on a zone-by-zone basis, according to the length of major urban roadside recorded as exceeding the daily or annual limit value. Table 1 below summarises the number of zones reported as exceeding the limit value and the total length (in kilometres) of major urban roadside exceeding the limit value for the years 2001 to 2009 (inclusive) with projected

[1] Grice et al (2008). UK air quality modelling for annual reporting 2008 on ambient air quality assessment under Council Directives 96/62/EC, 1999/30/EC and 2000/69/EC. Available at www.uk-air.defra.gov.uk

figures for 2010 (based on a 2008 baseline). 2010 was the year in which full compliance was due. This table 1 shows that the UK did not meet the limit value for NO_2 in 40 out of 43 zones in 2009 and is projected to not meet the limit value in 37 out of 43 zones in 2010. The roadsides assessed for compliance are along urban roads and whilst the total length assessed has changed over the decade, it now stands at 13,610 km. Therefore, the extent of roadside assessed as exceeding the limit value in 2009 was about 24 per cent of the total length assessed.

Table 1: Summary of number of zones and km of major urban roadside exceeding the limit value (LV) from 2001 to 2010

	Year									
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 Projection (2008)
Number of zones exceeding NO_2 annual mean LV	38	36	42	39	38	39	41	40	40	37
Kilometres of roads in exceedence of NO_2 annual mean LV +	5546	3346	7394	4754	5015	4745	4812	3623	3270	2163
Number of zones exceeding NO_2 hourly mean LV *	4	1	3	1	2	1	2	3	2	N/A

(+) It is not possible to model the length of km in exceedence of NO_2 hourly mean LV.

(*) It is not possible to project exceedences for NO_2 hourly mean LV

5. Many other Member States have not met the EU limit value for NO_2 and all major Member States have had significant problems in achieving the limit value by 2010. For this reason, Directive 2008/50/EC allows Member States to extend the deadline to achieve this limit value to 2015. In order to obtain an extension, Member States must prepare and submit to the European Commission plans setting out measures to achieve the limit value by the extended deadline as quickly as possible (and no later than 2015). These plans must be submitted for each zone in non-compliance by September 2011.

6. The reasons for the widespread difficulties in achieving NO_2 limit values are explained in more detail in the next section. In summary, it can be seen that the main reasons are: the underperformance of emission standards; increases in the fraction of NO_X emitted as NO_2; and the differing valuation methodologies in the UK and EU.

7. *The underperformance of emission standards on road vehicles (Euro standards)*: Recent evidence reviewing the effectiveness of previous Euro standards has suggested that the expected reductions in emissions especially of NO_X have not been realised. The underperformance of these standards would partially explain the difference between the previous and current modelled concentrations.

8. The fraction of NO_X emitted as NO_2 has also increased. This results in proportion of emissions of NO_X directly contribution to NO_2 concentrations has increased at the roadside.

9. *Differing valuation methodologies in appraisal in UK and EU*: The UK (Interdepartmental Group on Costs and Benefits (IGCB)) and EU (Clean Air For Europe (CAFE)) methodologies to value air pollution are similar in a wide range of aspects. However, differing assumptions has meant that the two can provide widely diverging valuations of similar changes in air quality. Table 2 below illustrates this gap for a common change in air quality.

Table 2: IGCB and CAFE valuation of air pollution (£ million annualised)[1]

	IGCB values (UK)			CAFÉ values (EU)			
	40 yr lag	No lag		Median VOLY[2]	Mean VOLY	Median VSL[3]	Mean VSL
NOx	733	1,068		3,914	6,725	6,022	10,038
Sulphur Dioxide (SO_2)	1,097	1,621		6,624	13,049	10,038	19,071
Particulate Matter (PM)	37,384 (PM_{10})	54,259 (PM_{10})		37,138 ($PM_{2.5}$)	73,271 ($PM_{2.5}$)	57,211 ($PM_{2.5}$)	110,408 ($PM_{2.5}$)

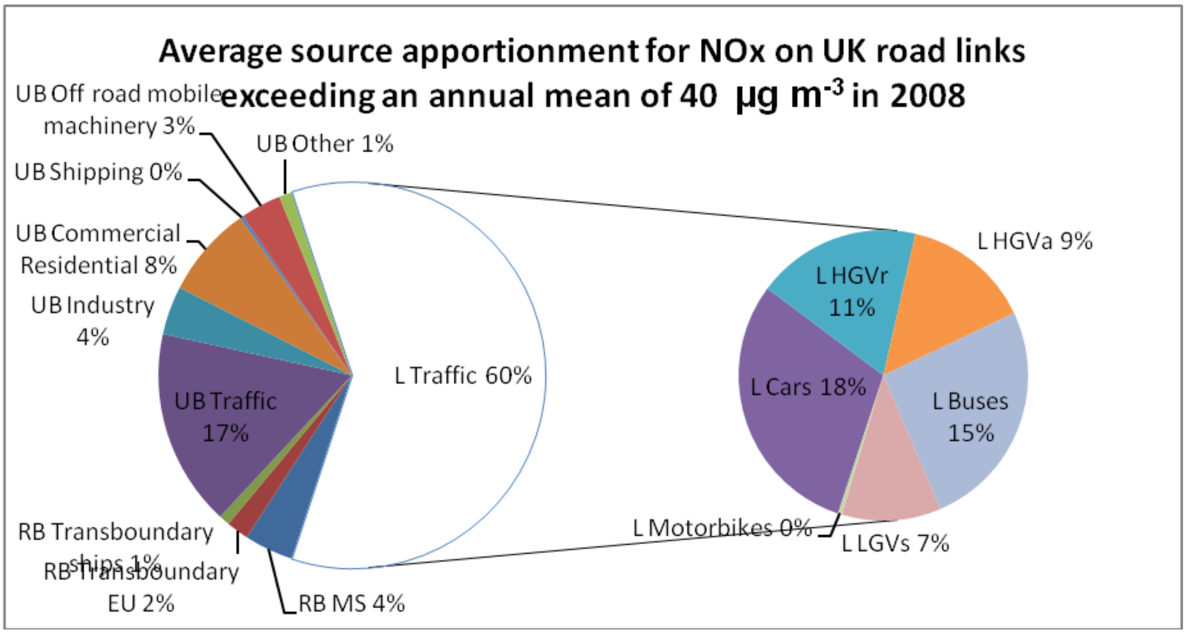
[1] Exchange rate used = £1:€1.1 (as at 21/1/2009)
[2] Value of Life-Year
[3] Value of a Statistical Life

10. Table 2 above shows that for a common change in air pollution, valuation in Europe can diverge substantially. Focusing on NO_X, the table shows that the EU value is between 3.6 and 13.7 times the UK value. This substantial gap may mean that measures to improve air quality that look desirable under the EU methodology do not look desirable in UK appraisal. This differential however can partially be explained by the differing roles of the two approaches with IGCB focusing solely on concentrations below the safety net while the CAFE values are used to inform the setting of the safety net.

Sources of NO_2 pollution

11. Figure 1 shows the mean source apportionment across all roadsides with exceedences of the annual NO_2 limit value in 2008. On average, local traffic (based on the roads assessed) is the source of 60 per cent of NOx concentrations (a mixture of NO_2 and NO). Urban background traffic contributes a further 17 per cent, with domestic and industry sources accounting for the remainder. Whilst source apportionment will vary for different road types across the UK, generally speaking, road transport represents the predominant emissions source. Therefore, reductions in NO_X emissions from these sources have the potential to deliver significant progress towards compliance with NO_2 limit values. Reducing emissions from other sources (industrial, domestic and commercial) will also be of assistance, but they have much lower potential for such improvements.

Figure 1: NOx source apportionment, UK road links in exceedence (2008)



Measures taken to reduce road transport emissions and their impact

12. The current and previous UK Governments have introduced a large number of measures that have reduced NO_X (and hence NO_2) pollution from road vehicles over the last decade. These have included:

- Promoting the uptake of ultra-low carbon vehicle technologies;
- Support for local transport initiatives by local government;
- Action to ensure road vehicle emissions standards are effectively enforced;
- Using taxes to encourage uptake of cleaner vehicles, including discounts for buying heavy duty vehicles meeting Euro standards that are not yet mandatory;
- Sustained investment in public transport, including subsidising rail travel and national and local support for bus operators, making buses a viable alternative to car travel (around £2.5bn in 2010);
- Support for action to clean up vehicle fleets and operations, including grant programmes to encourage operators to fit pollution abatement equipment and support liquid petroleum gas (LPG) and compressed natural gas (CNG) conversions (around £80m during 1997–2006), grants to freight operators to encourage shift from road to rail inland waterways (around £40m in 2010), £45m to bus operators and local companies to encourage them to build the market for new, cleaner bus technology, £20m to local authorities to incentivise smarter ticketing technology, and building air quality requirements into rail franchise specifications;
- Sustained investment to promote cycling, walking and other sustainable transport including grants for "Sustainable Travel Towns" (£10m in 2004–2006), cycling training (£6m in 2010/11), "Cycle Cities and Towns" (£19m in 2010/11), walking and cycling to school initiatives (£12m in 2010/11), bicycle and rail (£14m in 2009–2011), and work and leisure projects (£8m in 2009–2011);
- Smoothing traffic flow on strategic roads by actively managing traffic during busy times using signs and varying speed limits, and researching innovative options such as NOx-eating paint along motorway fencing; and
- Arguing internationally for tighter NOx limits for aircraft, and halting runway expansion at all London's major airports.

13. These and other measures have been introduced at national level by the UK Government, either working in Europe to agree emission standards for new vehicles, nationally through fiscal incentives, or locally through traffic management and other measures.

14. Since the NO_2 limit values first came into force in 1999, there have been significant reductions in UK emissions of NO_X. Between 2000 and 2009 total emissions of NO_X are calculated to have fallen by 39% and the UK is expected to meet its national emission ceiling for NO_X under Directive 2001/81/EC in 2010. Emissions from the road transport sector fell by 52% between 2000 and 2009. Despite these large emission reductions, NO_2 concentrations have not declined to the extent projected when the limits were first set.

15. There are a number of reasons for this lack of decline in NO_2 concentrations some of which are historic and relatively well defined and others that are only just emerging and are yet to be addressed. In 2009 the UK updated its road transport inventory to reflect new knowledge about real world emissions of NO_X from a range of vehicle classes. The evidence showed that NO_X emissions had not decreased by the amounts expected from the reductions in the corresponding EU limit values that apply to the emissions of these vehicles when tested over the regulatory cycle for type-approval and onward selling into the EU market. The most significant changes for the UK

inventory were for emissions from Euro 3 and 4 diesel cars and Euro III Heavy Goods Vehicles (HGVs), introduced in 2000 and 2005. Subsequent analysis has shown that this unanticipated lack of performance of vehicle abatement technologies led to a reduction in the expected decline of in NO_X road transport emissions between 1998 and 2010 of 56 kilo tonnes. This has been compounded by the increase in the fraction of NO_X directly emitted as NO_2 from diesel vehicle exhausts due to the fitting of oxidation catalysts and certain types of diesel particulate filters aimed at reducing other pollutant emissions from vehicles manufactured to Euro 3 and 4 and Euro III and IV standards. This leads to higher NO_2 concentrations close to emission sources such as urban roads.

16. Other unanticipated changes in the in the UK road transport fleet over the last 10 years have also meant that emissions of NO_X have not decreased as far as expected. To help tackle carbon dioxide emissions, there has been growth in diesel vehicle activity with a switch from petrol to diesel in the car population with a concomitant increase in NO_X emissions per vehicle. There have also been increases in van and local bus activity in some urban areas.

17. Despite the known poor real world performance of a number of diesel Euro Standards and increases in the fraction of NO_X emitted as NO_2, ambient concentrations of NO_2 were expected to continue to fall from 2004 onwards. This has not been the case and investigations are now underway to try and explain this occurrence. Emerging evidence from different sources suggests a number of reasons including:
    - emissions from aging Euro 1 and 2 petrol cars are higher than our inventory currently suggests
    - real world emissions of NO_X from diesel cars and Light Goods Vehicles (LGVs) have reduced little over the past 15 years despite the introduction of increasingly stringent Euro standards
    - selective catalytic reduction (SCR) used on HGVs is ineffective at reducing NO_X emissions under urban-type (slow speed and low engine temperature) driving conditions. Work in this area is at an early stage and there may well be other reasons for the observed trend in NO_2 concentrations.

18. It is important to stress that compliance with the limit values has been achieved over large parts of the UK, but delivering the necessary improvements in urban areas has proved considerably more challenging than originally anticipated. The reasons outlined above are complex and underline the difficulties in both predicting the impacts of existing road transport abatement measures and in identifying additional measures that we can have confidence will bring about further emission reductions. Evidence is still emerging and our knowledge and understanding of NO_2 road transport emission sources are not yet sufficiently well advances to be continue to develop, and with them, our understanding of the achievability of meeting the NO_2 limit values.

Rationale for intervention;

19. The key driver for action in this area is the non-compliance with international obligations on ambient NO_2 concentrations. These constraints play an important role in protecting national air quality and act as a safety net for the level of air pollution across the UK.

20. More specifically, the need for limits on ambient concentrations (in addition to controls on the emissions from different sources) can be separated into three key additional benefits:
    - Efficiency – measures to constrain the rate of emission from sources may not, on their own, lead to the optimal level of air pollution. This is because the level of pollution depends upon both the rate of emission from each source and the usage of different sources.
    - Uncertainty – there are considerable uncertainties around the available evidence on the impacts of air pollution. Therefore the precautionary principle suggests it is reasonable to provide some minimum standards.
    - Equity – air pollution is not equally distributed across the UK and therefore minimum standards may be desirable to manage the distribution of the health and environmental costs of air pollution.

The need for additional measures

21. All the measures described above have been taken into account in UK projections for compliance with the NO_2 limit values. However, despite these measures, we do not expect to achieve compliance by 2015 in all zones. Table 3 below summarises projections for future compliance until 2020. This shows that in 2015, the UK would still exceed the limit value in 22 out of 43 zones and in at least 1 zone (London) in 2020. As these projections are based on the assumptions discussed earlier about expected pollutant emissions reductions from newer vehicles, it is likely that NO_2 exceedences after 2013 will be more widespread than suggested by these projections

Table 3: Exceedence projections

	Year			
	2010	**2013**	**2015**	**2020**
Number of zones exceeding NO_2 annual mean LV	37	31	22	1
Kilometres in exceedence of NO_2 annual mean LV +	2163	1338	691	43

+ It is not possible to model the length of km in exceedence of NO_2 hourly mean LV.

