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Projections of PM_{10} and NO_x concentrations in 2010 for additional measures scenarios

A report produced for The Department of Environment, Food and Rural Affairs, The National Assembly for Wales, The Scottish Executive and the Department of the Environment in Northern Ireland

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Executive Summary

The Air Quality Strategy for England, Wales, Scotland and Northern Ireland currently sets the following objectives for PM_{10} particles, to be achieved by 31 December 2004:

- 50 μgm^{-3} as a 24-hour mean, not to be exceeded more than 35 times a year
- 40 μgm^{-3} as an annual mean, not to be exceeded.

These objectives are consistent with the Stage 1 limit values for PM_{10} included in the first EU Daughter Directive (AQDD), which are to be achieved by 1 January 2005. Indicative Stage 2 limit values for PM_{10} are also included in the first AQDD at 20 μgm^{-3} as an annual mean and 50 μgm^{-3} as a 24-hour mean, not to be exceeded more than 7 times a year, to be achieved by 1 January 2010.

The Government and devolved administrations recognise that the possible health gains from reducing PM_{10} levels are thought to be greater than those for any other pollutant. They are concerned to set sights beyond the immediate need to comply with the AQDD Stage 1 limit values. The Government and devolved administrations have therefore undertaken to assess the prospects of whether the AQS objectives for PM_{10} can be strengthened.

An analysis of the costs and benefits of different measures to reduce ambient PM_{10} concentrations will form an important part of this PM_{10} objective analysis.

Baseline emissions inventory projections for 2010 have been described in a companion 'baseline' report along with detailed descriptions of the methods used to calculate both site specific and mapped projections of PM_{10} and NO_2 concentrations in 2010. The site-specific projections provide a valuable tool for the rapid assessment of the impact of a range of policy measures on ambient PM_{10} concentrations. Maps of background concentrations are required for the assessment of the health and non-health benefits of policy measures to reduce PM_{10} concentrations. Maps of roadside concentrations can be used to assess the impact of policies on the number of road links with estimated concentrations exceeding threshold concentrations, such as existing or proposed AQS objectives or limit values. Projections have been calculated for the 2010, as this is the most likely year for which a more stringent AQS PM_{10} objective would apply.

This report provides a description of the measures included in an illustrative package of possible additional measures to reduce PM_{10} concentrations in the UK. Measures to reduce emissions from both road transport and stationary sources have been included in the illustrative package and the associated reductions in emissions have been calculated.

The impact of this illustrative package of measures on site specific projections of PM_{10} concentrations is described. For example, by 2010, using 1999 meteorology, the baseline scenario suggests that 9 of the 16 sites analysed would exceed the indicative Stage 2 limit value of 20 μgm^{-3} as an annual mean. The application of the package of additional measures reduces the annual mean PM_{10} concentrations to below this level at all but 2 of the sites. The biggest reduction in annual mean PM_{10} concentrations resulting from the illustrative scenario is at

Marylebone Road (3.4 μgm^{-3}) – illustrating the targeted nature of the package of measures on locations with elevated pollution levels. Reductions at urban background sites are typically of the order of 1-2 μgm^{-3}. By 2015 further reductions occur beyond that delivered in 2010, for both the baseline and illustrative scenario.

Maps of background PM_{10} concentrations have been calculated for both the baseline and illustrative additional measures scenarios. Across the UK the illustrative package of measures would be expected to reduce the population weighted annual mean PM_{10} concentration in 2010 by 0.751 μgm^{-3}, gravimetric.

Maps of roadside PM_{10} concentrations have also been calculated. Roadside PM_{10} concentrations are predicted to be much lower in 2010 than in the base years 1996-1999. Exceedences of 20 μgm^{-3}, gravimetric are however still expected to be common at the roadside for the baseline scenario, especially for the 1996 base year in England. The illustrative package of possible additional measures is predicted to have a significant impact on the number of road links with estimated annual mean PM_{10} concentrations in excess of 20 μgm^{-3}, gravimetric, particularly in Outer London and the Rest of England. The number of exceedences of 23 and 25 μgm^{-3}, gravimetric are also predicted to be considerably reduced. The number of exceedences of the various threshold concentrations for the baseline scenario in 2015 is considerably reduced compared with 2010, largely as a result of the continued decline in road traffic exhaust emissions. Once again the illustrative package of measures is seen to significantly reduce the number of road links exceeding the thresholds.

The illustrative package of possible additional measures includes measures to reduce emissions from both traffic and stationary sources of PM_{10}. PM_{10} concentrations have also been estimated for two components of this scenario considered separately. Considering the site specific and mapped background and roadside projections together it is clear that greater reductions in background concentrations are predicted for the stationary source measures than for the traffic measures. Ambient concentrations are, however, greater at roadside locations and measures to reduce emissions from road traffic are clearly more directly targeted at reducing these concentrations. The traffic measures would therefore be more effective at reducing roadside concentrations than the stationary source measures, particularly in London.

Contents

1 Introduction

1.1 POLICY CONTEXT

The Air Quality Strategy for England, Wales, Scotland and Northern Ireland (AQS, DETR et al, 2000) currently sets the following objectives for PM_{10} particles, to be achieved by 31 December 2004:

- 50 μgm^{-3} as a 24-hour mean, not to be exceeded more than 35 times a year
- 40 μgm^{-3} as an annual mean, not to be exceeded.

These objectives are consistent with the Stage 1 limit values for PM_{10} included in the first EU Daughter Directive (AQDD), which are to be achieved by 1 January 2005. The 24-hour mean objective and limit value is expected to be the more stringent of the two. Indicative Stage 2 limit values for PM_{10} are also included in the first AQDD at 20 μgm^{-3} as an annual mean and 50 μgm^{-3} as a 24-hour mean, not to be exceeded more than 7 times a year, to be achieved by 1 January 2010.

The Government and devolved administrations recognise that the possible health gains from reducing PM_{10} levels are thought to be greater than those for any other pollutant. They are concerned to set sights beyond the immediate need to comply with the AQDD Stage 1 limit values. The Government and devolved administrations have therefore undertaken to assess the prospects of whether the AQS objectives for PM_{10} can be strengthened (DETR et al, 2000).

An analysis of the costs and benefits of different measures to reduce ambient PM_{10} concentrations will form an important part of this PM_{10} objective analysis.

1.2 THE BASELINE REPORT

The methods that have been used to calculate site specific projections of PM_{10} and NO_x and NO_2 concentrations in 2010 from measurements at automatic monitoring network sites for the period from 1996 to 1999 have been presented by Stedman et al (2001c, the 'baseline report'). These site-specific projections provide a valuable tool for the rapid assessment of the impact of a range of policy measures on ambient PM_{10}, NO_x and NO_2 concentrations. The site-specific projections also have the advantage of not including the uncertainties associated with the empirical or dispersion modelling of concentrations.

The methods that have been used to calculate maps of PM_{10}, NO_x and NO_2 concentrations for the base years 1996 to 1999 and projections for 2010 have also been described in the baseline report (Stedman et al, 2001c). Maps have been calculated of background concentrations for the whole of the UK at a 1 km x 1 km square resolution and for roadside concentrations at a total of 7180 individual built-up major road links (A roads and motorways). The maps of background concentrations are required for the assessment of the health and non-health benefits of policy measures to reduce PM_{10} concentrations. The maps of roadside concentrations can be used to assess the impact of policies on the number of road links with estimated concentrations exceeding threshold concentrations, such as existing or proposed AQS objectives or limit values.

Projections of NO_2 concentrations have been calculated alongside those of PM_{10} because these are the two pollutants for which the objectives set out within the AQS and in the AQDD are likely to be the most challenging. It will therefore be useful to assess the impact on ambient NO_2 concentrations of measures taken to reduce PM_{10} since many measures will reduce concentrations of both pollutants.

Projections have been calculated for the 2010, as this is the most likely year for which a more stringent AQS PM_{10} objective would apply. The indicative stage 2 limit values for PM_{10} of the first AQDD are also to be achieved by 1 January 2010. 2010 is also the timeframe of the Ten Year Plan for Transport (DETR, 2000a), which set out the Government's strategy to tackle congestion and pollution and deliver better integrated, high quality, transport systems over the next decade.

1.3 THIS REPORT

The baseline report only describes projections of PM_{10}, NO_x and NO_2 concentrations from the base years 1996 to 1999 to 2010 for a single 'baseline' scenario, which represents our best estimate of the impact of current national and international policies on concentrations of these pollutants. Projections for an illustrative scenario incorporating the impact of a package of possible additional policy measures to reduce PM_{10} are required to assess the costs and benefits of these measures in comparison with the baseline. Projections for this 'additional measures' scenario are presented in this report, along with details of the packages of measures that this represents.

The results of the site-specific projections are presented. The maps of estimated PM_{10} and NO_2 are summarised by tabulating population weighted mean concentrations for background locations and the number of built-up major road links exceeding various threshold concentrations for roadside locations.

1.4 OTHER DOCUMENTS

The proposals for a new PM_{10} objective are presented in the Air Quality Strategy consultation document "Proposals for air quality objectives for particles, benzene, carbon monoxide and polycyclic aromatic hydrocarbons" (DEFRA et al, 2001). The technical annex of the consultation document includes PM_{10} emission inventories and projections and a summary of ambient PM_{10} monitoring data in the UK. This report, along with the additional technical reports listed below provides full details of the modelling methods and results described in the technical annex.

The analyses of PM_{10} and NO_2 concentrations described here are based on the methods described in the AQS (DETR et al, 2000) and supporting technical reports (Stedman et al, 1998a, Stedman et al, 1998b). These methods have been updated to incorporate more recent ambient air monitoring results, understanding of atmospheric chemistry and emissions estimates and projections.

Analyses of the health benefits (Stedman et al, 2001d) and non-health benefits (Watkiss et al, 2001) of the additional measures will also be published. These analyses of health and non-health benefits contribute to "An Economic Analysis of the Air Quality Strategy Objectives for Particles" (DEFRA 2001) along with an examination of the costs of possible measures to reduce

PM_{10} emissions and concentrations (AEA Technology, 2001) A separate report describing the verification of the mapping results for the base years has been prepared (Stedman and Handley, 2001).

2 Illustrative additional measures scenario

2.1 INTRODUCTION - POSSIBLE ADDITIONAL POLICY MEASURES

The full package of possible additional policy measures includes:

- Traffic measures as follows: Particulate traps on new diesel vehicles from 2006 + sulphur free fuels (<10ppm S) from 2005 and £90m 'area-targeted' retrofit programme (2001-2004). This represents a reduction from the UK total traffic PM_{10} emission in the baseline scenario in 2010 from 13.3 to 11.4 ktonnes.
- A full package of stationary source measures. Measures have been applied to the following sectors: Cement, Iron and Steel, Refineries, Lime Production, Aluminium production, Domestic Solid Fuel Combustion, Public Services, Other Industry (Large Processes), Other Industry (Combustion), Other Industry (Small Processes). This represents a reduction from the UK total stationary PM_{10} emission in 2010 from 79.2 to 48.2 ktonnes relative to the baseline.
- While the measures for quarries are included in these totals they have been considered separately from the stationary source measures described above in the modelling and benefits analyses. The measures represent a reduction in 2010 from the UK annual PM_{10} emission total from 12.1 to 2.5 ktonnes.

