Summary: Intervention & Options

Department /Agency: Defra	Title: Transposition of the Air Quality Directive (2008/50/EC).	
Stage: Final	**Version:** 2	**Date: 15/03/2010**
Related Publications: Impact Assessment for PM_{10} time extension notification (http://www.defra.gov.uk/corporate/consult/air-quality/index.htm)		

Available to view or download at:

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

Council Directive 2008/50/EC contains options for seeking additional time to meet limit values for certain pollutants, requires Member States to identify exceedences attributable to natural sources and consideration of the costs of additional action to achieve reductions in fine particulate matter ($PM_{2.5}$) in urban background areas. A separate IA has been produced to support the UK time extension notification for particulate matter (PM_{10}) and one is being prepared for the UK nitrogen dioxide (NO_2) notification consultation. The impacts of the deduction of natural sources and the $PM_{2.5}$ controls are assessed here.

What are the policy objectives and the intended effects?

New controls for $PM_{2.5}$ will further protect public health and the environment. This is balanced with provisions to secure additional time to meet PM_{10} and NO_2 limit values in response to challenges faced across Europe, and a new duty to deduct natural sources such as sea-salt from compliance assessment reports (for PM_{10}). The Directive must be transposed into national legislation by June 2010 and our aim is to do this in an effective, timely and proportionate manner to achieve the objectives of the Directive whilst minimising the burdens on business.

What policy options have been considered? Please justify any preferred option.

1. Do not transpose the Directive
2. Transposition, using the new provisions in relation to time extensions, deducting natural sources and meeting the obligatory standards on the control of $PM_{2.5}$.

Option 2 is our preferred option because it meets our statutory obligations providing flexibilities to improve air quality without imposing disproportionate costs.

*When will the policy be reviewed to establish the actual costs and b*enefits and the achievement of the desired effects?

The Directive is due to be reviewed in 2013 and the UK will review the costs and benefits of $PM_{2.5}$ controls prior to then.

Ministerial Sign-off For FINAL STAGE Impact Assessments:

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

Signed by the responsible Minister:

..... Date:

Summary: Analysis & Evidence

Policy Option:	Description:
Option 2	Transpose the Air Quality Directive

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition) **Yrs**		The key costs of this option are the health costs associated with not delivering additional improvement in air quality.
£ 0		
Average Annual Cost (excluding one-off)		
£ 46.5 Million	20	**Total Cost** (PV) **£ 684 Million**

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

The costs focus primarily on chronic mortality impacts and do not reflect any potential wider costs either on morbidly or other environmental benefits. The distributional impact of these costs has also not been quantified, for example by racial group.

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off **Yrs**		Reduced mitigation costs including technology costs, resources costs and cleaning costs.
£ 0		
Average Annual Benefit (excluding one-off)		
£ 106 Million	20	**Total Benefit** (PV) **£ 1,559 Million**

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

This estimate excludes the potential benefit of time extensions, of at least £3.9bn for PM_{10} (considered outside the scope of transposition and assessed separately to support the UK time extension in 2009)

Key Assumptions/Sensitivities/Risks

Key assumptions relate to the link between air pollution and chronic mortality and the approach to mitigating air pollution. The notable risk is that air pollution is shown to have wider health impacts than currently understood that might change the balance of the impacts.

Price Base Year 2008	Time Period Years 20	**Net Benefit Range** (NPV) £	**NET BENEFIT** (NPV Best estimate) £ **875 Million**

What is the geographic coverage of the policy/option?				UK
On what date will the policy be implemented?				June 2010
Which organisation(s) will enforce the policy?				Defra and DA's
What is the total annual cost of enforcement for these organisations?				£ 0
Does enforcement comply with Hampton principles?				Yes
Will implementation go beyond minimum EU requirements?				No
What is the value of the proposed offsetting measure per year?				£ N/A
What is the value of changes in greenhouse gas emissions?				£ 3 million saving
Will the proposal have a significant impact on competition?				No
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?	No	No	N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices) (Increase)

Increase of £ 0 Decrease of £ 0 **Net Impact** £ <£5m

Key: **Annual costs and benefits: Constant Prices**

Evidence Base (for summary sheets)

Introduction

Council Directive on ambient air quality and cleaner air for Europe (2008/50/EC) consolidates the framework and three daughter directives on ambient air quality together with the Council Decision on the Exchange of Information into a single directive, with the intention of simplifying the existing legislation. It also introduces three key new provisions reflecting the experiences of member states in implementation and improved understanding on the health impacts of particulate matter:

I. Additional time to meet limit values for PM_{10}[1] and NO_2 , subject to consideration by the Commission of air quality plans setting out how the limit values would be achieved by the extended deadlines.

II. A requirement for the deduction of natural contributions when assessing compliance with limit values;

III. A new control framework for $PM_{2.5}$;

Other minor changes have been introduced, many of which are points of clarification. The Directive must be transposed into national legislation by 11 June 2010.

Policy Options

This IA analyses the impacts of the following 2 options;

Option 1; Do nothing. Under this option, the UK government would not transpose the new Directive and would continue to be bound by the existing legislative framework. This option represents a reference point against which Option 2 is compared.

Given the attainment date for PM_{10} was 2005 and is 2010 for NO_2 this option would require additional measures be undertaken to immediately meet limit values across the UK.

Option 2; Transposition of the Air Quality Directive. Under this option, government uses the new time extension provisions, deducts natural sources for PM_{10} and meets obligatory standards on the control of $PM_{2.5}$ (the Exposure Concentration

[1] Particulate Matter (PM) is generally categorised on the basis of the size of the particles (for example PM2.5 is particles with a diameter of less than 2.5µm). PM is made up of a wide range of materials and arise from a variety of sources. Concentrations of PM comprise primary particles emitted directly into the atmosphere from combustion sources and secondary particles formed by chemical reactions in the air. PM derives from both human-made and natural sources (such as sea spray and Saharan dust). In the UK the biggest human-made sources are stationary fuel combustion and transport. Road transport gives rise to primary particles from engine emissions, tyre and brake wear and other non-exhaust emissions. Other primary sources include quarrying, construction and non-road mobile sources. Secondary PM is formed from emissions of ammonia, sulphur dioxide and oxides of nitrogen as well as from emissions of organic compounds from both combustion sources and vegetation.

Obligation and the Limit Value), with any justified action taken to ensure progress towards the National Exposure Reduction Target for $PM_{2.5}$ by 2020.

Under this option, UK would transpose the new Air Quality Directive by means of:

- **Using the additional time** available to meet limit values for PM_{10} and NO_2, subject to consideration by the Commission of air quality plans setting out how the limit values would be achieved by the extended deadlines.
- Deduction of **natural contributions** when assessing compliance with limit values in relation to PM_{10}, and hence the case for seeking additional time (see above);
- Compliance with a new limit value and Exposure Concentration Obligation for $PM_{2.5}$;

This option therefore assesses the impact of these provisions within the UK. To assess the costs and benefits it is necessary to consider the three key provisions individually.

The **additional time provision** provides important flexibility for the UK to achieve compliance in those small parts of the country where limit values are not already being achieved. Given the importance of this provision any such application has been or will be subject to public consultation.

In April 2009 following public consultation, the UK submitted to the Commission a notification to seek additional time to meet the limit value for PM_{10} and a separate Impact Assessment was produced in relation to that[2]. The notification sets out what actions will be taken to meet the limit values by the extended deadline of 2011. Details are set out in the Technical Report[3] to accompany the UK Time Extension notification forms.

The evidence undertaken for this notification suggested that use of the additional time would create a net benefit of around £3.3 billion, within a range of £0.7 - £5.5 billion. These benefits arise as a result of the avoided technology and operational costs associated with the necessary abatement to achieve compliance as soon as possible.

The UK will also be submitting a notification for additional time to meet the NO_2 limit value and a separate Impact Assessment will be produced in association with that. This will be subject to a separate public consultation in 2010.

The UK has yet to provide the necessary assurances to the Commission for them to grant the additional time to meet the daily limit value for PM_{10} in Greater London. There are also clear uncertainties around the detail of an application in relation to NO_2. As such, the potential impacts of using the additional time available are not included in the central benefit figures presented for this option. It must however be noted that the possibilities of additional time do present potential major net benefits to the UK.