22. In order to improve the likelihood of compliance across as much of the UK as possible by 2015, to reduce the risk of infraction, and to achieve health and environmental benefits as quickly as possible, it would be necessary to implement additional measures, or basket of measures, to reduce NO_2 pollution, especially from road transport sources in those zones with the greatest number of exceedences.

Review of additional measures to achieve the NO_2 limit value

23. Since 2008, a large number of different options to achieve the NO_2 limit value have been reviewed. The full range of national and local measures has been identified through:

- Review of the Defra Air Quality Strategy measures;
- Review of other measures implemented by Department for Transport, Highways Agency and local authorities (through their air quality action plans);
- Review of measures being considered in the Mayor of London's Air Quality Strategy;
- Discussions with technical experts and local authority air quality practitioners;
- EC advice on measures as contained in Directive 2008/50/EC.

24. The range of measures considered include:

- Technology options, including retrofitment of NOx abatement equipment, low emission vehicles, improvement of building heating efficiency, and so on;
- Behavioural options, including encouraging additional modal shift away from cars, traffic management, and eco-driving techniques;
- Local transport measures, including parking controls, improvement of bus management arrangements, and air quality measures in local transport planning; and
- Strategic options, such as national action to support Low Emission Zones.

Measures have been reviewed for:

- Their potential impact on exceedences of NO_2 limit values;
- Their practicality in terms of acceptability and timescales for implementation;
- Their likely costs; and
- Their scope for national or local application.

25. This work has also been supported by the development of a marginal abatement cost curve (MACC) tool for NO_2. This tool has allowed Government to assess a range of technologies for their cost effectiveness and NO_2 abatement potential, and to rank them in order of most cost-effective or most cost-beneficial. Additionally, the tool has allowed us to translate these emissions

reductions into their potential impact upon projected concentrations of NO_2 at roadside locations in all UK zones.

26. The MACC tool analysis suggests that measures to improve pre-Euro IV vehicle standards, especially for heavy goods vehicles (HGVs) and buses (either through retrofitment with NOx abatement equipment or through new vehicle purchase) might be the most cost-effective measure available to increase compliance with the limit value. This initial assessment is on the basis of the estimated reductions these Euro standards are intended to achieve, and does not take into account the uncertainties, set out above, suggesting the performance of some of these vehicles standards have not been as effective as previously thought at reducing NO_X in the real world. Currently, it is not possible to estimate what their real-world performance might be, but it is likely that impacts would be lower than those predicted.

- **Policy objective**

27. The policy objective is to reduce pollution from the most significant sources of NO_2 in order to quicken progress towards compliance with EU limit values for this pollutant, so as to achieve health and environmental benefits and avoid infraction. The timely submission of the plans for the abatement measures required to meet this objective would ensure that the Government has demonstrated that it is making its best efforts to improve air quality, and is seeking additional time on this basis. These plans must be publically consulted on in spring 2011 and must be submitted to the European Commission by the end of September 2011. These plans can include current and planned measures for abatement and additional measures under consideration but which require further investigation and agreement before being taken forward.

28. Our modelling of air quality in 2015 suggests that it would be possible to achieve compliance with the limit value in 2015 in 21 out of 43 zones of the UK on the basis of current or already planned measures, and without the need for additional measures. However, in the remaining 22 zones, our modelling indicates that it would not be possible to achieve compliance on the basis of current measures alone. Therefore, in order to present the best case possible for progress towards the limit values by 2015, it would be helpful to demonstrate what additional measures are under investigation to abate NO_2 and help to deliver compliance. Implementation of such measures though would be subject to further investigation and feasibility assessment as well as consultation on any delivery mechanism.

Options considered

29. For the purposes of this appraisal, a wide range of potential options have been evaluated to identify the most efficient means to enable progress in delivering compliance. Analysis was undertaken in a staged approach, initially comparing almost 100 technologies for abatement potential and cost. Based on the results of this broad filtering exercise, two options were considered in more detail for achieving compliance with NO_2 limit values by 2015. These are:

    - To continue with current and planned programmes for reducing emissions, primarily through measures described above (effectively the baseline or “do nothing” option); or
    - To implement (subject to further consideration of feasibility etc) additional measures to reduce emissions from HGVs and buses in order to significantly increase the level of progress towards compliance by 2015 in as many zones as possible.

The policy implications of each of these options are considered below.

Option 1: Continue with current and planned programmes

30. This option would be to continue with current and planned programmes for improving air quality as described in paragraph 12 above. This would make some progress towards compliance in 2015; our projections suggest that compliance would be achieved in about half (21) of UK zones by 2015, with the remaining zones achieving compliance by 2020 (and London after 2020).

31. This option would involve no additional costs or benefits over and above those already planned, but would mean that the UK continues to exceed the EU limit value for much longer than would be allowed for under the Directive. This would put the UK at continued risk of infraction from the European Commission for non-compliance. This would be counter to UK Government policy to comply with European obligations. Infraction would likely lead to significant financial penalties.

Option 2: Implement a national framework for Low Emission Zones (LEZs) to reduce emissions from Heavy Goods Vehicles (HGVs) and buses in urban areas

32. The MACC tool analysis reviews a large number of different technologies for NOx abatement. It suggests that measures to improve pre-Euro IV vehicle standards, especially for HGVs and Buses (either through retrofitment or through new vehicle purchase) would be the most cost-effective measures available in order to achieve compliance in as many zones as possible, and to make good overall progress towards achieving compliance as quickly as possible.

33. Concentrations of pollutants are focused in major urban areas in the UK. This includes London, but also zones in the Midlands, the North West, Yorkshire and the North East. A number of towns and cities that are located in those zones are currently predicted to continue to exceed limit values after 2015.

34. This option envisages that these measures would effectively bring forward already-envisaged improvements in vehicle standards. This would be through locally-focused low emission zones (LEZs) in those cities or local authorities with significant air quality problems. It is assumed these LEZs would be supported by a national system for the certification of equipment and vehicles that are compliant with the standards for entering the low emission zone, as well as additional guidance as is necessary to support local authorities in administering and enforcing the scheme.

35. As the introduction of any LEZs would be at the discretion of the relevant Local Authority the timing of any such measures is inherently uncertain. To allow the necessary modelling it has been assumed that all such schemes would be introduced and effective on 31 December 2014. This date has been selected as the latest possible time that they could be introduced to deliver progress within the time extension. On a practical note this is likely to be the earliest date by which we might expect LEZs to be fully functional. This is because time will be needed to design, implement and promote such a scheme as necessary.

Why is intervention necessary for this policy?

36. Legislation already allows local authorities to restrict vehicle access into the centres of towns and cities according to Euro standards. However, so far, only a small number of local authorities have introduced low emission zones (outside London) and these have been limited to buses, where fleets are distinct and it is possible to negotiate improvements with operators.

37. Discussions with local authorities have highlighted obstacles to implementing low emission zones more widely without further national support. In particular, local authorities have cited:

- Competition risks between urban centres, where a city that introduces an LEZ may face additional costs (or lose commercial advantage) over a neighbouring urban centre which has not implemented the measure;
- Inconsistent standards and enforcement, where different standards for abatement equipment or enforcement and administration systems in different authorities might lead to uncertainty for operators seeking to comply, and potentially push up costs significantly for both operators and authorities; and
- Concerns that LEZs might disperse pollution elsewhere, creating new air quality management areas or that LEZs might not be appropriate on through routes
- Opposition to measures which might be seen as costly for operators to comply and for local authorities to implement and administer.

38. In addition to the above, the Mayor of London has stated in his Air Quality Strategy that implementation of an LEZ for NO_X would be conditional on the introduction of a national framework and certification scheme for LEZs. Given that very few authorities outside London have introduced or given serious consideration to implementing a low emission zone, it is highly unlikely that the Mayor of London and authorities outside London would consider implementing low emission zones for NOx abatement without some central support or stronger encouragement from national Government.

39. A national framework would be one mechanism to help facilitate local decisions to implement low emission zones both in London and elsewhere, and would go some way to easing the concerns raised by local authorities by reducing competition risks and inconsistencies in standards. Such a national framework could provide:

- A consistent minimum standard for vehicles entering low emission zones;

- A process for recognition of retrofitment equipment eligible for use in the zone; and
- A process for recognition of vehicles that meet the minimum standard, either through retrofitment or other means.

40. In addition to this, it may be appropriate or even necessary for a national framework to provide guidance on enforcement and in-use compliance for checking vehicles and equipment, and providing advice and support on implementing an LEZ.

41. Timing for such a framework is also key given that the natural replacement in the fleet will slowly improve the emissions from the fleet. In evaluating this area it has been assumed that any new LEZs would be introduced on 31 December 2014 (the last day before the end of the potential time extension). While it is possible that some would be introduced before this date it is likely that full implementation would only be feasible on this timescale to allow the consultation, developments, and publication of any framework and to allow time for LAs to consider, react and implement any consequent actions.

Uncertainties

42. There are a number of uncertainties and sensitivities in implementing this measure, which are discussed in more detail in paragraphs 135 to 160. In particular, as stated above, the real-world performance of a range of vehicle classes has not been as strong as expected. Therefore, it is probable that the rate of emission reductions based on the redeployment of the fleet to comply with LEZs would not be as strong as is projected by this model.

43. Further investigation of these uncertainties is necessary before any final decisions could be made on whether or not to proceed with a national framework for LEZs in particular it is necessary to answer questions regarding:
    - The technical feasibility of abatement equipment available to reduce NOx exhaust emissions
    - The administrative options available for ensuring equipment and vehicles meet necessary standards for compliance
    - the likely costs of any framework both to Government and to local authorities
    - the likely costs of any framework for vehicle operators
    - the range of impacts possible, based on real world emissions, given that there are some uncertainties as to the effectiveness of current NOx reduction standards.
    - uncertainties relate to the expected behaviour of vehicle owners and the impacts of retrofit on fuel consumption and emissions of other pollutants, including greenhouse gases

44. These and other matters would require investigation which would continue following submission of Plans to the European Commission. This impact appraisal would therefore be developed to take into account these investigations and decisions would be made at a later stage on the basis of that investigation as to whether or not these measures are viable and should be pursued further.

- **Costs and benefits of each option (including administrative burden)**

Methodology

45. The evaluation of these options has been undertaken consistently with best practice guidance, including Green Book and IA guidance. In valuing changes in air quality, guidance is provided by the Interdepartmental Group on Costs and Benefits Air Quality subject group (IGCB(A)). This group recommend two broad methodologies for the valuation of changes in air quality: either social cost, where air quality changes occur within the UK's legally binding obligations, or abatement cost, where changes either occur in areas of non-compliance or where the change would cause non-compliance. As this work considers changes in air pollution within areas where legally binding objectives are not being met, the abatement cost approach has been applied. This methodology was introduced in March 2010 in the paper "Air Quality – Valuing Environmental Limits"[2].

[2] http://www.defra.gov.uk/environment/quality/air/airquality/panels/igcb/documents/100303-aq-valuing-env-limits.pdf

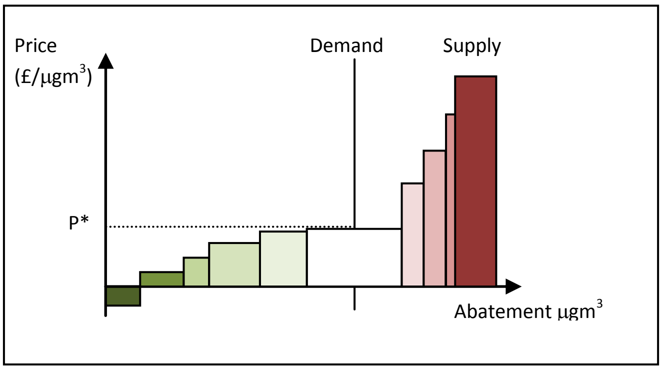
46. This approach reflects the importance of legally binding objectives by valuing changes in air pollution at the cost of alternative options which deliver the same (limit value) outcome. A proposal to reduce air quality in an area of exceedence needs to include the cost of restorative measures to compensate for these damages. Box 2 provides a brief summary of the rationale and application of this methodology.

Box 2: Abatement Cost Approach

In March 2010, the IGCB(A) introduced a supplementary methodology to monetise changes in air quality in situations where air quality did not comply with binding legal obligations. This methodology was introduced to address concerns that it had not been possible to fully reflect legal obligations in decision making. This gap can create contingent liabilities by committing to future expenditure to deliver on those legal obligations. In line with the Green Book[1], these impacts are valued in appraisal (such as the ‘target-consistent’ approach employed to value non-traded carbon[2]). This box briefly sets out the rationale and application for this methodology.

Monetary cost benefit analysis (CBA) provides a framework to compare different options to inform decision making. CBA provides a notable advantage for decision makers in presenting costs and benefits in the same metric – money. It thereby facilitates the direct comparison of different impacts both within the same option and across options. Monetisation of different impacts is calculated by multiplying the level of change by the marginal value of the change. For example, the value of fuel saving is estimated by the volume of fuel saved multiplied by the resource cost (derived from market price).

Key to the application of CBA is the valuation of impacts which are not traded on the market (“non-market goods”). As it is not possible to directly observe market prices for these goods, it is necessary to estimate the value of the outcome if a market were to operate. In this policy, the key non-market good is NO_2 abatement as measured in changes in concentrations. If a market were to operate for this outcome, the price would be determined by the interaction of the demand and supply conditions. In equilibrium, the price would be set at the level at which the supply and demand for abatement were equal (known as the “market clearing price”).



This diagram illustrates the modelling of the market. Supply is estimated using the marginal abatement cost. Demand is then set The intersection of these two identifies the marginal abatement technology and thereby the value of changes in ambient concentrations. In this diagram this price is identified as P*.

This estimated price will depend on the pollutant, the obligation and the location of the exceedence. Therefore for detailed application, this approach needs to be applied at the local level in order to accurately reflect the circumstances. Through this methodology, it is therefore possible to value (where a legal obligation is not met) both increases and reductions in concentrations. Further information on this guidance is available from www.defra.gov.uk.