The possible additional measures are described in more detail in the paragraphs below. Full details of the baseline assumptions can be found in the AQS consultation document (DEFRA et al, 2001) or the baseline report (Stedman et al, 2001c).

2.2 ROAD TRANSPORT MEASURES

The road transport measures that have been assessed in the are primarily aimed at technological measures to reduce PM_{10} emissions from diesel vehicles – the predominant source of PM_{10} emission from road transport over the medium term. For some of the scenarios the date of introduction of a measure has been allowed to vary to allow the impact of emission reductions in particular years to be estimated.

The scenarios set out below are not necessary mutually exclusive, and were ordered as follows:

- **S1**: the fitting of particulate traps to all new light duty and heavy duty diesel vehicles, potentially through a combination of regulatory and fiscal measures (from 2006)

- **S2**: early introduction of sulphur free diesel (<10ppm), potentially through a combination of regulatory and fiscal measures (from 2005)
- **S3**: short term retrofitting programmes for older diesel vehicles (between 2001 and 2004) targeted in a particular conurbation

2.2.1 S1: Fitting of particulate traps to all new diesel vehicles

Light duty diesel vehicles

Under this scenario, all new light duty diesel vehicles are fitted with particulate filters, which some manufacturers are already introducing to selected new diesel car models. This could be achieved through the development of tighter European emission standards (beyond Euro IV standards), which set an emission performance which will effectively mandate particulate filters (or equivalent emission abatement technology). Potential fiscal measures could also be used to encourage their early introduction.

It is assumed for the modelling that all new diesel cars and light vans will be fitted with particulate traps by either 2006 or 2008 - having the two dates allows a sensitivity analysis on the resulting emission reduction to be carried out. In terms of emission performance, a light duty vehicle with a particulate trap is assumed to achieve a 90% reduction relative to Euro II.

Heavy duty diesel vehicles

Although some heavy duty vehicles have already been fitted with particulate traps, their widespread application will almost certainly require the development of tighter European vehicle emission standards. This would require standards beyond existing Euro IV for new heavy duty diesel vehicles which would set a particle emission performance which will effectively mandate particulate traps (or equivalent emission abatement technology). Potential fiscal measures could be also used to encourage their early introduction.

It is assumed for the modelling that all new heavy duty vehicles will be fitted with particulate traps by either 2006 or 2008 - having the two dates allows a sensitivity analysis to be carried out. In terms of emission performance, a heavy duty vehicle fitted with a particulate trap is assumed to achieve a 90% reduction relative to Euro II. It should be noted that the modelling already assumes a 85% reduction relative to Euro II for the already stringent Euro IV particle emission limit value. This emission limit value is likely to be achieved through improved engine technology, which should significantly reduce PM_{10} emissions, but any development of tighter emission standards beyond Euro IV is expected to focus on the reduction of ultra-fine particles, which probably require particulate traps.

2.2.2 S2: Sulphur free diesel

This scenario assumes the widespread introduction of ‘sulphur free’ (<10ppm) diesel through a combination of regulatory standards and fiscal measures. The Commission has recently proposed that 10ppm sulphur diesel should be mandatory across the European Union in 2011, and widely available in Member States by 2005. Fuel duty incentives can be used to encourage its early introduction.

The modelling assumes that 10 ppm sulphur diesel will account for a 100% of the DERV market by 2005. The modelling uses the Commission’s assumptions about the emission reductions from 10ppm fuels relative to 2005 fuel (with a sulphur content of 50ppm). Table 2.1 sets out the emission reduction relative to vehicle type and Euro standard. The timing on the introduction of S free petrol is assumed to be the same as for diesel.

Table 2.1 Emission reductions for 10 ppm sulphur fuels relative to 2005 fuels (50ppm S)

Vehicle type		Emission reduction for 10ppm sulphur fuels		
		NO_x	HC	PM
Euro I/II/III LDVs	Petrol	10%	10%	0%
	Diesel	0%	0%	5%
Euro IV LDVs	Petrol	0%	0%	0%
	Diesel	0%	0%	0%
Euro I/II/III HDVs	Diesel	0%	0%	5%
Euro IV/+ HDVs	Diesel	0%	0%	0%

As the table indicates, the Commission has assumed in its modelling that there would be no additional reduction in emissions for Euro IV vehicles. This modelling also assumes that there is no emission reduction from vehicles fitted with a particulate trap and pre-Euro I vehicles.

2.2.3 S3: Retrofitting programme

The Department of Transport, Local Government and the Regions already has two retrofitting programmes to reduce emissions from existing diesel vehicles over the period 2001-2004: the original Clean Up programme and a dedicated HGV retrofitting programme (from the £100million haulage modernisation fund announced in the 2000 Pre-Budget Report). As the details of these retrofitting programmes were not finalised until recently, these programmes have not been included in the baseline case.

There are three distinct elements of this retrofitting scenario which were modelled, in total, in the following order:

- the existing £30m Clean Up programme
- the £30m dedicated HGV retrofitting programme
- a further £30m funding for the Clean Up programme

We have illustrated the maximum impact of the retrofit scenario by assuming that all of the conversions would take place in one city, that city being London. We have assumed that the retrofitting is spread over the years 2001 – 2003 in the proportion 25%, 33%, and 42 %. The modelling makes the following assumptions about the retrofitting technologies used, annual mileage of the vehicles retrofitted, emission reductions achievable, and the number of vehicles retrofitted.

Technologies

The technologies considered were: fitting trucks and buses with particulate traps or oxidation catalysts; fitting taxis with oxidation catalysts; converting taxis to run on LPG; converting trucks to run on CNG; and re-engining pre-Euro I trucks and buses.

Annual mileage

- Taxis – assumed that all mileage will be in central and inner London. Assume annual distance travelled is 40,000km, all of which is in London.
- Buses – assumed annual distance travelled is 38,500km, all of which is in London.
- Trucks – assumed that the typical annual distance travelled is 60,000km of which one third ie: 20,000km is in London.

Emission scaling factors

The following emission benefits from retrofitting have been assumed:

- Particulate traps – the fitting of a trap reduces particulate emissions by 90% over Euro II standards;
- Taxi oxidation catalysts – a 25% reduction in particulate emissions from Euro I;
- Truck oxidation catalysts – a 25% reduction in particulate emissions from Euro I;
- Converting taxis to LPG – conversion improves taxi from Euro I diesel to Euro III petrol standards;
- Converting trucks to CNG – conversion takes Euro I/II truck to the level of particulate emissions from a truck fitted with a particulate trap;
- Converting buses to CNG - conversion takes pre-Euro I bus to Euro III diesel for NO_x and to the level of particulate emissions from a bus fitted with a particulate trap;
- Re-engining buses and trucks - this takes pre-Euro I vehicle to Euro II.

Scenarios

The numbers of each vehicle type, retrofitted for the £90 million spend scenario, are listed in Table 2.2.

Table 2.2 The £90 million retrofit scenario

Vehicle Type, and retrofit option applied	Numbers of vehicles
London	
Taxi LPG	600
Taxi oxidation cat	10000
Truck oxidation cat	1500
Truck CRT see split in following table	27000
Bus CRT see split in following table	10000
Truck CNG see split in following table	500
Bus CNG	100
Bus re-engining	60
Truck re-engining see split in following table	60

Outside London	
Ignore taxi catalyst and LPG retrofits and assume additional number of bus trap retrofits Bus CRT (50% Euro I, 50% Euro II)	1200

Certain types of retrofits and conversions are spread out between different classes of heavy duty vehicles differently each year, as shown in Table 2.3 below.

Table 2.32 The Distribution of the Numbers of Retrofits and Conversions between Vehicle Types

Technology	Vehicle type	Euro standard converted/retro fitted	Distribution of the number of retrofits/conversions between vehicle types		
			2001	**2002**	**2003**
Truck CRT	Rigid HGV	Euro I	25%	30%	35%
		Euro II	25%	30%	35%
	Artic HGV	Euro I	25%	12%	6%
		Euro II	25%	28%	24%
Bus CRT		Euro I	50%	40%	30%
		Euro II	50%	60%	70%
Truck CNG	Rigid HGV	Euro I	25%	25%	25%
		Euro II	25%	25%	25%
	Artic HGV	Euro I	25%	25%	25%
		Euro II	25%	25%	25%
Truck re-engine	Rigid		50%	50%	50%
	Artic		50%	50%	50%

This highly area-focused and intense retrofit and conversion programme (i.e. in London) implies that by 2003 a very high proportion of Euro I heavy duty vehicles running in the area having been retrofitted or converted (>90%). A high proportion of Euro II heavy duty vehicles in the area would also have been retrofitted (>25% rigid HGVs, >70% buses).

2.3 STATIONARY SOURCE MEASURES

This section describes the main stationary sources that were considered and summarises the techniques available for emissions reduction. Not all the stationary sources of primary PM_{10} were assessed. Offshore sources of primary particles were not included in the analysis as the impact on mainland concentrations is likely to be limited. Other sectors such as construction, which could make a more significant contribution, were not included in the analysis due to a lack of information on emission factors and abatement costs.

Sectors that were assessed include domestic combustion, quarrying, industrial combustion, public and commercial buildings, petroleum refineries, the iron and steel industry, cement production, lime production and non ferrous metals.

For power stations, the market structure in the electricity supply industry (ESI) is already changing irrespective of any measures to reduce PM_{10} emissions, with generating capacity from coal-fired plants being progressively substituted by gas-fired plants, particularly by combined cycle gas turbine (CCGT) plants. By 2010 the UK ESI is projected to consist mainly of CCGT stations with a small amount of FGD coal and a small residual nuclear component. Under the baseline scenario emissions will be considerable reduced in absolute and relative terms. Consequently, for the purposes of the analysis it was assumed that no emissions abatement above the baseline scenario is feasible in the case of power stations.

2.3.1 Domestic Combustion

The major source of particulate emission is the combustion of solid fuel (comprising coal, anthracite, smokeless solid fuel, coke and wood) for space and water heating. Domestic combustion of natural gas also seems to contribute to a good proportion of PM_{10} emissions from the domestic sector. This might be surprising at first, as the emission factor for gas is very small In fact, the large total emissions from this source is due to the large number of households that burn gas.

