

Updated Projections of Air Quality in the UK for Base Case and Additional Measures for the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007

Report to The Department for Environment, Food and Rural
Affairs, Welsh Assembly Government, the Scottish
Executive and the Department of the Environment for
Northern Ireland

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Executive summary

The UK Government and the devolved administrations published an Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) in January 2000. It sets air quality standards and objectives for eight key pollutants to be achieved between 2003 and 2008. An addendum to the AQS was subsequently published in 2003.

The UK Government and the devolved administrations have undertaken a review of the AQS, which includes assessing progress towards the achievement of the AQS objectives and assessing the costs and benefits of possible additional measures to improve air quality in the UK. The focus of this review of possible measures is on the impact of measures on concentrations of particles, nitrogen dioxide and ozone, the pollutants for which the achievement of the objectives is likely to be the most challenging. The air quality strategy review consultation document (Defra et al, 2006a; Defra et al, 2006b) and An Economic Analysis to Inform the Air Quality Strategy Review Consultation: Third Report of the Interdepartmental Group on Costs and Benefits (Defra et al, 2006c) have already been published as part of this review. The final strategy, Defra et al (2007) is published simultaneously with this report.

This report describes air quality modelling work undertaken since publication of the consultation documents. Specifically it describes the GIS-based model predictions of air quality under baseline conditions for a 2004 base year and for a range of proposed additional policy measures for NO₂, PM₁₀ and PM_{2.5} carried out to support the AQS review. This modelling supplements modelling of baseline projections of air pollution from a 2003 base year (Grice et al, 2006) and projections of air pollution from this base year for an initial set of proposed additional policy measures (Stedman et al, 2006). The modelling has been made necessary for the following reasons:

- Proposed new and revised additional measures being considered in the AQS. These measures need to be modelled to assess their likely impact on future ambient concentrations of pollutants included in the AQS.
- The publication of new energy projections, UEP21 and UEP26, by the DTI, which will impact on both the baseline modelled projections of concentrations and on the additional measures.
- 2004 base year modelling and projections becoming available which enable the sensitivity of the modelling results to the base year to be investigated further.

Table ES1 gives details of the modelling work described in this report.

Table ES1 Proposed additional policy measures considered in this report

Report section	Energy projections used	Model base year	Description of modelling	Pollutants modelled
2	UEP12	2003	Measure A2	NO ₂ and PM ₁₀
		2003	Measure C2	NO ₂ and PM ₁₀
		2003	Measure R (combined C2 + E +N)	NO ₂ , PM ₁₀ and PM _{2.5}
		2003	Measure S (combined A2 + E + N)	NO ₂ , PM ₁₀ and PM _{2.5}
3	UEP21	2003, 2004	Baseline	NO ₂ , PM ₁₀ and PM _{2.5}
		2003, 2004	Measure Q (combined C + L +E)	NO ₂ , PM ₁₀ and PM _{2.5}
	UEP26	2003, 2004	Baseline	NO ₂ , PM ₁₀ and PM _{2.5}
		2003, 2004	Measure Q (combined C + L +E)	NO ₂ , PM ₁₀ and PM _{2.5}
4	UEP26	2004	Measure R (combined C2 + E +N)	NO ₂ , PM ₁₀ and PM _{2.5}
		2004	Measure S (combined A2 + E + N)	NO ₂ , PM ₁₀ and PM _{2.5}

The results of our assessment of air quality for these measures are presented in terms of the expected extent of exceedence of AQS objectives and population-weighted mean concentrations. Assessments have been carried out for the years for which the objectives have been set or for years under consideration within the review of possible additional measures (2010, 2015 and 2020).

Model projections for measures A2, C2, R and S showed that, generally, the 2003 base year projections resulted in higher concentrations and therefore a greater extent of roadside and background exceedences than the 2004 base year projections. However, the overall trends in each set of projections were very similar with the baseline and all measures predicted to result in declining concentrations of NO₂, PM₁₀ and PM_{2.5}. The most efficient measure across all these pollutants for each base year was measure R, followed closely by the other combined measure, measure S.

Modelling of new baseline concentration projections and projections for measure Q showed, generally, the model projections are relatively sensitive to the base year from which the projections are made, while changing which version of the DTI's energy projections used has less of an impact on the modelled concentrations across the UK. Concentrations modelled using a 2004 base year tended to be lower than those modelled using a 2003 base year. Regardless of which energy projections or base year was used, there were still predicted to be exceedences of the AQS objective for NO₂ of 40 µg m⁻³, by 2020 using measure Q. However, the total extent of exceedence for measure Q is predicted to be substantially less than under baseline conditions. Similarly, for PM₁₀, measure Q is predicted to reduce the extent of exceedences of 20 µg m⁻³ relative to the baseline, but not eliminate exceedences. Under baseline conditions, there are predicted to be relatively few exceedences of the 31.5 µg m⁻³ threshold.

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1 Introduction

1.1 The Air Quality Strategy

The UK Government and the devolved administrations published an Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) (DETR et al, 2000) in January 2000. It sets air quality standards and objectives for eight key pollutants to be achieved between 2003 and 2008. For seven of these pollutants local authorities are charged with the task of working towards the objectives. The standards and objectives are subject to regular review to take account of the latest information on the health effects of air pollution and technical and policy developments.

The AQS objectives for particles (PM₁₀), benzene and carbon monoxide were reviewed in 2000/01. An Addendum (Defra et al, 2003) was published in 2003, which incorporated tighter objectives for these pollutants and introduced an objective for polycyclic aromatic hydrocarbons.

The AQS aims to:

- Map out as far as possible future ambient air quality policy in the UK in the medium term
- Provide best practicable protection to human health by setting health-based objectives for air pollutants
- Contribute to the protection of the natural environment through objectives for the protection of vegetation and ecosystems
- Describe current and future levels of air pollution
- Provide a framework to help identify what we can all do to improve air quality.

1.2 The EU Framework and Daughter Directives

Directive 96/62/EC on Ambient Air Quality Assessment and Management (the Framework Directive (Council Directive 96/62/EC)) establishes a framework under which the EU sets limit values or target values for the concentrations of specified air pollutants in ambient air.

The first Daughter Directive (Council Directive 1999/30/EC) sets the limit values to be achieved for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particles and lead. The second Daughter Directive (Council Directive 2000/69/EC) sets out the limit values to be achieved for benzene and carbon monoxide. The third Daughter Directive (Council Directive 2002/3/EC) sets target values and long-term objectives for ozone. The fourth Daughter Directive (Council Directive 2004/107/EC) sets target values for arsenic, cadmium, nickel and polycyclic aromatic hydrocarbons.

1.3 2006 Review of the AQS

The UK Government and the devolved administrations have undertaken a review of the AQS. Amongst other things, this review assesses progress towards the achievement of the AQS objectives and assesses the costs and benefits of possible additional measures to improve air quality in the UK. The focus of this review of possible measures is on the impact of measures on concentrations of particles, nitrogen dioxide and ozone, the pollutants for which the achievement of the objectives is likely to be the most challenging. The air quality strategy review consultation document (Defra et al, 2006a; Defra et al, 2006b) and An Economic Analysis to Inform the Air Quality Strategy Review Consultation: Third Report of the Interdepartmental Group on Costs and Benefits (Defra et al, 2006c) have already been published as part of this review. The final strategy, Defra et al (2007) is published simultaneously with this report.

1.4 Previous Work on Baseline and Additional Measure Projections of Air Quality

GIS-based modelling predictions from a 2003 base year of our best estimates of air quality using baseline conditions (i.e. under current policies) were presented in the preceding technical report (Grice et al, 2006). Baseline projections were calculated for SO₂, NO₂, PM₁₀, PM_{2.5} and benzene for 2005, 2010, 2015 and 2020. GIS-based model predictions of air quality resulting from a variety of emissions measures from a 2003 base year for NO₂, PM₁₀, and PM_{2.5} were published simultaneously in an accompanying technical report (Stedman et al, 2006). These measure predictions were our best estimate of the likely impact of possible proposed national and international air quality policies on the future concentrations of NO₂, PM₁₀ and PM_{2.5}. For all this modelling, emissions projections based upon the DTI's most up to date energy projects available at the time, UEP12 (DTI, 2004), were used.

1.5 Further Projections of Air Quality

This report presents details of further GIS-based modelling of predicted air quality to support the review of the AQS carried out since the publication of the consultation documents (Defra et al, 2006a; Defra et al, 2006b; Defra et al, 2006c). This additional modelling has been made necessary for the following reasons:

- Proposed new and revised additional measures being considered in the AQS. These measures need to be modelled to assess their likely impact on future ambient concentrations of pollutants included in the AQS.
- The publication of new energy projections, UEP21 (DTI, 2006a) and UEP26 (DTI, 2006b), by the DTI, which will impact on both the baseline modelled projections of concentrations and on the additional measures.
- 2004 base year modelling and projections becoming available which enable the sensitivity of the modelling results to the base year to be investigated further.

This report presents this modelling in three sections (Table 1.1).

Table 1.1 Projections modelled in this report

Report section	Energy projections used	Model base year	Description of modelling	Pollutants modelled
2	UEP12	2003	Measure A2	NO ₂ and PM ₁₀
		2003	Measure C2	NO ₂ and PM ₁₀
		2003	Measure R (combined C2 + E +N)	NO ₂ , PM ₁₀ and PM _{2.5}
		2003	Measure S (combined A2 + E + N)	NO ₂ , PM ₁₀ and PM _{2.5}
3	UEP21	2003, 2004	Baseline	NO ₂ , PM ₁₀ and PM _{2.5}
		2003, 2004	Measure Q (combined C + L +E)	NO ₂ , PM ₁₀ and PM _{2.5}
	UEP26	2003, 2004	Baseline	NO ₂ , PM ₁₀ and PM _{2.5}
		2003, 2004	Measure Q (combined C + L +E)	NO ₂ , PM ₁₀ and PM _{2.5}
4	UEP26	2004	Measure R (combined C2 + E +N)	NO ₂ , PM ₁₀ and PM _{2.5}
		2004	Measure S (combined A2 + E + N)	NO ₂ , PM ₁₀ and PM _{2.5}

Where: A2 is a revised version of A (Euro 5 and VI low)

C2 is a revised version of C (Euro 5 and VI low including early introduction)

E is the LEV measure

L is the small combustion plant directive: NO_x and SO₂ (NB does not start until 2013 so no impact in 2010)

N is the shipping measure: NO_x and SO₂ reductions

First, section 2 presents model predictions of air quality in 2010, 2015 and 2020 resulting from variations of selected existing policy measures and new policy measures. These have been modelled from a 2003 base year using UEP12 energy projections. Using this base year and these energy projections enables a direct comparison of the impact of these new measures on air quality with the

baseline results presented in Grice et al (2006) and other additional measures modelled in Stedman et al (2006).

Section 3 then presents the modelling carried out to test the sensitivity of the baseline modelling results and measure Q results to using the 2004 base year projections and also to using UEP21 and UEP26 energy projections to drive emissions changes which feed into the concentration modelling.

Model projections of air quality resulting from the new preferred measures, R and S, are then presented in section 4. This modelling has been done using a 2004 base year and UEP26 energy projections so that it is fully up to date and is our best estimate of the impact of these measures on air quality for 2010, 2015 and 2020.

The results of our assessment for this modelling are presented in terms of the expected extent of exceedence of AQS objectives and in terms of population-weighted mean concentrations. This report does not estimate the health impacts off the measures, nor their costs. This is carried out elsewhere as part of the review of the Air Quality Strategy. The change in concentration of air pollutants estimated for the measures are a key input to the review of the Air Quality Strategy. This report should be read in conjunction with the air quality strategy review consultation document (Defra et al, 2006a; Defra et al, 2006b) and An Economic Analysis to Inform the Air Quality Strategy Review Consultation: Third Report of the Interdepartmental Group on Costs and Benefits (Defra et al, 2006c) and the accompanying technical reports (Grice et al, 2006; Stedman et al, 2006). Full details of the Cost Benefit analysis including an assessment of health impacts are included in the Economic Analysis document.

2 Measures A2, C2, R and S: 2003 base year, UEP12

2.1 Introduction

Stedman et al (2006) gives full details of measures that have been previously modelled as part of the 2006 review of the AQS for a 2003 base year using UEP12 energy projections.

This section presents further model predictions of air quality in 2010, 2015 and 2020 resulting from variations of existing policy measures, A2 and C2, and new combined measures, R and S. Details of these measures are given in Table 2.1. This table also gives details of measures E and N, which were modelled previously (see Stedman et al, 2006), because E and N are included in the new combined measures.

Emissions projections for 2010, 2015 and 2020 for these measures have been used to model projected air quality concentrations for NO₂, PM₁₀, and PM_{2.5} (R and S only) from a 2003 base year using the method outlined in the baseline report (2003 base year) for mapped concentration projections (see Grice et al, 2006 and Stedman et al, 2006 for a full description of this method). These results are therefore comparable with the baseline results in Grice et al (2006) and the results of the additional measures in Stedman et al (2006).

It should be noted that we have assumed here that emissions reductions result in a 50% response rate of secondary PM in the additional measures modelling, rather than 100% as was assumed in the results presented in Stedman et al (2006). A further discussion of why a 50% response rate has been chosen, and the impact of this on the overall effectiveness of the additional measures is presented in the section 7, the uncertainty analysis section, of Stedman et al (2006). The final AQS reports (refs) will include an assessment of the benefits for all the measures considered using this assumption of a 50% response rate of secondary PM

Table 2.1 New emissions projections measures

	Name of measure	Description of measure	When it applies	Where it applies*	New or existing measure
A2	Revised Euro V/VI Standards	This measure proposes: <ul style="list-style-type: none"> • 28% reduction in NOX from all new diesel LDVs in 2010; • 72% reduction in NOX from all new diesel LDVs in 2015; • 13% reduction in NOX from all new petrol LDVs by 2010; • 90% reduction in PM from all new diesel LDVs in 2010; and • 50% reduction in NOX from all new diesel HDVs. 	This measure is introduced from: Euro V: 2010 for cars and small LGVs; 2011 for medium, large LGVs Euro VI: 2015 for cars and small LGVs; 2016 for medium, large LGVs. Euro VI: 2013 for HDVs	This measure applies to all EU countries	New
C2	Programme of incentives for early uptake of revised Euro V and VI Standards	This measure assumes that a programme of incentives is introduced for a 2 year earlier introduction of Euro 5, Euro V and Euro VI (3 yrs for Euro VI HDVs). This measure is to be implemented based on Measure A2 i.e. the policy reverts back to Scenario A2 after the incentives have taken effect Details of the uptake rates of these incentives are given in the Appendix.	This measure is introduced from: Euro 5: 2008 for cars, small medium, and large LGVs (The analysis does not make a distinction on the basis of the size of the LGV) Euro V: 2007 for rigid HGVs Euro VI: 2010 for Articulated HGVs	This measure applies to UK	New
E	Programme of incentives to increase penetration of low emission vehicles (LEV)	Petrol LEVs assumed to deliver 38% reduction in NOX and 34% reduction in CO2 compared to Euro 4 petrol cars. Penetration of petrol LEVs 10% by 2010, 25% by 2020 Diesel LEVs assumed to deliver 80% reduction in NOX, 92% reduction in PM and 29% reduction in CO2 compared to Euro 4 diesel cars. Penetration of diesel LEVs 5% by 2010, 20% by 2020 It is assumed that petrol LEVs replace non-LEV petrol cars, diesel LEVs replace non-LEV diesel cars	This measure is introduced from 2006	This measure applies to UK	Existing ¹
N	Shipping Measure through IMO	Requirements on global fleet (for all ships > 100 tonnes) to: Use 1% rather than 1.5% Sulphur fuel from 2010 (applies to old and new vessels from 2010) Reduce NOX emissions by 30% from new ships from 2010 The introduction rate of new ships is assumed to be 1/30th of fleet per year.	The scheme is due to start from 2010	This measure applies to UK and all maritime	Existing ¹
R	Combined (C2 + E + N)	See measure C2, E and N above			New
S	Combined (A2 + E + N)	See measure A2, E and N above			New

¹See Stedman et al (2006) for modelling results for existing measures

2.2 Emissions Projections and Mapping

The two new individual measures, A2 and C2, are both road transport measures and the combined measures, R and S, both contain a new combination of road transport measures. Projections of NO_x and PM₁₀ emissions from road transport from the 2002 National Atmospheric Emissions Inventory (NAEI) (Dore et al, 2004) for 2010, 2015 and 2020 for these measures are presented in Table 2.2. Table 2.3 presents UK total emissions projections for these pollutants for these measures. Appendix 1 gives details of assumptions made in generating emissions projections for these measures.

Table 2.2 Projections of road transport emissions, from 2002 NAEI (ktonnes yr⁻¹)

Pollutant	AQS measure reference	2003	2005	2010	2015	2020
NO _x	Baseline	654.9	572.3	396.2	290.5	267.8
	A2			392.6	242.8	167.7
	C2			382.8	226.4	161.0
	R			381.5	223.3	156.1
	S			391.3	239.7	162.8
PM ₁₀	Baseline	28.2	25.4	18.7	14.5	14.0
	A2			18.3	9.3	5.3
	C2			17.3	8.6	4.9
	R			17.3	8.6	4.9
	S			18.3	9.3	5.3

Table 2.3 Projections of UK total emissions, from 2002 NAEI (ktonnes yr⁻¹)

Pollutant	AQS measure reference	2003	2005	2010	2015	2020
NO _x	Baseline	1529.8	1429.3	1151.0	1030.3	910.7
	A2			1147.4	982.6	810.6
	C2			1137.7	966.2	804.0
	R			1136.4	963.1	799.1
	S			1146.1	979.5	805.7
PM ₁₀	Baseline	156.5	148.5	134.9	135.4	143.5
	A2			134.5	130.2	134.8
	C2			133.6	129.5	134.4
	R			133.5	129.4	134.4
	S			134.5	130.2	134.8

Emissions on individual road links and background and area source road transport emissions maps have been calculated for each measure. The method used to generate these data and maps follows the method used for measures A and C, as described in Stedman et al (2006).

PM_{2.5} emissions on individual road links have been calculated as PM₁₀ road link emissions for the relevant measure multiplied by a factor of 0.9 as recommended by AQEG (AQEG, 2005). Road transport emissions maps used in the area source model for PM_{2.5} have been calculated by scaling the baseline PM_{2.5} maps of this for the relevant year by the ratio of the road transport area source PM₁₀ map for the relevant measure to the baseline PM₁₀ area source road transport map. Similarly brake and tyre wear emission maps for the area source model have been scaled using the ratio of these maps for PM₁₀ for the relevant measure divided by the baseline for the relevant year.

2.3 Modelling Method

Using the emissions data set out in section 2.2, projected annual mean concentration maps of NO₂, PM₁₀ and PM_{2.5} (R and S only) have been modelled for 2010, 2015 and 2020 for measures A2, C2, R and S from a 2003 base year, using UEP12 energy projections.

The basic modelling method used involves calculating background annual mean concentrations for each pollutant at a 1x1 km resolution. Background concentrations are made up from contributions from a number of sources (e.g. NO_x modelling has contributions from distant sources, large and small point sources and area sources). A roadside increment is then calculated for major roads in built up areas and added to the background concentration. This roadside concentration only applies within 10m of the kerb of the road modelled.

A brief introduction to the modelling methods used to produce concentration maps for 2010, 2015 and 2020 of NO₂, PM₁₀ and PM_{2.5} is given below. A more comprehensive description of the modelling methods can be found in Stedman et al (2005), which describes the 2003 base year modelling methods and results; Grice et al (2006), which describes baseline (i.e. under current policies) projections methods and results for 2005, 2010, 2015 and 2020; and Stedman et al (2006), which describes the additional measures modelling methods and results for 2010, 2015 and 2020.

2.3.1 NO₂/NO_x

Background annual mean NO_x concentrations have been considered to be made up from contributions from:

- Distant sources (characterised by rural background concentrations)
- Large point sources (i.e. point sources with emissions of greater than 500 tonnes yr⁻¹ in the 2002 NAEI)
- Small point sources (i.e. point sources with emissions of less than 500 tonnes yr⁻¹ in the 2002 NAEI)
- Local area sources

In line with the baseline modelling, the area source calibration from 2003 for NO_x has been used for the projected measures.

At locations close to busy roads an additional projected roadside contribution, the roadside increment, has been added to account for contributions to total NO_x from road traffic sources:

Roadside NO_x concentration = background NO_x concentration + roadside NO_x increment

In terms of the road transport emissions reductions associated with each of the four measures, the contribution of area source road transport emissions to background annual mean NO_x concentration has been modelled using the new 1 x 1 km area source NO_x road transport emissions maps for both measures. The roadside increment has been modelled using the new estimates of NO_x emissions from major road links for 2010, 2015 and 2020 for each measure (see section 2.2).

For the combined measures, R and S, emissions reductions from the relevant stationary source measures have been applied to the relevant sectors and the new road link emission estimates and road transport area source maps have been used for the road transport contribution.

For all measures, rural NO_x concentrations have been predicted by scaling the base year concentration field by the predicted change in UK total NO_x emissions for each measure.