The IGCB is currently working to integrate this methodology with appraisal across policy making. To do so it is developing further tools and guidance to support application of this methodology. Such tools will be tested with stakeholders for practicality and usability.

[1] Available at www.hm-treasury.gov.uk/d/green_book_complete.pdf

[2] Available at www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx

To analyse the efficacy of the wide range of different measures to improve air quality, a number of different techniques have been employed. The process was broadly separated into two stages:

- **Prioritisation** – The first stage was to compare the costs and abatement potential of almost one hundred technical abatement technologies. The results of this analysis were then used to prioritise the types of change that could most effectively reduce NO_2. A cost-effectiveness analysis was then used to assess the broad strategic levers which could deliver the prioritised abatement technologies.
- **Option appraisal** – Once the technologies and levers had been prioritised, a more in-depth analysis of the leading option was undertaken. It is this analysis which has been reported in the summary sheets of this impact assessment.

47. This section covers both of these stages and reports the evidence. It must be noted that in working through this process, new evidence has been built into the modelling; therefore, the assumptions between stages may not be consistent and consequently results differ. While these changes have altered the absolute results for different measures, they have not altered the relative ranking of the different options and so do not alter the preference between the options.

Prioritisation

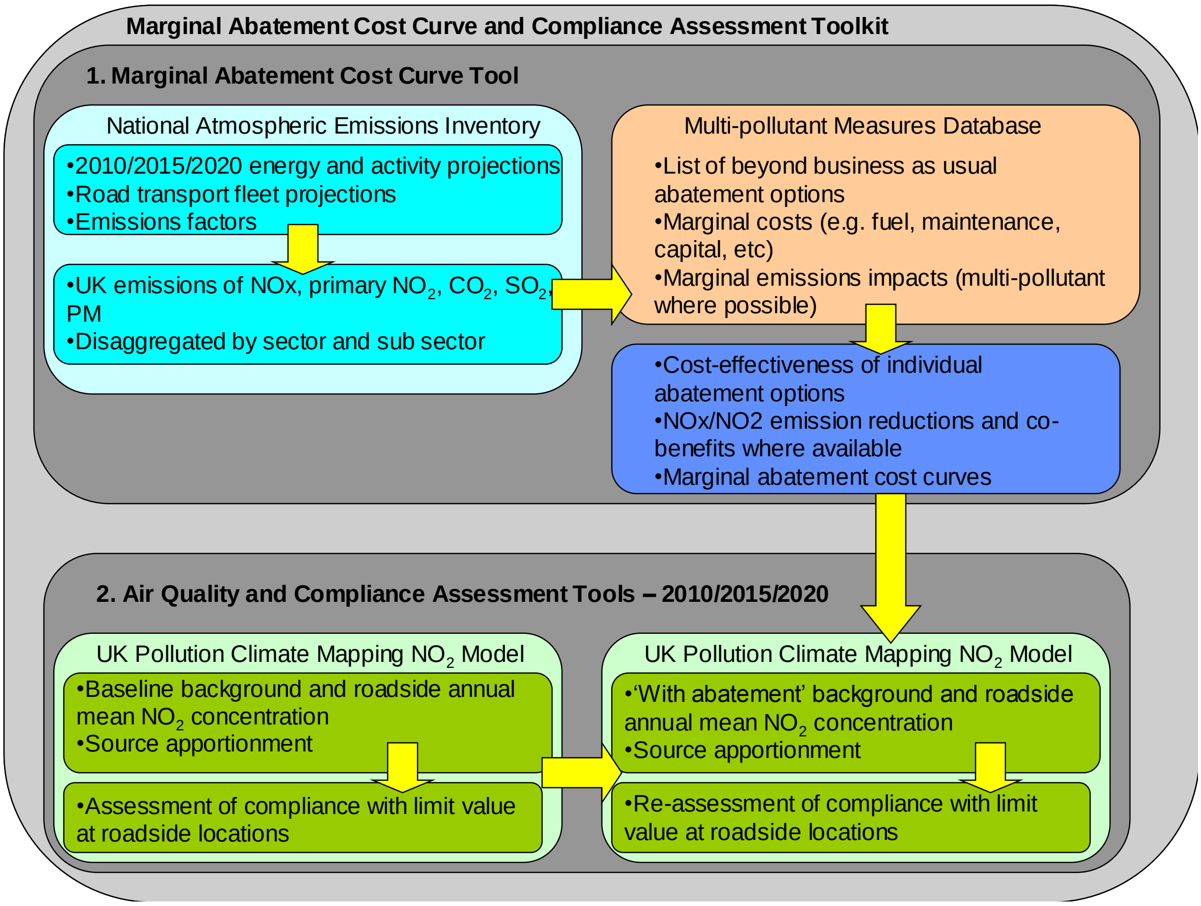
48. The prioritisation exercise was undertaken in a two stage process:

    - Technological potential – This stage considered the technical abatement opportunities from a wide range of sources. This stage focused exclusively on the potential abatement and therefore did not consider the potential routes to implementation.
    - Policy potential – The second stage then considered a range of options to deliver the types of technological changes prioritised above.

Technological Potential

49. To prioritise the wide range of potential abatement options, a marginal abatement costs curve (NO_X MACC) was developed. This tool ranks different abatement options based on their cost-effectiveness. Figure 2 below provides a schematic diagram to illustrate the data and tools used to develop the NO_X MACC.

Figure 2: Marginal Abatement Cost Curve Schematic



50. The NO_X MACC can be broadly separated into two parts:

- Marginal abatement cost curve tools, which estimate the marginal cost effectiveness of individual abatement options; and
- Air quality and compliance assessment tools, which assess the impact of either individual options or packages of options on compliance with NO_2 limit values.

This section explains each of these tools separately. Linking these tools occurs by taking the outputs of the marginal abatement cost curve and inputting them into the compliance tools, once an abatement option or package of abatement options has been selected.

Marginal abatement cost curve tools

51. Given the aim of delivering improvements towards our NO_2 obligation, the technologies identified focus primarily on domestic and road transport sources of NO_X. Table 4 below provides a summary of the 96 different technologies included within the NO_X MACC.

Table 4 Abatement options considered in the NO_X MACC

Sector	Sub-sector	Abatement options
Road Transport	Heavy Goods Vehicles	Retrofit SCR[1], Accelerated uptake of Euro VI
Road Transport	Buses and coaches	Retrofit SCR, Replace with diesel-electric hybrid, Accelerated uptake of Euro VI, Replace with hydrogen, Replace with electric
Road Transport	Petrol cars	Downsize to 1.4-2.0l, Replace with electric
Road Transport	Diesel LGV	Accelerated uptake of Euro 6
Road Transport	Diesel cars	Replace with electric
Road Transport	Diesel taxi	Replace with electric
Road Transport	Diesel LGV	Replace with electric
Domestic	Homes	Retrofit cavity wall insulation, Retrofit loft insulation, Improve domestic thermal efficiency, Improve boiler efficiency
Commercial	Buildings	Retrofit dry lining of solid wall, Retrofit external insulation of solid wall, Retrofit injection of cavity wall insulation, Retrofit metal deck flat roof insulation, Retrofit timber deck flat roof insulation, Relining of pitched roof, Retiling of pitched roof, Improve energy efficiency via boiler replacement
Power generation	Power stations	Fit selective catalytic reduction

[1] Selective catalytic reduction (SCR)

52. The Multi-Pollutant Measure Database (MPMD) is a database of potential measures which was developed to support the consideration of future air quality policies, such as a revised Gothenburg Protocol and National Emissions Ceiling Directive (NECD). This database was used for each of the options in Table 4 to provide estimates of the baseline emissions, stock data, potential uptake rate of abatement technologies, unit marginal costs and capital costs. The assumptions used in this modelling are based around the best available evidence however there are uncertainties around the actual performance.[3]

53. More information on the development and results of the MPMD is available from www.defra.gov.uk/environment/quality/air/airquality/eu-int/conventions/gothenburg.htm.

54. Where data permitted, the marginal effectiveness of each option has also been estimated on changes in particulate matter (PM), sulphur dioxide (SO_2), volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH_3), carbon dioxide (CO_2) and methane (CH_4). Where appropriate, these changes in emissions from the technologies have been valued in line with best practice from the Interdepartmental Group on Costs and Benefits for air pollutants (available from www.defra.gov.uk) and Department of Energy and Climate Change guidance for pollutants with climate change potential (available from www.decc.gov.uk).

Air quality and compliance assessment tools

55. The impact of abatement options on compliance is assessed based on existing methods and data used to support national air quality policy development.

56. Estimation of baseline concentrations is based on the outputs of the UK NO_2 Pollution Climate Mapping model (PCM). The PCM has been developed over several years to provide details on the mean NO_2 concentrations at UK background and major roadside locations. It does this by estimating local concentrations modelled from the National Atmospheric Emissions Inventory (NAEI) emissions database and is calibrated against the Automatic Urban and Rural Network of air pollution monitors. This is the primary tool for assessing and reporting annually to UK government and the European Commission the UK's level of compliance with the NO_2 limit value.

57. The air quality emission projections used in the MACC assessment are based on:

- Projected energy used: Updated Energy Projection 37 (UEP37) central polices, central growth and central prices – published April 2009
- Traffic projections - DfT's 2008 traffic forecasts, and TRL's updated emission factors 2009

[3] The real world performance of different technologies may differ from the modelled impacts. As noted above recent evidence on Euro standards suggest that they may not have been as effective as predicted.

- Emission factors: 2007 NAEI, compiled 2008/9.

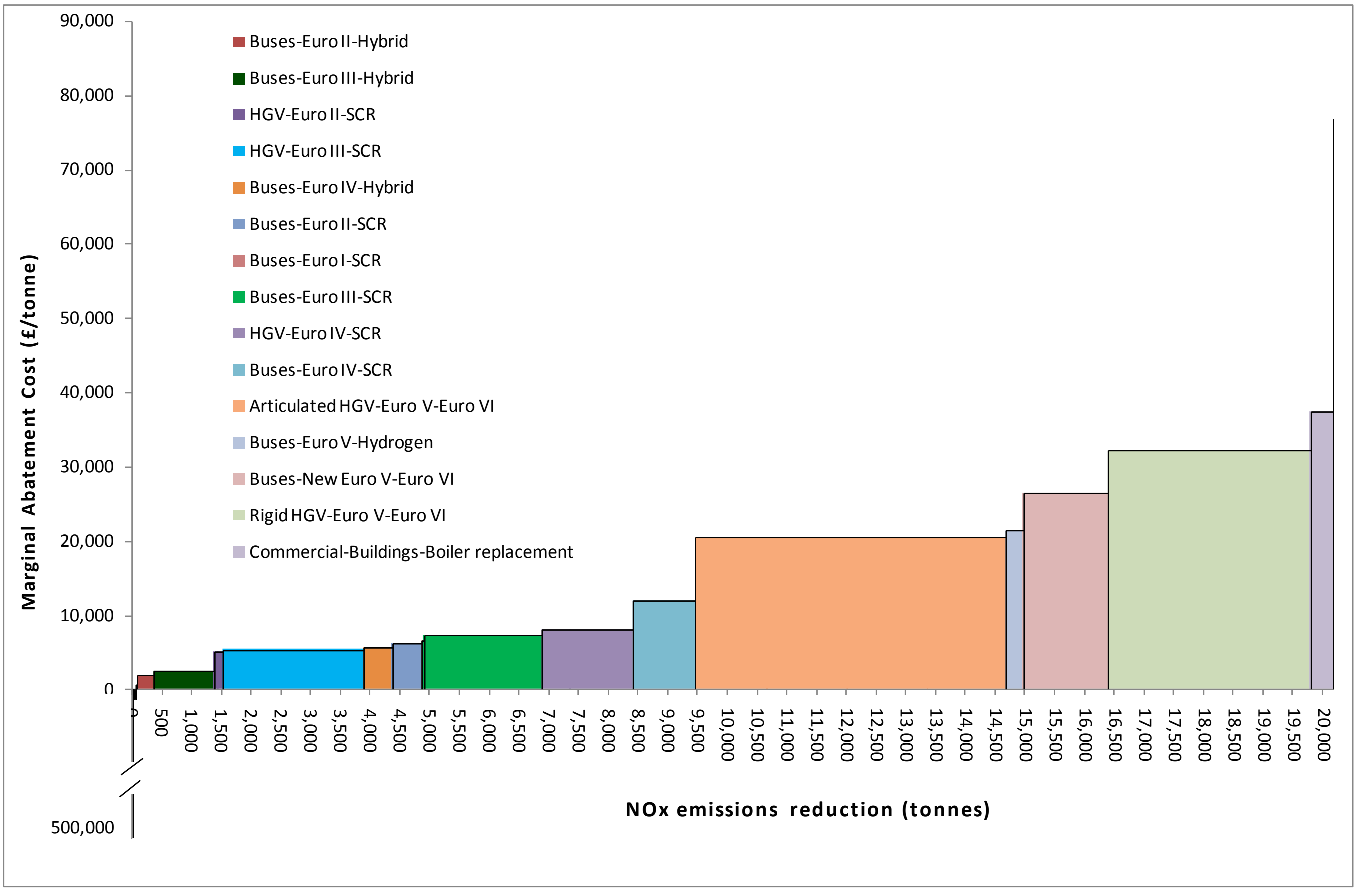
58. To model the changes in concentrations, selected changes in NOx and primary NO_2 emissions are taken from the marginal abatement cost curve tools and used to vary concentrations in areas associated with their sources. For example a measure that was estimated to reduce NO_X emissions from a source by 30 per cent would be modelled to reduce NO_X concentrations attributed to this source by 30 per cent. Therefore in this case if a source emitted 100 tonnes of NOx and accounted for 10 μgm^3 of NO_X concentrations then a 30 per cent reduction would be estimated to save 30 tonnes or 3 μgm^3 of NO_X. Once the reduction in NO_X concentration is calculated, this is deducted from the original NO_X concentration to give a new total NO_X. The NO_2 concentration is then calculated from this new NO_X total using the oxidant partitioning model.

Results

59. Bringing together the marginal abatement cost curve tools and the air quality and compliance assessment tools, it is then possible to rank all the different abatement options by cost effectiveness, and then for selected options or packages of options, estimate the impact on ambient concentrations. These changes in concentrations thereby provide an indication of the level of progress made by the selected option(s).