The additional PM_{10} emission abatement measures that were considered from the burning of coal and anthracite consisted of:

- Replacing open grates with enclosed appliances.
- Switching to smokeless solid fuel
- Switching to gas

2.48 Emissions from the burning of all fuels can be reduced by the use of energy saving measures such as insulation and double-glazing. These techniques were not included in the analysis since they already have significant uptakes in the UK housing stock, their effect is quite small and energy-saving measures are usually undertaken for other reasons. Closed appliances, in theory, as well as emitting less PM_{10} per kg of coal burned, are also more fuel-efficient and could therefore lead to a reduction in fuel use. In practice the increased thermal efficiency is likely to increase the level of heating rather than to decrease the rate of fuel consumption (AEA Technology, 2001). Moreover, according to recent evidence (BRE 1998), enclosed solid fuel appliances (i.e., “central heating” and “stoves”) already account for approximately 75% of all solid fuel burning appliances; the remaining 25% of solid fuel is burned in open fires. This means that the technique can at most be applied to 25% of these emissions.

2.3.2 Quarrying

The estimation of PM_{10} emissions from this sector is subject to considerable uncertainty. In particular, there are no emission factors for different types of quarries and for the different operations carried on in a quarry. There is also little information about the size distribution of emissions from quarries, although it is reasonable to assume that the majority of emissions from quarries will be in the coarse size fraction.

For the purposes of the analysis it was assumed that all types of quarry are the same and that only the following types of operations are carried out on site: Mineral extraction; Crushing &

Screening; Haulage and Conveyors. In the absence of more detailed information, it was also assumed that the total emissions from a quarry are divided equally among these operations. The available emission reduction measures include (Ove Arup, 1995):

- "good practice" measures (e.g. minimise drop heights)
- speed restrictions;
- water sprays;
- enclose and extraction and filtration systems;
- chemical dust suppressants
- improved road design.

It was assumed that in some cases the measures would not be applicable as additional measures, either because they have already been designed into operations, or because the impacts would be considered too small for action to be taken. An applicability of 50% was assumed in view of these factors and of the uncertainty associated with the diverse nature of the quarrying industry.

2.3.3 Industrial Combustion and Processes

This sector is made up of combustion, large and small processes. Process and space heating at industrial sites is usually generated in boilers of a wide range of sizes burning either natural gas, oil or coal. The combustion of solid and liquid fuels produces the largest emissions of particles, although coal-fired boilers are becoming increasingly rare in industry. Current regulations specify an emission limit that is easily attainable with a well-maintained boiler. Therefore, it was assumed for the purpose of the analysis that emissions from this source are currently unabated.

The abatement options that are in principle available in this sector include:

- fuel switching from coal and oil to gas
- use of ceramic filters
- use of fabric filters

The replacement of coal-fired boilers with gas-fired boiler is a process that is likely to happen anyway in the course of time as existing plants reach the end of their working lives. Oil fired boilers can be converted to gas simply by replacing the burner. In itself, this operation is relatively cheap, but it is particularly difficult to estimate the cost of establishing a new gas supply, which is very site specific and can vary from zero up to a very large amount. Because of the large uncertainties involved, and because only a small proportion of the emission from these sources is likely to be from coal or oil fired boilers anyway, the fuel switching option was not included in the analysis.

In practice, ceramic filters or fabric filters are likely to be the technology of choice if this sector is required to implement additional emission reduction measures. The choice between this two different technologies is likely to be based on the assessment of variation in cost-effectiveness according to differences in flow rate, particle load, filter specification (e.g. with respect to the fabric used), etc. between plant. A detailed assessment of the rate of adoption of ceramic vs. fabric filters was not attempted; instead it was assumed that firms would choose between two notional abatement options, a low cost and a high cost option. In terms of applicability, it was assumed that each of the two options would be implemented in 30% of the sector plants.

The small processes sector includes a wide range of processes; the emissions from which are likely to be amongst the least well characterised in the inventory. It is likely that the applicability of emission reduction measures would be less than 100% and an applicability of

60% has been assumed. It is also likely that a roughly 50% of these emissions will be in the coarse size fraction.

2.3.4 Public and commercial buildings

The oil, coal or gas fired boilers that typically provide space heating and hot water for public and commercial buildings are not usually subject to abatement, and are therefore a source of particulate emissions, although the latter are likely to be significant only for oil and coal fired boilers. The emission data show that in the public sector there is very little oil burned but a significant amount of coal, particularly in schools. This situation is likely to be different in the private sector, although no data are available to confirm this.

The abatement options that are in principle available in this sector include:
- fuel switching from coal and oil to gas
- use of ceramic filters

Fuel switching is likely to happen in the course of time, as old coal fired plants are replaced. Accelerating this process is thought to provide a negligible contribution to PM_{10} abatement. Ceramic filters were therefore identified as the preferred option for abatement of PM_{10} emissions in this sector. However, an applicability of 75% was assumed as emissions from some plants would be too low to warrant abatement or the plants would have too limited a remaining life to warrant the expense. Also, for some plant it would not be physically possible to install abatement devices.

2.3.5 Petroleum Refineries

The largest single source of particulate emissions from oil refineries is the fluid catalytic cracking unit (FCCU), which converts the heavier fractions of crude oil into gasoline. Currently only one FCCU in the UK is fitted with an electrostatic precipitator. The other FCCUs usually have two cyclones in series to remove particles from exhaust gases, but this does not remove all the particles, especially the smaller ones. The rest of the particulate emissions come from the many combustion plants, including the central boiler (typically fired using heavy oil) and various fired process heaters. These are sometimes fitted with electrostatic precipitators.

For every process, further emission abatement could be achieved through the following options:
- adopting wet flue gas scrubbing;
- fitting additional electrostatic precipitators;
- switching to gas in combustion processes.

As far as PM_{10} control is concerned, the first two measures have to be considered as alternatives. Indeed, it would not be reasonable to add wet scrubbing to control particles on top of an ESP (there are plants with both but for purposes of multi-pollutant controls). By contrast, switching to gas in combustion processes can be implemented in addition to one of the other measures. However, gas supply at certain UK refinery sites is likely to be insufficient to allow fuel switching.

2.3.6 Iron and Steel Industry

The different industrial process/installations in this sector include:

- Coke production
- Sinter production
- Blast Furnaces for the production of pig iron
- Basic oxygen furnaces for the production of steel
- Electric arc furnaces for the production of carbon and alloy steels

A wide range of abatement techniques are currently being applied across these industrial processes, ranging from good operational practice and conventional smoke-capture systems to gas-cleaning devices and modern electrostatic precipitators (EPs). Nonetheless, for some sources it would be possible to achieve further reductions in emissions at relatively low marginal costs by fitting relatively standard devices (e.g., fabric filters, EPs and cyclones). It is noted that the choice of the best technology for the UK is affected by the abatement technology already in place. For instance, modern EPs are currently fitted at all the existing UK sinter plants; therefore the only option available for achieving further emission reduction is to fit fabric filters in addition to the existing EPs.

2.3.7 Cement Production

Emissions of PM_{10} take place at several stages of the cement manufacturing process; the main source of particulate matter is from the kiln and clinker cooler exhaust stacks. Also, fugitive emissions of particulate matter can arise from materials handling and transfer operations, as well as from raw milling dry process facilities, and finish milling operations.

For every process, further emission abatement could be achieved through the following options:

- Fitting electrostatic precipitators (EPs);
- Fitting fabric filters
- Fitting EPs and fabric filters in series

2.3.8 Lime production

The lime making process involves heating crushed, aggregate-sized limestone to temperatures between 900 and 1200°C. Emissions from the blasting and crushing are part of quarry operations and not lime making emissions and are therefore discussed in the above section on quarrying. As far as lime production from aggregate limestone is concerned, the kiln is the most important source of particle emissions, followed by the hydrator. In addition, fugitive emissions can occur from almost any part of the process.

Modern lime works are equipped with electrostatic precipitators that remove at least 98 % of the particulate matter from exhaust gases. Other possible control devices include multiple cyclones, wet scrubbers, and baghouses. Further emission reductions could be obtained by:

- fitting EPs and fabric filters on rotary kilns;
- fitting fabric filters on other kilns;
- adopting wet scrubbers in lime hydrators

2.3.9 Non ferrous metals

The non ferrous metal industry (in particular aluminium production) accounted for 0.5% of overall UK primary emissions in 1998. Under the baseline scenario their contribution is expected to increase slightly both in absolute terms (to 1.19 Kte/year) and in percentage terms (to 1%) by 20101. The main abatement options in this sector that were considered in the analysis included electrostatic precipitators and fabric filters.

2.4 THE IMPACT OF THE POSSIBLE ADDITIONAL POLICY MEASURES ON UK ANNUAL PM_{10} EMISSIONS

The impact on UK annual PM_{10} emissions of both the illustrative package of possible transport, and stationary source measures and its individual components are set out in the proceeding tables. Table 2.4 shows the illustrative scenario. The total impact of this package is to reduce annual UK emissions by 32.9 ktonnes in 2010 (i.e. by 33%), by 33.8 ktonnes in 2015 (i.e. by 36%) and by 33.6 ktonnes in 2020 (i.e. by 36%).

Table 2.4 Annual UK PM_{10} emissions, with whole package of possible additional measures, 2010 to 2020, (ktonnes)

Source	2010	2010 illustrative scenario	2015	2015 illustrative scenario	2020	2020 illustrative scenario
Public Power	**7.2**	7.2	**5.1**	5.1	**4.4**	4.4
Petroleum Refining Plants	**3.8**	0.2	**4.1**	0.4	**4.2**	0.6
Other Comb. & Trans.	**3.9**	3.9	**4.3**	4.3	**4.6**	4.6
Residential Plant	**11.4**	8.8	**10.2**	7.5	**9.3**	6.7
Comm., Public & Agri. Comb	**5.6**	3.9	**5.6**	3.9	**5.5**	3.7
Iron_&_Steel Combustion	**1.9**	0.0	**2.2**	0.4	**2.5**	0.6
Other Comb. in Industry	**11.2**	8.9	**11.4**	9.1	**11.6**	9.3
Processes in Industry	**11.5**	2.2	**12.1**	2.8	**12.7**	3.4
Construction	**4.6**	4.6	**5.0**	5.0	**5.5**	5.5
Quarrying	**12.1**	2.5	**10.1**	0.5	**8.8**	0.0
Road Transport Combustion	**13.3**	11.4	**10.5**	7.7	**10.4**	7.0
Road Transport Brake & Tyre Wear	**5.8**	5.8	**6.3**	6.3	**6.7**	6.7
Off-Road Sources	**2.0**	2.0	**2.2**	2.2	**2.3**	2.3
Military	**0.3**	0.3	**0.3**	0.3	**0.3**	0.3
Railways	**0.3**	0.3	**0.3**	0.3	**0.3**	0.3
Shipping	**1.2**	1.2	**1.2**	1.2	**1.2**	1.2
Civil Aircraft	**0.2**	0.2	**0.3**	0.3	**0.3**	0.3
Waste Incineration	**1.8**	1.8	**1.9**	1.9	**2.1**	2.1
Animal Wastes	**n/a**	n/a	**n/a**	n/a	**n/a**	n/a
Non Livestock Agricult.	**n/a**	n/a	**n/a**	n/a	**n/a**	n/a
TOTAL	**98.3**	**65.4**	**92.9**	**59.1**	**92.5**	**58.9**

It should be noted that tonnage reductions in stationary source emissions in 2015 and 2020 are assumed to be the same as in 2010. The decline in quarry emission in the baseline leads to a reduction that is bigger than the total in 2020, so the emissions are set to zero in 2010. Since quarry emissions are not explicitly included in the modelling this does not influence the model results.