Related to the time extension notification for PM_{10}, the second key provision relates to the treatment of **natural sources** when assessing compliance with the limit values. The level of PM in ambient air is the result of both human activity (anthropogenic sources) as well as natural processes. Currently compliance against limit values is assessed against the total modelled levels of PM. The new provision in the Directive (Article 20 of Directive 2008/50/EC) requires Member States (under specific conditions) to deduct contributions of PM that occur naturally for the purpose of compliance reporting:

[2] The full consultation including the IA is available from http://www.defra.gov.uk/corporate/consult/air-quality/index.htm
[3] The technical report is available from: http://www.defra.gov.uk/environment/quality/air/airquality/eu-int/eu-directives/airqual-directives/documents/090423-pm10-tech-doc.pdf

Where the commission has been informed of an exceedance attributable to natural sources.....that exceedance shall not be considered as an exceedance for the purposes of this Directive[4].

Pending formal Commission Guidance, Member States have been advised to use what they consider to be the most appropriate methodology for the deduction of natural sources. In the UK the main natural source of PM_{10} is sea salt (Sodium Chloride). Unlike anthropogenic sources of particulate matter, sea-spray cannot be controlled. Furthermore, scientific evidence suggests that natural sources of PM (including sea salt) are relatively harmless to human health and the environment as compared with anthropogenic sources of PM, though the evidence on this is not conclusive[5].

Assessing compliance excluding the contribution of natural sources has the effect of reducing any identified exceedences. Depending on the extent of the contribution of sea-salt, the effect might be that the exceedences would no longer exist. In other cases, it would reduce the level of a reported exceedences.

Given that the Secretary of State is obliged to take action to achieve compliance in the event of exceedences being reported, this provision will reduce the level of abatement necessary to achieve compliance.

The analysis therefore looks to model the additional abatement that is avoided through the exclusion of the contribution from natural sources in considering exceedences. It should be noted that in compiling the UK time extension notification for PM_{10} , natural sources were deducted..

Finally, the Directive introduces **new controls for $PM_{2.5}$**. These aim to minimise the exposure of the whole population to PM $_{2.5}$ – this new 'exposure reduction' approach is focused on driving down concentrations across urban background areas. Certain elements of the new controls are mandatory – the limit value, and the exposure concentration obligation.

The $PM_{2.5}$ **limit value** applies everywhere from 2015 and aims to ensure a minimum standard of air quality for all people. There is also a $PM_{2.5}$ target value to aim for from 2010. Table 1 sets these out.

Table 1; Limit and target value (applying everywhere).

Standards applying across zones/agglomerations (compliance assessed in accordance with Annex III)		**Compliance date**
Target value	25 µg/m^3	January 2010
Limit value	25 µg/m^3	January 2015

The Exposure Concentration Obligation applies across UK urban background areas. It must be attained by 2015 – and will be calculated as the 3 year mean concentration averaged over the relevant sampling points for 2013--15.

The National Exposure Reduction Target is a % reduction in average concentration in UK urban background locations, to be achieved by 2020 by taking measures not entailing disproportionate costs. The target for 2020 is determined by the mean concentration in urban

[4] Directive 2008/50/EC (Article 20 (b))

[5] "There is a view that some components of particles from natural sources are less toxic than some components of particles from anthropogenic sources. However, this observation is based on more general principles rather than specific evidence. For example, sea salt (sodium chloride) is a common constituent of the body so is therefore assumed to be relatively harmless. There have been several studies of the effects of particles from different sources but these have not shown conclusively that all constituents of particles from natural sources are harmless. For example, the dust from Saharan dust storms has been shown to have some health effects" (Perez et al 2008).

background locations over the 3 years 2009 -2011 (this is termed the Average Exposure Indicator for 2010). The directive (Annex XIV) also specifies how the AEI for 2020 shall be calculated. The target for the UK therefore cannot yet be finally determined.

Table 2; Standards for urban background areas.

Standards applying across urban background areas		Compliance date
Exposure Concentration Obligation	20 µg/m^3	2015
National Exposure Reduction Target	% reduction according to the AEI	2020

The new provisions to a large extent mirror those set out in the 2007 Air Quality Strategy (see Box 1 below).

Box 1 *Developments since the Air Quality Strategy 2007*

The Air Quality Strategy (AQS 2007) presents data which show the UK to be on target to meet a 15% Exposure Reduction, assuming we put in place Measure Q. Measure Q included the early introduction of the Euro 5, 6 and VI vehicle emission standards, a programme to incentivise low emission vehicles, and reductions in emissions from international shipping.

The baseline used for the current assessment includes Euro 5, 6 and VI (their early introduction will make little difference to levels of uptake in 2020) and some of the impact of the agreement on a revised Annex VI to the MARPOL convention, which has a similar or stronger effect than the shipping measures proposed in AQS 2007. Nevertheless, whereas AQS 2007 showed that baseline plus measure Q gave a 16.1% exposure reduction from 2010 to 2020, the baseline used in this assessment shows only 6.4%[6]. AQS 2007 Volume 2 (pp 124-126) discusses the uncertainties in the $PM_{2.5}$ projections used for the AQS 2007 assessment, and the assessment used in this impact assessment is within the range suggested.

The main reasons for the difference in the two sets of projections are:

- changes to the energy projections used – AQS 2007 used Updated Energy Projection (UEP) 12, whereas the work to support this assessment used UEP 30. Differences in the level of energy projected and in particular the level of coal used for energy generation can have a significant impact on the level of secondary particles, and therefore the background concentrations of $PM_{2.5}$.
- While, the same basic model was used for both sets of projections, there have been a number of changes to the assumptions used. Most significant is the relationship between the emission of secondary particle precursor gases (mainly SO_2, NO_X and NH_3) and the formation of secondary particles. Secondary particles are a major component of $PM_{2.5}$ and so trends over time are very sensitive to changes in this relationship, as is shown by the analysis in AQS 2007 Volume 2. The outcome of the changes made to the model is that secondary particulate levels, and therefore $PM_{2.5}$, are not reduced as much for the same reduction in SO_2 and NO_X emissions in the second set of projections
- The AQS 2007 projections assumed a greater proportion of the $PM_{2.5}$ mass was nitrate,

[6] 7.4% if only prospective monitoring sites are used, rather than population weighted mean values used in the other assessments

and therefore changed with changes in precursor emissions. The model was adjusted to reflect more recent knowledge and apportioned a greater part of the mass to components such as sea salt, secondary organic aerosol and iron and calcium rich dusts, which tend not to change with changes in "controlled" emissions. This means that emission controls assumed for the decade 2010-2020 will have a lower impact on $PM_{2.5}$ concentrations.

Though there are considerable uncertainties attached to projections of $PM_{2.5}$ concentrations our current assessment is that both the limit and target values (Table 1) and the legally binding 2015 Exposure Concentration Obligation in urban areas (Table 2) will be achieved under business as usual (BAU) measures. This is based on the projections prepared for the PM_{10} time extension notification [7].

In addition, the projections indicate that the UK's National Exposure Reduction Target will likely be 10%. This would mean a target to abate particulates to reduce exposure to $PM_{2.5}$ by 10% in 2020 relative to the Average Exposure Indicator (AEI) for 2010. The 10% reduction target is determined by the expectation that the initial concentration of $PM_{2.5}$ for the AEI will be in the range of 8.5 $\mu g.m^{-3}$ and 13 $\mu g.m^{-3}$.

On the basis of these projections, additional abatement would be necessary in order to fully deliver meet the National Exposure Reduction Target, which Member States must take all necessary actions, not imposing disproportionate costs, to achieve by 2020. Option 2 assumes that foreseeable measures under development but which cannot yet be factored into the baseline projections would ensure further progress towards the National Exposure Reduction Target without incurring disproportionate costs. Once the Average Exposure Indicator is calculated, in 2011, this will confirm what the UK's National Exposure Reduction Target is, and the need for additional action will be reviewed. Any further action will however be considered on its own merit and will only be undertaken if it is seen not to impose a disproportionate cost.

Cost Benefit Analysis

Option 1: Do nothing (do not transpose)

This option provides the base case or counterfactual for the other options and so by definition the marginal impacts are zero. This does not however mean that this is a zero cost option but rather that in order to estimate its costs it is necessary to define an alternate base case.