60. Figure 3 below provides an illustration of the NO_X MACC in 2015 produced by the marginal abatement cost curve tools. This curve plots the marginal cost of abatement (per tonne of NO_X) on the X axis against the potential amount of abatement (in total tonnes of NO_X) on the Y axis. (In order to make this curve legible, options with a net benefit over £100,000 per tonne or costs over £700,000 per tonne are not shown.)

Figure 3: NO_X MACC (2015)[4]



61. Figure 3 shows that while substantial additional potential for abatement has been identified within these measures, the cost of that abatement varies substantially, from a net benefit of £78 million per tonne to a net cost of £7.4 million per tonne. The potential of each option to abate also varies significantly between 0.1 tonnes and 5.2 kilo tonnes in 2015.

62. Prioritisation of these abatement options was then undertaken on the basis of three criteria:

- Abatement cost: with preference given to the lower cost options;
- Abatement potential: with higher abatement potential preferred; and
- Interdependences: as a range of options are required, complementary packages were sought.

63. To focus on the more feasible options, Table 5 below shows the impacts (both as costs of abatement and abatement potential) of the different options identified with a marginal abatement cost of below £80,000 per tonne abated.

[4] Abatement measures such as petrol car downsizing options and changing Euro VI buses to electric vehicles have been omitted as all had high cost savings with relatively small emissions reductions; thus they skew the graph such that the other options are illegible.

Table 5: Marginal abatement cost curve, below £80,000 per tonne (2015)

Abatement option	Abatement cost (£/t 2015)	Abatement potential (t/NOx)
Petrol cars-Euro 6 >2.0l-Downsize 2l to 1.4-2l	-£78,038,063	7.1
Petrol cars-Euro 6 1.4-2.0l-Downsize 1.4-2l to under 1.4l	-£70,105,280	6.0
Petrol cars-Euro 5 >2.0l-Downsize 2l to 1.4-2l	-£37,048,081	78.1
Petrol cars-Euro 5 1.4-2.0l-Downsize 1.4-2l to under 1.4l	-£33,282,021	66.3
Buses-Euro VI-Electric	-£502,375	2.7
Buses-Euro V-Electric	-£100,741	19.7
Buses-Euro I-Electric	-£2,296	0.5
Buses-Euro IV-Electric	-£1,294	13.1
Buses-Euro III-Electric	-£1,231	24.7
Buses-Euro II-Electric	-£1,134	6.2
Buses-Euro I-Hybrid	£684	21.0
Buses-Euro II-Hybrid	£1,860	274.7
Buses-Euro III-Hybrid	£2,454	1017.1
HGV-Euro II-SCR	£5,099	155.0
HGV-Euro III-SCR	£5,380	2353.3
Buses-Euro IV-Hybrid	£5,604	481.5
Buses-Euro II-SCR	£6,251	498.6
Buses-Euro I-SCR	£6,625	37.3
Buses-Euro III-SCR	£7,257	1977.6
HGV-Euro IV-SCR	£8,053	1524.9
Buses-Euro IV-SCR	£11,889	1048.6
Articulated HGV-Euro V-Euro VI	£20,457	5224.9
Buses-Euro V-Hydrogen	£21,365	281.8
Buses-New Euro V-Euro VI	£26,452	1433.1
Rigid HGV-Euro V-Euro VI	£32,300	3394.5
Commercial-Buildings-Boiler replacement	£37,470	384.0
Diesel LGV-Euro 1-Electric	£76,795	0.7

64. Table 5 shows that, according to the MACC, abatement from heavy goods vehicles (including buses) is the most effective approach to deliver additional abatement. As the options are considered in isolation, it is not possible to simply add the different abatement options to determine their collective abatement potential as a package of abatement options. Taking an illustrative package of requirements where SCR is fitted to all buses and HGVs, this package would have an abatement potential of 7,595 tonnes in 2015 at a relatively low average abatement cost of £6,316 per tonne. In addition to the low costs estimated, focusing on a single subsector of road transport is advantageous in order to manage implementation costs.

65. Other options presented above were not prioritised, either for the lack of potential abatement or for the high implementation costs involved. For example, downsizing petrol cars was seen to be very cost effective, creating a net benefit of £38.6 million. However, the potential abatement for such a measure was relatively low, with a total abatement potential of 158 tonnes, while levers to encourage such a change would be difficult to implement.

Policy potential

66. The two options evaluated to deliver abatement through heavy goods vehicles are:

- Low Emission Zone (LEZ) framework, where a framework would be produced by central government to support the introduction of LEZs by local authorities where exceedences of NO_2 objectives are expected; and
- Clean HGV grants, where financial support would be given by central government in order to encourage HGV operators to reduce emissions from HGVs.

67. Assessment of these two options is undertaken using both a monetary cost-benefit analysis of the change in emissions and an assessment of the impact on exceedences of the NO_2 limit values. Monetary values of the change in emissions of air pollutants have been valued based on IGCB(A) damage costs. It should be noted that not all costs and benefits can be monetised and therefore this analysis does not present the full scale of social impacts.

68. Both the schemes are based on common estimates of both fleets in 2015. The potential of Euro IV vehicles for retrofitment is limited as part of the fleet already has the technology fitted. The modelling assumed that 80% of the Euro IV fleet in 2015 would not be suitable for retrofitment. This was based on DfT expert opinion. Table 6 provides the estimated fleet of HGVs and buses in 2015 with potential for SCR retrofitment

Table 6: HGV and bus fleet with potential for SCR by Euro standard (2015)

	Fleet 2015
Rigid HGV	
Euro II	2,590
Euro III	35,174
Euro IV	6,427
Articulated HGV	
Euro II	352
Euro III	11,956
Euro IV	2,716
Buses	
Euro II	4,654
Euro III	21,433
Euro IV	3,723
Source: National Transport Model	

LEZ framework

69. A LEZ framework is designed to support Local Authorities (LAs) in their air quality plans to meet the NO_2 limit value. The main part of the framework is the establishment of a certification scheme which will allow local authorities to determine if a vehicle is of the correct emissions standard to be allowed into the LEZ. Modelling of this measure has been based on the assumption that the response to the theoretical LEZ framework would be to install SCR to all pre-Euro V HGVs and buses.

70. At the initial screening stage the effectiveness of SCR was taken from the MPMD. The assumption of a 70% reduction in NOx emissions was used for HGVs and buses.

71. A key parameter in analysing the impacts of an LEZ framework is estimating the number of LAs which would be likely to introduce an LEZ. The concentration levels estimated by the air quality and compliance assessment tools set out above were used to estimate the number of LEZs. To simplify this decision, it was assumed that any LA with a modelled NO_2 concentration of above 45 $\mu g/^{m3}$ in 2015 could introduce an LEZ. As a result, 16 LAs were identified as possible candidates to introduce an LEZ. It was assumed that not all of the fleet would be impacted by these LEZs and consequently 30 per cent of the fleet are assumed never to enter these 16 zones.

Costs of LEZ framework

72. The primary costs of this measure can be separated into three parts:

- Technology costs: The unit and maintenance costs for SCR technology are shown in Table 7 below. The costs presented in Table 7 split the cost of SCR into two parts, being unit costs, reflecting the new equipment installed on the vehicles, and maintenance costs, reflecting the additional cost to operate a vehicle with SCR.

Table 7: Technology Cost

	Fleet	SCR cost	Total (£million)
Rigid HGV			
Euro II	2,590	£4,785	8.77
Euro III	35,174	£5,623	138.4
Euro IV	6,427	£6,664	30.0
Articulated HGV			
Euro II	352	£5,002	1.2
Euro III	11,956	£7,442	62.3
Euro IV	2,716	£10,240	19.5
Buses			
Euro II	4,654	£4,893	15.9
Euro III	21,433	£6,553	98.0
Euro IV	3,723	£8,453	22.0
Total			**£396.1**
Source: Defra DfT modelling based on lifetime remaining of vehicle			

- Operation costs: Introduction of a LEZ imposes costs in preparation, set-up and ongoing costs of implementation to each LA. Table 8, provides the estimated costs for each of these activities for each LEZ.

Table 8: Operation costs for a LEZ

	Transitional	Ongoing (per annum)
Preparation	£82,000	-
Set-up	£110,000	-
Implementation (per annum)	-	£85,000
Total (assuming five year operation)		**£617,000**
Source: Low Emission Zones in Europe, Sadler Consultants (2010)		

- Certification costs: Certification of the equipment and the installation of SCR are necessary to ensure that the technology will deliver the desired emission abatement. The certification costs are set out in Table 9.

Table 9: Certification costs

	Transitional
One-off	£4,000
Number of firms	8
Annual cost	£1,000
Duration (years)	5
Total	**£72,000**

73. The total costs of this framework and consequently, of the introduction of LEZs, are presented in Table 10 below.

Table 10: Costs of introducing LEZ framework in 2015 (£ millions)

Technology cost	Operational cost
Technology cost (total table 7)	£396.1
Operational cost (total table 8) [(a)]	£10.5
Certification cost (total table 9)	£0.07
Total	**£406**
(a) Based on the introduction of 17 LEZs	

Benefits of LEZ framework

74. The benefits of this option have been calculated according to the NO_X MACC methodology set out above (paragraphs 48-57). This analysis allows the estimation of both the monetary benefits resulting from reductions in emissions of PM and NO_X and the impact on the baseline exceedences of NO_2 limit values. Within this modelling, it was not possible to separate out the areas where there was an LEZ, so modelling was undertaken assuming LEZs occurred in all areas with an exceedence. This therefore provides a maximum potential benefit from a low emission zone applying across the entire country.

75. Table 11 below presents the monetised air quality benefits from the introduction of a LEZ framework.

Table 11: Air quality benefits of LEZ framework (£ millions)

Particulate Matter (PM)	Oxides of Nitrogen (NO_X)	Total
£46.6	£22.8	£69.4

76. The second key benefit from this measure is the progress against delivering the NO_2 limit value in the areas where an LEZ is introduced. The level of exceedence is measured on two ways: the number of road links and the length of urban road in exceedence. Table 12 below presents the progress made for a national LEZ on both these measures.

Table 12: Concentration change from national LEZ (2015)

	Baseline exceedences		LEZ scenario		Average concentration reduction ($\mu g/m^3$)
	Links	Length (km)	Links	Length (km)	
UK	550	491	284	197	7.9
Greater London	442	267	268	157	8.2
Rest of UK	108	224	16	42	6.6

Cost and Benefits of LEZ framework

77. Table 13 presents the net present value of the LEZ framework, the average modelled abatement in the areas of exceedence, and the marginal cost of abatement from this option.

Table 13: Marginal abatement cost of LEZ framework (2015)

Net abatement cost (£million)	Average abatement ($\mu g/m^3$)	Marginal abatement cost (£ million/ ($\mu g/m^3$))
£337	6.6	£51

Clean HGV grants

78. To encourage HGV and bus users to "clean" the fleet, this option would provide financial incentives for the installation of SCR to the HGV and bus fleet. The centre of this approach would be the provision of funding from central or local government to purchase and install abatement equipment on these vehicles. Modelling of this measure has been based on the assumption that the level of incentive would be sufficient to encourage all pre-Euro V HGVs and buses to retrofit SCR. Therefore the main difference between the grant and the LEZ is that the LEZ option targets a smaller proportion of the fleet.

Costs of clean HGV grants

79. As with a LEZ framework, the primary costs of this measure can be separated into three parts:

- Technology costs: The unit and maintenance costs for SCR technology are shown in Table 7 above.
- Certification costs: Certification of the equipment and the installation of SCR are necessary to ensure that the technology will deliver the desired emissions abatement. The certification costs are set out in Table 9.

- Administrative costs: Covering the advertising of the grant scheme, development of a database to maintain records of installations and verification costs for each vehicle. Table 14 below provides the estimated cost of these three elements.

Table 14: Administrative costs of clean HGV grants in 2015

Advertising cost	Database	Verification cost (per vehicle)	Total
£10 million	£150,000	£4.5 million	£14.6 million

80. The total cost of the costs of this option are summarised in Table 15 below.

Table 15: Costs of introducing clean HGV grants in 2015 (£ millions)

Technology cost	Certification cost	Administrative cost	Total
£570	£0.07	£15	£585

Benefits of clean HGV grants

81. The benefits of this option have been calculated according to the NO_X MACC methodology set out above (paragraphs 48-57). This analysis allows both the estimation of the monetary benefits resulting from reductions in emissions of PM and NO_X and the impact on the baseline exceedences of NO_2 limit values. Table 16 below presents the monetised air quality benefits from the introduction of a clean HGV grant.

Table 16: Air quality benefits of clean HGV grant (£ millions)

Particulate Matter (PM)	Oxides of Nitrogen (NO_X)	Total
£66.6	£32.5	£99.0

82. The second key benefit from this measure is the progress against delivering the NO_2 limit value in the areas where there is an exceedence. The level of exceedences is measured on two ways: the number of road links and the length of urban roads in exceedence. Table 17 below presents the progress on both these measures resulting from the introduction of a grant scheme.

Table 17: Concentration change from clean HGV grant (2015)

	Baseline exceedences		Grant scenario		Average concentration reduction ($\mu g/m^3$)
	Links	Length (km)	Links	Length (km)	
UK	550	491	275	190	8.3
Greater London	442	267	261	153	5.6
Rest of UK	108	224	14	38	6.9

Cost and benefits of clean HGV grant framework

83. Table 18 presents the net present value of the clean HGV grant, the average modelled abatement in the areas of exceedence, and the marginal cost of abatement. Estimation of the marginal abatement cost is based on the total net cost of implementing the option relative to the average abatement outside London where no LEZs are currently presumed to exist in the zones identified.