The impact of the individual policy measures on annual UK PM_{10} emissions in future years have been calculated separately and set out in Table 2.5. In addition the impact of the individual components of the package of transport measures on annual UK urban road transport emissions in 2010 is set out in Table 2.6

Table 2.5 Annual UK PM_{10} Emission reductions from individual measures in 2010, 2015,and 2020 ktonnes

Source	**2010**	**2015**	**2020**
Petroleum Refining Plants	-3.6	-3.6	-3.6
Residential Plant	-2.7	-2.7	-2.7
Comm., Public & Agri. Comb	-1.7	-1.7	-1.7
Iron_&_Steel Combustion	-1.8	-1.8	-1.8
Other Comb. in Industry	-2.3	-2.3	-2.3
Processes in Industry			
Other industry Small processes	-2.6	-2.6	-2.6
Other Industry Large processes	-1.0	-1.0	-1.0
Iron and Steel Basic oxygen Furnace	-0.4	-0.4	-0.4
Iron and Steel Coke production	-0.2	-0.2	-0.2
Iron and Steel Sinter plant	-1.7	-1.7	-1.7
Cement	-1.7	-1.7	-1.7
Aluminium Production	-0.8	-0.8	-0.8
Lime Production	-0.8	-0.8	-0.8
Total processes in industry	-9.3	-9.3	-9.3
Quarrying	-9.6	-9.6	-8.8
Road Transport Combustion			
Particulate trap	-1.62	-2.7	-3.37
Sulphur free fuels	-0.26	-0.08	-0.01
Retrofit	-0.040	-0.007	-0.001
Total Road Transport Combustion	-1.920	-2.787	-3.381
Total	**-32.9**	**-33.8**	**-33.6**

In addition, projections of emissions for road traffic have been calculated for the different transport scenarios by applying each measure sequentially to the model of emissions for the baseline scenario (Stedman et al, 2001c). Projections have been calculated for the NRTF/Ten Year Plan urban area types, in order to take account of the effects of different traffic speeds and traffic growth in these different areas. A summary of the resulting projected emissions for traffic is set out in Table 2.6. The table shows the impact of each measure on annual UK traffic emissions with different implementation dates of the measures. These are 2006 and 2008 for the introduction of particulate traps on new diesel vehicles and 2005 and 2010 for the introduction of sulphur free petrol and diesel (although in practice only sulphur free diesel impacts on the estimated particle emission estimates).

The impact of full package of emission reduction measures on ambient concentrations has been estimated. Of the traffic measures, particulate traps have the greatest impact on road traffic emissions and the impact on emissions is greater for the earlier introduction (2006, rather than 2008). The impact of sulphur free fuels is less and emissions in 2010 and later are not influenced by the date of introduction (2005 or 2010). The impact of the retrofit programme when targeted in one area (i.e. London) is very small on a national scale, but is more significant in the area itself. The effect on emissions in London in 2010 and beyond is relatively modest but is greater in the early to mid 2000s when it will play a valuable role in reducing road traffic emissions ahead of the achievement date for the current mandatory EC Stage 1 limit value for PM_{10}.

Table 2.6 Annual UK traffic PM_{10} emissions projections, 2005 – 2020 (ktonnes, as NO_2)

Scenario	2005	2010	2015	2020
Baseline	19.7	13.3	10.5	10.4
Particulate traps from 2006	19.7	11.7	7.8	7.0
Particulate traps from 2008	19.7	12.4	8.2	7.1
Particulate traps from 2006, 10 ppm S from 2005	19.3	11.4	7.8	7.0
Particulate traps from 2008, 10 ppm S from 2010	19.7	12.1	8.2	7.1
Particulate traps from 2006, 10 ppm S from 2005, Retrofit £90m 2001-03	19.2	11.4	7.7	7.0

2.5 THE IMPACT OF THE POSSIBLE ADDITIONAL POLICY MEASURES ON UK ANNUAL NO_x AND SO_2 EMISSIONS

The majority of the measures are not expected to have significant impacts on the UK emissions of NOx or SO_2 in 2010. The traffic measures have been estimated to reduce UK NOx emissions by approximately 23 ktonnes on the 2010 baseline and have no significant effect on SO_2. Table 2.7 shows the impact of each measure on annual UK traffic emissions with different implementation dates of the measures.

Measures to reduce domestic PM_{10} emissions (by fuel switching) have been assumed to have no significant effect on NOx and to reduce UK SO_2 emissions by approximately 7 ktonnes. Measures to reduce refinery PM_{10} emissions (by fuel switching) have been assumed to reduce UK NOx emissions by approximately 16 ktonnes and to reduce UK SO_2 emissions by approximately 64 ktonnes.

Table 2.7 Annual UK traffic NO_x emissions projections, 2005 – 2020 (ktonnes)

Scenario	2005	2010	2015	2020
Baseline	367	250	197	192
Particulate traps from 2006	376	232	184	182
Particulate traps from 2008	376	243	189	183
Particulate traps from 2006, 10 ppm S from 2005	365	228	183	182
Particulate traps from 2008, 10 ppm S from 2010	376	239	188	183
Particulate traps from 2006, 10 ppm S from 2005, Retrofit £90m 2001-03	365	228	183	182

The overall reductions in UK total emissions of sulphur dioxide implied by the additional measures to reduce PM_{10} are about 12% of the baseline sulphur dioxide emissions in 2010 and the impact of these reductions on ambient SO_2 has been estimated.

The overall reductions in UK total emissions of oxides of nitrogen in 2010 implied by the measures to reduce PM_{10} are relatively small (about 3%). The impact of the reduction in road traffic emissions on ambient NOx and NO_2 concentrations has been modelled since they will have a direct impact on roadside concentrations and a significant proportion these emission reductions will take place in population centres and therefore strongly influence population weighted mean concentrations. Reductions in NOx emissions from the refinery sector are however expected to have a relatively minor impact on background NO_2 concentrations and this impact has therefore not been modelled.

The impact of these reductions on ambient secondary PM_{10} concentrations has been included in the PM_{10} modelling. The methods that have been used to project secondary PM_{10} on the basis of a combination of measurement data and model results are described in the baseline report (Stedman et al, 2001c). We have assumed that 30% of the sulphate particle concentration in the UK in 2010 is of UK source origin, with the remainder being from other sources. Similarly we have assumed that UK sources contribute 45% of UK nitrate concentrations. The resulting scaling factors for estimating secondary PM_{10} concentrations in 2010 from base year values are listed in Table 2.8. These factors have been applied throughout the UK. Beyond 2010 concentrations of secondary particles have been assumed to remain at 2010 levels, and the reductions in secondary PM_{10} concentrations implied by the illustrative package of measures have similarly been held constant after 2010.

Table 2.8 Secondary PM_{10} reduction factors for 2010 (base year concentration = 1)

Base year	**1996**	**1997**	**1998**	**1999**
Baseline	0.565	0.574	0.631	0.677
Illustrative package of measures	0.553	0.558	0.615	0.662

2.6 POINT SOURCES

The contribution from individual point source emissions was not explicitly included in the baseline mapping. It is important, however, to assess the benefits of measures that reduce point source emissions in terms of reductions in concentrations. The reductions in PM_{10} emissions from point sources implied by the illustrative package of measures have been modelled using ADMS. Emissions from individual plant were modelled for the Iron and Steel and Refineries sectors. Emission from the Other Industry Combustion, Cement, Aluminium, Lime and Other Industry Large Processes sectors were modelled using a dispersion matrix approach, with emissions assumed to be from 1 km square volume sources of height 50 m. We have ensured that the reductions in primary PM_{10} in each grid square do not exceed the baseline primary concentration.

3 Site specific projections

3.1 PM_{10}

Measured annual mean PM_{10} concentrations for the years 1996 to 1999 are listed in Table 3.1. Data from TEOM instruments has been multiplied by a factor of 1.3, as recommended by APEG (1999) and discussed in the baseline report The methods used to calculate site-specific projections for PM_{10} are described in the baseline report (Stedman at al, 2001c) and associated documents (APEG, 1999, DETR et al, 2000, Stedman et al, 1998b, Stedman, et al 2000, Stedman et al, 2001b).

The projected PM_{10} annual mean concentrations for individual sites, for 2010, 2015 and 2020 for the baseline and illustrative package of possible additional measures scenario, for a range of meteorology, are shown in Tables 3.2, 3.3 and 3.4 below. For example, by 2010, under 1999 meteorology, the baseline scenario suggests that 9 of the 16 sites analysed would exceed the indicative Stage 2 limit value of 20 μgm^{-3} as an annual mean. The application of the package of additional measures reduces the annual mean PM_{10} concentrations to below this level at all but 2 of the sites. The analysis also shows the impact of years characterised by a high secondary particle contribution. In 2010, with 1996 meteorology, 9 out of 10 sites are predicted to exceed under the baseline scenario, falling to 7 sites with the illustrative package of measures scenario. In 2010, under 1999 meteorology the biggest reduction in annual mean PM_{10} concentrations resulting from the illustrative scenario is at Marylebone Road (3.4 μgm^{-3}) – illustrating the targeted nature of the package of measures. The smallest reduction from the additional measures is predicted to occur at the rural site at Rochester (0.3 μgm^{-3}), consistent with the relatively low primary particle contribution at this location. Reductions at urban background sites are typically of the order of 1-2 μgm^{-3}.

By 2015 further reductions occur beyond that delivered in 2010, for both the baseline and illustrative scenario. In this year, for the baseline scenario, for 1999 meteorology, 6 sites are predicted to exceed the EC Stage 2 indicative limit value - falling to 1 site exceeding for the illustrative scenario. The biggest reductions occur at roadside sites - annual mean concentrations at Marylebone Road are 3.4 μgm^{-3} lower (1999 meteorology) that those predicted for the baseline scenario. Reductions of about 1-2 μgm^{-3} occur at urban background sites. The predicted annual mean concentrations in 2015 can also be compared to what would be delivered for the same scenario in 2010. For the illustrative scenario, the largest additional reduction in annual mean concentration occurs at Marylebone Road (2.3 μgm^{-3}).

By 2020 very small additional reductions are expected beyond that already delivered by 2015. In 2020, for 1999 meteorology, 5 sites are predicted to exceed the EC Stage 2 annual mean indicative limit value for the baseline scenario, falling to 1 site for the illustrative scenario. When compared with what would be delivered by the illustrative scenario in 2015 (1999 meteorology) additional reductions in annual mean concentrations are typically only 0.1 – 0.2 μgm^{-3} at urban background sites. This rises to between 0.1-0.5 μgm^{-3} at roadside sites, with the highest additional reduction occurring at Marylebone Road.