It is UK government policy to transpose directives into national legislation. Not transposing the directive is therefore not an option.

Option 2: Transposition of the Air Quality Directive (using time extension notification provisions, deduction of natural sources and meeting legally binding standards for $PM_{2.5}$). Option 2 does not include taking specific additional actions to achieve compliance with the $PM_{2.5}$ National Exposure Reduction Target by 2020.

This appraisal focuses on the deduction of natural sources of PM_{10} emissions from compliance assessments. The time extension decisions are subject to bespoke analysis.

To assess the impact of excluding for compliance purposes exceedences attributable to natural sources it is necessary to assess the changes in the level of abatement and resulting ambient concentrations. The analysis assumes a concentration of 1.9$\mu g.m^{-3}$ can be attributed to natural sources of PM_{10}, as defined by the methodology used in the UK Time Extension Notification for

[7] http://www.defra.gov.uk/environment/airquality/eu-int/eu-directives/airqual-directives/notification.htm

PM_{10}[8]. The methodology used to derive this figure is explained on pages 42-49 of the Technical Document which supported this notification, and assumes that all natural PM can be attributed to sea salt. The analysis used here assumes that the exclusion of natural sources would reduce the amount of abatement undertaken to achieve compliance by 1.9µg.m^{-3}.[9]

In order to assess the associated impacts of abatement this analysis assumes that the marginal abatement method is retrofitting Diesel Particulate Filters (DPF) to the vehicle fleet. This measure has been selected as the marginal method as it was applied in the evidence base for the PM_{10} time extension notification. More information on the reasoning for selecting this as the marginal approach is provided in the previous impact assessment.

This analysis therefore estimates the impacts of not introducing a measure to uptake retrofitting to reduce concentrations by 1.9µg.m^{-3}. It must be noted in practice that this is a conservative assumption of the impacts as it only reflects the treatment of natural sources.

Benefits

The assumed marginal technology means that Option 2 will result in the reduced requirement to fit diesel particulate filters (DPFs) to the existing fleet. The benefits of these reduced requirements on fleet management are equivalent to the 'avoided costs' of abatement that otherwise would be incurred while complying with the more stringent abatement target. These benefits can be separated into three components:

- *Technology costs (avoided):* The unit costs of the DPF technology and the operational costs for the different vehicle types are outlined in Table 3 below. The costs presented are the costs per unit of producing the technology. The costs are annualised over the lifetime of the measure taking into account the vehicle survival rates.

  Table 3: Resource costs per unit of technology[10]

Vehicle Type	Unit Resource costs	Annual Cleaning costs
Diesel car	£614	£0
Diesel LGV	£1,106	£0
Articulated HGVs	£1,750	£240
Rigid HGVs	£1,350	£160
Captive Fleet	£1,350	£160

- *Cleaning costs of HGV diesel particulate filters:* The efficient operation of DPFs on HGVs also requires that they are cleaned annually. This cost therefore has been estimated using the cleaning costs set out in Table 3.
- *Resource costs (avoided) of fuel:* DPF technology also can have a negative impact on fuel economies for some vehicle types. A negative impact on fuel economy implies that the particular vehicle will use more fuel per km than the vehicle did before the retrofitting

[8] http://www.defra.gov.uk/environment/airquality/eu-int/eu-directives/airqual-directives/documents/090423-pm10-tech-doc.pdf
[9] The level of PM_{10} attributable to natural sources varies across the country, and 1.9µg.m^{-3} is the figure derived for the London area. Given that this is the area with by far the greatest residual PM_{10} compliance problem, it was considered appropriate to use this figure.
[10] Source Air Quality Strategy (2007) available from www.defra.gov.uk

took place (i.e. a fuel penalty). This measure also estimates the carbon impacts due to the negative impact on fuel economies (valued in accordance with Department for Transport guidance) and the resulting additional carbon emissions (valued according to the latest guidance from the Department for Energy and Climate Change) when DPFs are fitted. Fuel economy assumptions for the different vehicle types in this measure are presented in the Table 4

Table 4: Fuel penalty of retrofitting DPFs by vehicle type[11]

Vehicle Type	Impact on fuel economy
Diesel Car	- 5%
Diesel LGV	- 5%
Articulated HGV	0%
Rigid HGV	0%
Captive fleet[1]	0%
[1] Buses and Coaches	

The benefits (avoided costs) of this measure as described above are discounted at the standard appropriate HM Treasury Green Book rate and annualised over the lifetime of this measure (2009 – 2029) and presented in Table 5 below.

Table 5: Benefits of fleet management scheme (avoided costs relative to the baseline) retrofitting (£ millions)

Annualised Technology Costs avoided.	Annualised Resource cost of extra fuel consumed.	Annualised carbon cost from extra fuel consumed	Annualised cleaning costs of DPFs on HGVs avoided.	Annual PV of Benefits (Avoided Costs)
£88m	£8m	£3m	£7m	£106m

Costs

The costs of this option of the reduced requirement to fit DPF's relate to the health benefit that is being forgone by not undertaking the above abatement measure.

The emissions reductions from this technology are modelled to fall over time as the retrofitted vehicles exit the fleet. This natural fleet turnover combined with the uptake rate estimate the impact upon emissions and ambient concentrations associated with Option 2 as outlined in Table 6 below. These reflect the missed reductions in emissions resulting from the reduced level of abatement.

[11] The impact on fuel efficiencies are taken from the Updated Third Report of the Interdepartmental Group on Costs and Benefits released alongside the Air Quality Strategy (2007). Available from www.defra.gov.uk.

Table 6: Increase in emissions for Option 2

Country	Pollutant	Increase in Emissions (tonnes)				
		2010	2015	2020	2025	2030
UK	PM_{10}	2,884	831	239	69	26

The Government's Interdepartmental Group on Costs and Benefits (IGCB) impact-pathway methodology has been used to estimate the health impacts of the increase in emission resulting from the deduction of natural sources from compliance reports[12]. The IGCB methodology is best practice air quality appraisal guidance[13]. This option is assumed not to have any impact after 2030 when all the retrofitted vehicles are estimated to have left the fleet. Table 7 provides the health impacts generated by the above changes in emissions. This represents the number of life years lost, as well as the number of hospital admissions.

Table 7: Quantified costs of Option 2

PM life years lost (,000s)	PM – RHA (2010 p.a.) (,000s)	PM – CHA (2010 p.a.) (,000s)
30.4	49.1	49.1
PM – RHA Respiratory Hospitable Admissions attributable to changes in particulate matter PM – CHA Cardiovascular Hospitable Admissions attributable to changes in particulate matter		

These health costs have then been monetised using the per tonne damage costs under the IGCB methodology. The relevant annual damage cost estimate has been applied to the changes in emissions between 2010 and 2030, for each year within this change it has been assumed that the emission change applies to the mid-point of year. The costs are outlined in Table 8;

Table 8: Annual present value of health impacts of Option 2 (£millions)

PM life years saved	PM – RHA	PM – CHA
45.87	0.05 – 0.30	0.05 – 0.30
PM – RHA Respiratory Hospitable Admissions attributable to changes in particulate matter PM – CHA Cardiovascular Hospitable Admissions attributable to changes in particulate matter		

Consolidated costs and benefits of Option 2

Table 9 below presents the annual Net Present Value (NPV) of this option. The £106 million in benefits (avoided costs) are derived by summing all the benefits in Table 5. Likewise, the £46.5 million in costs is derived by summing the costs in Table 8. Therefore, Option 2 has a present value annual net benefit of £59.5 million.

[12] It should be noted that non-health impacts were not modelled for this option therefore the benefits may be marginally underestimated. However, the non-health impacts of PM typically only account for less than 0.5% of the health impacts.

[13] More information on the IGCB and its methodology is available from http://www.defra.gov.uk/environment/quality/air/airquality/panels/igcb/index.htm

Table 9: Annual costs and benefits of implementing Option 2 (£millions)

Annual PV of Benefits (£ million)	Annual PV of costs (£ million)	Annual NPV (£ million)
106	46.5	59.5

Table 10 below represents the annualised data in table 9 in the form of net present values for the year 2010, these have been calculated over a 20 year appraisal period;.