Table 18: Marginal abatement cost of clean HGV grant (2015)

Net abatement cost (£million)	Average abatement ($\mu g/m^3$)	Marginal abatement cost (£ million/ ($\mu g/m^3$))
£486	6.9	£70

Uncertainties and sensitivities

84. The aim of this analysis is to prioritise between the different levers aimed to deliver abatement through HGV and buses measures. Therefore, the key sensitivities set out below relate to the differing assumptions between these two options and the impact on the relative analysis:

- Uptake of SCR: A key difference between these options is the level of uptake of SCR. It is assumed that under the LEZ scheme, 30 per cent of the fleet would not install SCR as their lack of operations within the zones would not justify the investment. The grant, however, is assumed to cause all HGVs and buses to install SCR. The difference between these two uptake rates accounts for the majority of the difference in the cost between options.
- Constant cost: The cost of SCR is held constant irrespective of the scale of installation. It therefore does not reflect any potential capacity constraints which could increase the marginal cost of installation of abatement technologies. For example, one constraint might be the number of engineers available to install SCR. Once this capacity had been reached, the cost of installation would increase significantly in order to attract additional resource to this operation. Therefore the higher level of installation associated with a grant scheme has a higher potential to increase technology costs than a low emission zone.
- Flexibility: This modelling assumes that under either option, the reaction is always to install SCR. However, in some instances there may be other options which may be more economical, such as the replacement of older vehicles. While such flexibility could be encouraged effectively through a LEZ scheme, it would be less likely with a direct grant, which would need to place specific constraints on qualifying actions. This suggests the estimated technology cost of the LEZ scheme may be a maximum while for the grant scheme it may not.

Conclusion

85. The analysis shows that both options have the potential to deliver substantial improvements in ambient NO_2 concentrations in 2015. A comparison of the two options shows that they diverge in two key aspects:

- The LEZ framework is shown to be significantly more cost-effective than the clean HGV grant scheme. On average, the LEZ approach has a marginal abatement cost of £51 million per µg/m^3, whereas the grant scheme would impose a cost of £70 million per µg/m^3.
- A clean HGV grant scheme is shown to have higher abatement potential. The potential concentration reductions were 4 per cent higher in areas of exceedence (6.9 µg/m^3 versus 6.6 µg/m^3). The total reduction in emissions was significantly greater from the grant scheme, delivering an additional £29.6 million worth of savings.

86. Based on this analysis, it was decided to focus on developing options around a framework for Low Emission Zones. The LEZ framework was selected ahead of the grant scheme for three key reasons:

- **Targeting**: By focusing on areas in exceedence, the LEZ framework is able to offer substantially better marginal abatement cost, as set out above. A grant scheme was shown to increase the abatement cost in areas of compliance by almost 40 per cent. This saving was judged to more than compensate for the increased potential for abatement under the grant scheme.
- **Localism**: The LEZ framework allowed for additional flexibility to tailor the design to each local situation and enabled policy to be adjusted for the different behavioural responses from those affected. LAs, with their superior local knowledge, were judged to be best able to tailor and deliver an effective local scheme. It was also noted that under such a scheme, HGVs and buses could be encouraged towards the full range of responses, including retrofitment, redeployment and replacement.
- **Responsibility**: Finally, by making the emitters of air pollution face the costs of managing their emissions, the LEZ option was seen to be consistent with the "polluter pays" principle. This is in contrast with the grant scheme, which would place the entire cost of this abatement onto the public, either locally or nationally.

Option appraisal

87. This section focuses on the option appraisal undertaken to deliver the potential abatement improvements prioritised above. Based on the prioritisation exercise, it was decided to develop options around a framework for Low Emission Zones. It must be stressed that this option has been selected as the above analysis suggests it to be most efficient and effective means to deliver notable improvements, but is not the only option.

a) Methodology

88. The low emission zone (LEZ) modelled is based around an LEZ for buses and HGVs which only permits vehicles of a Euro IV emissions standard or higher. The analysis in the abatement options and implementation options sections above assumed that the LEZs would operate to a Euro V emissions standard. It also assumed that there would be 100 per cent uptake across the bus and HGV fleets[5]. These assumptions were refined in the detailed assessment of the LEZ. Rather than assuming 100 per cent, the uptake rates were modelled as described in the behavioural response section below. It was felt that a Euro IV LEZ would be more practical; one key consideration in this revision was the expected timing of the future phases of the London LEZ.

89. The two key factors in modelling the impact of introducing a LEZ framework are a) the locations introduced and b) the consequent impact of a LEZ. The impact of a LEZ is modelled based on the change in fleet and the effect this has on local emissions and concentrations of NO_2 and PM_{10}. The key determinant of the change in fleet is the behavioural response of vehicle owners; the details of how this was modelled are described in the behavioural response section below. The impact that the change in fleet has on concentrations is modelled using the MACC tool described above for areas outside London and the PCM model for London[6].

90. To assess the likely locations of LEZs, AEA Technology consultants modelled the impacts of the change in fleet, which is described below. The analysis then removed all Highways Agency roads as they are part of the strategic road network and may not be suitable for an LEZ. They removed a further three road links which were deemed to be unsuitable for LEZs based on visual checks of their locations. Finally, all links in London were removed from the analysis as London was modelled separately. This left 16 Local Authorities with exceedences of NO_2 which could potentially benefit from the introduction of an LEZ. Table 19 below shows the potential authorities and the number and length of exceedences before the introduction of a LEZ.

---

[5] This assumes that all vehicles entering an LEZ would be compliant. Evidence from the London LEZ show compliance rates of 98 % for owners and 96% for operators. Available from www.tfl.gov.uk

[6] See Annex A

Table 19: Potential Authorities and the baseline length of exceedences

	Local Authority	Number of links (Baseline)	Length of links (km) (Baseline)
1	Birmingham City Council	5	5.5
2	Leeds City Council	4	5.8
3	Middlesbrough Council	4	4.3
4	Wakefield Council	3	14.5
5	Ipswich Borough Council	2	1.7
6	Liverpool City Council	2	0.2
7	Bristol City Council	1	0.3
8	Gateshead Metropolitan Borough Council	1	0.6
9	Halton Borough Council	1	1.1
10	Manchester City Council	1	0.4
11	Newcastle upon Tyne City Council	1	0.2
12	Sandwell Metropolitan Borough Council	1	2.3
13	Selby District Council	1	3.5
14	Sheffield City Council	1	0.7
15	Southampton City Council	1	1.7
16	Walsall Metropolitan Borough Council	1	2.2

91. Correspondence with Transport for London (TfL) has suggested that the extension of the London LEZ, such that only HGVs and buses of a Euro IV standard (or higher) are allowed to enter, will only take place if a national scheme is created. Thus for the modelling, it is assumed that the costs and benefits of the London LEZ for Euro IV buses and HGVs are dependent on the creation of a national framework. The modelling for London was carried out by AEA consultants and uses slightly different assumptions to the rest of the modelling in this Impact Assessment.

92. The benefits of the LEZ measure in London have been modelled using a different methodology to the MACC tool used for the rest of the UK. This is because London has different baseline fleet assumptions to the rest of the UK and because an evaluation has already been carried out of the benefits of restricting access to vehicles other than Euro IV standard vehicles and above (as part of the Mayor's Air Quality Strategy (MAQS) published in December 2010). An alternative methodology based on the PCM model and emissions changes based on the MAQS therefore gives a better estimate of benefits.

93. The MAQS includes two specific measures relating to reducing NOx emissions for HGVs and buses in London designed to meet Euro IV standards for this pollutant in 2015: the Local Transport (LT) bus SCR Strategy and the London LEZ Phase 5 measures. The analyses carried out by TfL to support the development of the MAQS (published in December 2010) include the impact of these two measures on bus and HGV emissions of NOx in different parts of London (Central, WEZ Inner Ring Road, Inner London and Outer London). These calculations were carried out using the London Atmospheric Emission Inventory. A 50 per cent reduction in NOx emissions relative to Euro III has been assumed for the bus SCR measure. Non-LT buses and HGVs have been assumed to meet Euro IV standards[7].

94. In this analysis, the impact of these London-specific measures on emissions within the NAEI was calculated by scaling the bus and HGV NOx emissions for each road link and the area's road traffic emissions using location-specific scaling factors derived from the MAQS calculations. This approach was selected in order to provide an unbiased assessment of the impact of these

[7] These assumptions differ from the emissions reduction assumptions in the MACC modelling outside London.

measures within the PCM model. Primary NO_2 emission fractions were re-calculated on a link-by-link basis in order to take account of the changes in NOx emissions as a result of the measures.

b) Behavioural response

95. A low emission zone for buses and HGVs which only permits vehicles of a Euro IV emissions standard for NOx would mean that Euro I, II and III vehicles would no longer be able to enter the zone. The LEZs are expected to be introduced in 2015, thus the analysis uses forecasts of the fleet[8]. It has been assumed that the number of LEZs across the country would impact 70 per cent of the bus and HGV fleet.[9] Table 20 below shows 70 per cent of the total number of non-compliant buses and HGVs in 2015.

Table 20: Vehicles numbers impacted by a LEZ

Vehicle Type	2015
Buses - Euro I	258
Buses - Euro II	3,258
Buses - Euro III	15,003
Rigid HGVs - Euro I	-
Rigid HGVs - Euro II	1,813
Rigid HGVs - Euro III	24,622
Artic HGVs - Euro I	-
Artic HGVs - Euro II	247
Artic HGVs - Euro III	8,369

96. Owners of the non-compliant vehicles could respond to the introduction of LEZs in one of three ways:

- Redeploy: Some Euro I, II and III vehicles will be redeployed to other routes and replaced with Euro IV or Euro V vehicles. This can occur both within large organisations and across organisations, through the second-hand market. It has been assumed that redeployment is an option for HGVs but not for buses. This initial assumption is based on the localised nature of bus journeys and the extent to which operators are likely to already deploy cleaner vehicles into areas with air quality concerns. This assumption will however be tested in any further assessment of this option.

- Retrofitment: Some Euro I, II and III vehicle owners will retrofit their vehicles with emissions abatement technology to bring their emissions standards up to (at least) a Euro IV standard.

- Replacement: Some Euro I, II and III vehicle owners will replace their vehicles with new Euro VI vehicles.[10]

97. As the lowest cost option, it was assumed that the initial response of vehicle owners would be to redeploy their fleet as far as possible. This response also captures the purchase of second-hand Euro IV or V vehicles. It was assumed that there would be 18 per cent redeployment of HGVs; this assumption was based on expert judgement.

98. To select between retrofitment and redeployment, the relative cost of retrofitting technologies and the value of the vehicle were contrasted over time. Retrofitment was assumed to only take place if

[8] National Atmospheric Emissions Inventory (NAEI) April 2009

[9] This is assumed as a upper bound on the fleet effected. This value does not however directly impact on the benefits estimate and so has been used as a conservative assumption in estimating the net impact of this measure.

[10] Some users of older vehicles may decide to move to a second hand but newer vehicle. This is however covered under the redeployment behavioural response, through the use of the secondary market.

the value of the vehicle in 2015 was greater than the cost of retrofitment at that point in time. The cost of retrofitment, described further in section d iii) below, varies by vehicle type. There is the one-off cost of purchasing the retrofitment and an annually reoccurring maintenance cost.

99. Following HMT Green Book guidance, this economic assessment of the costs and benefits uses the resource cost of the retrofitment technology, as use of the market price would include the transfer of money from vehicle owners to retrofitment retailers in the assessment of the benefits.

100. The market prices and technology costs of retrofitment are shown in Table 21 below.

Table 21: Cost of retrofitment

	Market prices		Technology cost	
	One-off	Annual	One-off	Annual
Buses – Euro III	£5,000	£267	£3,120	£166
Rigid HGVs - Euro III	£7,370	£393	£4,600	£245
Artic HGVs - Euro III	£8,400	£448	£5,240	£280

101. The cost of a new bus and HGV is shown in Table 22 below.

Table 22: Costs of new Euro VI vehicles

Vehicle	Cost
Bus	£120,000
Rigid HGV	£80,000
Articulated HGV	£60,000

102. It was assumed that these new vehicles depreciate at a rate of 35 per cent in the first year and 18 per cent in all subsequent years. Using the prices and depreciation rates above, the number of years after which the value of a vehicle would be greater than the cost of retrofitment is shown below, with the estimated value of the vehicle after this number of years.

Table 23: The depreciated value of buses and HGVs

Vehicle	Number of years	Value
Buses	15	£4,847
Rigid HGVs	10	£6,537
Artic HGVs	11	£7,147

103. Table 23 above shows that after 15 years a bus is expected to be worth £4,847, which is less than the £5,000 cost of retrofitting the bus. Thus it is assumed that this bus will be replaced by a new Euro VI bus after 15 years of operation.

104. Table 24 below shows the proportions of redeployment, retrofitment and replacement for each vehicle class based on the assumptions described above.

Table 24: The expected uptake rates in 2015

Vehicle	Redeployment	Retrofitment	Replace
Buses - Euro I	0%	0%	100%
Buses - Euro II	0%	0%	100%
Buses - Euro III	0%	83%	17%
Rigid HGVs - Euro I	18%	0%	82%
Rigid HGVs - Euro II	18%	0%	82%
Rigid HGVs - Euro III	18%	82%	0%
Artic HGVs - Euro I	18%	0%	100%
Artic HGVs - Euro II	18%	0%	100%
Artic HGVs - Euro III	18%	68%	14%

105. Once the expected uptake rates above were decided, the costs and benefits of redeployment, retrofitment and replacement were investigated. The costs were estimated by Defra and DfT officials based on information from industry. Details can be found in the costs section below. The benefits were estimated using the MACC tool and the PCM model. Details can be found in the benefits section below.

c) Assumptions

106. In order to carry out the analysis, a number of assumptions needed to be made. The sub-sections below describe the assumptions which were made under the relevant headings.

i. Emissions standard

107. The model includes the option to replace old vehicles with newer ones. This move to a higher Euro standard is expected to reduce emissions of both NO_X and PM. However, it is known that the '"real life" performance of the Euro standards has not delivered the expected emissions reductions in some cases. The model assumes that the Euro standards deliver the emissions reductions as laid out in the National Atmospheric Emissions Inventory (NAEI).

ii. Effectiveness

108. Retrofitment is an emerging technology, thus the effectiveness of the technology is not certain and there is limited on-road test data.

109. The effectiveness assumptions which have been used in this IA are shown in Table 25 below. These have been arrived at through the following process:

- Initial estimates were taken from the MPMD.
- These were discussed with industry experts and supplemented by additional published data[11].
- Defra and DfT officials discussed the range of evidence available and arrived at an agreed position.