2.3.2 PM₁₀

The projected maps of annual mean background PM₁₀ concentrations are made up of contributions from:

- Large point sources of primary particles (i.e. point sources with emissions of greater than 200 tonnes yr⁻¹ in the 2002 NAEI)
- Small point sources of primary particles (i.e. point sources with emissions of less than 200 tonnes yr⁻¹ in the 2002 NAEI)
- Area sources of primary particles
- Secondary particles
- Residual particle concentrations, not explicitly modelled.

An additional roadside increment is added for roadside locations.

In terms of the road transport emissions reductions associated with each of the four measures, the contribution of area source road transport emissions to background annual mean PM₁₀ concentration has been modelled using the new 1 x 1 km area source PM₁₀ road transport emissions maps for all measures. The roadside increment has been modelled using the new estimates of PM₁₀ emissions from major road links for 2010, 2015 and 2020 (see section 2.2).

For the combined measures, emissions reductions have also been applied in line with reductions in emissions in the relevant stationary source sectors.

Secondary PM₁₀ has been estimated for each road transport measure on the basis of reductions in nitrates resulting from reductions in emissions of NO_x relative to the baseline in the road traffic measures. For the combined measures, secondary PM₁₀ has been estimated on basis of reductions in NO_x and SO₂ precursor emissions in all sectors included in combined measures relative to baseline projections for the relevant year. Baseline projections have been derived from the EMEP model as described in Grice et al (2006).

2.3.3 PM_{2.5}

Projected maps of annual mean PM_{2.5} concentrations for the measures R and S have been calculated. As in Grice et al (2006), gravimetric concentrations of PM_{2.5} have been modelled directly. This has been done using the same method as in the baseline projections, with the following differences.

For combined measures, emissions reductions have been applied in line with reductions in emissions in the relevant stationary source sectors and new road transport link emissions projections and area source maps generated for the relevant individual road transport measure have been used. Secondary PM_{2.5} has been estimated on basis of reductions in sulphates and nitrates caused by reduced emissions of SO₂ and NO_x in all sectors included in combined measures relative to baseline projections for the relevant year. Baseline projections have been derived from the EMEP model as described in Grice et al (2006).

2.4 NO₂ Results

The modelling results for the baseline and each of the measures modelled for 2010, 2015 and 2020 are summarised in Table 2.4-2.6 in terms of a comparison of modelled concentrations with the annual mean objective for NO₂ of 40 µg m⁻³. Estimates of the area exceeding and population exposed have been derived from the background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

All of the measures are predicted to reduce the extent of exceedences relative to the baseline for the years in which they operate. In terms of exceedences at the roadside, which is where most exceedences are predicted to be limited to by 2010, measure R is predicted to be the most effective across 2010, 2015 and 2020. Measure A2 is predicted to be least effective, although by 2020, it is predicted that only 3.3% of exceedences at the roadside would remain under this measure compared with 8.5% for the baseline.

Population-weighted annual mean NO₂ concentrations at background locations are presented in Table 2.7. This statistic represents the average concentration exposure of the UK population to NO₂ and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations.

The population-weighted mean concentrations for the measures show a similar, but not identical pattern of changes with the different measures to the extent of exceedences. The effectiveness of the measures for population-weighted mean is:

- 2010: R > C2 > S > A2 > Base
- 2015: R > C2 > S > A2 > Base
- 2020: R > S > C2 > A2 > Base

The concentrations presented in table 2.7 are given to a higher degree of precision than the modelling method warrants so that small differences in the model outputs can be seen. This is useful when certain measures only result in small changes, for example in the 3rd decimal place.

Table 2.4 Total road length (km) exceeding the NO₂ annual mean objective of 40 µg m⁻³

2010						
	Total	Base	A2	C2	R	S
London	1886	1023.6	1000.1	986.0	978.6	997.4
Rest of England	9430	1372.1	1343.8	1283.9	1279.3	1335.9
Scotland	1085	111.8	111.5	100.2	99.8	111.5
Wales	640	42.2	42.2	40.7	39.2	42.2
Northern Ireland	1044	17.6	17.6	14.0	14.0	17.6
Total	14084	2567.4	2515.1	2424.9	2411.0	2504.6
Percentage >40 µg m ⁻³		18.2%	17.9%	17.2%	17.1%	17.8%
2015						
	Total	Base	A2	C2	R	S
London	1886	651.5	505.5	471.7	467.2	495.6
Rest of England	9430	679.7	509.6	439.3	433.4	500.3
Scotland	1085	51.4	38.0	29.1	25.0	35.7
Wales	640	22.3	15.1	12.9	12.9	12.9
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0
Total	14084	1404.9	1068.2	953.0	938.4	1044.4
Percentage >40 µg m ⁻³		10.0%	7.6%	6.8%	6.7%	7.5%
2020						
	Total	Base	A2	C2	R	S
London	1886	564.2	296.2	277.6	245.3	267.7
Rest of England	9430	569.6	158.6	134.8	113.3	148.5
Scotland	1085	42.6	5.5	4.4	4.4	4.4
Wales	640	17.5	3.7	3.7	1.3	3.7
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0
Total	14084	1193.8	463.9	420.4	364.2	424.3
Percentage >40 µg m ⁻³		8.5%	3.3%	3.0%	2.6%	3.1%

Table 2.5 Total background area (km²) exceeding the NO₂ annual mean objective of 40 µg m⁻³

2010						
	Total	Base	A2	C2	R	S
London	1624	55.0	54.0	54.0	54.0	54.0
Rest of England	128770	19.0	16.0	16.0	16.0	18.0
Scotland	77791	2.0	1.0	1.0	1.0	1.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	76.0	71.0	71.0	71.0	73.0
Percentage >40 µg m ⁻³		0.03%	0.03%	0.03%	0.03%	0.03%
2015						
	Total	Base	A2	C2	R	S
London	1624	39.0	36.0	35.0	35.0	36.0
Rest of England	128770	12.0	9.0	8.0	8.0	8.0
Scotland	77791	0.0	0.0	0.0	0.0	0.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	51.0	45.0	43.0	43.0	44.0
Percentage >40 µg m ⁻³		0.02%	0.02%	0.02%	0.02%	0.02%
2020						
	Total	Base	A2	C2	R	S
London	1624	38.0	34.0	33.0	33.0	33.0
Rest of England	128770	15.0	8.0	8.0	8.0	8.0
Scotland	77791	0.0	0.0	0.0	0.0	0.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	53.0	42.0	41.0	41.0	41.0
Percentage >40 µg m ⁻³		0.02%	0.02%	0.02%	0.02%	0.02%

Table 2.6 Population in area exceeding the NO₂ annual mean objective of 40 µg m⁻³

2010						
	Total	Base	A2	C2	R	S
London	7730326	319019	305296	305296	305296	305296
Rest of England	41011137	17395	11528	11528	11528	17184
Scotland	4944573	6547	1547	1547	1547	1547
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	342961	318371	318371	318371	324027
Percentage >40 µg m ⁻³		0.6%	0.5%	0.5%	0.5%	0.6%
2015						
	Total	Base	A2	C2	R	S
London	7730326	156502	135142	120633	120633	135142
Rest of England	41011137	5946	4837	4668	4668	4668
Scotland	4944573	0	0	0	0	0
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	162448	139979	125301	125301	139810
Percentage >40 µg m ⁻³		0.3%	0.2%	0.2%	0.2%	0.2%
2020						
	Total	Base	A2	C2	R	S
London	7730326	154748	115408	114162	114162	114162
Rest of England	41011137	6071	4668	4668	4668	4668
Scotland	4944573	0	0	0	0	0
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	160819	120076	118829	118829	118829
Percentage >40 µg m ⁻³		0.3%	0.2%	0.2%	0.2%	0.2%

Table 2.7 Population weighted mean NO₂ concentrations (µg m⁻³)

2010					
	Base	A2	C2	R	S
Scotland	13.410	13.352	13.212	13.182	13.324
Wales	13.531	13.480	13.347	13.318	13.445
Northern Ireland	9.249	9.199	9.102	9.078	9.172
Inner London	34.022	33.884	33.669	33.623	33.838
Outer London	27.774	27.672	27.476	27.433	27.629
Rest of England	19.274	19.210	19.045	19.007	19.172
UK	19.522	19.453	19.289	19.252	19.416
2015					
	Base	A2	C2	R	S
Scotland	11.853	11.102	10.865	10.770	11.009
Wales	11.966	11.223	10.967	10.833	11.097
Northern Ireland	7.960	7.424	7.277	7.175	7.316
Inner London	31.591	30.368	30.045	29.892	30.215
Outer London	25.535	24.502	24.205	24.059	24.357
Rest of England	17.336	16.461	16.167	16.017	16.310
UK	17.608	16.732	16.447	16.304	16.589
2020					
	Base	A2	C2	R	S
Scotland	11.314	9.789	9.693	9.522	9.627
Wales	11.176	9.612	9.516	9.312	9.404
Northern Ireland	7.378	6.454	6.405	6.228	6.277
Inner London	30.927	28.587	28.450	28.182	28.319
Outer London	24.818	22.804	22.680	22.419	22.541
Rest of England	16.435	14.545	14.414	14.136	14.269
UK	16.777	14.933	14.809	14.549	14.674

2.5 PM₁₀ Results

Modelling results for PM₁₀ for the baseline and each of the measures for 2010, 2015 and 2020 are summarised in tables 2.8 to 2.10 in terms of a comparison of modelled concentrations with an annual mean concentration of 31.5 µg m⁻³ (roughly equivalent to the 2004 24-hour AQS objective (Stedman et al, 2001)). Tables 2.11 to 2.13 present the same results in terms of a comparison with the annual mean objective of 20 µg m⁻³. No results are presented for the annual mean objective of 40 µg m⁻³ because exceedences of this objective were predicted to have been almost entirely eliminated by 2010 under baseline conditions and for all the measures.

Model results for the additional measures have been compared with an annual mean threshold of 20 µg m⁻³ for the whole of the UK in order to simplify the presentation of the results for the large number of measures. 20 µg m⁻³ is the 2010 stage 2 indicative limit value and the 2010 AQS objective for England, excluding London, Wales and Northern Ireland. A comparison of predicted baseline concentrations with the AQS objectives for 2010 of 18 µg m⁻³ for Scotland and 23 µg m⁻³ for London has been presented by Grice et al (2006).

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

All of the measures are predicted to reduce the extent of exceedences of both 31.5 µg m⁻³ and 20 µg m⁻³ relative to the baseline. Background exceedences of 31.5 µg m⁻³ for the baseline in 2010, 2015 and 2020 are predicted to be very limited (4-6km² out of 242248km² assessed). Measure R is predicted to be the most effective at reducing exceedences of threshold at the roadside.

Exceedences of 20 µg m⁻³ are predicted to be more widespread at both roadside and background locations. Measure R is the most effective measure at reducing exceedences of this objective at both roadside and background locations. The other combined measure, measure S, is then the next most effective at reducing exceedences.

Population-weighted annual mean PM₁₀ concentrations at background locations are illustrated in Table 2.14. This statistic represents the average concentration exposure of the UK population and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations. The benefits of a measure will be related to the difference between the population-weighted mean concentration for the measure and that calculated for the baseline. The population-weighted mean concentrations show a generally similar pattern of changes with the different traffic measures to the extent of exceedences. The relative effectiveness of the measures for population-weighted mean is:

- 2010: R > S > C2 > A2 > Base
- 2015: R > S > C2 > A2 > Base
- 2020: R > S > C2 > A2 > Base

The concentrations presented in table 2.14 are given to a higher degree of precision than the modelling method warrants so that small differences in the model outputs can be seen. This is useful when certain measures only result in small changes, for example in the 3rd decimal place.

Table 2.8 Total road length (km) exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	1886	139.9	127.7	104.2	94.0	108.6
Rest of England	9430	158.1	149.0	116.8	103.8	132.2
Scotland	1085	2.8	0.0	0.0	0.0	0.0
Wales	640	0.0	0.0	0.0	0.0	0.0
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0
Total	14084	300.9	276.6	221.1	197.8	240.7
Percentage>31.5 µgm ⁻³		2.1%	2.0%	1.6%	1.4%	1.7%
2015						
	Total	Base	A2	C2	R	S
London	1886	31.1	3.1	2.6	2.6	2.6
Rest of England	9430	40.6	8.2	6.0	4.1	4.1
Scotland	1085	0.0	0.0	0.0	0.0	0.0
Wales	640	0.0	0.0	0.0	0.0	0.0
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0
Total	14084	71.7	11.3	8.6	6.7	6.7
Percentage>31.5 µgm ⁻³		0.5%	0.1%	0.1%	0.0%	0.0%
2020						
	Total	Base	A2	C2	R	S
London	1886	20.6	0.0	0.0	0.0	0.0
Rest of England	9430	27.7	1.9	1.9	0.0	0.0
Scotland	1085	0.0	0.0	0.0	0.0	0.0
Wales	640	0.0	0.0	0.0	0.0	0.0
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0
Total	14084	48.4	1.9	1.9	0.0	0.0
Percentage>31.5 µgm ⁻³		0.3%	0.0%	0.0%	0.0%	0.0%

Table 2.9 Total background area (km²) exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	1624	0.0	0.0	0.0	0.0	0.0
Rest of England	128770	6.0	4.0	4.0	3.0	3.0
Scotland	77791	0.0	0.0	0.0	0.0	0.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	6.0	4.0	4.0	3.0	3.0
Percentage>31.5 µgm ⁻³		0.00%	0.00%	0.00%	0.00%	0.00%
2015						
	Total	Base	A2	C2	R	S
London	1624	0.0	0.0	0.0	0.0	0.0
Rest of England	128770	4.0	2.0	2.0	2.0	2.0
Scotland	77791	0.0	0.0	0.0	0.0	0.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	4.0	2.0	2.0	2.0	2.0
Percentage>31.5 µgm ⁻³		0.00%	0.00%	0.00%	0.00%	0.00%
2020						
	Total	Base	A2	C2	R	S
London	1624	0.0	0.0	0.0	0.0	0.0
Rest of England	128770	5.0	3.0	3.0	2.0	2.0
Scotland	77791	0.0	0.0	0.0	0.0	0.0
Wales	20745	0.0	0.0	0.0	0.0	0.0
Northern Ireland	13318	0.0	0.0	0.0	0.0	0.0
Total	242248	5.0	3.0	3.0	2.0	2.0
Percentage>31.5 µgm ⁻³		0.00%	0.00%	0.00%	0.00%	0.00%

Table 2.10 Population in area exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	7730326	0	0	0	0	0
Rest of England	41011137	10242	5292	5292	3463	3463
Scotland	4944573	0	0	0	0	0
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	10242	5292	5292	3463	3463
Percentage>31.5 µgm ⁻³		0.02%	0.01%	0.01%	0.01%	0.01%
2015						
	Total	Base	A2	C2	R	S
London	7730326	0	0	0	0	0
Rest of England	41011137	3477	671	671	671	671
Scotland	4944573	0	0	0	0	0
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	3477	671	671	671	671
Percentage>31.5 µgm ⁻³		0.01%	0.00%	0.00%	0.00%	0.00%
2020						
	Total	Base	A2	C2	R	S
London	7730326	0	0	0	0	0
Rest of England	41011137	5306	686	686	671	671
Scotland	4944573	0	0	0	0	0
Wales	2850727	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0
Total	58160071	5306	686	686	671	671
Percentage>31.5 µgm ⁻³		0.01%	0.00%	0.00%	0.00%	0.00%

Table 2.11 Total road length (km) exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	1886	1884.6	1884.6	1884.6	1884.6	1884.6
Rest of England	9430	8375.7	8326.2	8229.9	8074.4	8186.8
Scotland	1085	187.3	175.1	146.2	134.0	158.3
Wales	640	336.4	330.5	307.6	284.4	301.5
Northern Ireland	1044	148.9	144.2	144.2	144.2	144.2
Total	14084	10932.9	10860.7	10712.5	10521.6	10675.4
Percentage >20 µgm ⁻³		77.6%	77.1%	76.1%	74.7%	75.8%
2015						
	Total	Base	A2	C2	R	S
London	1886	1884.6	1881.4	1881.4	1870.9	1875.3
Rest of England	9430	7202.7	5730.1	5391.8	4813.8	5156.5
Scotland	1085	79.5	32.2	25.1	25.1	30.6
Wales	640	193.5	104.9	100.7	92.8	97.5
Northern Ireland	1044	119.3	77.6	70.4	70.4	70.4
Total	14084	9479.6	7826.4	7469.3	6873.0	7230.3
Percentage >20 µgm ⁻³		67.3%	55.6%	53.0%	48.8%	51.3%
2020						
	Total	Base	A2	C2	R	S
London	1886	1880.8	1688.9	1655.7	1502.8	1559.0
Rest of England	9430	6292.1	2737.7	2596.6	2089.5	2252.0
Scotland	1085	66.5	3.7	3.7	3.7	3.7
Wales	640	141.0	54.3	47.9	35.1	41.3
Northern Ireland	1044	146.0	98.4	98.4	94.7	94.7
Total	14084	8526.4	4582.9	4402.3	3725.7	3950.7
Percentage >20 µgm ⁻³		60.5%	32.5%	31.3%	26.5%	28.1%

Table 2.12 Total background area (km²) exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	1624	1621.0	1625.0	1625.0	1618.0	1619.0
Rest of England	128770	17192.0	16931.0	16278.0	13671.0	14154.0
Scotland	77791	25.0	25.0	21.0	20.0	21.0
Wales	20745	267.0	264.0	253.0	222.0	229.0
Northern Ireland	13318	19.0	18.0	16.0	12.0	13.0
Total	242248	19124.0	18863.0	18193.0	15543.0	16036.0
Percentage >20 µg m ⁻³		7.89%	7.79%	7.51%	6.42%	6.62%
2015						
	Total	Base	A2	C2	R	S
London	1624	1523.0	1424.0	1400.0	1242.0	1297.0
Rest of England	128770	8207.0	6044.0	5692.0	4399.0	4635.0
Scotland	77791	18.0	16.0	16.0	13.0	13.0
Wales	20745	180.0	164.0	164.0	147.0	151.0
Northern Ireland	13318	10.0	4.0	3.0	2.0	2.0
Total	242248	9938.0	7652.0	7275.0	5803.0	6098.0
Percentage >20 µg m ⁻³		4.10%	3.16%	3.00%	2.40%	2.52%
2020						
	Total	Base	A2	C2	R	S
London	1624	1291.0	664.0	640.0	446.0	473.0
Rest of England	128770	4682.0	2615.0	2556.0	2014.0	2074.0
Scotland	77791	18.0	12.0	12.0	10.0	11.0
Wales	20745	163.0	127.0	124.0	109.0	110.0
Northern Ireland	13318	32.0	16.0	16.0	13.0	13.0
Total	242248	6186.0	3434.0	3348.0	2592.0	2681.0
Percentage >20 µg m ⁻³		2.55%	1.42%	1.38%	1.07%	1.11%

Table 2.13 Population in area exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³, gravimetric

2010						
	Total	Base	A2	C2	R	S
London	7730326	7727768	7778523	7778523	7772503	7773495
Rest of England	41011137	20904147	20640226	20054475	18263235	18734315
Scotland	4944573	41611	41611	37784	37588	39398
Wales	2850727	352663	342088	328871	277722	289218
Northern Ireland	1623309	65651	59956	53546	36499	42035
Total	58160071	29091840	28862404	28253198	26387547	26878461
Percentage >20 µg m ⁻³		50.0%	49.6%	48.6%	45.4%	46.2%
2015						
	Total	Base	A2	C2	R	S
London	7730326	7544505	7341497	7269572	6751878	6941919
Rest of England	41011137	13140915	9727002	9149350	7258571	7721144
Scotland	4944573	32421	25873	25873	17213	17213
Wales	2850727	180796	119659	119659	103514	105835
Northern Ireland	1623309	30106	10810	9156	7201	7201
Total	58160071	20928742	17224841	16573611	14138377	14793311
Percentage >20 µg m ⁻³		36.0%	29.6%	28.5%	24.3%	25.4%
2020						
	Total	Base	A2	C2	R	S
London	7730326	6919180	4077727	3923987	2756929	2916544
Rest of England	41011137	8313678	4275396	4141213	3303967	3424326
Scotland	4944573	32421	13928	13928	8124	10928
Wales	2850727	136343	78885	70506	61898	61935
Northern Ireland	1623309	115537	52720	52720	43289	43289
Total	58160071	15517158	8498655	8202355	6174207	6457022
Percentage >20 µg m ⁻³		26.7%	14.6%	14.1%	10.6%	11.1%

Table 2.14 Population weighted mean PM₁₀ concentrations (µg m⁻³)

2010					
	Base	A2	C2	R	S
Scotland	15.479	15.461	15.414	15.299	15.343
Wales	17.991	17.974	17.930	17.754	17.793
Northern Ireland	16.239	16.225	16.195	16.080	16.108
Inner London	23.567	23.510	23.378	23.139	23.264
Outer London	22.697	22.651	22.544	22.306	22.407
Rest of England	20.143	20.117	20.052	19.854	19.913
UK	19.880	19.852	19.785	19.592	19.654
2015					
	Base	A2	C2	R	S
Scotland	15.021	14.778	14.737	14.599	14.638
Wales	17.347	17.120	17.075	16.860	16.900
Northern Ireland	15.889	15.729	15.699	15.564	15.591
Inner London	22.460	21.760	21.646	21.346	21.454
Outer London	21.647	21.079	20.982	20.683	20.773
Rest of England	19.326	18.986	18.922	18.673	18.731
UK	19.084	18.729	18.664	18.424	18.482
2020					
	Base	A2	C2	R	S
Scotland	14.794	14.374	14.354	14.202	14.222
Wales	16.886	16.482	16.462	16.221	16.242
Northern Ireland	16.110	15.830	15.816	15.667	15.681
Inner London	21.772	20.562	20.505	20.165	20.222
Outer London	20.920	19.933	19.886	19.546	19.594
Rest of England	18.742	18.143	18.113	17.830	17.860
UK	18.543	17.921	17.890	17.617	17.648

2.6 PM_{2.5} results

There are currently no limit values or objectives for PM_{2.5}. Therefore modelled concentrations have been compared with indicative threshold concentrations of 12, 16 and 20 µg m⁻³ to illustrate the changes in predicted concentration in different years and for different measures. This comparison is shown in tables 2.15 to 2.17.