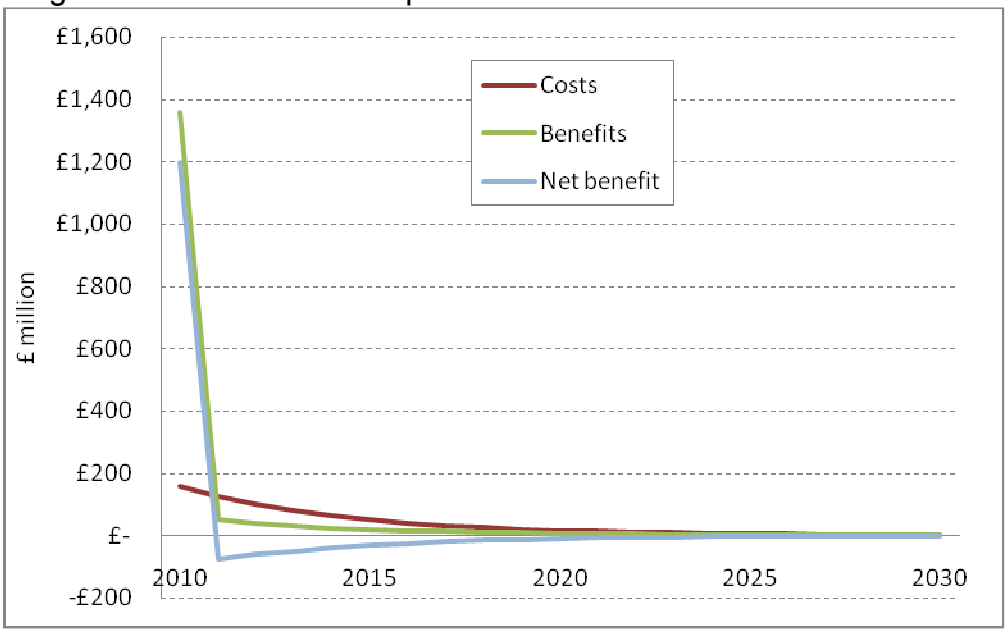
Table 10: Net Present Value of Option 2 (£million).

PV of Benefits (£million)	PV of costs (£million)	NPV (£million)
1,559	684	875

The results above indicate that the benefits of transposition substantially outweigh the costs. This analysis suggests that omitting natural sources from the assessment of compliance with the limit values would create a net annual benefit of £59.5million for each year over the life time of the retrofitted technology. This equates to a net benefit of £875 million between 2010 and 2030.

It should also be noted that these impacts are not evenly distributed over time as shown in Diagram 1 below.

Diagram 1: Distribution of impacts over time.



The majority of the £1,559 million PV of benefits (avoided costs) would be gained in the first year as the cost of the new technology is around £1,300 million. The ongoing benefits (avoided costs) of around £300 million, of additional fuel, carbon emissions and DPF cleaning, are also skewed towards the early period with over a fifth of the costs (22%) occurring in 2010 and only a fiftieth (2%) half way through the life of the vehicles in 2020.

The health costs are also skewed towards the early years after the retrofitting scheme. Of the £684 million in costs, over a fifth (21%) occur in 2010 falling to under one fiftieth (2%) half way through the life of the vehicles in 2020.

Sensitivities and uncertainties

A number of features of both the projections of air quality and the measure itself need to be borne in mind when considering the evidence :

1. ***Uncertainty in PM_{10} projections***: as noted in the Time Extension Notification for the achievement of the PM_{10} Limit Values[14], the PM_{10} data for this period was based on measurements using Partisol gravimetric analysers. In 2008, problems with the data produced by these instruments resulted in the data being corrected to account for certain systematic bias. This introduced further uncertainty into the base dataset.

2. ***Distributional impacts****:* sources of air pollution and consequently the exposure to air pollution are not evenly distributed across the UK. Urban areas in particular can be seen to suffer from worse air pollution whilst typically rural areas benefit from relatively good air quality. As a result the impacts of changes in air quality would not be expected to have the same impacts across different groups. This creates a potential for specific groups to be particularly affected by air pollution such as particular racial groups or vulnerable groups. While this variation is recognised, given the scale of the social benefits of the preferred option, it is not judged to be sufficient to alter the preferred option.

   Annex 1 provides the racial equality impact assessment which was undertaken in 2009 for the UK notification to apply for an extension to the compliance deadline for meeting PM_{10} limit values in ambient air to 2011. This analysis shows that the impact of air pollution is not evenly distributed across all racial groups, suggesting that individuals from ethnic minorities might face a disproportionately high cost. While the distribution of the health costs associated with natural sources of PM is likely to be more even across groups than the modelled scenario (based on road emissions) it is likely that the impact remains uneven.

3. **Estimation of health impacts**: while the above analysis has been undertaken in line with the best practice guidance from the Interdepartmental Group on Costs and Benefits (IGCB) uncertainty remains about the quantitative link between air pollution and health. This uncertainty covers both impacts on mortality and morbidity. However the key issue for the cost benefit analysis is the link between exposure to PM and chronic mortality. In line with the recommendation from the Committee on the Medical Effects of Air Pollution (COMEAP) the presented values based on a 6 % change in hazard rate per $10\mu g.m^{-3}$ should be considered within a the range 1% to 12%. Such variation would either reduce the estimated health cost by around 83% or increase it by 100%.

4. ***Baseline components***: the baseline used for this analysis draws on UEP 30, in addition to emission controls such as the introduction of Euro 5 and 6, which have already been agreed. However, <u>this baseline omits a number of features which may have a significant impact on air quality and the costs and benefits of measures over the period 2010-2020</u>:

   - Climate change measures: in July 2009, the Government, led by DECC, published the UK Low Carbon Transition Plan - a package of policy measures

and initiatives setting out the strategy on carbon reduction up to 2022. This included the Renewable Energy Strategy which sets out potentially radical changes to the way in which electricity, transport energy and heat are produced. This could impact on air quality in a number of ways:

  - reducing fossil fuel based electricity production will probably mean the reduction in emissions of SO_2 and NO_X from large combustion plant, with a consequent reduction in secondary PM_{10}. This will in turn reduce background PM_{10} concentrations over the period;

  - encouraging the uptake of low carbon vehicles could result in an increase in diesel powered vehicles (unless retrofit), with a consequent increase in PM emissions. However, it is anticipated that the period will also see an uptake of electric vehicles as technologies improve and costs reduce. This will have a reducing effect on PM_{10} concentrations, especially when coupled with low carbon electricity production (see above).

  - the use of non-combustion renewables for heat production (e.g. ground source heat pumps or solar thermal) will reduce PM_{10} emissions. However, the increased use of biomass to produce heat, especially where it replaces gas fired heating, will increase PM emissions. The Renewable Energy Strategy contains some measures to minimise this impact but it is likely that space heating emissions of PM will become more significant over the period.

- International action: as was set out in the Time Extension Notification for PM_{10}, transboundary movement of pollutants from other countries, principally those in Northern Europe, make a significant contribution to background levels of PM_{10} in the UK. Those countries who are part of the European Union are subject to the same EU legislation as the UK, both on air quality and national emissions. Similarly any subsequent changes in EU legislation will have both direct and indirect impact on the UK. For example it is expected that the European Commission will soon publish proposals for a new National Emissions Ceilings Directive with targets for 2020, which will reduce emissions of the precursors of secondary PM both in the UK and across the European Union. This and other measures (such as the application of the Renewable Energy Directive) will tend to reduce transboundary pollution and have a beneficial effect on background PM_{10} concentrations across the period.

- Technology costs: the analysis of the measure to improve air quality concentrations of PM relies exclusively on the uptake (through retrofitting) of new vehicle technologies. The technology costs used reflect today's prices. However, over the period, pressure to reduce the carbon emissions from transport is likely to result in both significant research and innovation and more widespread uptake of such technologies, with the result that the technology costs will reduce significantly. While this reduction cannot be quantified at this point, it is a pattern that has been seen with almost all new emission reduction technologies introduced in recent decades. This would imply the benefits (avoided costs) would be less than expected for option 2.

- Environmental impacts: the evidence provided above does not monetise and value the impacts on the natural environment from the identified measure to improve air quality. This potentially understates the costs of Option 2.

Conclusions and policy recommendation.