Table 25: Emissions Reduction from retrofitment to a Euro III vehicle

Vehicle	NO_X	PM
Buses	70%	90%
Rigid and Artic HGVs	50%	90%

[11] Emission Tests by Finnish VTT MB Actros, Euro3 Arno Amberla / Proventia Emission Control 04 June 2010

d) Costs

110. The costs are broken down below according to who will incur the cost. The costs are also broken down into one-off and annually reoccurring costs.

i. Local Authorities – preparation, set-up and enforcement costs

111. The cost of setting up the LEZ will fall on the Local Authority which chooses to set it up. The preparation involves assessing whether or not an LEZ would be suitable for the area in question. The set-up costs involve defining the boundary of the LEZ, putting up the necessary signs and advertisements, and establishing the databases and enforcement procedures which are needed to punish non-compliance. There will be annually reoccurring costs e.g. funding of the enforcement procedures. The estimated preparation, set-up and enforcement costs are shown in Table 26 below[12].

Table 26: Cost to a Local Authority

	Cost
One-off	£192,000
Annual[(a)]	£85,000
Total	**£617,000**
(a) LEZ assumed to last 5 years	

112. Within the cost modelling, it has been assumed that the cost to London of changing the existing LEZ to reach the LEZ 5 phase as proposed in the Mayor's Air Quality Strategy, introducing a Euro IV standard for NO_X is the same as the cost of setting up a new LEZ for other authorities.

ii. Cost to government - certification

113. Discussion with stakeholders has suggested that in order for a certification scheme to have credibility, it should be supported by central Government. Thus the cost of certification is assumed to fall on central government. There will be one-off costs e.g. identifying the equipment and equipment installers who will be certified; and annually reoccurring costs e.g. adding new LEZ-compliant vehicles to a database. The estimated certification costs[13] are shown in Table 27 below.

Table 27: Cost to Government

One-off	£32,000
Annual[(a)]	£8,000
Total	**£72,000**
(a) LEZ assumed to last 5 years	

iii. Cost to the fleet operators – retrofitment or replacement

114. Redeployment is defined as the redeployment of the fleet within a firm and purchases made in the second-hand market. Both of these actions are simply moving around the existing fleet and thus the economic cost is assumed to be zero.

115. The cost to vehicle owners has been estimated using the vehicle numbers, uptake rates and prices described in the methodology section above. Multiplying the percentage uptake rates of the different responses with their estimated costs gives the following results:

[12] Sadler Consultants, Low Emissions Zones in Europe, DfT February 2010

[13] Sadler Consultants, Low Emissions Zones in Europe, DfT February 2010

Table 28: The expected cost to vehicle owners (millions)

	Retrofitment		Replace	
	One-off	Annual[(a)]	One-off	Annual[(a)]
Buses - Euro I	-	-	£1.3	£0.07
Buses - Euro II	-	-	£15.8	£0.8
Buses - Euro III	£38.9	£2.1	£12.4	£0.7
		-		-
Rigid HGVs - Euro I	-	-	-	-
Rigid HGVs - Euro II	-	-	£9.7	£0.5
Rigid HGVs - Euro III	£92.9	£4,952,463	-	-
		-		-
Artic HGVs - Euro I	-	-	-	-
Artic HGVs - Euro II	-	-	£1,445,549	£0.08
Artic HGVs - Euro III	£29.8	£1.6	£8.4	£0.4
Totals	**£161.6**	**£8.6**	**£48.9**	**£2.6**
(a) LEZ assumed to last 5 years				

116. The LEZ schemes are assumed to last for five years, thus in order to estimate the total cost, the annual costs are multiplied by five. Given the nature of the costs set out above this covers the lifespan of most of the technological change. For each behavioural response longest expected impact is five years. Redeployment would stop being possible as pre Euro IV vehicles would have left the fleet, vehicles retrofitted with abatement technologies would come to the end of their operational life and the vehicles replaced would have been expected to be replaced in the baseline by this time.

Table 29: The expected total cost to vehicle owners (millions)

	Retrofitment	Replace	Totals
Buses	£49.2	£37.2	£86.5
Rigid HGVs	£117.6	£12.3	£129.9
Artic HGVs	£37.8	£12.4	£50.2
Totals	**£204.7**	**£62.0**	**£266.6**

117. Table 29 above shows that the total cost to vehicles owners over a five year period will be £266,643,000. Of this total, £86,467,000 will be the cost to bus owners, £129,947,000 will be the cost to owners of rigid HGVs, and £50,230,000 will be the cost to owners of articulated HGVs. The £266,643,000 total can also be split into the amount spent on retrofitment, which is estimated at £204,651,000 and the amount spent on replacement, which is £61,992,000.

Cost summary

Table 30: The expected total cost (millions)

	Cost
Local Authorities[(a)]	£10
Central Government	£0.07
Vehicle Owner	£267
Totals	**£277**
(a) Assuming 16 Local Authorities and London introduce a Euro IV LEZs (see below)	

e) Benefits

118. In order to examine the benefits of the LEZ scheme, the MACC tool was used for areas outside London and the PCM model for London. The tool produces statistics for the estimation of the reduction of the number and length of exceedences as well as the reduction in emissions and concentrations in all local authorities as a result of the measure. The MACC tool is based on a simplification of the larger, more complex Pollution Climate Mapping model (PCM). There will be a more detailed examination of the benefits, using the PCM model for all of the UK, in the consultation version of this IA.

Three key benefits have been identified at this stage:

i. Emissions and concentration change

119. Table 31 below shows the reduction in the number and length of exceedences as well as the reduction in emissions and concentrations in all local authorities as a result of the measure.

120. It should be noted that in order to choose the likely location of the LEZs, all Highways Agency roads and three others which were deemed by AEA consultants to be unsuitable were removed from the analysis outside London. Table 31 below shows the remaining 16 authorities, and the number and length of road links with exceedences in the baseline (no abatement measures in addition to those already planned) as well as with the application of a LEZ. Finally, the average reduction in concentrations of NO_2 is reported.

Table 31: Potential impact of Low Emissions Zones Outside London

	Local Authority	Number of links (Base)	Length of links (km) (Base)	Number of links (Scenario)	Length of links (km) (Scenario)	Average reduction (mg/m3)
1	Birmingham City Council	5	5.5	2	2.2	2.81
2	Leeds City Council	4	5.8	3	5.6	3.68
3	Middlesbrough Council	4	4.3	2	2.4	3.10
4	Wakefield Council	3	14.5	3	14.5	5.35
5	Ipswich Borough Council	2	1.7	2	1.7	4.18
6	Liverpool City Council	2	0.2	0	0	8.25
7	Bristol City Council	1	0.3	0	0	7.75
8	Gateshead Metropolitan Borough Council	1	0.6	0	0	4.14
9	Halton Borough Council	1	1.1	1	1.1	3.84
10	Manchester City Council	1	0.4	0	0	7.41
11	Newcastle upon Tyne City Council	1	0.2	0	0	4.14
12	Sandwell Metropolitan Borough Council	1	2.3	0	0	3.01
13	Selby District Council	1	3.5	1	3.5	5.69
14	Sheffield City Council	1	0.7	0	0	7.32
15	Southampton City Council	1	1.7	1	1.7	3.48
16	Walsall Metropolitan Borough Council	1	2.2	1	2.2	3.91
	Average	**2**	**2.8**	**1**	**4**	**4.88**
	Total	**30**	**44.9**	**16**	**35**	**78.05**

121. The analysis shows that the introduction of a Euro IV standard LEZ for HGVs and buses in the 16 Local Authorities above and London would reduce the number of road links in exceedence from 30 to 16 and the road length in exceedence from 44.9km to 35km. The average reduction in concentrations across the 16 Local Authorities is 4.88 $\mu g/m^3$. A more refined analysis of the impacts outside London is being developed. Initial results suggest that this will confirm the above results; the results are presented in uncertainties and sensitivities section below.

122. The impact of the LEZ framework on national level emissions and concentrations outside London is shown in Table 32 below.

Table 32: Low Emissions Zones – national level (not including London)[a]

	Number of links (Base)	Length of links (km) (Base)	Number of links (Scenario)	Length of links (km) (Scenario)	Average reduction (mg/m3)	Emission reduction (tNOx)
Rest of UK	35	54.607	23	41.055	2.73	11,454

(a) This analysis is based on 70 per cent of the fleet being impacted. The uptake rate of redeployment has been set to zero as national level redeployment is assumed to not be possible.

123. The analysis shows that the introduction of a Euro IV standard LEZ for HGVs and buses in the 16 Local Authorities above would reduce the number of road links in exceedence nationally (outside of London) from 35 to 23 and the length in exceedence from 54.6km to 41km. The average reduction in concentrations across the country is 2.73 $\mu g/m^3$ and the total reduction in emissions is 11,454 tonnes of NOx.

124. A more refined analysis of the likely impacts in London was performed by AEA consultants, and the results are shown in Table 33 below. For details of the methodology used, see Annex A.

Table 33: Low Emissions Zones – Greater London (AEA modelling)

	Number of links (Base)	Length of links (km) (Base)	Number of links (Scenario)	Length of links (km) (Scenario)	Average reduction (mg/m3)	Emission reduction (tNOx)
Greater London	609	397	505	325	3.1	1,187

i) Valuation of legal obligations

125. As set out above, the safety net provided by minimum ambient air quality standards has a significant value. This safety net delivers three key objectives with regard to:

- Efficiency – controls only on the rate of emission may not deliver the optimum concentrations as it would not constrain usage.
- Uncertainty – modelling the impacts of air pollution is inherently uncertain therefore a safety net provides a minimum standard of protection for all.
- Equity – air pollution is not evenly distributed across the UK. Therefore minimum levels of air pollution may protect vulnerable groups.

126. As set out in Box 2 above, in line with best practice air quality appraisal guidance established by the Interdepartmental Group on Costs and Benefits Air Quality subject group (IGCB(A)), the benefits of improvements in air quality where there is an exceedence has been defined as the avoided cost of the marginal abatement technology. The outputs of this methodology to estimate prices for non-market goods are commonly referred to as a "shadow prices".

127. The estimation of a shadow price of air pollution, however, depends upon the local circumstances – both in terms of the prevailing concentrations and the opportunities to abate. This variation reflects the need to allow local flexibility to ensure that progress is delivered in the most efficient manner. It has not been possible in this national assessment to estimate site-by-site shadow prices, and so a national estimate has been developed.

128. Box 3 below explains in detail how a shadow price for NO_X was estimated.

Box 3: Developing a shadow price for NOx abatement

In the absence of a market abatement price for NO_X abatement, the shadow price for NOx abatement has been derived using modelled levels of market supply and demand. The supply of NO_X abatement technologies is derived from the MACC tool (set out above). The demand for NO_X abatement is derived from the gap between limits set to achieve national compliance and the current situation. The interaction between the demand and the supply gives us the marginal technology appropriate to P* and thereby the shadow price.

It is not possible at the national level to identify which measures would be the most cost-effective in each individual location modelled to exceed the limit value. The reason this is a challenge is because the available set of technologies and their efficacy will vary depending on the location and the make-up of concentrations of air pollutants at that location.

Instead, the MACC tool has been used at the national level to estimate the potential supply of abatement. The demand for abatement was defined as the national compliance gap of 10.5 $\mu g/m^3$. A national level measure would not be able to deliver the reductions required in all areas. Therefore the demand for abatement was set at 5 $\mu g/m^3$. This average level was selected in order to balance the potential to be over-stringent in areas with a lower exceedence and to ensure notable progress for areas with higher concentrations.

Based on this analysis, the marginal technology identified by the MACC tool is the electrification of Euro IV buses. It is important to note that this technology cannot in itself provide the necessary level of improvement, but if all more cost-effective measures were undertaken, this would satisfy the estimated demand. The marginal abatement cost per tonne of this technology is £29,488. This has been used in this analysis as the shadow price of NO_X abatement.

It must be stressed that this shadow price has been estimates specifically for this analysis to give an average national shadow price. This price is however expected to vary by location both as a result of the level of abatement needed and the available abatement technologies. **Therefore this price should not be used in appraising abatement of other policy decisions which impact on NO_X emissions.** Rather a bespoke analysis of the locations under consideration should be undertaken.

129. To monetise the progress made towards the legal obligations delivered by the LEZ framework the expected reduction in emissions has been valued at the shadow price as set out in Box 3.

130. The reduction in emissions from the LEZ measure of 11,454 from Table 32 is multiplied by the derived marginal abatement cost for a tonne of NOx, £29,488 from Box 2.The total of £337,758,000 is the estimated cost of delivering the reduction in emissions through available technologies. This is therefore the monetised benefit of the reduction in NOx emissions which can be delivered through the LEZ measure.

iii) Health benefits

131. In addition to delivering progress towards the legal obligations, an LEZ framework would be expected to also deliver improvements in public health. To value these impacts, IGCB(A) damage costs have been applied to the estimated savings in both NO_X and PM.

132. Estimates for the reduction in emissions of these pollutants have been derived from the emissions and concentration modelling set out above. This modelling has been supplemented by the fleet projections by source in order to estimate the total air quality benefits over the lifetime of the different potential reactions to the implementation of the LEZs. In each case:

- Redeployment – has been assumed to deliver no reductions in emissions of air pollutants.
- Replacement – the benefit has been applied by modelling the level of reduction in the lifetime of the vehicle.
- Retrofitment – emissions reductions have been assumed to remain constant for the

remainder of the operational life of the vehicle.

133. Based on these assumptions, the health benefits of the particulate matter (PM) reductions associated with an LEZ framework are presented in Table 34 below.

Table 34: Health benefits of LEZ framework (£ million)

	PM
LEZ framework	£93.9

Benefits Summary

134. The benefits of an LEZ framework can broadly be separated into the progress towards delivering the NO_2 obligations and the associated health benefits. A summary of the key monetised benefits of the LEZ framework is presented in Table 35 below.