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

These modelling results show that both the combined measures modelled, R and S, are predicted reduce the extent of exceedences of the indicative concentration thresholds selected. Generally, measure R is predicted to be the more effective of the two measures in reducing the extent of exceedences.

Population-weighted annual mean PM_{2.5} concentrations at background locations are illustrated in Table 2.18 for the different measures. The population-weighted mean concentrations show a similar, but not identical pattern of changes with the different measures to the extent of exceedences. Population-weighted means for PM₁₀ for the baseline and combined measures are also listed in Table 2.18 for comparison with the results for PM_{2.5}. The change in population-weighted mean concentrations for each measure relative to the baseline measure is shown.

Table 2.18 also shows the changes in predicted population-weighted means for the measures for PM_{2.5} as a percentage of those for PM₁₀. These differences are caused by the relative proportions of the changes in PM concentration resulting from changes to primary and secondary PM. These differences may in part reflect differences in the modelling methods adopted for PM₁₀ and PM_{2.5}. The PM₁₀ model was calibrated using TEOM measurement data and then scaled by 1.3 to calculate gravimetric equivalent concentrations. PM_{2.5} measurement data are only available from a very limited number of monitoring sites. The PM_{2.5} model represents gravimetric concentrations directly. A more detailed discussion of how the PM_{2.5} modelling has been done is given in Grice et al (2006).

Table 2.15 Summary statistics for combined measures PM2.5 projections comparison with 12 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 12 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1886	1884.6	1884.6	1884.6	1884.6	1884.6	1884.6	1881.8	1296.0	1383.0
Rest of England	9430	8028.8	7616.3	7746.4	6274.2	4396.2	4563.2	4646.9	704.9	751.2
Scotland	1085	38.1	32.0	33.4	5.1	0.0	0.0	4.0	0.0	0.0
Wales	640	233.5	170.7	187.7	91.9	33.1	37.8	50.1	0.0	0.0
Northern Ireland	1044	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	14084	10185.1	9703.7	9852.2	8255.9	6313.9	6485.6	6582.9	2000.9	2134.1
Percentage >12 µgm ⁻³		72.32%	68.90%	69.95%	58.62%	44.83%	46.05%	46.74%	14.21%	15.15%
Total background area (km²) exceeding an annual mean concentration of 12 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1624	1624	1628	1628	1624	1603	1607	1468	136	146
Rest of England	128770	57524	53999	54222	21866	7542	7794	3510	382	394
Scotland	77791	0	0	0	0	0	0	0	0	0
Wales	20745	93	64	70	25	15	15	13	6	6
Northern Ireland	13318	0	0	0	0	0	0	0	0	0
Total	242248	59241	55691	55920	23515	9160	9416	4991	524	546
Percentage >12 µgm ⁻³		24.45%	22.99%	23.08%	9.71%	3.78%	3.89%	2.06%	0.22%	0.23%
Total population in area exceeding an annual mean concentration of 12 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7730326	7730326	7781081	7781081	7730326	7750780	7755926	7422172	785100	873311
Rest of England	41011137	24995661	23340917	23518357	17266493	9594167	9896636	6146668	580059	605503
Scotland	4944573	0	0	0	0	0	0	0	0	0
Wales	2850727	206009	147568	155346	32847	13326	13326	10010	2940	2940
Northern Ireland	1623309	0	0	0	0	0	0	0	0	0
Total	58160071	32931996	31269566	31454784	25029665	17358272	17665888	13578851	1368099	1481755
Percentage >12 µgm ⁻³		56.62%	53.76%	54.08%	43.04%	29.85%	30.37%	23.35%	2.35%	2.55%

Table 2.16 Summary statistics for combined measures PM2.5 projections comparison with 16 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 16 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1886	943	641	732	257	29	29	105	0	1
Rest of England	9430	587	406	460	73	1	1	26	0	0
Scotland	1085	0	0	0	0	0	0	0	0	0
Wales	640	6	1	1	0	0	0	0	0	0
Northern Ireland	1044	0	0	0	0	0	0	0	0	0
Total	14084	1536	1048	1193	330	29	29	131	0	1
Percentage >16 µgm ⁻³		10.91%	7.44%	8.47%	2.35%	0.21%	0.21%	0.93%	0.00%	0.01%
Total background area (km²) exceeding an annual mean concentration of 16 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1624	2	0	0	0	0	0	0	0	0
Rest of England	128770	21	14	14	3	2	2	2	0	0
Scotland	77791	0	0	0	0	0	0	0	0	0
Wales	20745	0	0	0	0	0	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	0	0	0
Total	242248	23	14	14	3	2	2	2	0	0
Percentage >16 µgm ⁻³		0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total population in area exceeding an annual mean concentration of 16 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7730326	9814	0	0	0	0	0	0	0	0
Rest of England	41011137	24332	14372	14372	1751	1735	1735	1735	0	0
Scotland	4944573	0	0	0	0	0	0	0	0	0
Wales	2850727	0	0	0	0	0	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	0	0	0
Total	58160071	34146	14372	14372	1751	1735	1735	1735	0	0
Percentage >16 µgm ⁻³		0.06%	0.02%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 2.17 Summary statistics for combined measures PM2.5 projections comparison with 20 µg m⁻³, gravimetric¹

Total road length (km) exceeding an annual mean concentration of 20 µg m⁻³										
	Total assessed	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1886	22	15	19	1	0	0	0	0	0
Rest of England	9430	3	0	3	0	0	0	0	0	0
Scotland	1085	0	0	0	0	0	0	0	0	0
Wales	640	0	0	0	0	0	0	0	0	0
Northern Ireland	1044	0	0	0	0	0	0	0	0	0
Total	14084	24	15	21	1	0	0	0	0	0
Percentage >20 µgm ⁻³		0.17%	0.11%	0.15%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%

¹ There are no predicted exceedences of 20 µg m⁻³ at background locations in any years modelled.

Table 2.18 Population weighted mean PM_{2.5} and PM₁₀ concentrations (µg m⁻³), gravimetric

2010										
	PM _{2.5}			PM ₁₀			Measure – baseline PM _{2.5}		(Measure – baseline PM _{2.5})/(Measure – baseline PM ₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	8.256	8.133	8.152	15.479	15.299	15.343	-0.124	-0.104	68.7%	76.3%
Wales	10.724	10.554	10.569	17.991	17.754	17.793	-0.170	-0.155	71.8%	78.2%
Northern Ireland	8.349	8.237	8.248	16.239	16.080	16.108	-0.112	-0.101	70.5%	76.9%
Inner London	14.642	14.363	14.416	23.567	23.139	23.264	-0.278	-0.226	65.1%	74.5%
Outer London	14.332	14.070	14.112	22.697	22.306	22.407	-0.263	-0.220	67.2%	75.8%
Rest of England	12.349	12.146	12.171	20.143	19.854	19.913	-0.203	-0.179	70.1%	77.6%
UK	12.064	11.864	11.890	19.880	19.592	19.654	-0.200	-0.174	69.5%	77.2%
2015										
	PM _{2.5}			PM ₁₀			Measure – baseline PM _{2.5}		(Measure – baseline PM _{2.5})/(Measure – baseline PM ₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	7.846	7.563	7.577	15.021	14.599	14.638	-0.283	-0.269	67.1%	70.2%
Wales	10.109	9.752	9.763	17.347	16.860	16.900	-0.357	-0.346	73.4%	77.5%
Northern Ireland	8.014	7.788	7.796	15.889	15.564	15.591	-0.226	-0.218	69.6%	73.2%
Inner London	13.617	12.933	12.969	22.460	21.346	21.454	-0.684	-0.648	61.4%	64.4%
Outer London	13.357	12.730	12.759	21.647	20.683	20.773	-0.628	-0.598	65.1%	68.5%
Rest of England	11.587	11.124	11.141	19.326	18.673	18.731	-0.463	-0.445	70.9%	74.8%
UK	11.322	10.864	10.882	19.084	18.424	18.482	-0.458	-0.440	69.4%	73.1%
2020										
	PM _{2.5}			PM ₁₀			Measure – baseline PM _{2.5}		(Measure – baseline PM _{2.5})/(Measure – baseline PM ₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	7.520	7.113	7.121	14.794	14.202	14.222	-0.407	-0.399	68.7%	69.8%
Wales	9.551	9.042	9.048	16.886	16.221	16.242	-0.509	-0.503	76.5%	78.1%
Northern Ireland	7.798	7.482	7.486	16.110	15.667	15.681	-0.316	-0.312	71.4%	72.8%
Inner London	12.799	11.800	11.820	21.772	20.165	20.222	-0.999	-0.979	62.2%	63.2%
Outer London	12.533	11.619	11.635	20.920	19.546	19.594	-0.913	-0.898	66.5%	67.7%
Rest of England	10.914	10.243	10.253	18.742	17.830	17.860	-0.671	-0.662	73.6%	75.1%
UK	10.680	10.016	10.026	18.543	17.617	17.648	-0.664	-0.654	71.7%	73.1%

3 Baseline and Measure Q: 2003 and 2004 base years, UEP21 and UEP26

3.1 Introduction

Since the additional measures report to support the 2006 review of the AQS (Stedman et al, 2006) was published, the following updates have occurred:

- The DTI have published new energy projections, UEP21 and UEP26. These supersede the previous energy projections, UEP12, used in earlier modelling to support the 2006 review of the AQS
- 2004 base year modelling and baseline modelling of projected NO₂, PM₁₀ and PM_{2.5} concentrations for 2010, 2015 and 2020 from this base year has been carried out. These projections compliment the 2003 base year modelling projections as our best estimate of future concentrations.

Appendix 2 gives details of the main differences between UEP12, UEP21 and UEP26.

This section presents modelling carried out to test the sensitivity to these changes of the baseline and measure Q (Defra's preferred measure at the time of publishing the air quality strategy review consultation document (Defra et al, 2006a; Defra et al, 2006b)). Modelling the baseline and measure Q using a 2003 base year, but with UEP21 and UEP26 enables a direct analysis of the impact of these new energy projections on the baseline and measure results. Then repeating this modelling for the 2004 base year demonstrates the impact of the new base year upon the model results.

A detailed description of measure Q is given in the additional measures report (Stedman et al, 2006). Measure Q is a combined measure. Table 3.1 gives details of the individual measures that make up measure Q. Measure O is also included here as well because, although it is a combined measure, it is the road transport component of measure Q.

Emissions projections estimates for years up to and including 2020 have been used in this section. For the two different base years, two different versions of the NAEI have been used. For the 2003 base year mapping, the 2002 NAEI (Dore et al, 2004) has been used. This is consistent with the baseline model projections presented in Grice et al (2006). For the 2004 base year mapping, the 2003 NAEI (Dore et al, 2005) has been used.

Table 3.1 Measure Q details (O is the road transport component of Q)

	Name of measure	Description of measure	Where it applies*	When it applies
C	Programme of incentives for early uptake of Euro V and VI Standards	This measure assumes that a programme of incentives is introduced for early introduction of Euro V and Euro VI. This measure is to be implemented based on Measure A i.e. the policy reverts back to Measure A after the incentives have taken effect The uptake rates of these incentives are: 2006: 0% Euro V LDVs 0% Euro V HDVs 2007: 25% Euro V LDVs 15% Euro V HDVs 2008: 50% Euro V LDVs 23% Euro V HDVs 2009: 75% Euro V LDVs (Euro V now mandatory for HDVs) 2010: 25% Euro VI HDVs (Euro V now mandatory for LDVs) 2011: 50% Euro VI HDVs 2012: 75% Euro VI HDVs 2013+ (Euro VI now mandatory for HDVs)	This measure is introduced from: 2007 for LDVs (Euro V) 2010 for HDVs (Euro VI)	This measure applies to UK
E	Programme of incentives to increase penetration of low emission vehicles (LEV)	Petrol LEVs assumed to deliver 38% reduction in NOX and 34% reduction in CO2 compared to Euro IV petrol cars. Penetration of petrol LEVs 10% by 2010, 25% by 2020 Diesel LEVs assumed to deliver 80% reduction in NOX, 92% reduction in PM10 and 28% reduction in CO2 compared to Euro IV diesel cars. Penetration of diesel LEVs 5% by 2010, 20% by 2020 It is assumed that petrol LEVs replace non-LEV petrol cars, diesel LEVs replace non-LEV diesel cars	This measure is introduced from 2006	This measure applies to UK
L	Small combustion plant measure	50% reduction in NO2 and SO2 in small combustion plants (20-50 MW). This measure is due to be applied following a potential EU Small Combustion Plant Directive or revision of existing IPPC or LCPD Directive in 2008.	This measure is due to be implemented in 2013	This measure applies to all EU countries
O	Combined measures C + E	See Measures C and E above.		
Q	Combined measures C + E + L	See Measures C, E and L above		

3.2 Baseline Emissions Projections and Mapping

3.2.1 Baseline Emission Projections in the 2002 NAEI

The baseline emissions projections used in the 2003 base year modelling have been calculated by the 2002 NAEI and represent the best estimates of emissions from the 2002 NAEI for current policies including current and agreed policies for the future. More details on the methods used to derive the baseline emissions projections are provided in Grice et al (2006). A summary giving the UK totals for NO_x, PM₁₀ and PM_{2.5} for key years is presented in Table 3.2. This gives details of the sectoral break down of emissions for the different energy projections considered (UEP12, UEP21 and UEP26). The split into different sectors is largely based on the sector descriptions used for international reporting of emissions but some sectors have been subdivided to enable subsequent model calculations.

Table 3.2 also gives national totals for SO₂. Only the UK total emission of SO₂ for the relevant years are presented because the SO₂ emissions data are only used here in the context of secondary PM calculations, which are not modelled as sector dependent.

Road traffic emissions projections have been produced using the 2002 NAEI and DfT's September 2004, 10 year plan for transport which uses 10 area types representing the different traffic growth in different sizes of urban area.

The emission projections in Table 3.2 show that there is a projected continuation in current trends of emission abatement resulting from current legislation.

3.2.2 Baseline Emissions Projections in the 2003 NAEI

The baseline emissions projections used in the 2004 base year modelling have been calculated by the 2003 NAEI and represent the best estimates of emissions from the 2003 NAEI for current policies including current and agreed policies for the future. Table 3.3 presents a summary of emissions projections for NO_x, PM₁₀, PM_{2.5} and SO₂ (total emissions only) from the 2003 NAEI for UEP21 and UEP26.

Road traffic emissions projections have been produced using the NAEI from a 2002 base year (Dore et al, 2004) and DfT's September 2004, 10 year plan for transport which uses 10 area types representing the different traffic growth in different sizes of urban area.

As with emissions projections in the 2002 NAEI, the emission projections from the 2002 NAEI (Table 3.2) show that there is a projected continuation in current trends of emission abatement resulting from current legislation. Differences in the emissions projections for the two base years generally related to the base year total and the level of emissions decrease from this overall for various sectors.

Table 3.2 Projections of UK total emissions using the 2002 NAEI (ktonnes yr⁻¹)

Pollutant	Source Sector	Base year	UEP12			UEP21			UEP26		
		2002	2010	2015	2020	2010	2015	2020	2010	2015	2020
NO _x	Agriculture Forestry and land use change	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0
	Aircraft	22016.0	24875.2	28254.6	31605.5	24616.6	28121.1	31625.6	24874.6	28254.6	31604.6
	Combustion in industry	148579.3	148535.8	155530.1	163867.8	129998.2	133860.0	137686.7	136491.3	139345.0	143258.5
	Combustion in commercial	28017.2	30247.1	32997.2	34675.4	30014.8	30893.2	31566.6	29127.8	29989.7	30792.7
	Combustion in domestic	73620.2	66479.2	67614.5	70358.2	66667.4	67818.5	68693.5	63762.2	64300.0	65392.9
	Combustion in Energy production and transformation	474391.5	361528.9	332327.8	223245.9	393741.1	429541.1	287322.8	432810.0	469166.8	319833.7
	Extraction and distribution of fossil fuels	689.6	1147.6	1221.3	1305.5	457.1	457.1	457.1	450.1	450.1	450.1
	Off road machinery	68722.1	52427.9	52427.9	52427.9	52427.9	52427.9	52427.9	52427.9	52427.9	52427.9
	Production process	2396.5	4277.7	4583.6	4911.7	3547.1	3549.7	3549.0	3546.8	3555.3	3558.0
	Railways	9324.8	7317.9	7221.8	6955.7	9452.0	9340.5	9117.7	9387.0	9266.3	9024.9
	Road transport	711298.2	396164.8	290493.6	267818.2	396164.8	290493.6	267818.2	396164.8	290493.6	267818.2
	Ships	50855.8	51803.6	50996.1	46457.2	61349.7	60469.2	58900.1	61070.3	60085.7	58436.8
	Waste treatment and disposal	4113.2	5912.8	6339.3	6824.0	3116.2	3121.3	3125.9	3341.1	3488.6	3654.7
	Total	1594304.5	1150998.5	1030287.8	910733.1	1171832.9	1110373.3	952571.2	1213734.0	1151103.7	986533.0
PM ₁₀	Agriculture Forestry and land use change	13535.8	13713.7	13792.9	13879.2	13535.8	13535.8	13535.8	13531.5	13575.1	13618.8
	Aircraft	192.2	223.9	266.4	309.0	223.9	266.4	308.9	223.9	266.4	308.9
	Brake and tyre wear	9184.9	10902.0	11359.2	11760.3	10902.0	11359.2	11760.3	10902.0	11359.2	11760.3
	Combustion in industry	17268.2	16212.0	16689.5	17261.3	15068.4	15035.9	15009.8	16217.8	16135.4	16192.3
	Combustion in commercial	4424.8	3394.4	3445.0	3493.8	3457.2	3471.7	3482.8	3043.6	3050.5	3061.7
	Construction	4642.8	5687.9	6167.8	6687.3	4998.7	4998.7	4998.7	4998.7	4998.7	4998.7
	Combustion in domestic	27515.6	11813.4	12069.7	15888.4	16564.8	16877.8	17436.0	15136.2	14930.2	15497.6
	Combustion in Energy production and transformation	12337.0	5593.5	5166.4	4905.7	5496.4	4795.0	3871.0	4157.1	4285.0	4080.9
	Off road machinery	6709.7	4382.3	4382.3	4382.3	4506.8	4506.8	4506.8	4506.8	4506.8	4506.8
	Production process	11537.4	14799.6	15698.4	16673.5	12358.2	12350.1	12326.1	13889.7	14583.3	15342.8
	Quarrying	20641.2	26120.4	28324.0	30709.6	17579.5	17579.5	17579.5	17579.5	17579.5	17579.5
	Railways	524.1	411.3	405.9	390.9	531.2	525.0	512.5	527.6	520.8	507.2
	Road transport	29827.5	18697.1	14518.5	14027.9	18697.1	14518.5	14027.9	18697.1	14518.5	14027.9
	Ships	953.0	970.5	955.4	921.9	1149.4	1132.9	1103.6	1144.2	1125.8	1095.0
	Waste treatment and disposal	1416.0	2006.1	2122.5	2255.2	1065.6	1070.8	1076.8	1072.0	1087.4	1104.6