The preferred option is to transpose the Directive undertaking additional abatement as justified to make progress towards the expected $PM_{2.5}$ National Exposure Reduction Target by 2020 (Option 2). This option is estimated to deliver a total net benefit of at least £875 million with substantial potential additional benefits arising from the opportunities for additional time to meet limit values where required.

Specific Impact Tests: Checklist

Use the table below to demonstrate how broadly you have considered the potential impacts of your policy options.

Ensure that the results of any tests that impact on the cost-benefit analysis are contained within the main evidence base; other results may be annexed.

See comments on distributional impacts on page 11.

Type of testing undertaken	*Results in Evidence Base?*	*Results annexed?*
Competition Assessment	No	Yes
Small Firms Impact Test	No	Yes
Legal Aid	No	Yes
Sustainable Development	Yes	No
Carbon Assessment	Yes	No
Other Environment	Yes	No
Health Impact Assessment	Yes	No
Race Equality	Yes	No
Disability Equality	No	Yes
Gender Equality	No	Yes
Human Rights	No	Yes
Rural Proofing	No	Yes

Annex 1: Racial Equality Impact Assessment (England): (analysis conducted in 2009 to inform the UK notification to the European Commission to extend the compliance deadline for meeting PM_{10} limit values in ambient air to 2011)

1. The EU Ambient Air Quality Directive (2008/50/EC), adopted in 2008 introduced a provision for Member States to apply for a time extension to 2011 for compliance with the existing limit values for PM $_{10}$. Such an extension will only be agreed by the European Commission where non-compliance has resulted from unexpected dispersion patterns, climatic conditions or transboundary impacts, and is accompanied by an air quality plan which sets out, amongst other things, how compliance will be achieved by the extended deadline (2011 at the latest).

2. In relation to $PM_{10,}$ the limit value is already achieved across 99% of the UK, including in many urban areas. The remaining areas of non-compliance are extremely small and comprise small urban 'hotspots', including parts of central London, or areas where industrial emissions make a significant contribution. In all these areas, the limit values are expected to be achieved by 2011. The UK submitted its notification to the Commission in April 2009, following a public consultation. An Impact Assessment was produced and published as part of the consultation package. www.defrawebd/environment/quality/air/airquality/eu-int/eu-directives/airqual-directives/notification.htm . A summary of consultation responses has also been published.

3. One respondent to the consultation suggested that delaying compliance could impose a disproportionate cost to ethnic minorities. The Impact Assessment published by Defra as part of the consultation concluded that the racial equality filter did not identify the need for a full racial equality assessment. This was because of 3 main factors:

   - Existing evidence did not provide any robust evidence that the impacts of air quality have a significantly different impact on people from different ethnic groups;
   - People from different ethnic groups would not be treated differently as a result of the proposal to submit a time extension notification; and
   - The proposal to use the additional time available under the Directive was not expected to favour particular ethnic groups but is rather seen to maximise social welfare across all ethnic groups.

4. Nevertheless, it was decided following this query to undertake such a more detailed analysis to estimate the scale of the likely impact across different ethnic groups of using the additional time available. A mapping approach was used, comparing 2001 census data with 2005 ambient air quality concentrations. Whilst this is methodology presents opportunities for quantitative analysis of the potential impacts, there are a number of caveats associated with the results.

   - The 2005 PM_{10} concentration data used to support the 2007 National Air Quality Strategy includes natural sources and would, if it were produced now, be subject to corrections for that (in accordance with the 2008 Directive) and other data

issues. Therefore, using the processes we currently follow, the absolute PM_{10} concentrations would in all likelihood be significantly lower than those shown, and the areas in non-compliance with the Limit Values would be reduced. However, the distribution of concentrations would remain roughly the same

- The data used is highly aggregated which may disguise local impacts. Latest projections show the remaining areas of exceedences are extremely small and localised eg national modelling showed 6.5 km of roads in central London exceeding the limit value in 2011 – well within the uncertainties of the model.
- Data for PM_{10} concentrations used is from motorways and A-roads in 2005, and not for minor roads. Therefore the estimates do not reflect any changes in the urban background concentration.
- Population data for minority ethnic groups is only available from the 2001 census. This means that in 2009 the data is eight years old. However, census data is comprehensive and consistent and is the only source of data on minority ethnic groups at the spatial scale demanded by this analysis.
- This analysis has involved using a Geographical Information System (GIS) to overlay PM_{10} emissions data with census 2001 data. Overlaying census data with PM_{10} emission data results in problems of scale. The PM_{10} emissions data is available per length of road and is measured by $\mu g/m^3$. The smallest spatial scale at which census data is available is for census output areas (COAs) which are small census geographies consisting of around 125 households or 300 people. As COAs are defined by population, they vary in actual size, with densely populated COAs being smaller than more sparsely populated COAs. The analysis has therefore used data for everyone living in the census output areas which overlap the concentration data.
- The analysis calculates the average exposure to PM_{10} emissions experienced by each ethnic group based on the population in each census output areas in England overlapping the road network. The coverage of the analysis is therefore the total population of those COAs which overlay these roads. This amounts to 11.7 million people.
- The analysis does <u>not</u> cover those people living in COAs which do not overlay the motorway/A-road network. Given that data is only available for England, this amounts to approximately 37.5 million people. This assumption was made on the basis that the vast majority of any changes in concentration from transport measures occur in the immediate area around roads.

5. The full analysis is provided below. It suggests that there is a difference in the costs of delaying achievement of the limit values by ethnic group. Both at national level and when split by urban and rural areas, individuals who identify themselves as White-British appear to be consistently exposed to lower concentrations of PM_{10}. Therefore the expected health costs of not achieving the limit values would be expected to be lower for this group than other ethnic groups. However, it must also be noted that the benefits of using the additional time available may also likely to be distributed in a similar manner with a disproportionate benefit accruing to ethnic minorities.[15] As indicated above,

[15] As any practical measures to achieve compliance will necessarily primarily focus on the areas of exceedences it is likely that the additional abatement costs such as retrofitting vehicles would be greater on vehicles within the affected area.

health experts advise there are no well established links between susceptibility to air pollution and ethnic group.

6. Given these findings, in line with the guidance from the Commission for Racial Equality there are four potential options:

   - **Option 1,** make changes to the proposed policy to address any concerns;
   - **Option 2,** introduce ways to remove or reduce potential for affecting some racial groups;
   - **Option 3,** find an alternative means to achieve policy aims; or
   - **Option 4,** justify the proposal because of the importance on grounds that have nothing to do with race.

7. Having considered each of these options it is felt that, by using the provisions in the new Directive to extend the compliance deadline in those small parts of the country where there have been some exceedences since the limit value came into force in 2005, some differential impacts across ethnic groups is unavoidable. While all reasonable measures are being undertaken to minimise differential impact across ethnic groups it is unlikely to completely remove the identified differential.

8. Defra has previously commissioned research specifically on social inequalities in relation to air quality. A report was published in 2006 that found in a number of urban areas of the UK the least affluent members of society tend to be exposed to the highest levels of air pollution. The report concluded that measures to improve air quality can therefore have a more pronounced effect in deprived areas and could help to reduce this social inequality. The research looked only at a few cities in the UK, but other independent research tends to support the general findings. In England, Northern Ireland, and Scotland, the most deprived communities tend to experience the highest air pollution levels (Pye *et al*, 2006[16]). In Wales, by contrast, it is the least deprived communities that experience the highest pollution levels. The reason for these observations is that, for most of the UK, the highest levels of deprivation tend to be found in urban areas. Urban areas tend to have dense road networks, high vehicle usage and the highest concentrations of most air pollutants. The majority of this pollution arises from road transport emissions, although, in Northern Ireland, there is an additional contribution from solid fuel burning. In Wales, the situation is reversed: the highest proportion of deprived communities tend to be found in the less densely-settled locations, such as in the South Wales valleys, with relatively fewer deprived communities situated in the urban centres of South Wales.

9. In this instance the remaining differential impact across ethnic groups is considered to be justified, though continued efforts will be needed, particularly at local and regional

[16] Pye, S., King, K., and Sturman, J. (2006) Air quality and social deprivation in the UK: an environmental inequalities analysis. AEA Technology, Netcen AEAT/ENV/R/2170 www.airquality.co.uk/archive/reports/cat09/0701110944_AQinequalitiesFNL_AEAT_0506.pdf

level to mitigate impacts on the disadvantaged groups. Summarised below are the considerations that have lead to this conclusion.