Table 35: Total benefits of LEZ framework (£ million)

	Concentration reduction	Health	Total
LEZ framework	£337.8	£93.9	£431.7

f)Conclusion

135. The monetised net benefit of the LEZ measure is shown in Table 36 below.

Table 36: Net benefit (£ millions)

	Benefits	Cost	Net Benefit
LEZ framework	£432	£277	£155

Uncertainties

136. This section describes the key uncertainties in the analysis:

- Behavioural response of vehicle owners: It is difficult to anticipate the response of vehicle owners. The modelling uses assumptions informed by TfL analysis of the London LEZ by Steer Davies Gleeve, and a report by Sadler Consultants (DfT, 2010). The uncertainty will be examined further in the consultation IA through the use of ranges in modelling the uptake of redeployment, retrofitment and replacement. It is difficult to anticipate whether the assumptions used are likely to overestimate or underestimate the scale of the behavioural response. Therefore, it is difficult to anticipate the likely impact that this uncertainty has on the overall impacts.
- Location of LEZs and fleet affected: The modelling assumed that the 16 Local Authorities with road links that were not part of the strategic road network which had exceedences of NO_2 would introduce a LEZ. This assumption will be examined through consultation with stakeholders. The modelling assumes that 70 per cent of the fleet are impacted through the introduction of 16 LAs. It is likely that this is an upper bound estimate and that the overall cost to vehicle owners will be less than the £267 million stated in the analysis above.
- Cost and effectiveness of abatement technologies: Retrofitment is an emerging technology and the effectiveness and cost are not known with certainty. The cost assumptions used in this IA have been arrived at through the same process as the effectiveness assumptions set out above (Initial estimates taken from the MPMD were then discussed with industry experts at three separate meetings. Defra and DfT officials discussed the range of evidence available and arrived at an agreed position.) The cost assumptions which have been used in the analysis are shown in Tables 21 and 22 above. It is difficult to anticipate whether this assumption is likely to overestimate or underestimate the cost and effectiveness of abatement retrofit equipment.
- Emissions and concentrations modelling and projections: Concentrations modelling is

complex. This has been further complicated by the uncertainties over the performance of Euro standards with respect to NOx emissions. The MACC tool is based on a simplification of the larger, more complex Pollution Climate Mapping model (PCM). There will be a more detailed examination of the benefits, using the PCM model, in the consultation version of this IA.

- **Risks and assumptions**

137. The seven overarching risks and uncertainties underpinning all the analysis presented in this IA are: a) the setting of the shadow price; b) the approach to valuing air quality; c) the impact of technical standards; d) the behavioural response to any new levers; e) the costs of technologies to deliver improvements; f) impact on market participation and used HGV market; and g) modelling the changes in ambient concentrations from a LEZ framework.

a) Shadow price of NO_X abatement

138. The marginal technology is Electrification of Euro IV buses at a cost of £29,000 per tonne of NOx abated. There is uncertainty in this figure from different sources. The amount of abatement required is estimated through derived supply and demand curves, these may be wrong. It may be that the supply of certain technologies is different to that in the MACC, either in terms of price or effectiveness. The demand for technologies has been derived by taking the rough average of the national compliance gap.

139. Changes in either the demand or the supply will affect the determination of the marginal technology. The table 37 below shows the current marginal technology, the electrification of Euro IV buses and the marginal technologies either side. That is the next cheapest and the next most costly marginal abatement technologies.

Table 37: Alternative marginal technologies, their price and effectiveness

	Marginal Abatement Cost	Tonnes reduced
Euro V Rigid HGVs replaced by Euro VI	£28,669	3,394
Electrification of Euro IV buses	£29,488	13
Replace Euro V buses with hydrogen buses	£73,477	282

140. The estimated reduction in tonnes from the LEZ scheme 11,454 is multiplied by the marginal abatement cost per tonne to give the overall estimated abatement cost. Table 38 below shows the total abatement cost calculated by multiplying the marginal abatement costs in table x by the expected reduction in tonnes from the LEZ measure of 11,454.

Table 38: Alternative marginal technologies and their total abatement cost

	Total Abatement Cost
Euro V Rigid HGVs replaced by Euro VI	£328,374,726
Electrification of Euro IV buses	£337,755,552
Replace Euro V buses with hydrogen buses	£841,605,558

141. The total abatement cost varies from £328 million to £842 million depending on the choice of the marginal technology. It should be noted that due to the abatement potential of the replacement of Euro V rigid HGVs by Euro VI vehicles is large at 3,394. This means that it is unlikely that the marginal abatement cost is lower than £328 million. This is because even if the demand and supply are overestimating the amount of abatement required replacement of Euro V rigid HGVs by Euro VI vehicles would still be the marginal technology. Any change in the total cost of abatement will impact on the net benefit of the policy as the avoided cost of alternative abatement is the benefit of the LEZ measure.

	Concentration reduction	Health benefits [a]	Costs	Net Benefit
Euro V Rigid HGVs replaced by Euro VI	£328	£94	£277	£145
Electrification of Euro IV buses	£338	£94	£277	£155
Replace Euro V buses with hydrogen buses	£842	£94	£277	£659

(a) Based on PM benefits only

Table 39 below shows the range of net benefit of the LEZ measure using the different shadow prices

142. The total net benefit ranges from £145 million to £659 million depending on the choice of the marginal technology.

b) Valuation of air quality

143. In line with agreed best practice set out by the IGCB(A), improvements towards legal obligations have been valued using the abatement cost methodology. This approach looks to place a value on the existing minimum standards of air quality set in our international obligations.

144. If we did not place any value on this safety net and ignored any risk of infraction, we could value the improvements in air quality solely on the associated health impacts. This approach would consequently substantially reduce the monetary benefits estimated from any action to improve air quality.

145. This alternate value of the air quality improvements has been undertaken based on IGCB(A) damage costs. As damage costs are not intended for use at this large scale of change, the results can only be considered as indicative. The European Commission Clean Air for Europe (CAFE) damage costs have also been applied as part of the sensitivity analysis relating to these values. Table 40 below provides the results of this analysis.

Table 40: Health benefits of LEZ framework (£ million)

	IGCB (central damage costs)	CAFE[1, 2] Low	CAFE[1, 2] High
NO_X	3.9	16.3	41.9
PM	93.9	75.7	225.3
Total	97.8	92.1	267.2

[1] Exchange rate used = £1:€1.1 (as at 21/1/2009)

[2] Future CAFE values estimated based on relative differential to central IGCB(A) values

146. Table 40 above shows that the health benefits from the LEZ framework are significant (approximately £97.8million) using the IGCB(A) approach. Using the alternative assumptions made in the CAFE methodology, this value changes to £92.1-£267.2million. While this presents a major improvement in health, only at the top end of the CAFE values would these health impacts be of a similar magnitude to the estimated costs.

147. Therefore if there were no legal obligations and the UK were to no longer value the safety net provided by the minimum air quality standards, then the monetary cost benefit analysis would not provide support for additional action to deliver additional abatement to move towards the NO_2 limit value through an LEZ framework.

c) Impact of technological standards

148. As noted previously some recent evidence on the effectiveness of SCR under slow speed, low

engine temperature conditions has suggested that they may not deliver the modelled level of abatement in urban areas. In designing the LEZ framework, this has been recognised and hence the certification scheme has been included specifically to address such concerns on the retrofitment of abatement technologies. Such a certification system has been employed for the London Low Emission Zone.

149. However, if this certification were to be ineffective, the modelled emission reductions may be overstated in this analysis. Given the uncertainties involved, it is not possible to estimate the likely scale of any such impact. To illustrate the potential risk of this, a linear approximation of the impact on the monetised benefits of such ineffectiveness is presented in Table 41 below. This sensitivity shows the level of underperformance necessary for the measure to become non-cost beneficial.

Table 41: Sensitivity of LEZ framework to underperformance

	Central estimates		Performance to cause Switching
	Benefits	Cost	
LEZ framework	£432	£222	51.4%

150. As shown above, only if the technical standards were to produce less than 51.4% of the expected emission reductions would the costs be expected to outweigh the monetised benefits.

d) Behavioural response

151. In order to estimate the costs and benefits of a LEZ framework, a number of behavioural responses have been assumed. The two key assumptions are a) the proportion of the total fleet impacted upon; and b) the response split between redeployment, replacement and retrofitment. This section focuses on the impact on costs of these uncertainties (rather than the impact on benefits which are more difficult to estimate).

152. Firstly, the LEZ framework is assumed to impact upon 70 per cent of non-compliant vehicles. It is likely that this is an upper bound estimate for the percentage of the fleet impacted. Therefore the total cost to vehicle owners (of retrofitment and replacement) is likely to be an upper bound estimate. However, to illustrate the importance of this assumption, two additional estimates have been provided: a) if the proportion of the fleet affected were to increase by 20 per cent; and b) if it were to fall by 20 per cent. The impacts of this are shown in Table 42 below.

Table 42: Net benefit with 20% increase/decrease in fleet change

	Low	Central	High
Fleet affected	£209	£155	£102

153. The second key area of assumption is the behavioural response between redeployment, replacement and retrofitment. To illustrate the importance of these three assumptions, sensitivity modelling has been undertaken which increases the level of each type of response by 20 per cent. To allow this increase, it is assumed that this is equally offset by reductions in the other two reactions. For example, the 20 per cent increase in redeployment is offset equally by reductions in replacement and retrofitment. The results of this analysis are presented in Table 43 below.

Table 43: Net benefit with changes in each behavioural response (£million)

	20% increase	Central	20% decrease
Redeployment	£165	£155	£146
Replacement	£150	£155	£166
Retrofitment	£135	£155	£253

154. Tables 42 and 43 above demonstrate that although the behavioural responses to the introduction of an LEZ are uncertain across the range of responses, this scheme is consistently cost-beneficial.

e) Technology costs

155. There is notable uncertainty surrounding the cost of the technology required to deliver the necessary improvements in air quality. In particular, it has been noted in previous work that there is an observed difference between the estimated and realised technology costs to improve air quality. Past evidence (especially from the Evaluation of the Air Quality Strategy[14]) has shown that the ex-post implementation costs of many policies have been less than the predicted (ex-ante) costs.

156. The study assessed the reasons for some of the differences between ex-ante and ex-post costs. It was concluded that there are sometimes errors in the baseline predictions. There are also often omissions of measures that allow cost-effective reductions (options other than end of pipe, and so on) and limited consideration of technological innovation. The study found no evidence of industry providing exaggerated cost estimates, but stressed that the costs put forward by industry were usually based on pessimistic/'worst case' assumptions, or calculated with a limited field of reference (i.e. without regard to potential for advances/learning, new measures, the fall of costs with large scale production, and so on). Moreover, in many cases, the ex-ante costs are based on specific technical components that in practice the manufacturers did not need to fit to comply with new legislation.

157. The study arrived at the key conclusion that "legislation itself acts as a spur to research and innovation".[15]

158. The study presented a broad overview of the differences in the ex-ante and ex-post costs of the road transport and ESI measures (presented in Table 44 below). From the tables, we see that the differences in the ex-ante and ex-post cost of both road transport and ESI sectors are quite significant.

Table 44: Summary of ex-ante and ex-post costs (1990 – 2001)

	Ex ante	Ex post
Road transport measures	£16,109M – £22,807M	Estimated £2,000M – £4,000M
Electricity sector	~£6,000M to ~£30,000M	~£2,000M

159. Using the upper and lower estimates of the differential between ex-ante and ex-post costs, Table 45 provides upper and lower estimates of the costs of the options assessed in this IA. In applying these estimates, the bias has only been applied to fixed costs and not the ongoing costs that are less likely to be susceptible to the same level of bias (as ongoing costs are more easily adjusted as technology develops and operation scale stabilises).

Table 45: Impact of innovation (£ millions)

	Central estimate (£million)	High bias (£ million)	Low bias (£ million)
LEZ framework	£266	£65	£100

160. of an LEZ are uncertain across the range of responses, this scheme is consistently cost-beneficial.

f)Secondary economic impacts

161. The introduction of a number of LEZs would impact on the operators of non-compliant vehicles in 2015. This may therefore have secondary impacts both on the participation of operators and on the market for used HGVs.

162. In response to the increased costs one potential reaction for operators would be to exit the market and pursue other activities. However the scale of this impact not expected to be a substantial concern for three key reasons:

- Only a small proportion of the fleet would be expected to continue to operate non-compliant vehicles. In 2015 only around 35,000 non-compliant HGVs are expected to remain in operation accounting for just 6.6% of the fleet. This fleet then declines rapidly over the period 2015 – 2020.

[14] 'An Evaluation of the Air Quality Strategy', Defra (2005a). Available at http://www.defra.gov.uk/environment/airquality/strategy/evaluation/report-index.htm
[15] Op cite

- Operators of non-compliant vehicles face three options if they want to continue to operate within a LEZ: redistribute within their fleet; retrofit their existing vehicle; or replace the vehicle with a new vehicle. Selecting between these options and exiting the market will be informed by the relative costs. On average it is estimated that action would increase operational costs by just 1.5% for a period of around 2½ years.
- Finally in considering the London LEZ TfL commissioned Steer Davies Gleave to assess the economic impacts. The conclusion of this assessment was:

> *In the long term, operators exiting the London market would not cause job losses. However, there might be a redistribution of work to business that are better placed to operate in London with compliant vehicles*

163. The second market that is likely to be impacted is that for used non-compliant vehicles. Where an operator decided to exit the market or to replace their vehicle they may choose to sell their non-compliant vehicle. The consequent increase in supply of such vehicles could then reduce the price for such vehicles in the used market.

164. Assessing the likely impact on the price in this market is an extremely challenging piece of analysis. The analysis presented above therefore takes the conservative assumption that all replaced vehicles are destroyed and are therefore not placed on the used market. This assumption likely overestimates the costs of such decisions as it means that the total value of these vehicles is lost whereas if they were placed on the market some of the value would be expected to be retained.

165. To estimate the reduced value of these vehicles in the used market level of loss from selling these vehicles requires the modelling of the market conditions. To judge the viability of such a market it is necessary to consider three factors: the potential change in supply; the potential demand; and the incentives for the market to enable such transactions: Taking these three areas in turn:

- The increase in supply of non-compliance vehicles is significant yet relatively small. From the modelling above it is estimated that the number of non-compliant vehicles placed onto the market equate to around 0.5% of the fleet.
- Demand for these vehicles will also remain in a significant proportion of the market. By targeting LEZs on areas with areas of exceedence it is estimated that around 30% of the current fleet will not be impacted. Therefore there is scope for the non-compliant fleet to be redistributed through the market to areas where there are no LEZs.
- Finally incentives will also be created in the market to support the reallocation of vehicles across the UK. The introduction of LEZs would effect on both existing vehicles both compliant and non-compliant. Demand for non-compliant vehicles will be reduced but equally demand for compliant vehicles will be increased.