Pollutant	Source Sector	Base year	UEP12			UEP21			UEP26		
		2002	2010	2015	2020	2010	2015	2020	2010	2015	2020
	total	160710.2	134928.2	135364.0	143546.3	126135.1	122024.4	121536.3	125627.9	122522.9	123683.0
PM _{2.5}	Agriculture Forestry and land use change	2162.2	2194.7	2204.0	2214.6	2162.2	2162.2	2162.2	2161.9	2164.8	2167.8
	Aircraft	146.1	47.5	56.6	65.6	170.2	202.5	234.8	170.2	202.5	234.8
	Brake and tyre wear	5055.0	5268.1	5417.1	5566.7	5268.1	5417.1	5566.7	5268.1	5417.1	5566.7
	Combustion in industry	12708.2	11104.1	11436.9	11832.2	10240.3	10246.6	10252.1	11658.8	11606.7	11632.8
	Combustion in commercial	2998.9	2057.5	2101.0	2138.7	2180.7	2195.2	2206.4	1847.5	1856.7	1867.9
	Construction	1439.3	1763.3	1912.0	2073.1	1549.6	1549.6	1549.6	1549.6	1549.6	1549.6
	Combustion in domestic	15062.0	8326.8	8892.6	10727.4	9879.2	10427.2	11114.6	7950.1	7467.1	7200.2
	Combustion in Energy production and transformation	6678.3	3176.4	3150.6	3234.5	3165.2	2993.3	2718.9	2548.2	2761.2	2787.6
	Off road machinery	5190.3	3377.0	3377.0	3377.0	3377.0	3377.0	3377.0	3377.0	3377.0	3377.0
	Production process	6345.4	8081.3	8573.1	9114.8	6729.3	6725.3	6713.2	7498.8	7845.9	8225.8
	Quarrying	5986.0	7574.9	8214.0	8905.8	5098.1	5098.1	5098.1	5098.1	5098.1	5098.1
	Railways	492.7	386.6	381.5	367.5	499.4	493.5	481.7	495.9	489.6	476.8
	Road transport	26809.6	16827.2	13066.7	12625.1	16827.2	13066.7	12625.1	16827.2	13066.7	12625.1
	Ships	895.8	5329.1	5310.6	5250.0	1080.5	1065.0	1037.4	1075.5	1058.2	1029.3
Waste treatment and disposal	1416.0	1072.0	1087.4	1104.6	1048.6	1048.6	1048.6	1072.0	1087.4	1104.6	
	Total	93385.7	76586.7	75181.1	78597.5	69275.6	66067.9	66186.3	68599.0	65048.6	64944.0
SO ₂	Total	1081.8	518.9	429.3	387.6	496.5	399.4	322.9	435.5	402.6	351.6

Table 3.3 Projections of UK total emissions using the 2003 NAEI (ktonnes yr⁻¹)

Pollutant	Source Sector	Base year	UEP21			UEP26		
		2002	2010	2015	2020	2010	2015	2020
NO _x	Agriculture Forestry and land use change	152.5	152.5	152.5	152.5	152.5	152.5	152.5
	Aircraft	18266.1	20580.3	23101.0	25591.7	18266.1	20580.3	23101.0
	Combustion in industry	186096.6	155378.9	156609.2	157525.7	186096.6	165560.8	165229.4
	Combustion in commercial	26889.9	27828.1	28884.2	29693.6	26889.9	19107.2	19709.3
	Combustion in domestic	111700.3	100655.6	102144.1	103223.3	111700.3	96136.4	96762.6
	Combustion in Energy production and transformation	469103.4	296629.9	295078.2	152889.8	469103.4	333727.2	340401.4
	Extraction and distribution of fossil fuels	689.6	450.1	450.1	450.1	689.6	450.1	450.1
	Off road machinery	38130.2	38130.2	38130.2	38130.2	38130.2	47853.6	47853.6
	Production process	2599.6	3525.9	3528.5	3527.8	2599.6	3525.6	3534.2
	Railways	9739.2	10918.0	10789.3	10531.9	9739.2	10842.9	10703.5
	Road transport	654853.9	396164.8	290493.6	267818.2	396164.8	290493.6	267818.2
	Ships	74118.1	53322.2	52778.7	51627.3	74118.1	61086.7	60101.4
	Waste treatment and disposal	4521.4	3758.7	3908.6	4076.2	4521.4	3758.7	3908.6
	Nature	1571.4	1571.4	1571.4	1571.4	1571.4	1571.4	1571.4
Total	1598432.2	1109066.6	1007619.5	846809.5	1339743.0	1054846.9	1041297.2	
PM ₁₀	Agriculture Forestry and land use change	13840.4	13921.9	13965.7	14009.5	13921.9	13965.7	14009.5
	Aircraft	63.3	73.9	87.8	101.8	73.9	87.8	101.8
	Brake and tyre wear	9262.7	10902.0	11359.2	11760.3	10902.0	11359.2	11760.3
	Combustion in industry	14272.3	15546.5	15501.2	15469.7	16885.6	16771.2	16776.5
	Combustion in commercial	3170.5	3318.4	3376.2	3430.4	3010.9	3019.9	3032.3
	Construction	1029.5	1116.5	1116.5	1116.5	1116.5	1116.5	1116.5
	Combustion in domestic	20270.7	19464.9	19523.9	19856.3	18507.3	18173.7	18537.1
	Combustion in Energy production and transformation	12786.0	7057.6	6831.2	6161.1	5492.0	6003.7	5977.0
	Off road machinery	3757.4	3757.4	3757.4	3757.4	4038.1	4038.1	4038.1
	Production process	10362.4	11529.2	11851.0	12193.9	11529.2	11851.1	12194.0
	Quarrying	8582.0	7070.6	7070.6	7070.6	7070.6	7070.6	7070.6
	Railways	213.1	238.9	236.1	230.5	237.3	234.2	228.1
	Road transport	28217.6	18697.1	14518.5	14027.9	18697.1	14518.5	14027.9
	Ships	1389.4	1149.7	1133.2	1103.9	1144.5	1126.1	1095.2

Pollutant	Source Sector	Base year	UEP21			UEP26		
		2002	2010	2015	2020	2010	2015	2020
	Waste treatment and disposal	6260.2	5918.1	5930.6	5944.6	5918.1	5930.6	5944.6
	Nature	4356.7	4356.7	4356.7	4356.7	4356.7	4356.7	4356.7
	Solvents	4941.2	4887.4	4850.0	4806.5	5711.1	4911.4	4732.9
	Total	142775.4	129006.7	125466.0	125397.4	128612.7	124534.9	124999.0
PM _{2.5}	Agriculture Forestry and land use change	2225.6	2231.1	2234.0	2237.0	2231.1	2234.0	2237.0
	Aircraft	48.1	56.1	66.7	77.4	76.9	78.7	80.5
	Brake and tyre wear	5048.7	6013.1	6270.4	6494.3	6013.1	6270.4	6494.3
	Combustion in industry	9953.3	10550.1	10551.0	10552.0	11711.8	11657.7	11682.0
	Combustion in commercial	1890.1	2066.2	2106.1	2142.3	1825.9	1837.2	1849.6
	Construction	319.2	346.1	346.1	346.1	346.1	346.1	346.1
	Combustion in domestic	12741.4	12669.1	12927.0	13356.4	12395.6	12519.4	12976.7
	Combustion in Energy production and transformation	7017.3	4652.0	4961.9	4936.3	3833.8	4446.4	4641.5
	Off road machinery	2909.6	2909.6	2909.6	2909.6	3112.0	3112.0	3112.0
	Production process	6185.3	6758.7	6915.9	7083.8	6758.7	6915.9	7083.8
	Quarrying	2488.8	2050.5	2050.5	2050.5	2050.5	2050.5	2050.5
	Railways	200.3	224.6	221.9	216.6	223.0	220.2	214.4
	Road transport	25084.8	16827.2	13066.7	12625.1	16827.2	13066.7	12625.1
	Ships	1306.0	1080.7	1065.2	1037.7	1075.8	1058.5	1029.5
	Waste treatment and disposal	6024.8	5682.7	5695.2	5709.2	5682.7	5695.2	5709.2
	Nature	3821.7	3821.7	3821.7	3821.7	3821.7	3821.7	3821.7
	Solvents	1729.4	1710.6	1697.5	1682.3	1998.9	1719.0	1656.5
Total	88994.5	79650.1	76907.5	77278.1	79985.0	77049.7	77610.5	
SO ₂	Total	978.2	507.4	409.9	332.9	431.0	396.9	344.7

3.2.3 Baseline Emissions Mapping Method

For both base years modelled, the method to map emissions and project emissions maps forward for future years remains unchanged.

For non-road transport area source emissions, 1 x 1km area source emission maps from the relevant edition of the NAEI have been used as a base for the projected emissions maps for 2010, 2015 and 2020. These maps have been scaled for the appropriate year and pollutant by the UK total emission projections for each sector (see Tables 3.2 and 3.3).

For road transport area source emissions maps and point sources, a more complex method has been used. A detailed description of this method is given Grice et al (2006).

3.3 Measure Q Emissions Projections and Mapping

3.3.1 Measure Q Emissions Projections in the 2002 NAEI

Table 3.4 presents emissions projections from the 2002 NAEI for the baseline and measure O (the road transport component of measure Q) for the road transport sector. Table 3.5 presents emissions projections for measure L, which impacts on stationary sources only. Emissions projections are shown from 2015 onwards only as the measure does not come into force until 2013. Measure Q combines these two sets of emissions reductions.

Table 3.4 Projections of road transport emissions, from 2002 NAEI (ktonnes yr⁻¹)

Pollutant	AQS measure ref	2003	2005	2010	2015	2020
NO _x	Base	654.9	572.3	396.2	290.5	267.8
	O (C + E)			384.0	240.2	188.8
PM ₁₀	Base	28.2	25.4	18.7	14.5	14.0
	O (C + E)			16.3	7.9	4.6

3.3.2 Measure Q Emissions Projections and Mapping in the 2003 NAEI

Table 3.6 presents emissions projections from the 2002 NAEI for the baseline and measure O (the road transport component of measure Q) for the road transport sector. Table 3.7 presents emissions projections for measure L, which impacts on stationary sources only. Emissions projections are shown from 2015 onwards only as the measure does not come into force until 2013. Measure Q combines these two sets of emissions reductions.

Table 3.6 Projections of road transport emissions, from 2003 NAEI (ktonnes yr⁻¹)

Pollutant	AQS measure ref	2004	2005	2010	2015	2020
NO _x	Base	610.8	572.3	396.2	290.5	267.8
	O (C + E)			384.0	240.2	188.8
PM ₁₀	Base	27.1	25.4	18.7	14.5	14.0
	O (C + E)			16.3	7.9	4.6

Table 3.5 Emissions projections for measure L (small combustion plant measure), from 2002 NAEI (ktonnes yr⁻¹)

	Source	Fuel	UEP12				UEP21				UEP26			
			2015		2020		2015		2020		2015		2020	
			Base	L	Base	L	Base	L	Base	L	Base	L	Base	L
NO _x	Miscellaneous	all fuels	14.3	13.7	14.7	14.1	10.7	10.2	11.1	10.5	12.2	11.6	12.7	12.0
	Public services	all fuels	17.2	16.6	18.5	17.9	8.5	8.0	8.8	8.3	10.9	10.2	11.3	10.5
	Autogenerators	all fuels	15.7	15.6	16.5	16.4	6.4	6.3	6.2	6.1	5.4	5.3	5.2	5.1
	Other industry combustion	all fuels	77.7	67.8	81.9	71.4	55.9	47.3	59.3	50.2	60.1	51.6	63.3	54.4
SO ₂	Public services	all fuels	5.2	4.7	5.1	4.6	3.5	3.2	3.5	3.2	3.5	3.2	3.5	3.2
	Autogenerators	all fuels	17.6	17.4	16.9	16.6	18.7	18.4	18.0	17.7	18.7	18.4	18.0	17.7
	Other industry combustion	all fuels	43.1	38.3	42.9	38.1	31.4	27.7	31.5	27.8	31.4	27.7	31.5	27.8

Table 3.7 Emissions projections for measure L (small combustion plant measure), from 2003 NAEI (ktonnes yr⁻¹)

	Source	Fuel	UEP21				UEP26			
			2015		2020		2015		2020	
			Base	L	Base	L	Base	L	Base	L
NO _x	Miscellaneous	all fuels	14.2	13.5	14.7	14.0	6.6	6.2	6.8	6.5
	Public services	all fuels	8.9	8.4	9.2	8.7	10.4	9.6	10.7	9.9
	Autogenerators	all fuels	5.8	5.7	5.6	5.5	5.5	5.5	5.5	5.5
	Other industry combustion	all fuels	67.4	57.1	71.3	60.5	62.7	53.9	66.1	56.7
SO ₂	Public services	all fuels	3.5	3.2	3.5	3.2	3.5	3.2	3.5	3.2
	Autogenerators	all fuels	18.7	18.4	18.0	17.7	18.7	18.4	18.0	17.7
	Other industry combustion	all fuels	31.4	27.7	31.5	27.8	31.4	27.7	31.5	27.8

3.3.3 Measure Q Emissions Mapping Method

Emissions on individual road links and the background area source road transport emissions maps for measure O (C and E combined) have been calculated. Both C and E affect emissions through changes in the overall make up of the vehicle fleet. This affects the emissions factors (i.e. how much of a given pollutant is emitted per vehicle km travelled) for each vehicle class (e.g. car, LGV) and DfT area type due to technology changes without changing the number of vehicle km travelled by each vehicle class on each road link or grid square. To map road transport emissions for measure O, which is the road transport component of measure Q, the method set out in Grice et al (2006) has been followed with the emission factors for each measure used rather than the baseline being used. This approach has been used for both base years of modelling.

3.4 Baseline Projections Modelling Method

3.4.1 2003 Base Year

A detailed description of the method used to model projections using the 2003 base year with UEP12 energy projections is given in Grice et al (2006). The method to model concentrations of NO₂, PM₁₀ and PM_{2.5} for this base year with UEP21 and UEP26 energy projections follows this method, except that the new energy projections have been used to scale the emissions maps, instead of the UEP12 projections. This therefore makes the modelled concentration projections from using UEP12, UEP21 and UEP26 directly comparable with each other, as the energy projections are the only part of the modelling to have changed.

3.4.2 2004 Base Year

The mapping method for the 2004 base year is presented in Stedman et al (2005). Projections from the 2004 base year follow a similar method to the 2003 base year projections (Grice et al, 2006), but with the differences described below.

For NO₂, the corrected rural NO_x map generated for the 2004 base year (see Stedman et al, 2005b for a description of how this was created) has been split into three component grids:

- Regional NO_x from UK sources
- NO_x from EU sources
- NO_x from maritime sources

This source apportionment has been carried out using projected 2010 EMEP grids (Tim Oxley pers. comm., 2006) for these sources as follows. The EMEP grids have been summed to give a total grid for the three sources and then a grid of the proportion of the total NO_x has been calculated for each source. The 2004 corrected rural NO_x grid has then been multiplied by the grids containing the proportion of NO_x for each source to give 2004 grids for each of the three sources of rural NO_x in the UK. These grids have then been scaled forward to 2010, 2015 and 2020 using UK total NO_x emissions estimates for these years from the 2003 NAEI for UK and EU sources and maritime NO_x emissions projections provided by EMEP for maritime sources (Tarrason, 2005).

For PM₁₀, the 2004 base year has been modelled using gravimetric data to calibrate the model. Additionally, a more detailed source apportionment for secondary PM has been used, which includes NH₄ and secondary organic aerosol for the first time. The model also included long-range transport of primary PM₁₀ for the first time. Stedman et al (2005b) and Stedman et al (2007) give further details of how each of these has been implemented in the 2004 base year modelling. 2004 maps generated in modelling of each of these sources of PM₁₀ for the 2004 base year have been scaled forward to 2010, 2015 and 2020. Secondary inorganic aerosol concentrations have been projected forwards on a national basis using the results of the EMEP model in the same way as was used for the 2003 base year projections (Grice et al, 2006). Secondary organic aerosol concentrations have been assumed to remain at 2004 levels in future years on the basis that the majority is generated from non-anthropogenic sources. The contribution from the residual PM has also been kept constant.

For $PM_{2.5}$, the method for modelling the 2004 base year is given in Stedman et al (2007). Source apportionment of $PM_{2.5}$ for the 2004 base year modelling is fully consistent with the PM_{10} modelling as both sets of maps have been calibrated using gravimetric monitoring data. The modelling method to project maps of $PM_{2.5}$ to 2010, 2015 and 2020 closely follows the method for PM_{10} set out above.

3.5 Measure Q Modelling Method

3.5.1 2003 Base Year

The modelling method for measure Q for 2010, 2015 and 2020 from a 2003 base year, using UEP12 energy projections is detailed in Stedman et al (2006). The method used here is the same except that the alternative version of the DTI's energy projections are used.

Additionally in modelling secondary PM, a 50% response rate of secondary PM reduction to the emissions reduction caused by the additional measures has been assumed. This is the case for all the PM_{10} and $PM_{2.5}$ results presented in this section for UEP12, UEP21 and UEP26.

3.5.2 2004 Base Year

The modelling method for measure Q for 2010, 2015 and 2020 from a 2004 base year, using the three different sets of energy projections closely follows the method for modelling measure Q set out in Stedman et al (2006) with the following differences.

For NO_2 , maps containing rural NO_x from the UK, the EU and maritime sources have been scaled for future years taking into account projected emissions reductions in the relevant sectors resulting from measure Q.

For PM_{10} and $PM_{2.5}$, the 2004 secondary grids and the 2004 long range primary transport grid have been scaled forward to 2010, 2015 and 2020 in the same way as in 2004 baseline projections, but taking into account emissions reductions in the relevant sectors.

Additionally in modelling secondary PM, a 50% response rate of secondary PM reduction to the emissions reduction caused by the additional measures has been assumed. This is the case for all the PM_{10} and $PM_{2.5}$ results presented in this section for UEP21 and UEP26.

3.6 NO₂ Results

The modelling results for the baseline and each of the measures modelled for 2010, 2015 and 2020 are summarised in Table 3.9-3.11 in terms of a comparison of modelled concentrations with the annual mean objective for NO₂ of 40 µg m⁻³. Estimates of the area exceeding and population exposed have been derived from the background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

Most exceedences of the 40 µg m⁻³ are predicted to be limited to roadside locations by 2010. Generally the total road length of exceedencing in 2010, 2015 and 2020 under baseline conditions for a given base year shows very little variability as a function of the different energy projections used. Similarly, a comparison of the different measure Q model runs for different energy projections, but the same base year shows relatively little variability in terms of total length of exceedence for measure Q. The modelled extent of exceedences for NO₂ instead seems to be much more sensitive to the base year used, with results using the 2004 base year typically showing lower concentrations across the UK, and hence a smaller extent of exceedences.

For both base years, measure Q reduced the extent of exceedences compared to the baseline an increasing amount the further forward in time the projections go up to 2020.

Population-weighted annual mean NO₂ concentrations at background locations are presented in Table 3.12. This statistic represents the average concentration exposure of the UK population to NO₂ and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations.

The population-weighted mean results again show that the base year used has a greater impact on the results than which energy projections have been used. However, regardless of the base year and energy projections used, measure Q does significantly reduce the UK population weighted mean concentration by 2020 compared to the baseline.