10. The decision on whether to apply for a time extension or not only provides scope for two potential options. Therefore under **option 1** the only potential would be to change the preferred option to not apply for the time extension. Rather than our preferred approach of allowing current/planned measures to take effect to achieve compliance by 2011, such a decision would require the UK immediately undertake major action to achieve compliance with the limit values.

11. As set out in the associated consultation Impact Assessment, looking to immediately achieve limit values would impose substantial net social cost estimated at over £3 billion. Given the areas in the UK where the limit values are not yet met are now extremely small, and the fact that projections show compliance being achieved by 2011, such costs are considered to be disproportionate. The short time-frames now involved would also mean this is not a viable option. Not applying for the time extension would furthermore also impose a major risk of infraction from the European Commission, potentially resulting in fines. Finally this option could be considered to be gold plating the Air Quality Directive. This is because the Directive specifically provides for member states to submit time extension notifications under circumstances such as those faced in the UK. To date 18 member states, including the UK have submitted notifications covering 304 zones across the EU.

12. The notification to the Commission contains details of all the local, regional and national measures being taken to improve air quality and achieve compliance. All of these actions will go some way to reducing the uneven distribution of the impacts of air pollution but is unlikely to completely remove it, given the contribution of specific sources such as traffic, to PM_{10} concentrations. The Mayor London's Air Quality Strategy, due to be published later this year, will also have an important role to play in relation to further improvements in PM_{10} and also NO_2 concentrations.

13. In this instance, the policy approach of seeking the additional time available to meet the limit values is justified for reasons that have nothing to do with race (**Option 4).**

14. **Option 2** involves undertaking an approach to mitigate the additional impact on the disadvantaged groups. As set out above, measures to improve air quality are being taken in relevant areas and the Mayor of London's Air Quality Strategy is also expected to contribute to this. **Option 3** is not relevant in this case as there are no alternative options to achieve the policy goals other than those set out in Option 1.

Quantitative Analysis

Summary

15. Overall the analysis undertaken suggests that there is a notable difference in the impact of delaying achievement of the limit values by ethnic group. Based on analysis of people living in areas geographically overlapping the motorway and A road network, both at the national level and when split by urban and rural areas, individuals who identify themselves as White – British are consistently exposed to lower concentrations of PM_{10}. Therefore the expected health costs of not achieving limit values would be expected to be lower for this group than other ethnic groups.

16. However, it must be noted that this analysis could not equally be applied to the benefits of the preferred option. While a quantitative analysis was not possible it is likely that the benefits would also likely to be distributed in a similar manner with a disproportionate benefit accruing to racial minorities. This is felt to be the case as any measures aimed to achieve compliance would try to focus on areas of exceedence and so adjustment costs, in the form of abatement equipment or transport restrictions, would be greater on populations in these areas.

Background and scope

17. The EU Ambient Air Quality Directive (2008/50/EC) (2008 Directive) introduced a provision for Member States to apply for additional time to comply with limit values. Such an extension would only be granted where non-compliance has resulted from unexpected dispersion patterns, climatic conditions or transboundary impacts and is accompanied by an air quality setting out how compliance will be achieved by the extended deadline.

18. On 27 January 2009 Defra went to out to consult on the option of applying for such a time extension in relation to particulate matter of diameter less than 10 micrometers (PM_{10}). Specifically it related to the EU limit value on annual average concentrations of 40μg /m^3 (and for London, also the daily limit value (50μg /m^3 not to be exceeded more than 35 times a year). These limit values came into force in January 2005. Since that date the UK has reported exceedences in some areas. Though the areas of exceedences are extremely small they are in densely populated areas such as central London. Nevertheless, over 99% of the UK (land area) is already in compliance.

19. Based on the measures currently being implemented or planned all areas are expected to comply with the limits by 2011 (the extended deadline, if granted). In addition to the practical and logistical challenge in bringing forward compliance, the necessary actions would also impose a disproportionate cost on UK society. The Impact Assessment produced for the consultation suggested the minimum cost of achieving earlier compliance would be around £6 billion while the associated benefits were around £2.5 billion. Therefore attempting to immediately achieve compliance would impose a net cost of around £3.5 billion. Therefore the preferred option was to use the provision in the Directive to secure the additional time available.

20. As a result of public consultation, a number of amendments were made to the notification to the Commission to secure additional time. However, nothing emerged

in the consultation responses that justified not submitting a notification to the Commission and instead seeking to take immediate action. The UK notification was submitted in April 2009. A summary of consultation responses was published on Defra's website.

21. One respondent argued that delaying compliance would impose a disproportionate cost to ethnic minorities. While the racial equality filter did not identify the need for a full racial equality assessment it was decided following this query to undertake such an analysis.

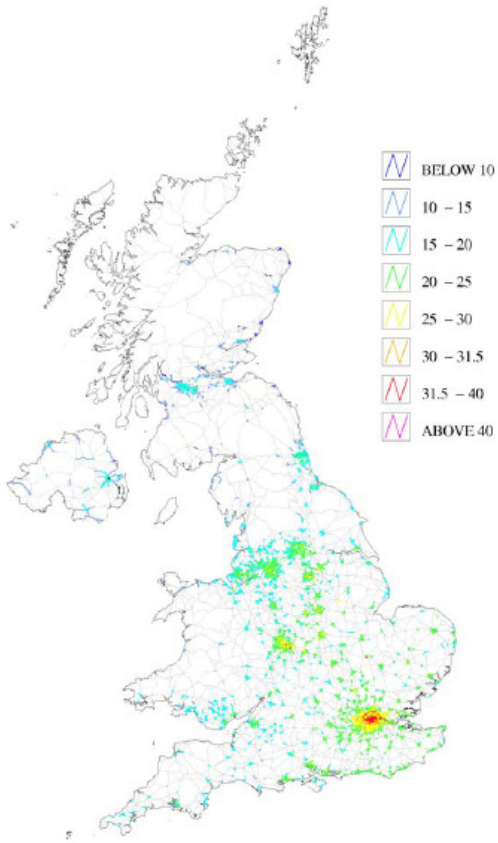
22. This note sets out the work that has been undertaken to assess the ethnic impacts of such a time extension.

Initial Racial Equality Impact Assessment

23. As an initial consideration of the potential for differential impacts across ethnic groups the emissions of road transport PM_{10} was compared against the distribution of ethnic diversity. This comparison was deemed to be appropriate as the identified mechanism to improve air quality was a mass retro fitment scheme and so would reduce roadside emissions by what may be approximated by a given proportion across the network. In the initial assessment the ethnic diversity has been defined as the proportion of the residential population not classified as White-British.

24. Figure 1 provides a diagrammatical comparison of the roadside concentrations across the UK. The emission levels provided are taken from modelling by the Pollution Climate Mapping Model (PCM model) used to assess compliance with EU limit values. To ensure a proportionate approach the map used was taken from previous modelling undertaken for the Air Quality Strategy 2007.