166. Given this market situation it is likely that operators could reduce the costs of replacement set out above by disposing of their vehicles through the second-hand market and purchasing used compliant vehicles. Table 46 below adjusts the costs depending on the proportion of the value of the vehicle lost.

Table 46: Summary of ex-ante and ex-post costs (1990 – 2001)

	Total cost	Net Benefit
100% (Current estimate)	£277m	£155m
75%	£261m	£171m
50%	£238m	£194m
25%	£220m	£212m
0%	£215m	£217m

g) Impact on ambient concentrations

167. As noted above modelling of the impact of the proposed framework on ambient concentrations has been modelled using the MACC tool. While this is expected to provide a reasonable approximation of the likely impacts the PCM model is the best available methodology to estimate the impact of changes in emissions on air quality.

168. Owing to the resource intensive nature of the PCM model it was not justifiable to use this approach for each stage in the development of options. However, to provide more detailed information for any subsequent consideration and to check the results of the MACC tool it was run for the final LEZ scenario set out above. The results of this modelling and the MACC results are presented in table 47 below.

Table 47: Comparison of MACC tool and PCM

	Local Authority	Number of links (Base)		Length of links (km) (Base)		Number of links (Scenario)		Length of links (km) (Scenario)		Average reduction (mg/m3)	
		MACC	PCM	MACC	PCM	MACC	PCM	MACC	PCM	MACC	PCM
1	Birmingham City Council	**5**	9	**5.5**	9.6	**2**	3	**2.2**	3.0	**2.81**	3.1
2	Leeds City Council	**4**	4	**5.8**	5.8	**3**	4	**5.6**	5.8	**3.68**	4.4
3	Middlesbrough Council	**4**	4	**4.3**	4.3	**2**	2	**2.4**	2.4	**3.10**	3.7
4	Wakefield Council	**3**	3	**14.5**	14.5	**3**	3	**14.5**	14.5	**5.35**	6.9
5	Ipswich Borough Council	**2**	2	**1.7**	1.7	**2**	2	**1.7**	1.7	**4.18**	1.3
6	Liverpool City Council	**2**	3	**0.2**	0.4	**0**	0	**0**	0.0	**8.25**	9.2
7	Bristol City Council	**1**	1	**0.3**	0.3	**0**	0	**0**	0.0	**7.75**	8.9
8	Gateshead Metropolitan Borough Council	**1**	1	**0.6**	0.6	**0**	0	**0**	0.0	**4.14**	4.9
9	Halton Borough Council	**1**	1	**1.1**	1.1	**1**	1	**1.1**	1.1	**3.84**	4.7
10	Manchester City Council	**1**	1	**0.4**	0.4	**0**	0	**0**	0.0	**7.41**	9.0
11	Newcastle upon Tyne City Council	**1**	1	**0.2**	0.2	**0**	0	**0**	0.0	**4.14**	4.9
12	Sandwell Metropolitan Borough Council	**1**	3	**2.3**	4.1	**0**	1	**0**	2.3	**3.01**	2.9
13	Selby District Council	**1**	1	**3.5**	3.5	**1**	1	**3.5**	3.5	**5.69**	2.0
14	Sheffield City Council	**1**	2	**0.7**	1.7	**0**	0	**0**	0.0	**7.32**	7.2
15	Southampton City Council	**1**	1	**1.7**	1.7	**1**	1	**1.7**	1.7	**3.48**	4.2
16	Walsall Metropolitan Borough Council	**1**	1	**2.2**	2.2	**1**	1	**2.2**	2.2	**3.91**	4.9
	Average	**2**	2	**2.8**	3.3	**1**	1	**4**	2.4	**4.88**	5.13
	Total	**30**	38	**44.9**	52.0	**16**	19	**35**	38.1	**78.05**	82.03

169. Broadly the two sets of results are consistent with only a slight divergence between the two sets of results. Taken as a whole the two key messages are: firstly that the MACC tools on average across the 16 areas is underestimating the abatement potential, by around 5 per cent; and that the baseline in the PCM is notably worse than expected in the MACC.

170. There are however a couple of differences which require some additional explanation:

- Birmingham City Council, the baseline situation is significantly worse owing to changes in the underlying modelling. However, the effectiveness of this option is broadly consistent in the two models.
- Ipswich Borough Council and Selby District Council were both included in LEZ for the MACC analysis but not in the PCM modelling. This was the result of a more detailed assessment of the suitability of the areas for a LEZ.

171. Taking out the results in these three areas, to make the comparison as close as possible, this suggests that the MACC might be understating the potential compliance benefits by around 15 per cent. If this were also reflected in the final analysis we would expect the net benefit of the LEZ framework to increase from to £155 to £208 million (an increase of over a third). The total impact of the LEZ framework under this sensitivity is presented in table 48 below.

Table 48: LEZ framework monetised costs and benefits (£ millions)

	Benefits	Cost	Net Benefit
LEZ framework	£485	£277	£208

Wider risks and uncertainties

172. Details of further risks and assumptions at each stage can be found in the relevant sections above. The two key risks and assumptions identified are the behavioural responses of owners and the location of LEZs.

173. Within each of the three stages of the analysis, a key risk has been identified:

- Stage 1: The MACC tool uses measures from the MPMD. This is focused on measures around road transport and commercial buildings. There is a small risk that new technologies have emerged that are not contained within the MPMD, and therefore the MACC tool.
- Stage 2: The comparison with a grant scheme. The key assumption here is around the uptake of the different responses (redeploy, replace, retrofit) under the two different schemes.
- Stage 3: The uncertain costs and benefits of moving to a vehicle with a higher Euro standard, which are described in detail in the relevant sections above.

- **Direct costs and benefits to business calculations (following OIOO methodology)**

174. The direct cost to business is the £267 million cost to vehicle owners of either retrofitting their vehicle to achieve compliance or upgrading to a new, lower emitting, vehicle. This measure falls out of scope of OIOO as it is derived from an EU Directive.

- **Wider impacts**

175. A substantial part of the air quality improvements from the LEZ framework is delivered through the replacement of the existing fleet with new vehicles. Of the fleet affected, replacement has been modelled to occur for around a third of all buses, 15 per cent of articulated HGVs and 5% of rigid HGVs. This replacement of the fleet would be expected to deliver substantial wider environmental benefits, most notably in relation to fuel savings and carbon emissions. It has not been possible to estimate and value the scale of these benefits within this document; however, they are expected to be substantial. Further work on the scale of these impacts will be incorporated into the consultation stage impact assessment.

176. Within the LEZ, there is 100 per cent compliance (i.e. there are no vehicles below a Euro IV standard). The modelling assumes that the creation of 17 LEZs (including London) impacts on 70 per cent of the fleet. The impact that this change in the fleet will have on concentrations on areas outside the specific exceedences is not modelled. It is likely that the major change in the fleet as modelled above would have a significant impact on exceedences in areas not assumed to introduce a LEZ.

177. Deposition of pollutants derived from NOx emissions contribute to acidification and/or eutrophication of sensitive habitats, leading to loss of biodiversity, often at locations far removed from the source of the original emissions. NOx also contributes to the formation of secondary particles and ground-level ozone, both of which are associated with ill-health effects. Ground-level ozone also damages vegetation. The LEZ measure is expected to reduce national emissions of NOx by 13 kilo tonnes, reducing these adverse environmental impacts although, with the exception of the formation of secondary particles, it has not been possible to quantify these benefits.

178. The National Emission Ceilings Directive (2001/81/EC) (NECD) and the Convention on Long Range Trans-boundary Air Pollution Gothenburg Protocol both set national ceilings for emissions of pollutants (including NOx) to be met by 2010. The Gothenburg Protocol is currently being revised and a proposal to revise the NECD is expected in 2013. Both revisions are expected to set more stringent emission ceilings for NOx to be achievement in 2020 or beyond. The reductions in national emissions resulting from the LEZ measure will help the UK comply in the future with these revised national ceilings.

179. There are also a number of other wider impacts which it has not been possible to fully include in this analysis, including:

- If the UK were to be infracted its ability to influence future EU negotiations with air quality impacts may be reduced.
- Increases in the cost to hauliers may disadvantage smaller firms as they tend to have an older fleet than larger firms
- Competitiveness in the bus market may also be affected as smaller operators tend to own and operate older and therefore less clean vehicles.

- **Summary and preferred option with description of implementation plan**

180. The UK is not projected to achieve the national limit value for ambient concentrations of air pollutant nitrogen dioxide (NO_2) by 2015, and hence faces a high risk of infraction. Some additional beyond business as usual measures would reduce this risk and support the UK application for an extension of the deadline to meet the Directive's requirements. The most cost-effective measure for reducing NO_2 concentrations is retrofitment or replacement of heavy good vehicles (HGVs) and buses with high Euro standard engines. The cheapest lever available to deliver retrofitment and replacement is the establishment of a national framework for Low Emissions Zones (LEZs) in the 17 urban areas of exceedence, which would then be implemented by Local Authorities.

181. In addition to being modelled as the most cost effective measures a LEZ framework also has notable advantages over other additional measures in terms of:

- **Targeting**: By focusing on areas in exceedence, the LEZ framework is able to offer substantially better marginal abatement cost, as set out above. In comparison to a grant scheme was shown to increase the abatement cost in areas of compliance by almost 40 per cent.
- **Localism**: The LEZ framework allowed for additional flexibility to tailor the design to each local situation and enabled policy to be adjusted for the different behavioural responses from those affected. LAs, with their superior local knowledge, were judged to be best able to tailor and deliver an effective local scheme. It was also noted that under such a scheme, HGVs and buses could be encouraged towards the full range of responses, including retrofitment, redeployment and replacement.
- **Responsibility**: Finally, by making the emitters of air pollution face the costs of managing their emissions, the LEZ option was seen to be consistent with the "polluter pays" principle. This is in contrast with the grant scheme, which would place the entire cost of this abatement onto the public, either locally or nationally

Annex 1 – Methodology of London modelling performed by AEA

182. This annex describes the methodology used by AEA to model the LEZ measure in London. A difference in baseline assumptions accounts for the difference in 2015 baseline figures between this detailed modelling and the initial work carried out using the MACC. In particular, the revised baseline used by AEA increases the number of baseline road links in exceedence in Greater London from 444 to 609. This is partly due to improved assumptions about the impacts of different stages of the London LEZ and updated assumptions on fleet turnover to reflect the recent economic downturn both of which led to a projected increase in emissions in 2015The GIS-based PCM model has been used to calculate the impact of the Mayor's Air Quality Strategy (MAQS), the Bus SCR Strategy and London LEZ Phase 5 measures on ambient NO_2 concentrations at the roadside in London.

183. The assessment of the national LEZ measure estimates the impact of an LEZ measure that reduces the emissions of both NOx and PM_{10} from HGVs and buses by assuming that all vehicles within the LEZ meet at least Euro IV emissions standards. The baseline assessment for 2015 already includes the impact of the London LEZ Phase 4, which will require HGVs and buses to meet Euro IV standards for PM_{10} in 2015. This difference in baseline assumptions for London means that it makes sense to carry out an assessment of the impact of measures that require Euro IV standards for NOx emissions in London separately from the PCM model calculations of the impact of the proposed national LEZ in other UK urban areas.

184. The MAQS includes two specific measures relating to reducing NOx emissions for HGVs and buses in London, which are designed to ensure that these vehicles meet NOx Euro IV standards in 2015. These are the Bus SCR Strategy and London LEZ Phase 5 measures. The Bus SCR Strategy is the measure within the MAQS which delivers the improvements to the bus fleet that would be needed to meet the requirements of London LEZ Phase 5.

185. The analyses carried out by TfL to support the development of the MAQS (published in December 2010) include the impact of these two measures on bus and HGV emissions of NOx in different parts of London (Central, WEZ, Inner Ring Road, Inner London and Outer London). These calculations were carried out using the London Atmospheric Emission Inventory. A 50 per cent reduction in NOx emissions relative to Euro III has been assumed for the bus SCR retrofitment measure. Non-Local transport buses and HGVs have been assumed to meet Euro IV standards through retrofitment or replacement of vehicles.

186. The UK-wide assessments to support the development of the local authority Air Quality Plans for NO_2 Time Extension Notice (TEN) have been carried out using the NAEI and the PCM model. The impact of these London-specific measures on emissions within the NAEI was therefore calculated by scaling the bus and HGV NOx emissions for each road link with an exceedence and the area's road traffic emissions using location-specific scaling factors derived from the MAQS calculations. This approach was selected in order to provide an unbiased assessment of the impact of these measures within the PCM model. Primary NO_2 emission fractions were re-calculated on a link-by-link basis to take account of the changes in NOx emissions as a result of the measures.

Annexes

Annex 1 should be used to set out the Post Implementation Review Plan as detailed below. Further annexes may be added where the Specific Impact Tests yield information relevant to an overall understanding of policy options.

Annex 1: Post Implementation Review (PIR) Plan

A PIR should be undertaken, usually three to five years after implementation of the policy, but exceptionally a longer period may be more appropriate. If the policy is subject to a sunset clause, the review should be carried out sufficiently early that any renewal or amendment to legislation can be enacted before the expiry date. A PIR should examine the extent to which the implemented regulations have achieved their objectives, assess their costs and benefits and identify whether they are having any unintended consequences. Please set out the PIR Plan as detailed below. If there is no plan to do a PIR please provide reasons below.

Basis of the review: [The basis of the review could be statutory (forming part of the legislation), i.e. a sunset clause or a duty to review , or there could be a political commitment to review (PIR)];
Review objective: [Is it intended as a proportionate check that regulation is operating as expected to tackle the problem of concern?; or as a wider exploration of the policy approach taken?; or as a link from policy objective to outcome?]
Review approach and rationale: [e.g. describe here the review approach (in-depth evaluation, scope review of monitoring data, scan of stakeholder views, etc.) and the rationale that made choosing such an approach]
Baseline: [The current (baseline) position against which the change introduced by the legislation can be measured]
Success criteria: [Criteria showing achievement of the policy objectives as set out in the final impact assessment; criteria for modifying or replacing the policy if it does not achieve its objectives]
Monitoring information arrangements: [Provide further details of the planned/existing arrangements in place that will allow a systematic collection systematic collection of monitoring information for future policy review]
Reasons for not planning a review: [If there is no plan to do a PIR please provide reasons here]

Add annexes here.