Table 3.1 Measured annual mean PM_{10} concentrations 1996 to 1999 (mgm^{-3}, gravimetric)

	measured PM_{10}			
Base year	1996	1997	1998	1999
London Bloomsbury	39.0	35.1	29.9	28.6
Birmingham Centre	32.5	28.6	24.7	23.4
Cardiff Centre	32.5	33.8	28.6	27.3
Edinburgh Centre	24.7	23.4	19.5	19.5
Belfast Centre	31.2	32.5	27.3	26.0
Liverpool Centre	32.5	32.5	28.6	26.0
Rochester	31.2	26.0	22.1	20.8
Newcastle Centre	31.2	27.3	23.4	20.8
Manchester Piccadilly	33.8	31.2	27.3	26.0
Bristol Centre	32.5	31.2	27.3	26.0
Haringey Roadside		33.8	28.6	28.6
Glasgow Roadside		40.3	35.1	27.3
Marylebone Road		50.7	41.6	45.5
Camden Roadside		41.6	32.5	33.8
Sutton Roadside		31.2	27.3	26.0
Bury Roadside		39.0	33.8	31.2

Table 3.2 Projected annual mean PM_{10} concentrations 2010 from base years 1996 to 1999 (mgm^{-3}, gravimetric) for the baseline scenario and the illustrative package of measures scenario

	projected PM_{10} 2010 Baseline				projected PM10 2010 illustrative scenario			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	24.4	22.7	21.3	21.6	22.5	20.4	19.6	19.9
Birmingham Centre	21.3	19.5	18.4	18.5	20.1	18.1	17.4	17.5
Cardiff Centre	21.9	23.1	21.3	21.4	20.4	20.7	19.4	19.5
Edinburgh Centre	17.5	17.0	15.6	16.1	16.8	16.0	15.0	15.5
Belfast Centre	20.8	22.0	20.2	20.4	19.1	19.5	18.3	18.4
Liverpool Centre	21.8	22.3	21.2	20.5	20.6	20.6	19.8	19.2
Rochester	21.6	18.9	17.5	17.2	20.8	18.1	17.0	16.9
Newcastle Centre	20.3	18.6	17.5	16.8	19.2	17.3	16.6	16.1
Manchester Piccadilly	21.5	20.4	19.6	19.7	20.2	18.7	18.2	18.4
Bristol Centre	21.5	21.2	20.1	20.3	20.3	19.5	18.8	18.9
Haringey Roadside		21.3	20.0	20.9		19.4	18.6	19.4
Glasgow Roadside		22.1	21.5	18.6		20.2	19.8	17.7
Marylebone Road		26.3	24.5	27.7		23.1	21.9	24.3
Camden Roadside		24.3	21.5	23.3		21.6	19.7	21.1
Sutton Roadside		20.1	19.4	19.6		18.7	18.3	18.5
Bury Roadside		22.2	21.7	21.3		20.3	19.9	19.8

Table 3.3. Projected annual mean PM_{10} concentrations 2015 from base years 1996 to 1999 (mgm^{-3}, gravimetric) for the baseline scenario and the illustrative package of measures scenario

	projected PM_{10} 2015 Baseline				projected PM_{10} 2015 illustrative scenario			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	23.8	21.9	20.7	21.0	21.9	19.6	19.0	19.3
Birmingham Centre	20.8	18.9	18.0	18.1	19.5	17.3	16.8	17.0
Cardiff Centre	21.5	22.5	20.8	20.9	19.9	19.9	18.7	18.9
Edinburgh Centre	17.2	16.6	15.4	15.9	16.4	15.5	14.7	15.2
Belfast Centre	20.4	21.3	19.7	19.8	18.6	18.6	17.6	17.8
Liverpool Centre	21.3	21.5	20.6	19.9	20.0	19.6	18.9	18.5
Rochester	21.4	18.7	17.4	17.2	20.6	17.8	16.9	16.9
Newcastle Centre	19.8	18.6	17.1	16.5	18.5	17.3	16.0	15.7
Manchester Piccadilly	20.9	19.6	18.9	19.1	19.4	17.7	17.3	17.6
Bristol Centre	21.1	20.5	19.6	19.8	19.7	18.6	18.0	18.2
Haringey Roadside		20.5	19.3	20.2		18.6	18.0	18.7
Glasgow Roadside		20.1	19.7	17.3		17.6	17.5	15.9
Marylebone Road		24.2	22.8	25.4		21.0	20.2	22.0
Camden Roadside		22.9	20.5	22.1		20.2	18.7	19.9
Sutton Roadside		19.4	18.9	19.1		17.9	17.7	18.0
Bury Roadside		20.8	20.5	20.1		18.4	18.4	18.2

Table 3.4 Projected annual mean PM_{10} concentrations 2020 from base years 1996 to 1999 (mgm^{-3}, gravimetric) for the baseline scenario and the illustrative package of measures scenario

	projected PM_{10} 2020 Baseline				projected PM_{10} 2020 illustrative scenario			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	23.7	21.8	20.6	20.9	21.8	19.4	18.8	19.1
Birmingham Centre	20.7	18.8	17.9	18.0	19.3	17.0	16.7	16.8
Cardiff Centre	21.4	22.4	20.7	20.9	19.7	19.6	18.5	18.7
Edinburgh Centre	17.2	16.5	15.3	15.8	16.3	15.3	14.6	15.1
Belfast Centre	20.3	21.3	19.6	19.8	18.5	18.5	17.5	17.7
Liverpool Centre	21.2	21.4	20.4	19.8	19.8	19.3	18.7	18.3
Rochester	21.4	18.7	17.4	17.2	20.5	17.7	16.9	16.8
Newcastle Centre	19.7	17.9	17.0	16.4	18.3	16.2	15.9	15.6
Manchester Piccadilly	20.8	19.5	18.8	19.0	19.2	17.4	17.1	17.3
Bristol Centre	21.0	20.4	19.6	19.7	19.5	18.4	17.9	18.1
Haringey Roadside		20.4	19.2	20.1		18.3	17.8	18.5
Glasgow Roadside		19.8	19.5	17.1		17.0	16.9	15.5
Marylebone Road		23.9	22.5	25.0		20.4	19.8	21.5
Camden Roadside		22.7	20.4	21.9		19.8	18.5	19.6
Sutton Roadside		19.3	18.8	19.1		17.8	17.6	17.9
Bury Roadside		20.6	20.4	20.0		18.0	18.0	17.9

3.2 NO_2

Measured annual mean NO_2 concentrations for the years 1996 to 1999 are listed in Table 3.5. Site specific projections for the baseline and traffic measures within the illustrative package of measures in 2010 are listed in Tables 3.6 and 3.7. The impact of the industrial measures has not been modelled, as discussed above. Projections for years later than 2010 have not been calculated for NO_2 because the main aim of this work is to assess the impact of the policy measures on ambient PM_{10} concentrations. The projections of NO_2 for the traffic measures do, however, illustrate some of the additional benefits that would result from measures taken to reduce particle concentrations. The methods used to calculate site-specific projections for NO_2 are described in the baseline report (Stedman at al, 2001c) and associated documents (DETR et al, 2000, Stedman et al, 1998a, Stedman, 1999, Stedman et al, 2000). Annual mean NO_2 concentrations have been estimated from projected annual mean NO_x concentrations using non-linear relationships (Stedman et al, 2001c). Both measured and estimated annul mean NO_2 concentrations are tabulated for the base years.

By 2010, for the full range of meteorology investigated, the baseline scenario suggests that 9 of the 22 sites analysed would exceed the NO_2 limit value of 40 μgm^{-3} as an annual mean. The application of the package of additional traffic measures reduces the annual mean NO_2 concentrations to below this level at an additional 2 sites.

Table 3.5 Measured annual mean NO_x and NO_2 concentrations 1996 to 1999 (μgm^{-3}, as NO_2)

	measured NO_x				measured NO_2				estimated NO_2			
Base year	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	153	161	128	136	69	71	65	67	72	74	64	66
Birmingham Centre	82	80	74	63	44	44	42	38	43	43	41	37
Cardiff Centre	73	76	69	55	40	38	40	32	40	41	39	34
Edinburgh Centre	97	103	101	84	48	48	48	42	48	50	49	44
Belfast Centre	75	75	60	61	38	39	34	35	41	41	36	36
Liverpool Centre	99	103	92	97	48	44	38	42	49	50	46	48
Newcastle Centre	90	90	79	57	41	40	36	31	46	46	42	35
Manchester Piccadilly	112	100	87	86	54	41	40	43	52	49	45	45
Bristol Centre	113	124	92	80	48	44	40	38	52	56	46	43
West London	120	132	99	99	53	57	52	55	54	58	49	49
London Bridge Place	130	132	103	105	63	59	57	63	64	65	55	55
Manchester Town Hall	101	101	82	76	53	52	42	42	49	49	43	41
Leeds Centre	115	124	101	88	52	52	46	44	53	56	49	45
Hull Centre	101	90	84	76	42	40	38	38	49	46	44	41
Haringey Roadside	168	187	143	130	57	59	53	48	53	56	48	45
Glasgow Roadside		309	271	252		71	71	69		76	70	67
London Marylebone Road			374	390			92	92			85	87
Camden Roadside		277	243	208		70	64	66		71	66	60
Sutton Roadside	141	147	117	118	46	50	42	44	47	49	42	43
Bury Roadside		363	309	269		75	74	73		84	76	70
Tower Hamlets Roadside	313	298	246	239	65	71	65	67	76	74	66	65
London Cromwell Road	372		235	256	92		82	92	85		64	68

Table 3.6 Projected annual mean NO_x and NO_2 concentrations 2010 from base years 1996 to 1999 ($\mu g m^{-3}$, as NO_2) for the baseline scenario

	projected NO_x 2010				projected NO_2 2010			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	82.5	93.4	79.7	88.8	46.7	50.9	45.5	49.1
Birmingham Centre	39.8	42.0	41.8	38.0	28.1	29.0	28.9	27.3
Cardiff Centre	35.8	40.5	39.4	33.9	26.3	28.4	27.9	25.5
Edinburgh Centre	47.9	54.7	57.9	51.1	31.3	33.9	35.1	32.6
Belfast Centre	40.1	43.1	36.8	39.5	28.2	29.4	26.8	27.9
Liverpool Centre	54.1	60.2	57.4	64.2	33.7	36.0	34.9	37.4
Newcastle Centre	41.7	45.0	42.6	33.2	28.8	30.2	29.2	25.2
Manchester Piccadilly	51.7	50.0	47.0	49.7	32.8	32.2	31.0	32.0
Bristol Centre	53.6	63.5	50.9	47.6	33.5	37.1	32.5	31.2
West London	60.8	71.8	57.9	61.5	36.2	40.0	35.1	36.4
London Bridge Place	66.9	73.2	61.4	66.2	40.3	42.9	37.9	40.0
Manchester Town Hall	48.3	52.0	45.8	45.5	31.5	32.9	30.5	30.4
Leeds Centre	53.1	61.8	54.7	50.9	33.4	36.5	33.9	32.5
Hull Centre	45.2	43.4	44.5	43.2	30.3	29.6	30.0	29.5
Haringey Roadside	73.2	83.8	72.5	71.2	31.9	34.7	31.8	31.4
Glasgow Roadside		131.5	125.0	126.3		45.4	44.0	44.3
London Marylebone Road			181.5	200.4			55.1	58.5
Camden Roadside		117.6	112.0	105.4		42.5	41.3	39.8
Sutton Roadside	57.1	62.6	55.3	59.5	27.5	29.1	27.0	28.2
Bury Roadside		137.9	127.9	122.0		46.7	44.7	43.4
Tower Hamlets Roadside	125.3	128.3	116.6	121.0	44.1	44.7	42.2	43.2
London Cromwell Road	153.9		119.8	136.3	49.9		42.9	46.4