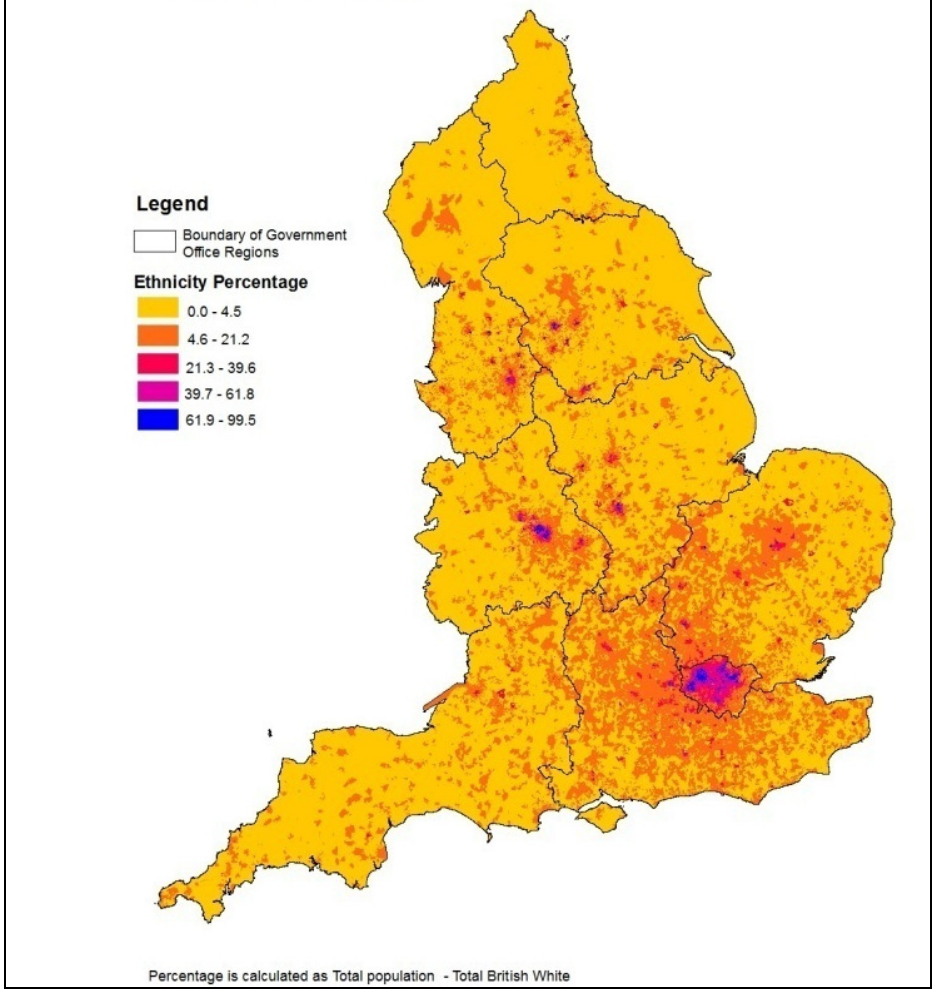
Figure 1: Ambient PM_{10} concentrations across the UK ($\mu g/m^3$ 2005)



25. Figure 2 provides an indication of ethnic diversity across England. As there is no generally agreed definition of ethnic diversity therefore in this diagram ethnic diversity has been defined as the proportion of the residential population not classified as White – British in the 2001 census.[17]

[17] Despite its age the 2001 Census is seen as the best available evidence on the distribution of different racial groupings as it provides a consistent, comprehensive and clear indication.

Figure 2: Ethnicity diversity by census output area (2001)



Conclusions of Initial Racial Impact Assessment

26. Based on this initial assessment it was agreed that there was reasonable basis for a more detailed racial equality assessment. A visual comparison of the high levels of concentration and ethnic diversity shows a clear overlap between poor air quality and an ethnically diverse residential population. As the proposed measure to retrofit the is expected to proportionally reduce concentrations equally across the UK it would be expected to have a disproportionate benefit to minority ethnic groups. Thereby the delay in compliance would be expected not to deliver the small amount improvements in ethnic equality associated with achievement.

Quantitative analysis

27. A visual comparison of the location of ethnic grouping with the potential improvements suggested that being granted a time extension could fail to realise improvements in ethnic equality and therefore it was decided to undertake a more detailed quantitative assessment of the potential impacts.

28. To provide such analysis GIS mapping technologies were employed to quantitatively compare the PM_{10} emissions from road sources against ethnic groups. The key aim of this analysis was to estimate the average exposure by ethnic group that would

provide a strong indication of the potential ethnic distribution of the impact of receiving a time extension.

29. Unfortunately emission mapping and ethnic information are collected on different systems and so were not directly comparable. The PCM model estimates ambient concentrations based on a geographical basis at a 1km by 1km resolution across the UK. The best available data on ethnic make-up is taken from the 2001 census. Despite its age the Census is seen as the best available source as it provides a consistent, comprehensive and definitive data set. However, it is only available by census output area. Census output areas are defined by a given total population and so the geographical scope may vary between areas, for example highly populated areas will have a smaller geographical area than more sparsely populated areas.

30. To bring together the two data sets it was necessary to adjust the basis of one of the measures. In this case the adjustment was made to the ambient concentration data to estimate an average across the different census output areas. Using GIS software to overlay the roads onto the census output areas, it was then possible using GIS tools to calculate the average emissions level for each census output area.

31. This level was then multiplied by the number of people in each ethnic group within that census output area to give the emissions level for each group in the area.

32. Having estimated the average concentration across all census output areas it was possible to estimate an average exposure level by ethnic group for the whole country. To do so it was assumed that the average ambient concentration within a census output area was experienced by all ethnic groups.

33. To intuitively explain this approach, assume that there are two areas and two ethnic groups. Area 1 has 60 per cent group A and 40 per cent group B, Area 2 then has 40 per cent group A and 60 per cent group B. Area 1 also has a higher concentration of PM_{10} than area 2 with an average of 100$\mu g/m^3$ in area 1 and 50$\mu g/m^3$ in area 2. This being the case the average exposure of group A is 80$\mu g/m^3$ while the average exposure of group B is 70$\mu g/m^3$.

34. The average exposure has then been multiplied by the proportional reduction in concentrations expected from the modelled mass retrofitting scheme to estimate the potential change in exposure by ethnic group. For example in relation to White British the total average exposure is 21.14μg/m^3 but following a mass retrofitting scheme it is modelled to fall by 0.96μg/m^3 to 20.18μg/m^3.

35. The full results of this analysis are provided in table 1 below.

Table 1: Average PM_{10} Concentration Exposure from road sources by ethnic group (μg/m^3)

	Exposure	Change	Total population	% Total population
White - British	21.14	0.96	**9,657,149**	82.7%
All ethnic	24.84	1.13	**2,015,050**	17.3%
White - Irish	23.90	1.08	180,461	1.5%
White - other	24.95	1.13	413,684	3.5%
Mixed - White and Black Caribbean	24.05	1.09	62,424	0.5%
Mixed - White and Black African	24.73	1.12	22,779	0.2%
Mixed - White and Asian	23.68	1.07	52,628	0.5%
Mixed - other	24.44	1.11	44,953	0.4%
Asian or Asian-British - Indian	24.40	1.11	334,221	2.9%
Asian or Asian-British - Pakistani	23.15	1.05	227,048	1.9%
Asian or Asian-British – Bangladeshi	26.42	1.20	91,376	0.8%
Asian or Asian-British - other	25.11	1.14	76,754	0.7%
Black or Black-British Caribbean	26.22	1.19	172,316	1.5%
Black or Black-British African	27.22	1.23	159,518	1.4%
Black or Black-British other	26.34	1.19	29,186	0.3%
Chinese	23.99	1.09	75,326	0.6%
Other Ethnic	25.26	1.15	72,376	0.6%
All People	**21.78**	**0.99**	11,672,199	100.0%

36. The results presented in table 1 show that exposure to PM_{10} from road sources varies significantly by ethnic group. On average White British are exposed to an ambient concentration from road sources of 21.1 μg/m^3 which are 14.9 per cent lower than the average ethnic exposure. However this covers a wide disparity between ethnic groups which range from 23.7μg/m^3 to 27.2μg/m^3 for Mixed White and Asian and Black or Black-British African respectively.

37. It is also important to reflect that the aggregation across these groups will hide a significant amount of information. This is a particular issue as the groups become wider and therefore specifically for the 83 % of the population who consider themselves White British. It is possibly that within this group there will be substantial variation and therefore likely that a proportion of this group will be exposed to equivalent or higher levels of exposure than all other ethnic groups while another group will be exposed to very low levels.

38. These results then mean that the distribution of the health cost of applying for and utilising a time extension would be greater for the average member of society from an ethnic minority than a person who classed themselves as White British. The

difference depends upon the ethnic group with individuals who class themselves as Mixed White and Asian facing 12 per cent greater cost and individuals who class themselves Black or Black-British African facing 29 per cent higher cost.

39. It must however be noted that owing to the relative size of the populations of each ethnic group the aggregate impact on White – British will be significantly greater than any other group. To illustrated this Table 1 presents the relative size of each ethnic group. Showing that 82.5% of the population covered by this analysis class themselves as White – British and therefore, for this analysis ethnic minorities (Non – White British) comprise 17.3% of the population.