Table 3.9 Total road length (km) exceeding an annual mean NO₂ concentration of 40 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1024	989	1022	987	1029	988	1890	796	753	775	738
Rest of England	9430	1372	1298	1364	1292	1397	1306	9578	1033	974	1047	984
Scotland	1085	112	106	111	95	111	98	1078	71	65	68	62
Wales	640	42	41	42	41	42	42	641	36	33	36	33
Northern Ireland	1044	18	14	18	14	18	18	1031	4	0	4	0
Total	14084	2567	2448	2557	2429	2597	2452	14218	1939	1824	1931	1816
Percentage >40 µgm-3		18.2%	17.4%	18.2%	17.2%	18.4%	17.4%		13.6%	12.8%	13.6%	12.8%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	651	478	652	481	657	488	1890	430	294	408	296
Rest of England	9430	680	468	689	476	694	483	9578	499	278	503	283
Scotland	1085	51	32	51	32	51	32	1078	32	12	32	12
Wales	640	22	13	22	15	22	15	641	14	7	14	7
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	1405	991	1414	1005	1424	1018	14218	976	592	957	599
Percentage >40 µgm-3		10.0%	7.0%	10.0%	7.1%	10.1%	7.2%		6.9%	4.2%	6.7%	4.2%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	564	310	549	293	550	296	1890	342	161	320	168
Rest of England	9430	570	180	562	184	571	186	9578	410	40	412	44
Scotland	1085	43	5	41	5	41	5	1078	24	3	24	3
Wales	640	17	4	17	4	20	4	641	14	1	14	1
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	1194	499	1170	486	1181	491	14218	790	205	771	216
Percentage >40 µgm-3		8.5%	3.5%	8.3%	3.5%	8.4%	3.5%		5.6%	1.4%	5.4%	1.5%

Table 3.10 Total background area (km²) exceeding an annual mean NO₂ concentration of 40 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	55	54	54	52	55	53	1628	16	15	8	7
Rest of England	128770	19	16	19	17	20	18	128764	0	0	0	0
Scotland	77791	2	1	1	1	1	1	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	76	71	74	70	76	72	243212	16	15	8	7
Percentage >40 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	39	35	38	34	38	34	1628	6	3	3	4
Rest of England	128770	12	8	12	8	12	9	128764	0	0	0	0
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	51	43	50	42	50	43	243212	6	3	3	4
Percentage >40 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	38	31	35	27	35	27	1628	7	3	4	3
Rest of England	128770	15	8	15	8	15	8	128764	0	0	0	0
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	53	39	50	35	50	35	243212	7	3	4	3
Percentage >40 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%

Table 3.11 Population in area exceeding an annual mean NO₂ concentration of 40 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	319019	305296	305296	278127	319019	291356	7784707	86355	75905	41,280	24,700
Rest of England	41011137	17395	11528	13275	12817	17641	13029	40983864	0	0	0	0
Scotland	4944573	6547	1547	1547	1547	1547	1547	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	342961	318371	320118	292492	338207	305931	58251571	86355	75905	41,280	24,700
Percentage >40 µgm-3		0.6%	0.5%	0.6%	0.5%	0.6%	0.5%		0.1%	0.1%	0.1%	0.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	156502	120633	154748	115408	154748	115408	7784707	20480	10772	8,446	17,317
Rest of England	41011137	5946	4668	5946	4668	5946	4837	40983864	0	0	0	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	162448	125301	160694	120076	160694	120245	58251571	20480	10772	8,446	17,317
Percentage >40 µgm-3		0.3%	0.2%	0.3%	0.2%	0.3%	0.2%		0.0%	0.0%	0.0%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	154748	104328	120633	77545	120633	77545	7784707	20541	8446	7,001	8,446
Rest of England	41011137	6071	4668	6071	4668	6071	4668	40983864	0	0	0	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	160819	108995	126704	82213	126704	82213	58251571	20541	8446	7,001	8,446
Percentage >40 µgm-3		0.3%	0.2%	0.2%	0.1%	0.2%	0.1%		0.0%	0.0%	0.0%	0.0%

Table 3.12 Population weighted mean NO₂ concentrations (µg m⁻³)

2010										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	13.41	13.23	13.36	13.18	13.47	13.29	10.08	9.96	10.06	9.93
Wales	13.53	13.37	13.58	13.41	13.80	13.63	10.56	10.43	10.68	10.55
Northern Ireland	9.25	9.12	9.29	9.17	9.41	9.28	7.09	7.02	7.09	7.00
Inner London	34.02	33.70	33.85	33.52	33.96	33.64	29.33	29.09	28.68	28.44
Outer London	27.77	27.51	27.75	27.48	27.89	27.62	23.43	23.23	23.26	23.06
Rest of England	19.27	19.07	19.32	19.11	19.54	19.33	15.52	15.37	15.65	15.49
UK	19.52	19.31	19.54	19.33	19.74	19.53	15.80	15.65	15.86	15.70
2010										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	11.85	10.81	11.93	10.92	12.01	11.01	8.96	8.29	8.91	8.36
Wales	11.97	10.94	12.32	11.36	12.52	11.57	9.54	8.91	9.66	9.04
Northern Ireland	7.96	7.31	8.22	7.60	8.31	7.71	6.40	5.98	6.38	6.03
Inner London	31.59	29.68	31.56	29.74	31.61	29.81	27.07	25.92	26.34	26.09
Outer London	25.54	24.12	25.75	24.39	25.85	24.49	21.51	20.56	21.29	20.71
Rest of England	17.34	16.17	17.71	16.59	17.91	16.81	14.09	13.21	14.20	13.38
UK	17.61	16.42	17.92	16.78	18.10	16.97	14.36	13.50	14.40	13.66
2010										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	11.31	9.81	11.17	9.69	11.24	9.77	8.60	7.60	8.56	7.67
Wales	11.18	9.67	11.23	9.76	11.42	9.94	9.03	8.10	9.14	8.25
Northern Ireland	7.38	6.46	7.46	6.52	7.54	6.62	6.17	5.55	6.15	5.62
Inner London	30.93	28.28	30.36	27.81	30.41	27.87	26.45	24.77	25.73	24.97
Outer London	24.82	22.76	24.66	22.65	24.74	22.74	20.94	19.51	20.74	19.69
Rest of England	16.43	14.63	16.49	14.73	16.68	14.93	13.47	12.11	13.59	12.31
UK	16.78	14.98	16.77	15.02	16.94	15.19	13.78	12.48	13.83	12.66

3.7 PM₁₀ results

Modelling results for PM₁₀ for the baseline and each of the measures for 2010, 2015 and 2020 are summarised in tables 3.13 to 3.15 in terms of a comparison of modelled concentrations with an annual mean concentration of 31.5 µg m⁻³ (roughly equivalent to the 2004 24-hour AQS objective (Stedman et al, 2001)). Tables 3.16 to 3.18 present the same results in terms of a comparison with the annual mean objective of 20 µg m⁻³. No results are presented for the annual mean objective of 40 µg m⁻³ because exceedences of this objective were predicted to have been almost entirely eliminated by 2010 under baseline conditions and for all the measures.

Model results for the additional measures have been compared with an annual mean threshold of 20 µg m⁻³ for the whole of the UK in order to simplify the presentation of the results for the large number of measures. 20 µg m⁻³ is the 2010 stage 2 indicative limit value and the 2010 AQS objective for England, excluding London, Wales and Northern Ireland. A comparison of predicted baseline concentrations with the AQS objectives for 2010 of 18 µg m⁻³ for Scotland and 23 µg m⁻³ for London has been presented in Grice et al (2006).

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

Please note that for the measure Q results in Tables 3.13 to 3.19, a 50% response rate of secondary PM to emissions reduction has been assumed.

The majority of exceedences occur at the 20 µg m⁻³ threshold. As with NO₂, the baseline and measure Q seem to be more sensitive to the base year used, with less difference apparent between modelling carried out with the same base year, but different energy projections.

The overall trends in number of exceedences are the same regardless of base year or energy projections used in that the extent of exceedence under baseline conditions is predicted to decrease between 2010 and 2015 and between 2015 and 2020. Measure Q in 2010 is generally predicted to reduce the extent of exceedences slightly relative to the baseline and then in 2015 and 2020 this reduction relative to the baseline is predicted to increase.

Population weighted mean PM₁₀ concentrations at background locations are presented in Table 3.19. This statistic represents the average concentration exposure of the UK population to PM₁₀ and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations. The benefits of a measure will be related to the difference between the population-weighted mean concentration for the measure and that calculated for the baseline. The projected model results for this statistic show a generally similar pattern of changes to the extent of exceedences results.

Table 3.13 Total road length (km) exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	140	76	137	72	132	70	1890	46	26	46	21
Rest of England	9430	158	96	136	58	149	78	9578	56	41	57	48
Scotland	1085	3	0	3	0	3	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	2	2	2	2
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	301	172	275	130	284	147	14218	104	70	106	71
Percentage>31.5 µg m ⁻³		2.1%	1.2%	2.0%	0.9%	2.0%	1.0%		0.7%	0.5%	0.7%	0.5%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	31	1	30	30	30	1	1890	8	0	8	0
Rest of England	9430	41	6	9	9	29	0	9578	35	28	38	31
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	2	0	2	2
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	72	7	38	38	59	1	14218	45	28	48	33
Percentage>31.5 µg m ⁻³		0.5%	0.0%	0.3%	0.3%	0.4%	0.0%		0.3%	0.2%	0.3%	0.2%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	21	0	18	0	20	0	1890	2	0	2	0
Rest of England	9430	28	2	2	0	15	0	9578	32	20	33	25
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	2	0	2	0
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	48	2	20	0	35	0	14218	36	20	37	25
Percentage>31.5 µg m ⁻³		0.3%	0.0%	0.1%	0.0%	0.2%	0.0%		0.3%	0.1%	0.3%	0.2%

Table 3.14 Total background area (km²) exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	6	3	0	0	0	0	128764	0	0	0	0
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	6	3	0	0	0	0	243212	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	4	2	0	0	0	0	128764	0	0	0	0
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	4	2	0	0	0	0	243212	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	5	3	0	0	0	0	128764	0	0	0	0
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	0	0	0	0
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	5	3	0	0	0	0	243212	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%

Table 3.15 Population in area exceeding an annual mean PM₁₀ concentration of 31.5 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	10242	3463	0	0	0	0	40983864	0	0	0	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	10242	3463	0	0	0	0	58251571	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	3477	671	0	0	0	0	40983864	0	0	0	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	3477	671	0	0	0	0	58251571	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	5306	686	0	0	0	0	40983864	0	0	0	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	0	0	0	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	5306	686	0	0	0	0	58251571	0	0	0	0
Percentage>31.5 µgm ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%

Table 3.16 Total road length (km) exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1885	1885	1885	1885	1885	1885	1890	1885	1885	1885	1885
Rest of England	9430	8376	8117	8392	8120	8366	8082	9578	7285	7009	7285	7031
Scotland	1085	187	128	179	123	179	125	1078	76	57	81	69
Wales	640	336	288	351	298	344	287	641	140	118	147	119
Northern Ireland	1044	149	144	204	191	188	178	1031	208	191	173	158
Total	14084	10933	10563	11010	10618	10962	10557	14218	9594	9259	9570	9261
Percentage >20 µg m ⁻³		77.6%	75.0%	78.2%	75.4%	77.8%	75.0%		67.5%	65.1%	67.3%	65.1%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1885	1877	1885	1877	1885	1880	1890	1881	1861	1881	1854
Rest of England	9430	7203	5110	7230	5022	7315	5200	9578	6222	4726	6264	4784
Scotland	1085	80	19	73	15	77	17	1078	41	8	41	8
Wales	640	193	94	195	88	193	93	641	95	49	95	49
Northern Ireland	1044	119	70	175	107	146	100	1031	155	141	150	134
Total	14084	9480	7170	9558	7108	9615	7291	14218	8394	6785	8431	6830
Percentage >20 µg m ⁻³		67.3%	50.9%	67.9%	50.5%	68.3%	51.8%		59.0%	47.7%	59.3%	48.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1881	1608	1880	1413	1881	1549	1890	1864	1588	1869	1546
Rest of England	9430	6292	2508	5849	1877	6095	2202	9578	5342	2782	5426	2878
Scotland	1085	67	4	59	2	62	4	1078	33	3	34	5
Wales	640	141	48	116	34	118	38	641	69	29	71	32
Northern Ireland	1044	146	98	157	98	134	67	1031	155	134	150	127
Total	14084	8526	4266	8061	3424	8289	3860	14218	7462	4536	7550	4587
Percentage >20 µg m ⁻³		60.5%	30.3%	57.2%	24.3%	58.9%	27.4%		52.5%	31.9%	53.1%	32.3%

Table 3.17 Total background area (km²) exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1621	1621	1621	1621	1625	1622	1628	1461	1376	1456	1374
Rest of England	128770	17192	15952	16553	15314	16002	14698	128764	6188	5330	6257	5397
Scotland	77791	25	20	22	20	22	20	77941	2	2	4	2
Wales	20745	267	245	212	190	210	180	20745	29	26	32	26
Northern Ireland	13318	19	15	52	49	40	39	14134	79	76	68	65
Total	242248	19124	17853	18460	17194	17899	16559	243212	7759	6810	7817	6864
Percentage >20 µgm ⁻³		7.9%	7.4%	7.6%	7.1%	7.4%	6.8%		3.2%	2.8%	3.2%	2.8%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1523	1368	1514	1339	1528	1389	1628	830	232	876	252
Rest of England	128770	8207	5459	7429	4716	7998	5227	128764	2819	1517	2957	1607
Scotland	77791	18	16	15	12	18	13	77941	2	0	2	0
Wales	20745	180	161	98	77	106	81	20745	22	20	23	21
Northern Ireland	13318	10	3	43	29	27	16	14134	67	54	53	43
Total	242248	9938	7007	9099	6173	9677	6726	243212	3740	1823	3911	1923
Percentage >20 µgm ⁻³		4.1%	2.9%	3.8%	2.5%	4.0%	2.8%		1.5%	0.7%	1.6%	0.8%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1291	626	1124	402	1217	510	1628	291	19	341	26
Rest of England	128770	4682	2580	2985	1502	3564	1841	128764	1570	720	1685	798
Scotland	77791	18	12	12	8	13	9	77941	0	0	1	0
Wales	20745	163	124	59	41	64	48	20745	19	19	19	19
Northern Ireland	13318	32	15	35	20	19	12	14134	67	50	51	39
Total	242248	6186	3357	4215	1973	4877	2420	243212	1947	808	2097	882
Percentage >20 µgm ⁻³		2.6%	1.4%	1.7%	0.8%	2.0%	1.0%		0.8%	0.3%	0.9%	0.4%

Table 3.18 Population in area exceeding an annual mean PM₁₀ concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	7727768	7727768	7727768	7727768	7778523	7776836	7784707	7430028	7180968	7415955	7177718
Rest of England	41011137	20904147	19695480	20762094	19523916	20451458	19154658	40983864	12363111	10916129	12619700	11134048
Scotland	4944573	41611	32715	39594	32715	39594	32715	4963288	980	980	7427	980
Wales	2850727	352663	308536	326628	281511	326289	276737	2855075	42526	27415	49620	27415
Northern Ireland	1623309	65651	48009	188167	175274	142683	139846	1664637	280748	271410	243822	231832
Total	58160071	29091840	27812508	29044251	27741183	28738548	27380793	58251571	20117394	18396903	20336524	18571993
Percentage >20 µgm ⁻³		50.0%	47.8%	49.9%	47.7%	49.4%	47.1%		34.5%	31.6%	34.9%	31.9%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	7544505	7147069	7523097	7055078	7602654	7234850	7784707	4716071	1257362	4958024	1350447
Rest of England	41011137	13140915	8794642	12540412	8202153	13312100	8977386	40983864	6539612	3265494	6824122	3476177
Scotland	4944573	32421	25873	22655	13928	32421	17213	4963288	980	0	980	0
Wales	2850727	180796	113936	135688	86016	150792	90858	2855075	26789	26581	27034	26720
Northern Ireland	1623309	30106	9156	150744	96085	95089	53725	1664637	241704	202961	193336	166579
Total	58160071	20928742	16090676	20372595	15453260	21193055	16374031	58251571	11525156	4752399	12003496	5019923
Percentage >20 µgm ⁻³		36.0%	27.7%	35.0%	26.6%	36.4%	28.2%		19.8%	8.2%	20.6%	8.6%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	6919180	3820330	6321483	2479460	6695112	3186113	7784707	1676460	37123	1947662	55347
Rest of England	41011137	8313678	4179626	5988452	2635168	7088933	3379777	40983864	3727401	1389824	3995384	1531201
Scotland	4944573	32421	13928	13928	6919	17213	7532	4963288	0	0	766	0
Wales	2850727	136343	70506	71280	28749	88333	49578	2855075	26540	26540	26540	26540
Northern Ireland	1623309	115537	48897	127164	66542	62237	40818	1664637	241704	187229	187584	151688
Total	58160071	15517158	8133287	12522307	5216837	13951827	6663818	58251571	5672104	1640717	6157935	1764777
Percentage >20 µgm ⁻³		26.7%	14.0%	21.5%	9.0%	24.0%	11.5%		9.7%	2.8%	10.6%	3.0%

Table 3.19 Population weighted mean PM₁₀ concentrations (µg m⁻³)

2010										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	15.48	15.38	15.51	15.40	15.47	15.36	12.78	12.65	12.78	12.65
Wales	17.99	17.90	17.99	17.90	17.95	17.85	15.27	15.15	15.27	15.15
Northern Ireland	16.24	16.18	16.79	16.73	16.57	16.51	15.15	15.07	14.97	14.89
Inner London	23.57	23.26	23.49	23.18	23.45	23.13	21.43	21.14	21.43	21.14
Outer London	22.70	22.46	22.60	22.36	22.58	22.34	21.18	20.91	21.19	20.91
Rest of England	20.14	20.01	20.08	19.95	20.08	19.93	18.69	18.50	18.72	18.53
UK	19.88	19.74	19.84	19.70	19.82	19.67	18.23	18.05	18.25	18.06
2015										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	15.02	14.70	15.03	14.71	15.04	14.73	12.38	12.01	12.37	12.00
Wales	17.35	17.05	17.32	17.03	17.36	17.07	14.72	14.36	14.74	14.39
Northern Ireland	15.89	15.68	16.43	16.23	16.19	15.99	14.86	14.62	14.61	14.37
Inner London	22.46	21.52	22.36	21.43	22.44	21.51	20.39	19.52	20.43	19.57
Outer London	21.65	20.90	21.53	20.80	21.64	20.90	20.14	19.32	20.19	19.37
Rest of England	19.33	18.88	19.24	18.81	19.34	18.91	17.88	17.32	17.92	17.36
UK	19.08	18.62	19.03	18.57	19.10	18.65	17.46	16.90	17.48	16.93
2020										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	14.79	14.35	14.61	14.17	14.65	14.22	12.14	11.61	12.14	11.61
Wales	16.89	16.47	16.65	16.23	16.73	16.32	14.27	13.76	14.31	13.81
Northern Ireland	16.11	15.82	16.10	15.81	15.88	15.60	14.71	14.36	14.47	14.12
Inner London	21.77	20.45	21.42	20.10	21.56	20.24	19.60	18.37	19.68	18.44
Outer London	20.92	19.87	20.58	19.53	20.74	19.70	19.34	18.17	19.43	18.26
Rest of England	18.74	18.12	18.43	17.81	18.59	17.98	17.24	16.45	17.31	16.52
UK	18.54	17.89	18.25	17.60	18.38	17.74	16.85	16.06	16.91	16.12

3.8 PM_{2.5} Results

There are currently no limit values or objectives for PM_{2.5}. Therefore modelled concentrations have been compared with indicative threshold concentrations of 12, 16 and 20 µg m⁻³ to illustrate the changes in predicted concentration in different years and for different measures. This comparison is shown in tables 3.20 to 3.28.

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

Please note that for the measure Q results in Tables 3.20 to 3.29, a 50% response rate of secondary PM to emissions reduction has been assumed.

Population-weighted annual mean PM_{2.5} concentrations at background locations are presented in Table 3.29 for the different measures. The population-weighted mean concentrations show a similar, but not identical pattern of changes with the different measures to the extent of exceedences. The concentrations presented in table 4.7 are given to a higher degree of precision than the modelling method warrants so that small differences in the model outputs can be seen. This is useful when certain measures only result in small changes, for example in the 3rd decimal place.

Table 3.20 Total road length (km) exceeding an annual mean PM_{2.5} concentration of 12 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1885	1885	1885	1885	1885	1885	1890	1888	1888	1888	1888
Rest of England	9430	8029	7745	7981	7663	7964	7615	9578	8021	7781	7990	7764
Scotland	1085	38	29	38	29	38	29	1078	71	57	77	57
Wales	640	234	187	222	181	213	173	641	158	137	158	141
Northern Ireland	1044	0	0	0	0	0	0	1031	142	137	142	129
Total	14084	10185	9845	10126	9758	10100	9702	14218	10280	10000	10255	9978
Percentage>12 µgm ⁻³		72.3%	69.9%	71.9%	69.3%	71.7%	68.9%		72.3%	70.3%	72.1%	70.2%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1885	1885	1885	1885	1885	1885	1890	1888	1885	1888	1885
Rest of England	9430	6274	4783	6249	4776	6340	4894	9578	7076	5727	7106	5801
Scotland	1085	5	0	5	0	5	0	1078	37	5	38	5
Wales	640	92	35	90	34	94	36	641	105	50	110	50
Northern Ireland	1044	0	0	0	0	0	0	1031	129	123	129	123
Total	14084	8256	6702	8228	6695	8324	6814	14218	9236	7789	9271	7864
Percentage>12 µgm ⁻³		58.6%	47.6%	58.4%	47.5%	59.1%	48.4%		65.0%	54.8%	65.2%	55.3%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1882	1699	1881	1583	1882	1684	1890	1884	1845	1885	1859
Rest of England	9430	4647	1254	4308	858	4472	1117	9578	6238	3535	6384	3749
Scotland	1085	4	0	3	0	3	0	1078	27	3	27	3
Wales	640	50	0	47	0	49	0	641	69	23	80	23
Northern Ireland	1044	0	0	0	0	0	0	1031	129	126	129	126
Total	14084	6583	2953	6240	2441	6406	2802	14218	8348	5533	8504	5760
Percentage>12 µgm ⁻³		46.7%	21.0%	44.3%	17.3%	45.5%	19.9%		58.7%	38.9%	59.8%	40.5%

Table 3.21 Total background area (km²) exceeding an annual mean PM_{2.5} concentration of 12 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1624	1624	1624	1624	1628	1628	1628	1628	1628	1628	1628
Rest of England	128770	57524	56645	56943	56104	56517	55615	128764	18301	16280	17256	15322
Scotland	77791	0	0	0	0	0	0	77941	12	9	12	9
Wales	20745	93	79	79	69	77	63	20745	88	67	92	69
Northern Ireland	13318	0	0	0	0	0	0	14134	77	72	73	71
Total	242248	59241	58348	58646	57797	58222	57306	243212	20106	18056	19061	17099
Percentage>12 µgm-3		24.5%	24.1%	24.2%	23.9%	24.0%	23.7%		8.3%	7.4%	7.8%	7.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1624	1622	1624	1624	1628	1628	1628	1610	1495	1611	1502
Rest of England	128770	21866	12359	23792	13932	26938	16487	128764	8702	4868	8954	5111
Scotland	77791	0	0	0	0	0	0	77941	9	8	9	9
Wales	20745	25	18	19	13	25	17	20745	48	39	48	39
Northern Ireland	13318	0	0	0	0	0	0	14134	70	50	59	47
Total	242248	23515	13999	25435	15569	28591	18132	243212	10439	6460	10681	6708
Percentage>12 µgm-3		9.7%	5.8%	10.5%	6.4%	11.8%	7.5%		4.3%	2.7%	4.4%	2.8%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	1468	553	1411	373	1465	520	1628	1455	413	1476	506
Rest of England	128770	3510	803	2504	478	3176	683	128764	4611	1463	5030	1684
Scotland	77791	0	0	0	0	0	0	77941	8	5	9	9
Wales	20745	13	9	9	7	11	9	20745	38	35	40	37
Northern Ireland	13318	0	0	0	0	0	0	14134	68	47	60	45
Total	242248	4991	1365	3924	858	4652	1212	243212	6180	1963	6615	2281
Percentage>12 µgm-3		2.1%	0.6%	1.6%	0.4%	1.9%	0.5%		2.5%	0.8%	2.7%	0.9%