Table 3.7 Projected annual mean NO_x and NO_2 concentrations 2010 from base years 1996 to 1999 ($\mu g m^{-3}$, as NO_2) for the traffic measures within the illustrative package of measures scenario

	projected NO_x 2010				projected NO_2 2010			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	77.2	87.3	74.6	83.0	44.5	48.5	43.5	46.9
Birmingham Centre	38.1	40.1	40.0	36.4	27.3	28.2	28.1	26.6
Cardiff Centre	34.7	39.2	38.2	32.8	25.8	27.8	27.4	25.0
Edinburgh Centre	46.1	52.6	55.7	49.2	30.6	33.2	34.3	31.9
Belfast Centre	38.9	41.7	35.7	38.3	27.7	28.9	26.3	27.4
Liverpool Centre	52.3	58.2	55.5	62.0	33.1	35.3	34.2	36.6
Newcastle Centre	39.7	42.8	40.5	31.7	28.0	29.3	28.3	24.5
Manchester Piccadilly	49.3	47.7	44.9	47.4	31.9	31.3	30.2	31.2
Bristol Centre	51.6	61.2	49.0	45.9	32.8	36.3	31.8	30.5
West London	56.4	66.4	53.8	57.1	34.6	38.1	33.6	34.8
London Bridge Place	62.2	68.0	57.1	61.5	38.3	40.7	36.1	38.0
Manchester Town Hall	46.3	49.8	43.8	43.6	30.7	32.1	29.7	29.6
Leeds Centre	50.7	58.9	52.1	48.6	32.4	35.5	33.0	31.6
Hull Centre	43.8	42.1	43.2	41.9	29.7	29.0	29.5	28.9
Haringey Roadside	65.5	73.9	64.9	63.9	29.9	32.1	29.7	29.5
Glasgow Roadside		121.5	115.5	116.7		43.3	42.0	42.3
London Marylebone Road			160.2	175.9			51.1	54.1
Camden Roadside		102.6	98.0	92.6		39.1	38.1	36.8
Sutton Roadside	50.5	54.9	49.0	52.4	25.6	26.9	25.1	26.1
Bury Roadside		126.6	117.6	112.3		44.4	42.5	41.3
Tower Hamlets Roadside	109.9	112.3	102.7	106.3	40.8	41.3	39.2	40.0
London Cromwell Road	135.7		107.2	121.0	46.3		40.2	43.2

4 Maps of background concentrations

4.1 PM_{10}

The methods used to calculate maps of background PM_{10} and NO_2 concentrations are described in the baseline report (Stedman at al, 2001c) and associated documents (DEFRA et al, 2001, DETR et al, 2000, Stedman et al, 1997, Stedman, 1998, Stedman, et al, 1998a, Stedman, 1999, Stedman and Bush, 2000, Stedman et al, 2001a).

The population weighted annual mean background PM_{10} concentration is a key output from the mapping studies as it is the statistic required for the calculation of the health benefits of reductions in ambient concentrations (Stedman et al, 2001d, DEFRA, 2001). Population weighted mean concentrations are listed in Table 4.1 for the base years 1996 and 1999 and for 2010 for the baseline and illustrative package of measures scenarios. The difference between the baseline and illustrative scenario in 2010 has also been calculated and is listed in Table 4.2. The largest change in population weighted mean concentration for the illustrative package of measures is in London; the rest of England is similar to the value for the UK as a whole.

Table 4.1 Population weighted annual mean background PM_{10} concentrations for the base years 1996 and 1999 and for 2010 for the baseline and illustrative package of measures scenarios (μgm^{-3}, gravimetric)

Base year	1996	1997	1998	1999
Base years				
Scotland	21.940	19.828	18.716	18.379
Wales	25.243	21.645	20.389	19.588
Northern Ireland	25.721	24.698	22.627	20.623
Inner London	37.808	33.849	28.213	27.272
Outer London	34.673	30.144	26.273	25.462
Rest of England	28.559	24.460	22.835	21.965
UK	28.587	24.748	22.834	21.984
2010 Baseline				
Scotland	16.312	15.216	15.108	15.360
Wales	18.330	16.457	16.309	16.293
Northern Ireland	17.862	17.273	16.881	16.526
Inner London	24.068	22.214	20.497	20.795
Outer London	22.847	20.604	19.579	19.850
Rest of England	19.990	17.874	17.701	17.775
UK	19.913	17.943	17.641	17.738
2010 Illustrative package of measures				
Scotland	15.911	14.705	14.672	14.965
Wales	17.727	15.726	15.673	15.715
Northern Ireland	17.364	16.614	16.326	16.038
Inner London	22.875	20.807	19.441	19.761
Outer London	21.849	19.411	18.683	18.984
Rest of England	19.273	16.985	16.962	17.099
UK	19.194	17.057	16.914	17.068

Table 4.2 The change in population weighted annual mean background PM_{10} concentrations in 2010 for the baseline and illustrative package of measures scenarios (μgm^{-3}, gravimetric)

Base year	1996	1997	1998	1999	mean
Scotland	-0.400	-0.511	-0.436	-0.395	-0.436
Wales	-0.603	-0.731	-0.637	-0.579	-0.637
Northern Ireland	-0.497	-0.658	-0.554	-0.488	-0.549
Inner London	-1.193	-1.407	-1.056	-1.034	-1.172
Outer London	-0.998	-1.193	-0.896	-0.866	-0.988
Rest of England	-0.717	-0.889	-0.739	-0.676	-0.755
UK	-0.719	-0.886	-0.727	-0.670	-0.751

4.2 NO_2 AND SO_2

Details of the air quality modelling methods used to calculate the maps of annual mean background NO_2 concentration are provided in the AQS consultation document (DEFRA et al 2001) and the baseline report (Stedman et al, 2001c). Maps of annual mean background SO_2 concentration in 2010 for the baseline and illustrative additional measures scenario were calculated using the dispersion modelling approach adopted for the first review of the AQS and described by Abbot and Vincent (1999).

Population weighted mean NO_2 concentrations are listed in Table 4.3 for the base years 1996 to 1999 and for 2010 for the baseline and traffic measures within the illustrative package of measures scenarios. The difference between the baseline and illustrative traffic measures scenario in 2010 has also been calculated and is listed in Table 4.4. The largest change in population weighted mean concentration for the traffic measures is in London. The difference in concentrations resulting from the package of measures in London is larger relative to the rest of the UK for NO_2 than for PM_{10}, reflecting the importance of traffic emissions in city locations. The modelled changes in PM_{10} concentrations also incorporate reductions in secondary particle concentrations in all areas. Overall the changes in NO_2 concentrations are relatively modest but can be used to illustrate some of the additional benefits that could occur following measures to reduce particle concentrations (Stedman et al, 2001d, DEFRA, 2001).

Table 4.3 Population weighted annual mean background NO_2 concentrations for the base years 1996 and 1999 and for 2010 for the baseline and illustrative package of traffic measures scenarios ($\mu g m^{-3}$)

Base year	1996	1997	1998	1999
Base years				
Scotland	23.069	22.769	19.986	18.813
Wales	24.389	23.897	21.309	20.169
Northern Ireland	20.430	19.935	17.650	16.528
Inner London	52.988	54.697	47.572	47.386
Outer London	45.883	46.791	41.269	40.703
Rest of England	34.943	34.475	31.128	29.837
UK	34.542	34.283	30.731	29.565
2010 baseline				
Scotland	12.597	13.191	11.860	11.618
Wales	13.289	13.819	12.646	12.438
Northern Ireland	11.694	12.156	11.124	10.935
Inner London	35.022	37.837	34.213	35.196
Outer London	29.590	31.533	28.944	29.551
Rest of England	21.313	22.080	20.606	20.491
UK	21.074	21.981	20.373	20.341
2010 Illustrative package of measures				
Scotland	12.140	12.722	11.420	11.183
Wales	12.880	13.394	12.257	12.053
Northern Ireland	11.337	11.790	10.777	10.595
Inner London	33.481	36.123	32.721	33.642
Outer London	28.356	30.167	27.750	28.312
Rest of England	20.749	21.502	20.054	19.941
UK	20.441	21.318	19.756	19.720

Table 4.4 The change in population weighted annual mean background NO_2 concentrations in 2010 for the baseline and illustrative package of traffic measures scenarios ($\mu g m^{-3}$)

Base year	1996	1997	1998	1999	mean
Scotland	-0.457	-0.470	-0.441	-0.434	-0.450
Wales	-0.409	-0.425	-0.390	-0.384	-0.402
Northern Ireland	-0.357	-0.365	-0.347	-0.341	-0.352
Inner London	-1.542	-1.714	-1.493	-1.554	-1.576
Outer London	-1.234	-1.365	-1.194	-1.239	-1.258
Rest of England	-0.564	-0.579	-0.553	-0.550	-0.562
UK	-0.633	-0.663	-0.617	-0.621	-0.634

Population weighted mean SO_2 concentrations are listed in Table 4.5 for the 1998 base year and for 2010 for the baseline and the illustrative package of measures scenarios (measures in the domestic and refineries sectors are predicted to reduce SO_2 emissions). The difference between the baseline and illustrative measures scenario in 2010 has been calculated and is also listed in Table 4.5. The largest change in population weighted mean concentration for SO_2 is in Northern Ireland, where measures to reduce domestic PM_{10} emissions would also have a significant impact on local SO_2 concentrations. The modelled changes in SO_2 concentration can be used to illustrate the SO_2 related health benefits of the possible measures to reduce particle concentrations (Stedman et al, 2001d, DEFRA, 2001).