40. A large contributory factor to the observed difference in exposure was known to be the fact that urban areas tend to have a wider diversity of ethnic groups. Therefore to test the above results it was decided to recalculate the average exposures by ethnic groups split between the urban and rural populations. There is a greater tendency for ethnic groups to live in more urban areas, which is where the higher emissions are. Using the rural urban definition, which defines each output area in the country as urban or rural, the average emissions per ethnic group were recalculated for urban census output areas and then for rural census output areas. Table 2 below provides the results of this analysis.

41. Specifically, table 2 highlights that for the urban rural split the exposure to PM of each ethnic group as compared to the average White – British exposure. As can be seen from table 1, in both urban and rural areas White – British are consistently exposed to lower concentrations of PM_{10} as compared with all other ethnic groups. However, the differential between White – British and Non White – British is more pronounced in urban areas as opposed to rural areas.

Table 2: PM_{10} concentration by ethnic group and rural and urban areas ($\mu g/m^3$)

	Urban		Rural	
	$\mu g/m^3$	% WB	$\mu g/m^3$	% WB
White - British	21.28	n/a	18.37	n/a
All ethnic	24.91	+17.05 %	19.09	+3.94%
White - Irish	24.00	+12.77 %	19.11	+4.03%
White - other	25.09	+17.91 %	18.94	+3.10%
Mixed - White and Black Caribbean	24.12	+13.33 %	18.55	+0.98%
Mixed - White and Black African	24.80	+16.52 %	18.84	+2.56%
Mixed - White and Asian	23.77	+11.72 %	19.07	+3.81%
Mixed - other	24.53	+15.28 %	18.93	+3.05%
Asian or Asian-British - Indian	24.42	+14.77 %	19.92	+8.45%
Asian or Asian-British - Pakistani	23.16	+8.84%	18.80	+2.34%
Asian or Asian-British – Bangladeshi	26.43	+24.21 %	18.58	+1.14%
Asian or Asian-British - other	25.15	+18.18 %	19.57	+6.53%
Black or Black-British Caribbean	26.24	+23.31 %	19.72	+7.35%
Black or Black British African	27.25	+28.04 %	19.97	+8.71%
Black or Black-British other	26.37	+23.91 %	19.74	+7.46%
Chinese	24.09	+13.21 %	18.59	+1.19%
Other Ethnic	25.37	+19.21 %	19.18	+4.42%
All People	**21.93**	**+3.04%**	**18.41**	**+0.21%**

42. Table 2 above shows that while the rural urban split accounts for the majority of the differential exposure by ethnic group in both locations on average White - British are exposed to lower concentrations of PM_{10} than other ethnic groups. Therefore the health cost of delaying compliance would be higher for individuals who were not identified as White British.

43. In urban locations on average individuals of White British descent are seen to be exposed to 17.1 per cent less PM_{10} than other ethnic groups. For rural locations this gap is reduced to 3.9 per cent. Exposure also varies substantially across ethnic groups. However in both urban and rural areas Black or Black-British African are exposed to the highest exposure. However the gap is significantly lower in rural areas falling from 28.0 per cent to 8.7 per cent higher exposure than individuals identified as White British.

44. The ethnic group with the least additional exposure varies between urban and rural areas. For urban areas Asian or Asian-British – Pakistani are exposed to the closest levels to White – British being exposed to 8.8% higher concentrations. In rural areas however it is Mixed - White and Black Caribbean that face the closest exposure only being exposed to 1.0 per cent higher concentrations. This level of difference is so small that the two groups might be described as having broadly equivalent exposure.

45. In addition to the level of exposure by ethnic group it is also important to consider if different ethnic groups might have differing reactions to exposure.

46. The Health Protection Agency (HPA) believe that there is no consensus to suggest a well established link between susceptibility to air pollution and ethnic group. Whilst there is a potential for differential impacts by ethnic group it is not possible to identify any such effects with any reasonable level of certainty.

47. The HPA are aware of a small number of papers, which suggest that the effect of PM_{10} on hospital admissions and mortality does not vary by race (Zanobetti et al 2000 Env. Health Perspect. 108:841-5; Zeka et al 2006 Am J Epidemiol 163: 849-59). There are also studies that show that air pollution does have an effect in different ethnic groups although these did not necessarily compare the effect with other ethnic groups e.g. Ostro et al (2001) Epidemiology 12:200-208 showed that there is indeed an effect of air pollution on asthma symptoms in black Americans.

48. However, it is well known that there are higher rates of cardiovascular disease and diabetes in certain Asian groups. Air pollution is known to affect cardiovascular disease and there are a few studies now on effects of air pollution in diabetics. It is less known whether there are such marked differences amongst ethnic groups for respiratory diseases although there may be issues relating to poorer compliance with treatment or access to services if there is a language barrier.

49. There is a big issue in the States with regard to asthmatic responses to cockroach allergen which predominantly affects inner cities where a higher proportion of people from ethnic minorities live.

50. There are some studies on ozone and genetic polymorphisms showing that people with different versions of particular genes are more susceptible. Genetic polymorphisms may be distributed unevenly according to race (this could, of course, have a beneficial or adverse effect in different groups). For example, a paper by Islam et al 2008 Am J Respir Crit Care Med 177(4):388-95, found an increased risk of asthma in Hispanic whites with a particular genetic polymorphism when they were exposed to ozone but further studies are needed to confirm this effect.

51. Therefore, on the basis of this evidence there is a potential that there may be differential impacts by ethnic group. However, given the strength of evidence it is not possible to identify any such effects with a reasonable level of certainty.

Conclusions

52. Overall the analysis undertaken suggests that there is a notable difference in the impact of delaying achievement of the limit values by ethnic group. Both at the national level and when split by urban and rural areas, individuals who identify themselves as White – British are consistently exposed to lower concentrations of

PM_{10}. Therefore the expected health costs of not achieving limit values would be expected to be lower for this group than other ethnic groups.

53. The level of the differential varies both by area and by ethnic group however some key findings are that:

    - Nationally, for those who live in areas overlapping the motorway and A road network in England, on average ethnic groups not classified as White – British are exposed to 17.5 per cent higher concentrations of PM_{10};
    - In urban areas the average gap is 17.1 per cent which is reduced in rural areas to 3.9 per cent.
    - Across the different areas individuals identified as Black or Black-British African are exposed to the highest levels of PM_{10} of up to almost 30 per cent higher than White British.
    - Mixed - White and Black Caribbean in rural areas is the only group that may be seen to have a broadly equivalent exposure having just a 1 per cent higher exposure than White British.
    - Policies therefore need to evaluate if there are any measures that could justifiably be introduced to ensure that the preferred option does not have a disproportionate impact on minority ethnic groups.

54. However a major caveat to these conclusions is that the analysis has only considered the distribution of the costs of this policy. It does not provide a similar consideration of the associated benefits. While it is not possible to readily undertake a similar analysis it is likely that the benefits would also occur disproportionately on to ethnic minorities. This is likely for the same geographical reasons that the costs are unevenly distributed. As more ethnically diverse areas tend to have worse air pollution we would expect the mitigation costs to also be focused on these areas for example through transport or domestic measures.[18]

[18] This might however be offset to some extent by any public provision.

Annex 2: Specific Impact Tests

This annex sets out the reasons for not undertaking a detailed assessment for particular specific impact tests. The tests which are included in the evidence base and annexes are therefore not included.

Competition assessment

Option 2, transposing the Air Quality Directive, was not seen to create any significant competition issues as it would not directly or indirectly limit the number or range of suppliers, limit the ability of suppliers to compete or limit suppliers incentives to compete vigorously.

Small firms impact test

The preferred option was not judged to warrant a detailed small firms impact assessment as it was not likely to have a detrimental impact on small businesses. As this option would avoid imposing additional costs on all businesses, associated with any additional abatement measures, which could potentially have had a negative impact on small firms.

Legal aid

Transposition of the Air Quality Directive was not expected to create any new issues around the funding legal aid, advice to the public on rights, obligations and entitlements.

Disability equality

The preferred option is not expected to have a significant impact on disability equality.

Gender equality

The national impacts of air quality is not expected to be significantly different for men or women.

Human rights

Human rights are not judged to be significantly affected by this policy.

Rural proofing

The impact on rural areas between the different policy options assessed is not expected to be significant.