Table 3.22 Population in area exceeding an annual mean PM_{2.5} concentration of 12 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	7730326	7730326	7730326	7730326	7781081	7781081	7784707	7781081	7781081	7781081	7781081
Rest of England	41011137	24995661	24294752	24636594	23941076	24446025	23703411	40983864	22348302	20983873	22036966	20631221
Scotland	4944573	0	0	0	0	0	0	4963288	27107	15491	27107	15491
Wales	2850727	206009	173783	181143	166826	180541	149697	2855075	153174	113596	150359	114485
Northern Ireland	1623309	0	0	0	0	0	0	1664637	271445	258403	260691	253302
Total	58160071	32931996	32198860	32548063	31838227	32407648	31634189	58251571	30581108	29152443	30256203	28795580
Percentage>12 µgm-3		56.6%	55.4%	56.0%	54.7%	55.7%	54.4%		52.5%	50.0%	51.9%	49.4%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	7730326	7729432	7730326	7730326	7781081	7781081	7784707	7767710	7544378	7767857	7557930
Rest of England	41011137	17266493	12791555	17405658	13271206	18091669	14006115	40983864	15730492	10002573	16048878	10418771
Scotland	4944573	0	0	0	0	0	0	4963288	15491	15464	15491	15491
Wales	2850727	32847	20787	25355	10956	41048	19917	2855075	62334	33454	62334	33454
Northern Ireland	1623309	0	0	0	0	0	0	1664637	253234	187697	212329	180839
Total	58160071	25029665	20541773	25161339	21012487	25913797	21807114	58251571	23829261	17783566	24106889	18206484
Percentage>12 µgm-3		43.0%	35.3%	43.3%	36.1%	44.6%	37.5%		40.9%	30.5%	41.4%	31.3%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	7422172	3412749	7288106	2428055	7456233	3234987	7784707	7431841	2574345	7479598	3108331
Rest of England	41011137	6146668	1436320	4384705	707724	5438356	1133136	40983864	10128985	3255939	10832300	3836294
Scotland	4944573	0	0	0	0	0	0	4963288	15464	11573	15491	15491
Wales	2850727	10010	3202	3202	1263	7535	3202	2855075	33361	31778	33523	32851
Northern Ireland	1623309	0	0	0	0	0	0	1664637	243467	178647	216256	173855
Total	58160071	13578851	4852270	11676012	3137041	12902124	4371325	58251571	17853117	6052282	18577167	7166822
Percentage>12 µgm-3		23.3%	8.3%	20.1%	5.4%	22.2%	7.5%		30.6%	10.4%	31.9%	12.3%

Table 3.23 Total road length (km) exceeding an annual mean PM_{2.5} concentration of 16 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	943	663	923	646	909	625	1890	747	529	713	510
Rest of England	9430	587	399	544	351	561	357	9578	969	670	1002	702
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	6	1	6	1	6	1	641	11	11	11	11
Northern Ireland	1044	0	0	0	0	0	0	1031	24	14	19	14
Total	14084	1536	1063	1473	998	1476	983	14218	1750	1224	1745	1237
Percentage>16 µgm-3		10.9%	7.5%	10.5%	7.1%	10.5%	7.0%		12.3%	8.6%	12.3%	8.7%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	257	24	268	268	276	276	1890	306	306	304	304
Rest of England	9430	73	3	62	62	80	80	9578	336	336	379	379
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	10	10	10	10
Northern Ireland	1044	0	0	0	0	0	0	1031	14	14	14	14
Total	14084	330	27	330	330	356	356	14218	666	666	707	707
Percentage>16 µgm-3		2.3%	0.2%	2.3%	2.3%	2.5%	2.5%		4.7%	4.7%	5.0%	5.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	105	0	90	0	98	0	1890	197	9	201	9
Rest of England	9430	26	0	14	0	23	0	9578	194	51	228	61
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	10	2	10	10
Northern Ireland	1044	0	0	0	0	0	0	1031	14	0	14	0
Total	14084	131	0	104	0	121	0	14218	415	63	452	80
Percentage>16 µgm-3		0.9%	0.0%	0.7%	0.0%	0.9%	0.0%		2.9%	0.4%	3.2%	0.6%

Table 3.24 Total background area (km²) exceeding an annual mean PM_{2.5} concentration of 16 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	2	0	0	0	1	0	1628	9	3	9	2
Rest of England	128770	21	17	15	10	15	14	128764	170	140	193	153
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	19	19	19	19
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	23	17	15	10	16	14	243212	198	162	221	174
Percentage>16 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.1%	0.1%	0.1%	0.1%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	3	3	2	2	3	2	128764	99	78	109	80
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	17	12	19	16
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	3	3	2	2	3	2	243212	116	90	128	96
Percentage>16 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.1%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	2	1	1	0	1	0	128764	83	63	88	67
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	17	10	17	11
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	2	1	1	0	1	0	243212	100	73	105	78
Percentage>16 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%

Table 3.25 Population in area exceeding an annual mean PM_{2.5} concentration of 16 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	9814	0	0	0	307	0	7784707	29357	7199	29357	516
Rest of England	41011137	24332	18931	14385	4563	14385	12863	40983864	286833	232097	359804	276033
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	25539	25539	25539	25539
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	34146	18931	14385	4563	14692	12863	58251571	341729	264835	414701	302088
Percentage>16 µgm-3		0.1%	0.0%	0.0%	0.0%	0.0%	0.0%		0.6%	0.5%	0.7%	0.5%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	1751	1751	78	78	1508	78	40983864	124786	100944	144088	104455
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	25210	7986	25539	21519
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	1751	1751	78	78	1508	78	58251571	149995	108930	169627	125973
Percentage>16 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.3%	0.2%	0.3%	0.2%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	1735	62	62	0	62	0	40983864	109263	78921	115278	90129
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	25210	3746	25210	3767
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	1735	62	62	0	62	0	58251571	134472	82667	140488	93896
Percentage>16 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.2%	0.1%	0.2%	0.2%

Table 3.26 Total road length (km) exceeding an annual mean PM_{2.5} concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	22	10	22	10	21	9	1890	16	4	13	4
Rest of England	9430	3	0	3	0	3	0	9578	40	39	41	39
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	2	2	2	2
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	24	10	24	10	24	9	14218	59	45	57	44
Percentage>20 µgm-3		0.2%	0.1%	0.2%	0.1%	0.2%	0.1%		0.4%	0.3%	0.4%	0.3%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	1	0	1	0	1	0	1890	2	0	2	0
Rest of England	9430	0	0	0	0	0	0	9578	38	28	38	32
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	2	0	2	0
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	1	0	1	0	1	0	14218	42	28	42	32
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.3%	0.2%	0.3%	0.2%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1886	0	0	0	0	0	0	1890	0	0	0	0
Rest of England	9430	0	0	0	0	0	0	9578	33	22	38	22
Scotland	1085	0	0	0	0	0	0	1078	0	0	0	0
Wales	640	0	0	0	0	0	0	641	0	0	2	0
Northern Ireland	1044	0	0	0	0	0	0	1031	0	0	0	0
Total	14084	0	0	0	0	0	0	14218	33	22	40	22
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.2%	0.2%	0.3%	0.2%

Table 3.27 Total background area (km²) exceeding an annual mean PM_{2.5} concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	0	0	0	0	0	0	128764	27	24	27	27
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	1	1	2	1
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	0	0	0	0	0	0	243212	28	25	29	28
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	0	0	0	0	0	0	128764	20	16	23	19
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	1	1	1	1
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	0	0	0	0	0	0	243212	21	17	24	20
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	1624	0	0	0	0	0	0	1628	0	0	0	0
Rest of England	128770	0	0	0	0	0	0	128764	27	24	27	27
Scotland	77791	0	0	0	0	0	0	77941	0	0	0	0
Wales	20745	0	0	0	0	0	0	20745	1	1	2	1
Northern Ireland	13318	0	0	0	0	0	0	14134	0	0	0	0
Total	242248	0	0	0	0	0	0	243212	28	25	29	28
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.0%	0.0%

Table 3.28 Population in area exceeding an annual mean PM_{2.5} concentration of 20 µg m⁻³

2010												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	0	0	0	0	0	0	40983864	39393	34573	39393	39393
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	151	151	1960	151
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	0	0	0	0	0	0	58251571	39545	34724	41354	39545
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.1%	0.1%	0.1%	0.1%
2015												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	0	0	0	0	0	0	40983864	22592	17587	30432	21584
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	151	151	151	151
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	0	0	0	0	0	0	58251571	22743	17738	30584	21735
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.0%	0.0%	0.1%	0.0%
2020												
	2003 base year							2004 base year				
	Total	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	Total	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
London	7730326	0	0	0	0	0	0	7784707	0	0	0	0
Rest of England	41011137	0	0	0	0	0	0	40983864	39393	0	39393	0
Scotland	4944573	0	0	0	0	0	0	4963288	0	0	0	0
Wales	2850727	0	0	0	0	0	0	2855075	151	0	1960	0
Northern Ireland	1623309	0	0	0	0	0	0	1664637	0	0	0	0
Total	58160071	0	0	0	0	0	0	58251571	39545	0	41354	0
Percentage>20 µgm-3		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		0.1%	0.0%	0.1%	0.0%

Table 3.29 Population weighted mean PM_{2.5} concentrations (µg m⁻³)

2010										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	8.256	8.199	8.240	8.183	8.206	8.146	8.051	7.954	8.041	7.944
Wales	10.724	10.671	10.698	10.645	10.669	10.611	9.834	9.747	9.816	9.729
Northern Ireland	8.349	8.313	8.422	8.387	8.280	8.241	9.206	9.147	9.151	9.091
Inner London	14.642	14.483	14.632	14.473	14.588	14.421	14.343	14.106	14.289	14.052
Outer London	14.332	14.203	14.310	14.181	14.285	14.148	13.976	13.765	13.932	13.721
Rest of England	12.349	12.270	12.310	12.231	12.293	12.207	12.076	11.939	12.061	11.924
UK	12.064	11.981	12.033	11.951	12.008	11.920	11.790	11.651	11.770	11.631
2015										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	7.846	7.651	7.841	7.653	7.835	7.647	7.757	7.484	7.763	7.491
Wales	10.109	9.902	10.107	9.911	10.134	9.937	9.434	9.180	9.455	9.201
Northern Ireland	8.014	7.882	8.098	7.972	7.927	7.800	9.022	8.855	8.964	8.796
Inner London	13.617	13.106	13.648	13.152	13.679	13.182	13.523	12.865	13.527	12.870
Outer London	13.357	12.919	13.378	12.956	13.432	13.009	13.198	12.603	13.214	12.620
Rest of England	11.587	11.294	11.577	11.297	11.626	11.345	11.500	11.101	11.530	11.132
UK	11.322	11.026	11.321	11.036	11.357	11.072	11.231	10.829	11.254	10.853
2020										
	2003 base year						2004 base year			
	UEP12Base	UEP12 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q	UEP21Base	UEP21 Q	UEP26Base	UEP26 Q
Scotland	7.520	7.252	7.446	7.178	7.440	7.175	7.585	7.200	7.607	7.222
Wales	9.551	9.271	9.459	9.178	9.497	9.222	9.123	8.763	9.170	8.812
Northern Ireland	7.798	7.620	7.754	7.575	7.530	7.354	8.928	8.693	8.888	8.654
Inner London	12.799	12.097	12.705	12.003	12.749	12.055	12.983	12.060	13.025	12.103
Outer London	12.533	11.933	12.436	11.836	12.507	11.915	12.655	11.819	12.710	11.875
Rest of England	10.914	10.514	10.799	10.398	10.862	10.467	11.073	10.508	11.136	10.572
UK	10.680	10.274	10.573	10.167	10.621	10.221	10.827	10.260	10.881	10.315

4 Measures R and S: 2004 base year, UEP26

4.1 Introduction

This section presents model projections of air quality resulting from Defra's new measures, R and S. This modelling has been done using a 2004 base year, which uses emissions projections from the 2003 NAEI (Dore et al, 2005) and UEP26 energy projections so that it is fully up to date. The model results presented here are therefore our current best estimate of the impact of these measures on air quality for 2010, 2015 and 2020.

Table 2.1 presents an overview of measures R and S. Appendix 1 gives further details of assumptions made in generating emissions projections for these measures.

4.2 Emissions Projections and Mapping

4.2.1 Road Transport Emissions

Measures R and S, both contain a new combination of road transport measures with two pre-existing stationary source measures ($R = C2 + E + N$, $S = A2 + E + N$). Emissions projections of NO_x and PM_{10} from road transport from the 2003 NAEI for 2010, 2015 and 2020 for these measures are presented in Table 4.1.

Table 4.1 Projections of road transport emissions, from 2003 NAEI (ktonnes yr^{-1})

Pollutant	AQS measure reference	2003	2005	2010	2015	2020
NO _x	Baseline	654.9	572.3	396.2	290.5	267.8
	R			381.5	223.3	156.1
	S			391.3	239.7	162.8
PM ₁₀	Baseline	28.2	25.4	18.7	14.5	14.0
	R			17.3	8.6	4.9
	S			18.3	9.3	5.3

Emissions on individual road links and background and area source road transport emissions maps have been calculated for each measure. The method used to generate these data and maps follows the method used for measures A and C, as described in Stedman et al (2006).

$\text{PM}_{2.5}$ emissions on individual road links have been calculated as PM_{10} road link emissions for the relevant measure multiplied by a factor of 0.9 as recommended by AQEG (AQEG, 2005). Road transport emissions maps used in the area source model for $\text{PM}_{2.5}$ have been calculated by scaling the baseline $\text{PM}_{2.5}$ maps of this for the relevant year by the ratio of the road transport area source PM_{10} map for the relevant measure to the baseline PM_{10} area source road transport map. Similarly brake and tyre wear emission maps for the area source model have been scaled using the ratio of these maps for PM_{10} for the relevant measure divided by the baseline for the relevant year.

4.2.2 Non Traffic Emissions

Both the combined measures R and S include one non traffic measure, measure N (Shipping Measure through IMO). Table 4.2 gives details of emissions projections for this measure from the 2003 NAEI

Table 4.1 Projected emissions for measure N (shipping measure through IMO), from 2003 NAEI (ktonnes yr⁻¹)

Pollutant	Source	Fuel	2010		2015		2020	
			Base	N	Base	N	Base	N
NO _x	Shipping - coastal	Fuel oil	3.35	3.27	3.22	2.74	3.03	2.20
	Shipping - coastal	Gas oil	35.34	34.46	34.89	29.66	33.98	24.64

For measure N shipping emissions have been reduced by one third relative to the baseline.

4.3 Modelling Method

The method set out in sections 3.2 and 3.3 for carrying out model projections of NO₂, PM₁₀ and PM_{2.5} for 2010, 2015 and 2020 using a 2004 base year has been closely followed here, but with the relevant emissions projections for measures R and S (see section 4.2) used to scale the sectoral emissions maps.

4.4 NO₂ Results

The modelling results for the baseline and each of the measures modelled for 2010, 2015 and 2020 are summarised in Table 4.3 in terms of a comparison of modelled concentrations with the annual mean objective for NO₂ of 40 µg m⁻³. Estimates of the area exceeding and population exposed have been derived from the background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

Most exceedences of the 40 µg m⁻³ are predicted to be limited to roadside locations by 2010. Generally measure R is predicted to be more effective than measure S at reducing the length of roadside with exceedences. However, by 2020 both measures are predicted to have reduced the total length exceeding to around 1% of the total length assessed, compared with 5.4% of the total length assessed under baseline conditions.

Population-weighted annual mean NO₂ concentrations at background locations are presented in Table 4.4. This statistic represents the average concentration exposure of the UK population to NO₂ and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations.

The population-weighted mean results also suggest that measure R will be slightly more effective than measure S at reducing NO₂ concentrations. However, compared with the baseline, both measures are predicted to significantly reduce population exposure to NO₂ by 2020.

Table 4.3 Summary statistics for measures R and S of exceedences of the NO₂ annual mean objective of 40 µg m⁻³

Total road length (km) exceeding an annual mean concentration of 40 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1890	775	731	763	408	252	278	320	107	111
Rest of England	9578	1047	974	1024	503	236	322	412	18	21
Scotland	1078	68	60	64	32	8	8	24	0	3
Wales	641	36	33	33	14	4	7	14	0	1
Northern Ireland	1031	4	0	0	0	0	0	0	0	0
Total	14218	1931	1798	1884	957	499	615	771	126	136
Percentage >40 µg m ⁻³		13.6%	12.9%	13.6%	6.7%	3.6%	4.4%	5.4%	0.9%	1.0%
Total background area (km²) exceeding an annual mean concentration of 40 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1628	8	7	7	3	1	1	4	1	1
Rest of England	128764	0	0	0	0	0	0	0	0	0
Scotland	77941	0	0	0	0	0	0	0	0	0
Wales	20745	0	0	0	0	0	0	0	0	0
Northern Ireland	14134	0	0	0	0	0	0	0	0	0
Total	243212	8	7	7	3	1	1	4	1	1
Percentage >40 µg m ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Population in area exceeding an annual mean concentration of 40 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7784707	41280	24700	24700	8446	32	32	7001	32	32
Rest of England	40983864	0	0	0	0	0	0	0	0	0
Scotland	4963288	0	0	0	0	0	0	0	0	0
Wales	2855075	0	0	0	0	0	0	0	0	0
Northern Ireland	1664637	0	0	0	0	0	0	0	0	0
Total	58251571	41280	24700	24700	8446	32	32	7001	32	32
Percentage >40 µg m ⁻³		0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 4.4 Population weighted mean NO₂ concentrations for measures R and S (µg m⁻³)

	2010			2015			2020		
	Base	R	S	Base	R	S	Base	R	S
Scotland	10.06	9.89	10.00	8.91	8.12	8.28	8.56	7.19	7.26
Wales	10.68	10.50	10.61	9.66	8.81	8.97	9.14	7.68	7.74
Northern Ireland	7.09	6.95	7.03	6.38	5.85	5.94	6.15	5.27	5.30
Inner London	28.68	28.37	28.53	26.34	24.99	25.23	25.73	23.51	23.61
Outer London	23.26	23.00	23.14	21.29	20.15	20.36	20.74	18.79	18.88
Rest of England	15.65	15.43	15.56	14.20	13.12	13.34	13.59	11.65	11.75
UK	15.86	15.64	15.76	14.40	13.35	13.55	13.83	11.98	12.07

4.5 PM₁₀ Results

Modelling results for PM₁₀ for the baseline and each of the measures for 2010, 2015 and 2020 are summarised in Table 4.5 in terms of a comparison of modelled concentrations with an annual mean concentration of 31.5 µg m⁻³ (roughly equivalent to the 2004 24-hour AQS objective (Stedman et al, 2001)). Table 4.6 presents the same results in terms of a comparison with the annual mean objective of 20 µg m⁻³. No results are presented for the annual mean objective of 40 µg m⁻³ because exceedences of this objective were predicted to have been almost entirely eliminated by 2010 under baseline conditions and for all the measures.

Model results for the additional measures have been compared with an annual mean threshold of 20 µg m⁻³ for the whole of the UK in order to simplify the presentation of the results for the large number of measures. 20 µg m⁻³ is the 2010 stage 2 indicative limit value and the 2010 AQS objective for England, excluding London, Wales and Northern Ireland. A comparison of predicted baseline concentrations with the AQS objectives for 2010 of 18 µg m⁻³ for Scotland and 23 µg m⁻³ for London has been presented in Grice et al (2006).

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

Exceedences of 20 µg m⁻³ are predicted to be more widespread at both roadside and background locations compared with exceedences of 31.5 µg m⁻³. Measure R is predicted to be the more effective of the two measure at reducing exceedences of this objective at both roadside and background locations.

Population-weighted annual mean PM₁₀ concentrations at background locations are presented in Table 4.7. This statistic represents the average concentration exposure of the UK population and can be used to calculate the health impacts of air pollutants and the expected health benefits resulting from reductions in ambient concentrations. The benefits of a measure will be related to the difference between the population-weighted mean concentration for the measure and that calculated for the baseline. The population-weighted mean concentrations show a generally similar pattern of changes with the different measures to the extent of exceedences.

The concentrations presented in table 4.7 are given to a higher degree of precision than the modelling method warrants so that small differences in the model outputs can be seen. This is useful when certain measures only result in small changes, for example in the 3rd decimal place.