Table 4.5 Population weighted annual mean background SO_2 concentrations for the base year 1998 and for 2010 for the baseline and illustrative package of measures scenarios ($\mu g m^{-3}$)

	Base year (1998)	**2010 Baseline**	**2010 Illustrative package of measures**	**2010 change from baseline to illustrative package**
Scotland	2.487	1.280	1.200	-0.080
Wales	3.526	1.954	1.874	-0.081
Northern Ireland	5.908	2.056	1.486	-0.570
Inner London	6.242	2.954	2.889	-0.065
Outer London	6.546	3.320	3.250	-0.070
Rest of England	5.625	2.711	2.572	-0.139
UK	5.352	2.587	2.452	-0.135

5 Maps of roadside concentrations

5.1 PM_{10}

The methods used to calculate maps of roadside PM_{10} concentrations are described in the baseline report (Stedman et al, 2001c). Table 5.1 lists the numbers of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in the base years 1996 to 1999. Tables 5.2 and 5.3 list exceedences for the baseline and measures scenario in 2010 for the base years 1996 to 1999. Projections for 2015 are listed in Tables 5.4 and 5.5. Projections for 2015 are shown for the 1996 and 1999 base years.

Roadside PM_{10} concentrations are predicted to be much lower in 2010 than in the base years. Exceedences of 20 μgm^{-3}, gravimetric are however still expected to be common at the roadside for the baseline scenario, especially for the 1996 base year in England. Fewer exceedences of 20 μgm^{-3}, gravimetric are expected in 2010 for the 1999 base year. Exceedences of 25 μgm^{-3}, gravimetric are largely confined to Inner London.

The illustrative package of possible additional measures is predicted to have a significant impact on the number of road links with estimated annual mean PM_{10} concentrations in excess of 20 μgm^{-3}, gravimetric, particularly in Outer London and the Rest of England. The number of exceedences of 23 and 25 μgm^{-3}, gravimetric is also predicted to be considerably reduced.

The number of exceedences of the various threshold concentrations for the baseline scenario in 2015 is considerably reduced compared with 2010, largely as a result of the continued decline in road traffic exhaust emissions. Once again the illustrative package of measures is seen to significantly reduce the number of road links exceeding the thresholds. Exceedences of 23 μgm^{-3}, gravimetric are removed in all areas except Inner London for the 1999 base year and exceedences of 20 μgm^{-3}, gravimetric are largely confined to Inner London.

Table 5.1 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds for the base years 1996 to 1999

Base year		1996				1997				1998				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20	28	25	23	20	28	25	23	20
Geographical area	Total																
Scotland	548	113	265	380	499	63	171	252	384	12	71	164	329	7	39	110	302
Wales	282	77	216	275	279	20	58	133	239	5	27	66	215	1	12	39	177
Northern Ireland	101	29	49	77	99	23	32	46	79	18	27	32	61	10	17	26	49
Inner London	760	760	760	760	760	760	760	760	760	760	760	760	760	758	760	760	760
Outer London	789	787	787	787	787	787	787	787	787	714	787	787	787	554	786	787	787
Rest of England	4700	4189	4585	4652	4664	2109	3755	4313	4624	836	2689	3968	4590	354	1877	3497	4541
Total	7180	5955	6662	6931	7088	3762	5563	6291	6873	2345	4361	5777	6742	1684	3491	5219	6616

Table 5.2 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2010 for the base years 1996 to 1999 for the baseline scenario

Base year		1996				1997				1998				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20	28	25	23	20	28	25	23	20
Geographical area	Total																
Scotland	548	0	1	4	10	0	1	4	16	0	0	4	7	0	0	3	7
Wales	282	0	0	0	39	0	0	0	13	0	0	0	6	0	0	0	3
Northern Ireland	101	0	1	4	17	1	4	7	18	0	1	4	13	0	1	2	11
Inner London	760	136	691	760	760	48	373	687	760	8	75	360	760	9	107	428	760
Outer London	789	8	178	755	787	2	16	158	782	0	5	31	748	1	7	43	770
Rest of England	4700	1	24	396	3648	0	10	54	1264	0	3	25	903	0	2	23	892
Total	7180	145	895	1919	5261	51	404	910	2853	8	84	424	2437	10	117	499	2443

Table 5.3 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2010 for the base years 1996 to 1999 for the illustrative additional measures scenario

Base year		1996				1997				1998				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20	28	25	23	20	28	25	23	20
Geographical area	Total																
Scotland	548	0	0	1	6	0	0	0	6	0	0	0	5	0	0	0	5
Wales	282	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
Northern Ireland	101	0	1	3	10	0	1	5	12	0	1	3	10	0	0	1	7
Inner London	760	21	318	751	760	3	69	360	758	0	9	66	722	0	15	95	751
Outer London	789	1	17	365	787	0	2	13	604	0	0	5	282	0	1	5	431
Rest of England	4700	0	2	46	2425	0	0	2	254	0	0	2	179	0	0	2	175
Total	7180	22	338	1166	3999	3	72	380	1634	0	10	76	1198	0	16	103	1369

Table 5.4 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2015 for the base years 1996 and 1999 for the baseline scenario

Base year		1996				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20
Geographical area	Total								
Scotland	548	0	0	1	6	0	0	0	5
Wales	282	0	0	0	30	0	0	0	0
Northern Ireland	101	0	1	2	10	0	0	1	7
Inner London	760	36	551	760	760	0	24	166	760
Outer London	789	2	44	652	787	0	2	13	688
Rest of England	4700	0	3	132	3149	0	0	2	427
Total	7180	38	559	1547	4742	0	26	182	1887

Table A5.5The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2015 for the base years 1996 and 1999 for the illustrative additional measures scenario

Base year		1996				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20
Geographical area	Total								
Scotland	548	0	0	0	2	0	0	0	0
Wales	282	0	0	0	1	0	0	0	0
Northern Ireland	101	0	0	0	9	0	0	0	3
Inner London	760	0	70	616	760	0	0	7	588
Outer London	789	0	3	91	787	0	0	0	91
Rest of England	4700	0	0	0	1684	0	0	0	16
Total	7180	0	73	708	3243	0	0	7	698

5.2 NO_2

Details of the air quality modelling methods used to calculate the maps of annual mean roadside NO_2 concentration are provided in the AQS consultation document (DEFRA et al 2001) and the baseline report (Stedman et al, 2001c).

Table 5.6 lists the numbers of built-up major road links with estimated NO_2 concentrations greater than or equal 40 μgm^{-3} (the annual mean limit value) in the base years 1996 to 1999. Tables 5.7 and 5.8 list exceedences for the baseline and traffic measures within the illustrative scenario in 2010 for the base years 1996 to 1999.

Roadside NO_2 concentrations are predicted to decline sharply from the base year values to those predicted for 2010. The majority of road links exceeding 40 μgm^{-3} in 2010 are in London. The additional traffic measures are predicted to reduce the number of road links with concentrations greater than 40 μgm^{-3} in 2010 by approximately a third for the 1996, 1998 and 1999 base years and by approximately a quarter for the 1997 base year. While not directly targeted at reducing NO_2 concentrations, it is clear that this package of measures would make a valuable contribution to reducing roadside NO_2 concentrations.

Table 5.6 The number of built-up major road links with estimated NO_2 concentrations greater than or equal to 40 μgm^{-3} for the base years 1996 to 1999

Base year		1996	1997	1998	1999
Geographical area	Total				
Scotland	548	246	226	170	148
Wales	282	72	62	37	34
Northern Ireland	101	27	23	14	11
Inner London	760	760	760	760	759
Outer London	789	786	786	767	755
Rest of England	4700	3460	3242	2482	2218
Total	7180	5351	5099	4230	3925

Table 5.7 The number of built-up major road links with estimated NO_2 concentrations greater than or equal to 40 μgm^{-3} for the baseline scenario in 2010 for the base years 1996 to 1999

(Base year)		2010 (1996)	2010 (1997)	2010 (1998)	2010 (1999)
Geographical area	Total				
Scotland	548	8	8	7	7
Wales	282	0	0	0	0
Northern Ireland	101	1	1	1	1
Inner London	760	425	502	360	421
Outer London	789	41	51	31	38
Rest of England	4700	110	126	68	77
Total	7180	585	688	467	544

Table 5.8 The number of built-up major road links with estimated NO_2 concentrations greater than or equal to 40 μgm^{-3} for the traffic measures within the illustrative package of additional measures scenario in 2010 for the base years 1996 to 1999

(Base year)		2010 (1996)	2010 (1997)	2010 (1998)	2010 (1999)
Geographical area	Total				
Scotland	548	7	7	6	6
Wales	282	0	0	0	0
Northern Ireland	101	1	1	1	1
Inner London	760	277	403	235	290
Outer London	789	19	25	16	18
Rest of England	4700	68	76	43	48
Total	7180	372	512	301	363

6 Illustrative calculations of industry and road transport measures

6.1 INTRODUCTION

The illustrative package of possible additional measures includes measures to reduce emissions from both traffic and stationary sources of PM_{10}. PM_{10} concentrations in 2010, 2015 and 2020 have also been estimated for two components of this scenario considered separately.

6.2 SITE SPECIFIC PROJECTIONS

Site specific projections are listed in Tables 6.1 to 6.3 and can be compared with the projections for the baseline and full package of measures scenarios in Tables 3.2, 3.3 and 3.4. Average reductions in concentrations at the background and roadside sites for which projections have been calculated are listed in Table 6.4 for the various scenarios, relative to the baseline. The stationary source measures are predicted to be more effective in reducing concentrations at background sites for all of the years examined. Conversely the traffic measures are predicted to be more effective in reducing concentrations at roadside sites for all of the years examined.

Table 6.1 Projected annual mean PM_{10} concentrations 2010 from base years 1996 to 1999 (μgm^{-3}, gravimetric) for the stationary source and traffic measures of the illustrative scenario

	projected PM_{10} 2010 Stationary source measures				projected PM10 2010 Traffic measures			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	23.2	21.3	20.3	20.5	23.7	21.9	20.7	21.0
Birmingham Centre	20.4	18.5	17.7	17.8	20.9	19.1	18.1	18.2
Cardiff Centre	20.7	21.2	19.8	19.9	21.6	22.6	20.9	21.0
Edinburgh Centre	17.0	16.2	15.1	15.6	17.3	16.7	15.4	15.9
Belfast Centre	19.4	19.8	18.5	18.7	20.6	21.7	19.9	20.1
Liverpool Centre	20.9	21.1	20.2	19.6	21.4	21.8	20.8	20.1
Rochester	21.0	18.2	17.1	17.0	21.4	18.8	17.4	17.2
Newcastle Centre	19.5	17.7	16.9	16.3	19.9	18.2	17.2	16.6
Manchester Piccadilly	20.6	19.3	18.6	18.8	21.1	19.9	19.1	19.3
Bristol Centre	20.6	19.9	19.1	19.3	21.1	20.7	19.7	19.9
Haringey Roadside		20.4	19.4	20.3		20.4	19.2	20.1
Glasgow Roadside		21.5	20.9	18.6		20.8	20.3	17.7
Marylebone Road		25.2	23.7	26.6		24.2	22.8	25.4
Camden Roadside		23.0	20.7	22.3		22.9	20.5	22.0
Sutton Roadside		19.4	18.9	19.1		19.4	18.8	19.1
Bury Roadside		21.3	20.7	20.6		21.2	20.9	20.5