Table 4.5 Summary statistics for measures R and S of exceedences of a PM₁₀ annual mean concentration of 31.5 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 31.5 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1890	46	23	40	8	0	0	2	0	0
Rest of England	9578	57	50	55	38	31	31	33	24	24
Scotland	1078	0	0	0	0	0	0	0	0	0
Wales	641	2	2	2	2	0	0	2	0	0
Northern Ireland	1031	0	0	0	0	0	0	0	0	0
Total	14218	106	76	97	48	31	31	37	24	24
Percentage >31.5 µg m ⁻³		0.7%	0.5%	0.7%	0.3%	0.2%	0.2%	0.3%	0.2%	0.2%
Total background area (km²) exceeding an annual mean concentration of 31.5 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1628	0	0	0	0	0	0	0	0	0
Rest of England	128764	0	0	0	0	0	0	0	0	0
Scotland	77941	0	0	0	0	0	0	0	0	0
Wales	20745	0	0	0	0	0	0	0	0	0
Northern Ireland	14134	0	0	0	0	0	0	0	0	0
Total	243212	0	0	0	0	0	0	0	0	0
Percentage >31.5 µg m ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Population in area exceeding an annual mean concentration of 31.5 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7784707	0	0	0	0	0	0	0	0	0
Rest of England	40983864	0	0	0	0	0	0	0	0	0
Scotland	4963288	0	0	0	0	0	0	0	0	0
Wales	2855075	0	0	0	0	0	0	0	0	0
Northern Ireland	1664637	0	0	0	0	0	0	0	0	0
Total	58251571	0	0	0	0	0	0	0	0	0
Percentage >31.5 µg m ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 4.6 Summary statistics for measures R and S of exceedences of a PM₁₀ annual mean concentration of 20 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 20 µg m⁻³										
	2010				2015			2020		
	Total	Base	R	S	Base	R	S	Base	R	S
London	1890	1885	1885	1885	1881	1851	1858	1869	1431	1479
Rest of England	9578	7285	6993	7127	6264	4603	4812	5426	2541	2654
Scotland	1078	81	69	75	41	8	15	34	5	7
Wales	641	147	117	131	95	49	49	71	25	29
Northern Ireland	1031	173	158	163	150	134	134	150	118	127
Total	14218	9570	9222	9381	8431	6646	6868	7550	4119	4295
Percentage >20 µg m ⁻³		67.3%	64.9%	66.0%	59.3%	46.7%	48.3%	53.1%	29.0%	30.2%
Total background area (km²) exceeding an annual mean concentration of 20 µg m⁻³										
	2010				2015			2020		
	Total	Base	R	S	Base	R	S	Base	R	S
London	1628	1456	1319	1372	876	204	242	341	13	15
Rest of England	128764	6257	5001	5337	2957	1432	1530	1685	686	708
Scotland	77941	4	2	3	2	0	0	1	0	0
Wales	20745	32	25	26	23	20	20	19	19	19
Northern Ireland	14134	68	65	65	53	43	43	51	37	37
Total	243212	7817	6412	6803	3911	1699	1835	2097	755	779
Percentage >20 µg m ⁻³		3.2%	2.6%	2.8%	1.6%	0.7%	0.8%	0.9%	0.3%	0.3%
Population in area exceeding an annual mean concentration of 20 µg m⁻³										
	2010				2015			2020		
	Total	Base	R	S	Base	R	S	Base	R	S
London	7784707	7415955	6992797	7168516	4958024	1061078	1305160	1947662	22079	25260
Rest of England	40983864	12619700	10636086	11267532	6824122	3094044	3357671	3995384	1317060	1376541
Scotland	4963288	7427	980	6615	980	0	0	766	0	0
Wales	2855075	49620	27256	27415	27034	26581	26581	26540	26540	26540
Northern Ireland	1664637	243822	231832	231832	193336	166579	166579	187584	144425	144425
Total	58251571	20336524	17888951	18701909	12003496	4348281	4855990	6157935	1510104	1572767
Percentage >20 µg m ⁻³		34.9%	30.7%	32.1%	20.6%	7.5%	8.3%	10.6%	2.6%	2.7%

Table 4.7 Population weighted mean PM₁₀ concentrations for measures R and S (µg m⁻³)

	2010			2015			2020		
	Base	R	S	Base	R	S	Base	R	S
Scotland	12.780	12.630	12.685	12.373	11.957	11.999	12.141	11.528	11.551
Wales	15.270	15.076	15.128	14.737	14.276	14.319	14.311	13.647	13.670
Northern Ireland	14.970	14.849	14.884	14.609	14.312	14.340	14.468	14.040	14.055
Inner London	21.433	21.070	21.193	20.431	19.438	19.539	19.680	18.207	18.261
Outer London	21.188	20.832	20.951	20.187	19.223	19.320	19.426	17.999	18.051
Rest of England	18.717	18.449	18.530	17.916	17.227	17.295	17.306	16.298	16.334
UK	18.248	17.987	18.068	17.481	16.803	16.870	16.908	15.913	15.949

4.6 PM_{2.5} Results

There are currently no limit values or objectives for PM_{2.5}. Therefore modelled concentrations have been compared with indicative threshold concentrations of 12, 16 and 20 µg m⁻³ to illustrate the changes in predicted concentration in different years and for different measures. This comparison is shown in tables 4.8 to 4.10.

Estimates of area and population exposure have been derived from background maps only. No attempt has been made to derive estimates of population exposed using roadside concentrations because these maps will only apply within approximately 10 metres of the road kerb. Accurately representing the population distribution at an appropriate level of detail for this would be impractical in a national scale assessment. The estimates of population exposed may therefore underestimate actual population exposure where members of the population live near roads.

These modelling results show that both the combined measures modelled, R and S, are predicted reduce the extent of exceedences of the indicative concentration thresholds selected. Generally, measure R is predicted to be the more effective of the two measures in reducing the extent of exceedences.

Population-weighted annual mean PM_{2.5} concentrations at background locations are illustrated in Table 4.11 for the different measures. The population-weighted mean concentrations show a similar, but not identical pattern of changes with the different measures to the extent of exceedences. Population-weighted means for PM₁₀ for the baseline and combined measures are also listed in Table 4.11 for comparison with the results for PM_{2.5}. The change in population-weighted mean concentrations for each measure relative to the baseline measure is shown.

Table 4.11 also shows the changes in predicted population-weighted means for the measures for PM_{2.5} as a percentage of those for PM₁₀. These differences are caused by the relative proportions of the changes in PM concentration resulting from changes to primary and secondary PM. These differences may in part reflect differences in the modelling methods adopted for PM₁₀ and PM_{2.5}. The PM₁₀ model was calibrated using TEOM measurement data and then scaled by 1.3 to calculate gravimetric equivalent concentrations. PM_{2.5} measurement data are only available from a very limited number of monitoring sites. The PM_{2.5} model represents gravimetric concentrations directly. A more detailed discussion of how the PM_{2.5} modelling has been done is given in Grice et al (2006).

Table 4.8 Summary statistics for measures R and S of exceedences of a PM_{2.5} annual mean concentration of 12 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 12 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1890	1888	1888	1888	1888	1884	1884	1885	1815	1827
Rest of England	9578	7990	7659	7793	7106	5559	5762	6384	3253	3404
Scotland	1078	77	62	66	38	8	8	27	3	3
Wales	641	158	136	147	110	48	54	80	23	25
Northern Ireland	1031	142	129	137	129	123	123	129	111	111
Total	14218	10255	9873	10031	9271	7621	7831	8504	5205	5370
Percentage >12 µg m ⁻³		72.1%	69.4%	70.6%	65.2%	53.6%	55.1%	59.8%	36.6%	37.8%
Total background area (km²) exceeding an annual mean concentration of 12 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1628	1628	1626	1627	1611	1420	1454	1476	290	331
Rest of England	128764	17256	13115	13893	8954	4202	4563	5030	1317	1395
Scotland	77941	12	9	10	9	9	9	9	9	9
Wales	20745	92	66	68	48	38	39	40	34	35
Northern Ireland	14134	73	67	71	59	46	47	60	43	44
Total	243212	19061	14883	15669	10681	5715	6112	6615	1693	1814
Percentage >12 µg m ⁻³		7.8%	6.1%	6.4%	4.4%	2.3%	2.5%	2.7%	0.7%	0.7%
Population in area exceeding an annual mean concentration of 12 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7784707	7781081	7780187	7780767	7767857	7347127	7433492	7479598	1777033	2032388
Rest of England	40983864	22036966	19511793	20174698	16048878	9094670	9730862	10832300	2960753	3152829
Scotland	4963288	27107	15491	17038	15491	15491	15491	15491	15491	15491
Wales	2855075	150359	112743	119140	62334	32944	33454	33523	30561	31778
Northern Ireland	1664637	260691	238916	253302	212329	176691	180839	216256	171119	171582
Total	58251571	30256203	27659130	28344945	24106889	16666923	17394137	18577167	4954957	5404067
Percentage >12 µg m ⁻³		51.9%	47.5%	48.7%	41.4%	28.6%	29.9%	31.9%	8.5%	9.3%

Table 4.9 Summary statistics for measures R and S of exceedences of a PM_{2.5} annual mean concentration of 16 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 16 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1890	713	506	588	304	77	77	201	10	11
Rest of England	9578	1002	685	817	379	107	107	228	58	58
Scotland	1078	0	0	0	0	0	0	0	0	0
Wales	641	11	11	11	10	10	10	10	2	10
Northern Ireland	1031	19	14	19	14	0	0	14	0	0
Total	14218	1745	1217	1435	707	194	194	452	70	79
Percentage >16 µg m ⁻³		12.3%	8.6%	10.1%	5.0%	1.4%	1.4%	3.2%	0.5%	0.6%
Total background area (km²) exceeding an annual mean concentration of 16 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1628	9	2	4	0	0	0	0	0	0
Rest of England	128764	193	142	152	109	75	77	88	62	63
Scotland	77941	0	0	0	0	0	0	0	0	0
Wales	20745	19	19	19	19	15	16	17	11	11
Northern Ireland	14134	0	0	0	0	0	0	0	0	0
Total	243212	221	163	175	128	90	93	105	73	74
Percentage >16 µg m ⁻³		0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Population in area exceeding an annual mean concentration of 16 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	7784707	29357	516	8930	0	0	0	0	0	0
Rest of England	40983864	359804	248631	279129	144088	99093	104049	115278	81141	83280
Scotland	4963288	0	0	0	0	0	0	0	0	0
Wales	2855075	25539	25539	25539	25539	17825	21519	25210	3767	3767
Northern Ireland	1664637	0	0	0	0	0	0	0	0	0
Total	58251571	414701	274686	313598	169627	116918	125567	140488	84908	87047
Percentage >16 µg m ⁻³		0.7%	0.5%	0.5%	0.3%	0.2%	0.2%	0.2%	0.1%	0.1%

Table 4.10 Summary statistics for measures R and S of exceedences of a PM_{2.5} annual mean concentration of 20 µg m⁻³, gravimetric

Total road length (km) exceeding an annual mean concentration of 20 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1890	13	5	7	2	0	0	0	0	0
Rest of England	9578	41	39	39	38	32	32	38	22	22
Scotland	1078	0	0	0	0	0	0	0	0	0
Wales	641	2	2	2	2	0	0	2	0	0
Northern Ireland	1031	0	0	0	0	0	0	0	0	0
Total	14218	57	46	48	42	32	32	40	22	22
Percentage >20 µg m ⁻³		0.4%	0.3%	0.3%	0.3%	0.2%	0.2%	0.3%	0.2%	0.2%
Total background area (km²) exceeding an annual mean concentration of 20 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	1628	0	0	0	0	0	0	0	0	0
Rest of England	128764	27	27	27	23	17	17	27	27	27
Scotland	77941	0	0	0	0	0	0	0	0	0
Wales	20745	2	1	1	1	1	1	2	1	1
Northern Ireland	14134	0	0	0	0	0	0	0	0	0
Total	243212	29	28	28	24	18	18	29	28	28
Percentage >20 µg m ⁻³		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Population in area exceeding an annual mean concentration of 20 µg m⁻³										
	Total	2010			2015			2020		
		Base	R	S	Base	R	S	Base	R	S
London	0	0	0	0	0	0	0	0	0	0
Rest of England	39393	39393	39393	30432	19399	19399	39393	39393	0	39393
Scotland	0	0	0	0	0	0	0	0	0	0
Wales	1960	151	151	151	151	151	1960	151	0	1960
Northern Ireland	0	0	0	0	0	0	0	0	0	0
Total	41354	39545	39545	30584	19550	19550	41354	39545	0	41354
Percentage >20 µg m ⁻³	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%	0.0%	0.1%

Table 4.11 Population weighted mean PM_{2.5} concentrations for measures R and S (µg m⁻³)

2010										
	PM_{2.5}			PM₁₀			Measure – baseline PM_{2.5}		(Measure – baseline PM_{2.5})/(Measure – baseline PM₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	8.041	7.918	7.958	12.780	12.630	12.685	-0.122	-0.082	81.8%	86.9%
Wales	9.816	9.654	9.691	15.270	15.076	15.128	-0.162	-0.125	84.0%	88.2%
Northern Ireland	9.151	9.050	9.075	14.970	14.849	14.884	-0.100	-0.075	82.6%	87.4%
Inner London	14.289	13.983	14.079	21.433	21.070	21.193	-0.306	-0.209	84.4%	87.5%
Outer London	13.932	13.639	13.727	21.188	20.832	20.951	-0.293	-0.205	82.4%	86.5%
Rest of England	12.061	11.840	11.899	18.717	18.449	18.530	-0.221	-0.162	82.5%	87.0%
UK	11.770	11.554	11.613	18.248	17.987	18.068	-0.215	-0.156	82.6%	87.1%
2015										
	PM_{2.5}			PM₁₀			Measure – baseline PM_{2.5}		(Measure – baseline PM_{2.5})/(Measure – baseline PM₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	7.763	7.454	7.484	12.373	11.957	11.999	-0.309	-0.279	74.2%	74.6%
Wales	9.455	9.114	9.144	14.737	14.276	14.319	-0.341	-0.311	74.0%	74.6%
Northern Ireland	8.964	8.750	8.769	14.609	14.312	14.340	-0.214	-0.195	72.1%	72.7%
Inner London	13.527	12.776	12.849	20.431	19.438	19.539	-0.751	-0.678	75.5%	76.0%
Outer London	13.214	12.509	12.576	20.187	19.223	19.320	-0.705	-0.638	73.2%	73.6%
Rest of England	11.530	11.025	11.071	17.916	17.227	17.295	-0.505	-0.458	73.3%	73.8%
UK	11.254	10.755	10.801	17.481	16.803	16.870	-0.498	-0.452	73.5%	74.0%
2020										
	PM_{2.5}			PM₁₀			Measure – baseline PM_{2.5}		(Measure – baseline PM_{2.5})/(Measure – baseline PM₁₀)	
	Base	R	S	Base	R	S	R	S	R	S
Scotland	7.607	7.163	7.179	12.141	11.528	11.551	-0.444	-0.428	72.5%	72.5%
Wales	9.170	8.698	8.714	14.311	13.647	13.670	-0.472	-0.456	71.1%	71.2%
Northern Ireland	8.888	8.594	8.604	14.468	14.040	14.055	-0.294	-0.284	68.8%	68.9%
Inner London	13.025	11.952	11.990	19.680	18.207	18.261	-1.073	-1.035	72.8%	72.9%
Outer London	12.710	11.704	11.740	19.426	17.999	18.051	-1.006	-0.970	70.5%	70.5%
Rest of England	11.136	10.422	10.446	17.306	16.298	16.334	-0.714	-0.689	70.8%	70.9%
UK	10.881	10.175	10.199	16.908	15.913	15.949	-0.706	-0.681	71.0%	71.0%

5 Conclusions

GIS-based model predictions of air quality for a range of measures, for two different base years using a range of energy projections have been produced for NO₂, PM₁₀, and PM_{2.5} for 2010, 2015 and 2020. This work has been presented in three distinct sections:

- Model runs using a 2003 base year, with UEP12 energy projections for new measures A2, C2, R and S to enable a direct comparison of these measures with other additional measures modelled in Stedman et al (2006)
- Sensitivity analysis of the baseline and measure Q (Defra's preferred measure at the time of publishing the 2006 Review of the AQS consultation document (Defra et al, 2006a; Defra et al, 2006b)) to 3 sets of energy projections (UEP12, UEP21 and UEP26) and two different base years (2003 and 2004)
- Our current best estimate of Defra's new measures, R and S, from a 2004 base year using UEP26 energy projections.

Conclusions from this modelling are presented below.

5.1 Sensitivity Analysis of the Baseline and Measure Q

Figure 5.1 presents graphs summarising model projections in terms of population weighted mean concentrations of NO₂, PM₁₀ and PM_{2.5} for the baseline and measure Q from a 2003 and 2004 base year, using a range of energy projections.

This analysis has shown that generally, the model projections are relatively sensitive to the base year from which the projections are made, while changing which version of the DTI's energy projections used has less of an impact on the modelled concentrations across the UK. Concentrations modelled using a 2004 base year tended to be lower than those modelled using a 2003 base year.

Regardless of which energy projections or base year was used, there were still predicted to be exceedences of the AQS objective for NO₂ of 40 µg m⁻³, by 2020 using measure Q. However, the total extent of exceedence for measure Q is predicted to be substantially less than under baseline conditions.

Similarly, for PM₁₀, measure Q is predicted to reduce the extent of exceedences of 20 µg m⁻³ relative to the baseline, but not eliminate exceedences. Under baseline conditions, there are predicted to be relatively few exceedences of the 31.5 µg m⁻³ threshold.

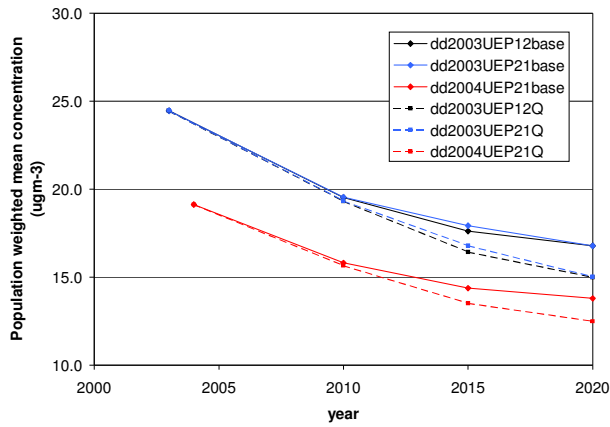
5.2 Measures A2, C2, R and S

Figure 5.2 presents graphs summarising the model projections for the baseline and measures A2, C2, R and S in terms of population weighted mean concentrations of NO₂, PM₁₀ and PM_{2.5} for a range of different model conditions.

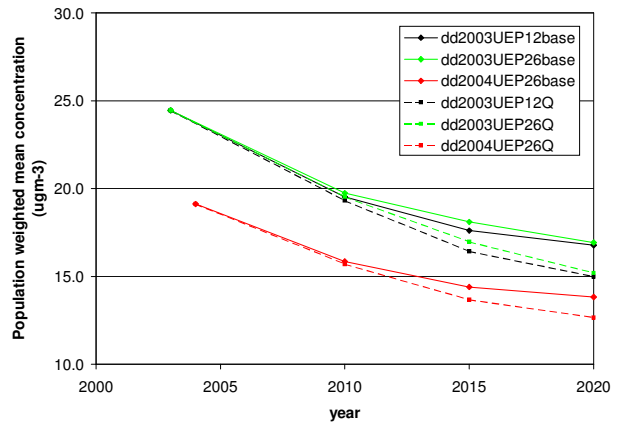
Generally, the 2003 base year projections resulted in higher concentrations and therefore a greater extent of roadside and background exceedences than the 2004 base year projections. However, the overall trends in each set of projections were very similar with the baseline and all measures predicted to result in declining concentrations of NO₂, PM₁₀ and PM_{2.5}. The most efficient measure across all these pollutants for each base year was measure R, followed closely by the other combined measure, measure S.

Figure 5.1. Summary results of sensitivity analysis on the baseline and measure Q, in terms of population weighted mean concentrations

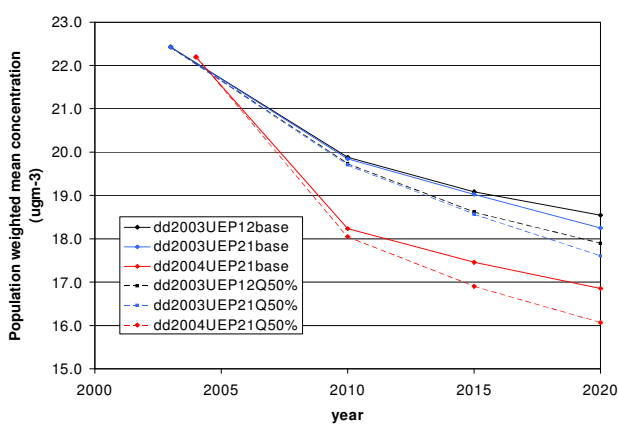
a) NO₂, UEP12 and UEP21



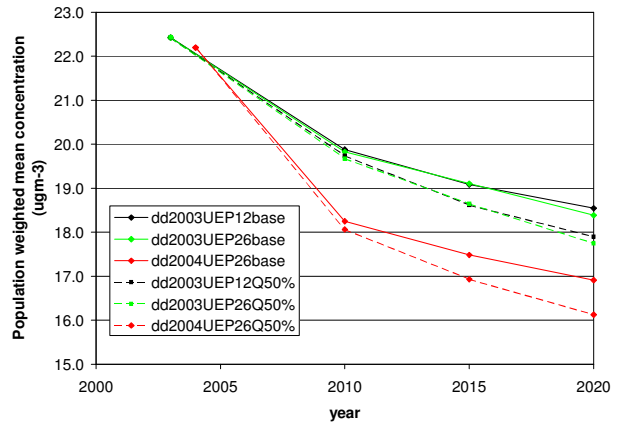
b) NO₂, UEP12 and UEP26



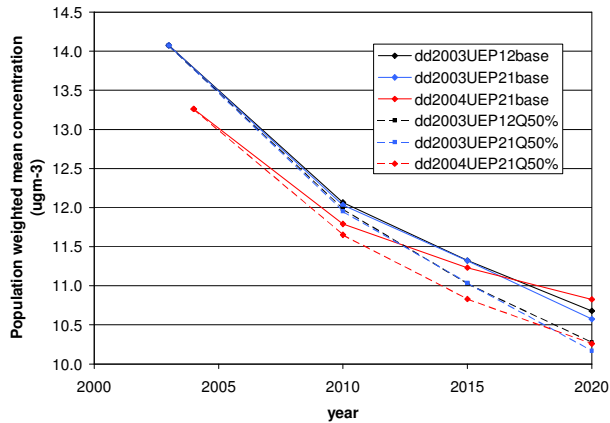
c) PM₁₀, UEP12 and UEP21



d) PM₁₀, UEP12 and UEP26



e) PM_{2.5}, UEP12 and UEP21



f) PM_{2.5}, UEP12 and UEP26

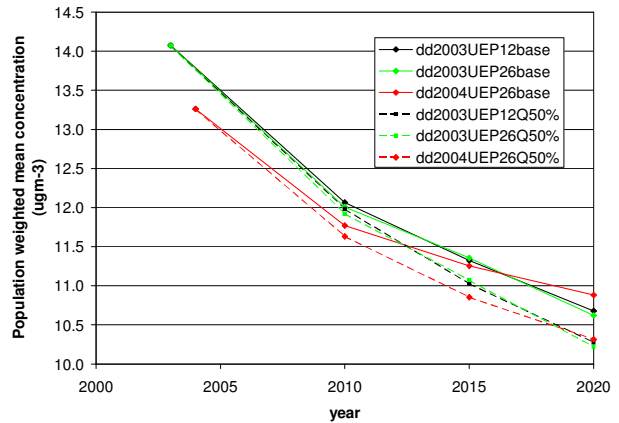
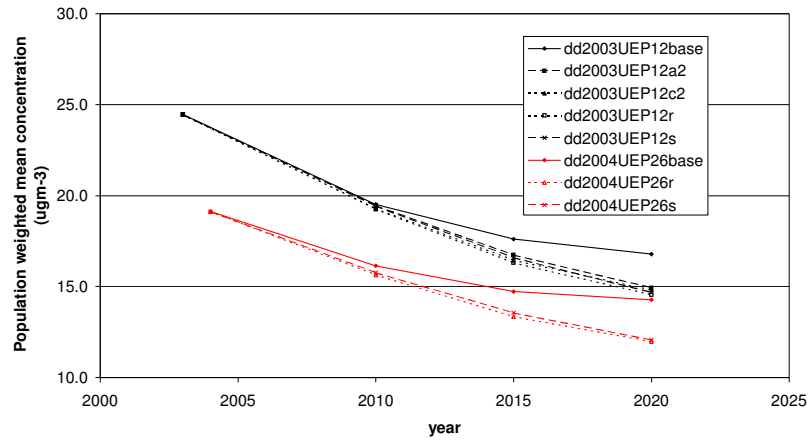
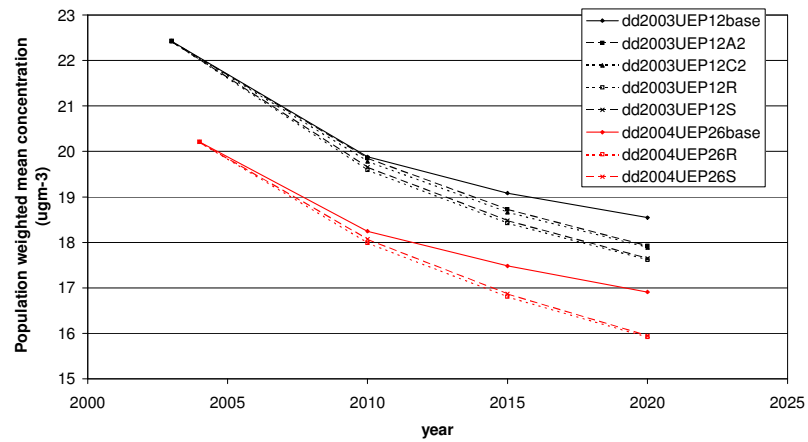


Figure 5.2. Summary results of modelling of new additional measures A2, C2, R and S, in terms of population weighted mean concentrations

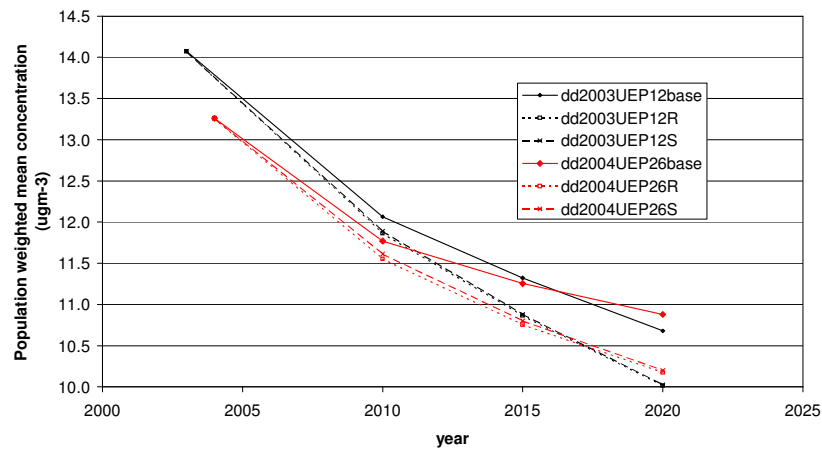
a) NO₂



b) PM₁₀



c) PM_{2.5}



6 Acknowledgements

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Appendices

- Appendix 1: Detailed Assumptions Made for AQS Measures A2 and C2 Affecting Emissions from Road Transport and Combined Measures R and S
- Appendix 2: Summary of the main differences in DTI's UEP12, UEP17 and UEP21-revise energy forecasts

Appendix 1: Detailed Assumptions Made for AQS Measures A2 and C2 Affecting Emissions from Road Transport and Combined Measures R and S

Measure A2: revised Euro V/VI standards

This Measure involves the introduction of Euro V standards affecting NOx emissions from all new petrol cars and LGVs from 2010/2011. NOx standards for all new diesel cars and LGVs are introduced in two stages: 2010/2011 for Euro V standards followed by tighter limits for Euro VI from 2015/2016. All new diesel cars and LGVs are fitted with DPFs reducing PM emissions (Euro V) from 2010/2011. Euro VI standards for HDVs are introduced from 2013. The standards for NOx emissions for light duty vehicles involve changes to emission limits and durability standards.

NOx			% reduction rel. to Euro IV	Introduction	Note
	Petrol cars/small vans	Euro V	12.5%	1st Jan 2010	160,000 durability, deterioration factor 1.4, but no change in degradation rate
	Med/large petrol vans	Euro V	15%	1st Jan 2011	
	Diesel cars/small vans	Euro V	28%	1st Jan 2010	160,000 durability, but no change in degradation rate
	Med/large diesel vans	Euro V	28%	1st Jan 2011	
	Diesel cars/small vans	Euro VI	72%	1st Jan 2015	160,000 durability, but no change in degradation rate. Includes 5% catalyst failure and higher cold start emissions for Euro VI, with SCR or LNT
	Med/large diesel vans	Euro VI	75%	1st Jan 2016	
	HGVs and buses	Euro VI	50% reduction relative to Euro V occurring from 1st Jan 2013		
PM	Petrol cars and LGVs	Euro V	No change from Euro IV		
	Diesel cars/small vans	Euro V	90%	1st Jan 2010	DPFs fitted on all LDVs.
	Med/large diesel vans	Euro V	90%	1st Jan 2011	
	HGVs and buses	Euro VI	No change from Euro IV/V		

Measure C2: Early revised Euro V/VI standards

This Measure is the same as Measure A2, but with a programme of incentives introduced for a 2 year earlier introduction of Euro V and Euro VI (3 yrs for Euro VI HDVs). The earlier penetration of Euro V/VI standards is shown in the following table expressed as the percentage of new vehicle sales meeting each Euro standard. For petrol cars and vans (LGVs), the Euro V standards apply only to NOx. For diesel cars and vans, Euro V is relevant to NOx and PM, but the Euro VI standards are only relevant to NOx, i.e. there are no further reductions in PM emissions beyond Euro V. For HGVs and buses, the Euro V standards are already introduced by legislation (2008), but this scenario assumes their slightly earlier introduction from 2007, as modelled in Measure C. The Euro VI standards for HDVs apply only to NOx, i.e. there are no further reductions in PM emissions beyond Euro V.

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016+
Petrol cars and vans (small)	Euro IV	100%	67%	34%	0%	0%	0%	0%	0%	0%	0%
	Euro V	0%	33%	66%	100%	100%	100%	100%	100%	100%	100%
Petrol vans (med/large)	Euro IV	100%	100%	67%	34%	0%	0%	0%	0%	0%	0%
	Euro V	0%	0%	33%	66%	100%	100%	100%	100%	100%	100%
Diesel cars and vans (small)	Euro IV	100%	67%	34%	0%	0%	0%	0%	0%	0%	0%
	Euro V	0%	33%	66%	100%	100%	100%	67%	34%	0%	0%
	Euro VI	0%	0%	0%	0%	0%	0%	33%	66%	100%	100%
Diesel vans (med/large)	Euro IV	100%	100%	67%	34%	0%	0%	0%	0%	0%	0%
	Euro V	0%	0%	33%	66%	100%	100%	100%	67%	34%	0%
	Euro VI	0%	0%	0%	0%	0%	0%	0%	33%	66%	100%
HGVs and buses	Euro IV	85%	52.5%	0%	0%	0%	0%	0%	0%	0%	0%
	Euro V	15%	47.5%	100%	75%	50%	25%	0%	0%	0%	0%
	Euro VI	0%	0%	0%	25%	50%	75%	100%	100%	100%	100%

Measure R: Combination of measures C2 (early revised euro V/VI), E (LEV) and N (shipping)

This Measure combines the two road transport measures C2 and E and the shipping Measure N. Details of Measures E and N were given in Stedman et al (2006). The penetration rates defined for Measure E define the LEV penetration rates in this combined scenario. LEVs are assumed to displace the lowest Euro standards still being sold in a given year. So, for example, petrol LEVs displace Euro IV petrol cars from 2006-2009 and then Euro V petrol cars from 2010 onwards. Diesel LEVs displace Euro IV diesel cars from 2006-2009, Euro V diesel cars from 2010 to 2014 and Euro VI diesel cars from 2015 onwards.

Measure S: Combination of measures A2 (revised euro V/VI), E (LEV) and N (shipping)

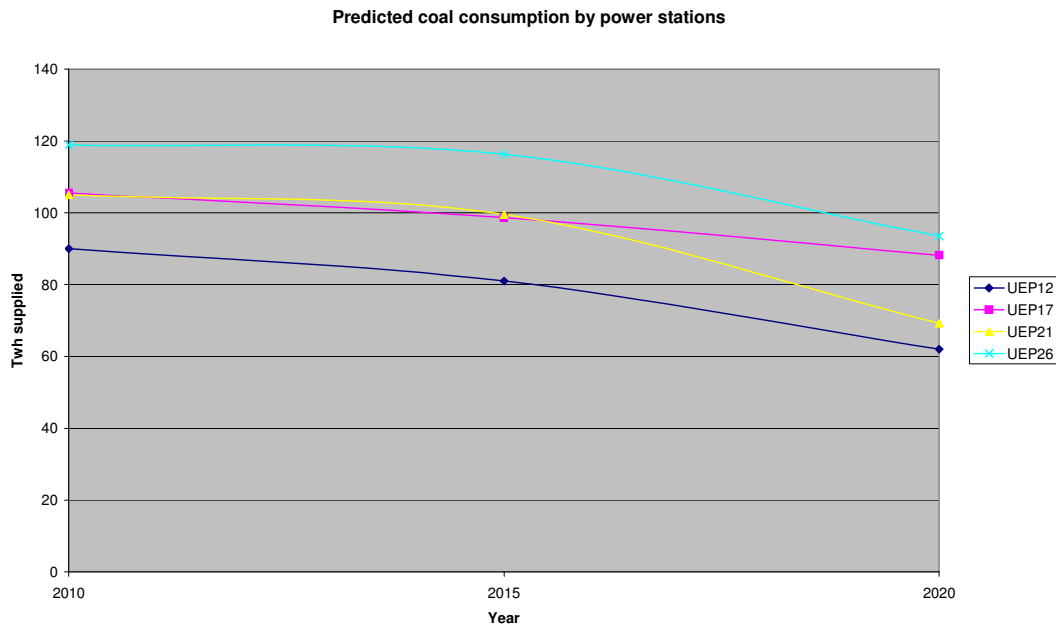
This Measure combines the two road transport Measures A2 and E and the shipping Measure N. Details of Measures E and N were given in Stedman et al (2006). The penetration rates defined for Measure E define the LEV penetration rates in this combined scenario. LEVs are assumed to displace the lowest Euro standards still being sold in a given year. So, for example, petrol LEVs displace Euro IV petrol cars from 2006-2009 and then Euro V petrol cars from 2010 onwards. Diesel LEVs displace Euro IV diesel cars from 2006-2009, Euro V diesel cars from 2010 to 2014 and Euro VI diesel cars from 2015 onwards.

**Appendix 2: Summary of the main differences
in DTI's UEP12, UEP17, UEP21-revise and
UEP26 (favourable to coal) energy forecasts**

This appendix summarises the main differences in DTI’s UEP12, UEP17, UEP21 ‘revise’ and UEP26 (favourable to coal) energy forecasts. The UEP21 ‘revise’ forecasts are based on the average of two scenarios – favourable to gas and favourable to coal. The ‘UEP21 ‘revise’ forecasts will from now on in this appendix be referred to as UEP21; and UEP26 (favourable to coal) will be referred to as UEP26. DTI’s UEP12 energy projections were provided in September 2004, UEP17 in November 2005, UEP21 in February 2006 and UEP26 in October 2006.

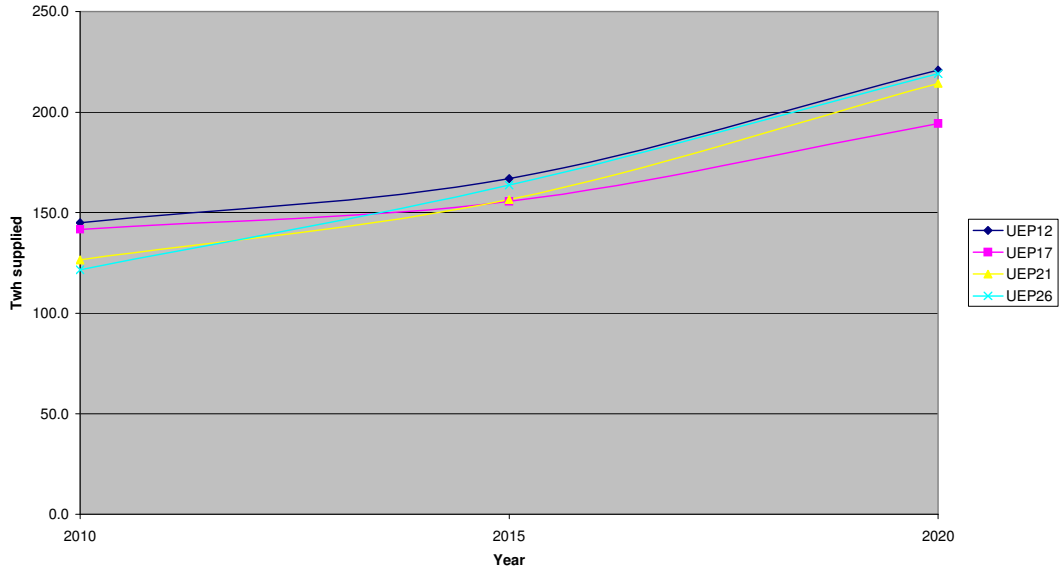
Power station sector

All UEP versions show a downward trend in coal consumption by power stations between 2010 and 2020. UEP26 predicts higher coal consumption by power plant in 2010 and 2015 and to a lesser extent in 2020, than in previous UEP versions. The higher coal consumption does not however lead to higher predicted SO₂ emissions from this sector than in previous energy papers, due to UEP26 forecasting the fitting of FGD at more coal fired power plants.



Gas consumption by power stations is forecast to increase over time in all UEP versions, with the largest growth taking place in UEP26. Predicted gas consumption in UEP26 is similar to that in UEP21 in 2010 and similar to UEP12 in 2015 and 2020.

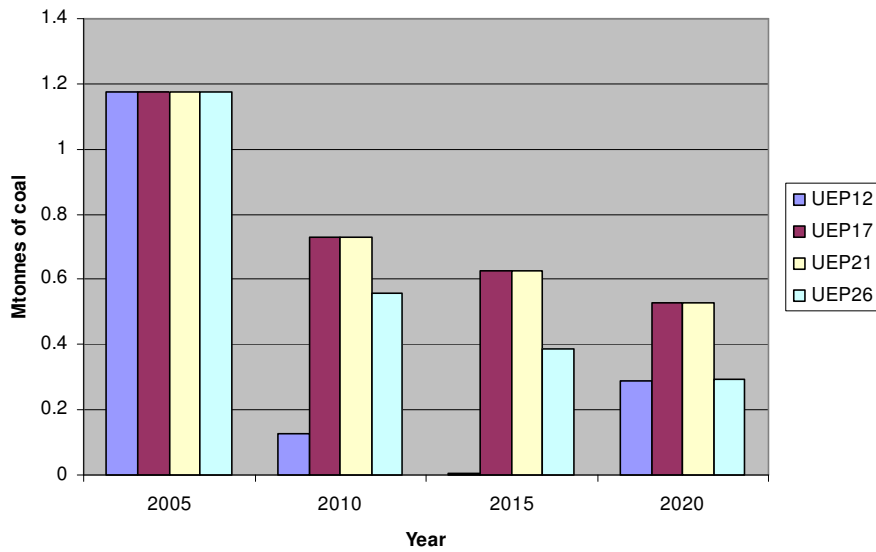
Predicted gas consumption by power stations



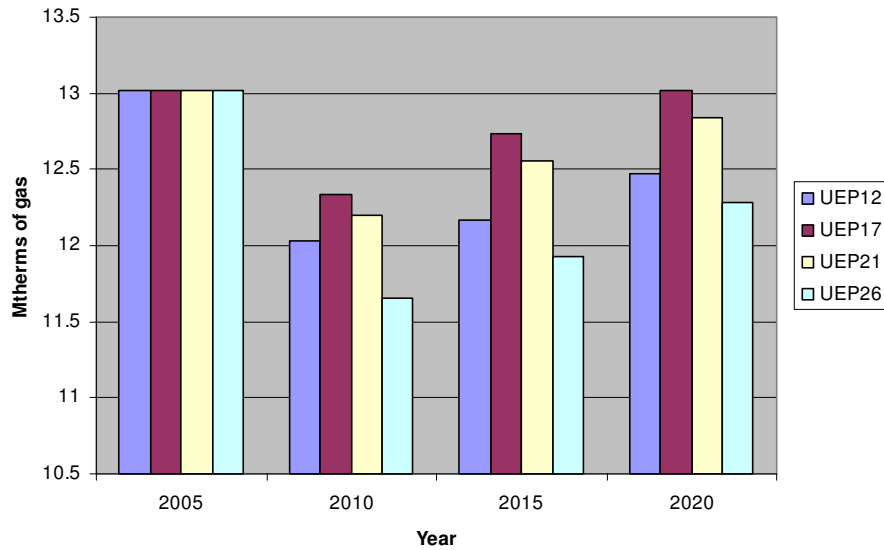
Domestic sector

UEP26 forecasts a more marked decrease in domestic coal between 2005 and 2020 than in UEP21 and UEP17. Domestic gas combustion is projected to decrease between 2005 and 2010 but then increase to 2020.

A comparison of domestic coal consumption



A comparison of domestic gas consumption



Services sector

Like in the domestic sector, gas consumption in the services sector is forecast to increase between 2010 and 2020 but at a slower rate than in UEP17 and UEP12. Future consumption is predicted to be similar to that in UEP21. Coal consumption however is predicted to decline slightly in UEP26 and UEP21. This is in contrast with that predicted in UEP12 and UEP17 where consumption was predicted to increase.

Other industry combustion

Coal combustion in the 'other industry' combustion sector is forecast to increase under UEP26 in future years. Whilst UEP12, UEP17, UEP21 also showed an increase between 2005 and 2020 the predicted increase was not as large.

Predicted gas consumption between 2010 and 2020 is similar in all the updated energy papers. A 20% increase is forecast between 2005 and 2020.