Table 6.2 Projected annual mean PM_{10} concentrations 2015 from base years 1996 to 1999 (μgm^{-3}, gravimetric) for the stationary source and traffic measures of the illustrative scenario

	projected PM_{10} 2015 Stationary source measures				projected PM10 2015 Traffic measures			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	22.6	20.5	19.7	19.9	23.1	21.1	20.1	20.4
Birmingham Centre	20.0	17.9	17.3	17.4	20.3	18.3	17.6	17.6
Cardiff Centre	20.3	20.6	19.3	19.5	21.1	21.8	20.2	20.4
Edinburgh Centre	16.7	15.9	14.9	15.4	17.0	16.2	15.1	15.6
Belfast Centre	18.9	19.2	18.0	18.2	20.0	20.8	19.3	19.4
Liverpool Centre	20.4	20.3	19.6	19.1	20.8	20.8	20.0	19.4
Rochester	20.8	18.0	17.0	16.9	21.2	18.5	17.3	17.1
Newcastle Centre	19.0	17.7	16.4	16.0	19.3	18.2	16.6	16.2
Manchester Piccadilly	20.0	18.5	18.0	18.2	20.3	18.8	18.3	18.5
Bristol Centre	20.2	19.3	18.6	18.8	20.6	19.8	19.0	19.2
Haringey Roadside		19.5	18.7	19.5		19.5	18.6	19.4
Glasgow Roadside		19.5	19.2	17.2		18.2	18.0	16.0
Marylebone Road		23.1	21.9	24.3		22.1	21.1	23.1
Camden Roadside		21.6	19.8	21.2		21.5	19.5	20.8
Sutton Roadside		18.7	18.4	18.6		18.6	18.3	18.5
Bury Roadside		19.8	19.5	19.4		19.4	19.4	19.0

Table 6.3 Projected annual mean PM_{10} concentrations 2020 from base years 1996 to 1999 (μgm^{-3}, gravimetric) for the stationary source and traffic measures of the illustrative scenario

	projected PM_{10} 2020 Stationary source measures				projected PM10 2020 Traffic measures			
Base year	1996	1997	1998	1999	1996	1997	1998	1999
London Bloomsbury	22.5	20.4	19.6	19.9	22.9	20.8	19.9	20.2
Birmingham Centre	19.9	17.8	17.2	17.3	20.2	18.1	17.4	17.5
Cardiff Centre	20.3	20.5	19.2	19.4	20.9	21.5	20.0	20.2
Edinburgh Centre	16.7	15.8	14.9	15.4	16.9	16.1	15.1	15.6
Belfast Centre	18.9	19.1	18.0	18.1	19.9	20.6	19.1	19.3
Liverpool Centre	20.3	20.2	19.4	18.9	20.6	20.5	19.7	19.2
Rochester	20.8	18.0	17.0	16.9	21.2	18.4	17.3	17.1
Newcastle Centre	19.0	17.0	16.4	16.0	19.1	17.1	16.5	16.1
Manchester Piccadilly	19.9	18.4	17.9	18.1	20.1	18.6	18.1	18.3
Bristol Centre	20.1	19.2	18.6	18.8	20.4	19.6	18.9	19.0
Haringey Roadside		19.4	18.7	19.5		19.3	18.4	19.2
Glasgow Roadside		19.2	18.9	17.1		17.6	17.5	15.5
Marylebone Road		22.8	21.7	23.9		21.5	20.6	22.5
Camden Roadside		21.4	19.6	21.0		21.1	19.2	20.5
Sutton Roadside		18.6	18.3	18.6		18.5	18.1	18.4
Bury Roadside		19.7	19.4	19.3		18.9	19.0	18.6

Table 6.4 Summary of changes in annual mean PM_{10} concentrations for the illustrative scenario relative to the baseline from the site specific analysis (mgm^{-3}, gravimetric)

Scenario	Background sites	Roadside sites
2010 (Total Package)	-1.4	-1.9
2010 (Stationary measures)	-1.0	-0.8
2010 (Traffic measures)	-0.4	-1.1
2015 (Total Package)	-1.5	-2.0
2015 (Stationary measures)	-1.0	-0.8
2015 (Traffic measures)	-0.5	-1.3
2020 (Total Package)	-1.6	-2.2
2020 (Stationary measures)	-1.0	-0.8
2020 (Traffic measures)	-0.6	-1.4

6.3 MAPS OF BACKGROUND CONCENTRATIONS

The modelling results in terms of changes in mapped population weighted annual mean background PM_{10} concentrations in 2010 have been broken down in Tables 6.5 and 6.6 by the separating the impacts stationary and road transport measures. The reduction in population weighted annual mean PM_{10} concentration in 2010 is predicted to be greater for the industrial measures in isolation than for the traffic measures in isolation.

Table 6.5 The change in population weighted annual mean background PM_{10} concentrations in 2010 for the baseline and stationary source measures within the illustrative scenario (mgm^{-3}, gravimetric)

Base year	1996	1997	1998	1999	mean
Scotland	-0.312	-0.388	-0.332	-0.303	-0.334
Wales	-0.522	-0.626	-0.545	-0.498	-0.548
Northern Ireland	-0.432	-0.574	-0.480	-0.423	-0.477
Inner London	-0.688	-0.734	-0.628	-0.613	-0.666
Outer London	-0.642	-0.723	-0.586	-0.564	-0.629
Rest of England	-0.587	-0.715	-0.597	-0.548	-0.612
UK	-0.564	-0.679	-0.568	-0.524	-0.584

Table 6.6 The change in population weighted annual mean background PM_{10} concentrations in 2010 for the baseline and traffic measures within the illustrative scenario (mgm^{-3}, gravimetric)

Base year	1996	1997	1998	1999	mean
Scotland	-0.089	-0.123	-0.104	-0.092	-0.102
Wales	-0.081	-0.104	-0.092	-0.081	-0.089
Northern Ireland	-0.065	-0.084	-0.074	-0.065	-0.072
Inner London	-0.505	-0.672	-0.427	-0.420	-0.506
Outer London	-0.356	-0.470	-0.310	-0.301	-0.359
Rest of England	-0.130	-0.173	-0.142	-0.128	-0.143
UK	-0.155	-0.207	-0.159	-0.146	-0.167

6.4 MAPS OF ROADSIDE CONCENTRATIONS

The number of urban road links with estimated concentrations exceeding various thresholds in 2010 has also been calculated for the stationary source and traffic measures components of the illustrative scenario. The results of these illustrative calculations are listed in Table 6.7 and 6.8 and can be compared with the results for the baseline and full illustrative scenario in Tables 5.2 and 5.3. As expected the number of road links exceeding the threshold concentrations for these two parts of the scenario is intermediate between the number of exceedences for the baseline and full illustrative package of measures scenarios.

There are very few exceedences of 20 μgm^{-3} in Scotland, Wales or Northern Ireland for any of the scenarios. The traffic measures are seen to be more effective at reducing the total number of exceedences in London but the industrial measures are seen to be more effective in the rest of England. Over the UK as a whole the industry measures are more effective at reducing the number of exceedences of 20 μgm^{-3}, while the traffic measures are more effective for the higher thresholds. This dependence on threshold is largely due to the large number of predicted exceedences in London, with all or almost all road links with concentrations greater than 20 μgm^{-3} for all scenarios. The percentage of the total number of road links with concentrations greater than or equal to illustrative thresholds for the various scenarios is listed in Table 6.9.

Table 6.7 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2010 for the base years 1996 to 1999 for the illustrative scenario (stationary source measures only)

Base year		1996				1997				1998				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20	28	25	23	20	28	25	23	20
Geographical area	Total																
Scotland	548	0	0	3	7	0	0	3	7	0	0	2	6	0	0	2	6
Wales	282	0	0	0	21	0	0	0	3	0	0	0	1	0	0	0	0
Northern Ireland	101	0	1	4	14	1	4	6	15	0	1	4	11	0	1	1	10
Inner London	760	92	605	760	760	36	246	607	760	4	52	232	758	5	67	300	759
Outer London	789	5	88	684	787	2	10	67	759	0	4	19	636	0	5	26	719
Rest of England	4700	1	8	161	2938	0	2	16	588	0	1	9	407	0	1	8	416
Total	7180	97	702	1612	4527	39	262	699	2132	4	58	266	1819	5	74	337	1910

Table A6.8 The number of built-up major road links with estimated PM_{10} concentrations greater than or equal to various thresholds in 2010 for the base years 1996 to 1999 for the illustrative scenario (traffic measures only)

Base year		1996				1997				1998				1999			
Threshold (μgm^{-3}, gravimetric)		28	25	23	20	28	25	23	20	28	25	23	20	28	25	23	20
Geographical area	Total																
Scotland	548	0	0	2	7	0	0	2	6	0	0	1	6	0	0	1	6
Wales	282	0	0	0	33	0	0	0	10	0	0	0	2	0	0	0	1
Northern Ireland	101	0	1	3	13	1	3	5	14	0	1	3	10	0	0	1	10
Inner London	760	37	516	760	760	5	143	523	760	0	18	135	757	0	24	175	760
Outer London	789	2	45	670	787	0	4	31	757	0	2	8	587	0	2	13	709
Rest of England	4700	0	9	199	3330	0	2	22	856	0	1	11	594	0	0	8	571
Total	7180	39	571	1634	4930	6	152	583	2403	0	22	158	1956	0	26	198	2057

Table 6.9 The percentage of urban road links exceeding illustrative threshold concentrations in 2010 for various scenarios for the 1999 base year for the illustrative package of measures scenario (<1 % means less than 1 % but not 0%).

Scenario	Threshold (μgm^{-3}, gravimetric)	Baseline	full package of measures	stationary source measures only	traffic measures only
Scotland, Wales and NI	20	3 %	1 %	2 %	2 %
Scotland, Wales and NI	23	1 %	<1 %	<1 %	<1 %
Scotland, Wales and NI	25	<1 %	0 %	<1 %	0 %
London	20	99 %	76 %	95 %	95 %
London	23	30 %	6 %	21 %	12 %
London	25	7 %	1 %	5 %	2 %
Rest of England	20	19 %	4 %	9 %	12 %
Rest of England	23	<1 %	0 %	<1 %	<1 %
Rest of England	25	0 %	0 %	0 %	0 %

6.5 DISCUSSION

Considering the site specific and mapped background and roadside projections together it is clear that greater reductions in background concentrations are predicted for the stationary source measures than for the traffic measures. This is as expected given the relative reductions in UK emissions (23.3 ktonnes for stationary sources (but excluding quarries) and 1.9 ktonnes for traffic (Table 2.5). Ambient concentrations are, however, greater at roadside locations and measures to reduce emissions from road traffic are clearly more directly targeted at reducing these concentrations since both the roadside increment and background components of PM_{10} are reduced by such measures. The traffic measures would therefore be more effective at reducing roadside concentrations in London than the stationary source measures. The fitting of particulate traps from 2006 would also continue to reduce traffic emissions well beyond 2010 (Table 2.6) leading to further decreases in roadside concentrations.

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