ED48300

Technical and Non-technical Options to Reduce Emissions of Air Pollutants from Road Transport

Final Report to Defra

March 2005

ED48300

Title	Technical and Non-technical Options to Reduce Emissions of Air Pollutants from Road Transport
Customer	The Department for Environment, Food and Rural Affairs, the National Assembly for Wales, the Department of the Environment in Northern Ireland, and the Scottish Executive Environment and Rural Affairs Department.
Customer reference	CPEA13
Confidentiality, copyright and reproduction	Copyright AEA Technology Environment
File reference	AEAT/ED48300
Report number	AEAT/ED48300/R02
Report status	Final: Version D

Sujith Kollamthodi
AEA Technology Environment
154/1.04 Harwell
Didcot
Oxfordshire
OX11 0QJ
Telephone +44(0)870 190 6513
Facsimile +44(0)870 190 6327

	Name	Signature	Date
Author	Sujith Kollamthodi		31st March 2005
Reviewed by	Paul Watkiss		31st March 2005
Approved by	Paul Watkiss		31st March 2005

Executive summary

Overview

Road transport is one of the largest contributors to emissions of nitrogen dioxide and particulate matter, and emission reductions from this sector will be very important if upcoming air quality limit values are to be achieved. Emissions and air quality modelling work carried out to date by Defra's Air Quality Expert Group and AEA Technology indicates that the UK will not meet forthcoming limit values for nitrogen dioxide and particulate concentrations specified in both EU legislation and in the UK's Air Quality Strategy. There is therefore a need to examine additional measures that could be used to reduce emissions from the road transport sector. After 2010 there is likely to be further pressure to improve air quality to an even greater extent and more measures may need to be implemented, with the ultimate long-term aim of achieving ultra-low or zero-emissions from the road transport sector.

AEA Technology Environment was commissioned by the Department for the Environment, Food and Rural Affairs (Defra), the Devolved Administrations, and the Department for Transport (DfT) to carry out an investigation of additional measures that could be used for reducing emissions from road transport over three different time scales: 2005 to 2010, 2011 to 2025, and 2026 to 2050. The study has consisted of reviewing the available options, developing scenarios for the deployment of options, and conducting more detailed analysis to rank and prioritise scenario options for further investigation. Finally, an initial investigation of the costs and emissions benefits associated with combinations of options has been carried out. This work has contributed to the review of the Air Quality Strategy by providing a list of prioritised scenario options that may lead to emissions benefits and associated air quality benefits.

Assessment of options and scenario development

The study has included an investigation of both technical options (e.g. alternative fuels, new vehicle technologies, and emissions abatement equipment) and non-technical options (e.g. fiscal measures, traffic demand management, access control, etc). A review of possible options was carried out at the beginning of the study (presented in a separate report), and this has been followed up by the development of a range of scenarios for each of the three time periods for the possible deployment of the various options. Where possible, a quantitative assessment of the total costs and emissions benefits associated with each scenario was carried out. Additionally, the study has included a qualitative assessment of the wider impacts associated with each option, including effects on emissions of other pollutants and carbon dioxide, traffic congestion, traffic noise, accidents, and social impacts.

Options for the **2005-2010 time period** are given below in Table 1.1, options for the **2011-2025 time period** are presented in Table 1.2, and options for the **2025-2050 time period** can be found in Table 1.3.

Table 1.1: Options assessed for the 2005-2010 time period

Technical options	Non-technical options
Retrofit SCR for heavy duty vehicles	Scrappage scheme for pre-Euro and Euro 1 passenger cars
Retrofit EGR for heavy duty vehicles	Low Emission Zones
Increased uptake of CNG heavy duty vehicles	Access control measures to restrict private car use in urban centres
Uptake of Euro 5 emission standards for light duty vehicles	Lorry road user charging scheme
Low emission passenger cars	Public transport priority measures
Hybrid buses	Speed policy review for motorways
Water Diesel Emulsion fuels for heavy duty vehicles	Car clubs

Table 1.2: Options assessed for the 2011-2025 time period

Technical options	Non-technical options
Batrery powered electric vehicles	Scrappage scheme for Euro 2, Euro 3 and Euro 4 vehicles
Hydrogen fuel cell powered vehicles for captive fleets	National road pricing scheme for all vehicles
New diesel formulations	Extended Low Emission Zones
	Freight distribution centres and intermodal freight transfer
	Further integrated land use and transport planning
	Dynamic route planning
	Emissions trading schemes for heavy duty vehicles and taxis
	Personal carbon accounts

Table 1.3: Options assessed for the 2011-2025 time period

Options
Large-scale uptake of hydrogen fuel cell passenger cars
Automated highways
Complete substitution of petrol and diesel by biofuels
Fast moving walkways for short urban journeys
Dedicated road freight systems
Passenger cars with inter-modal functionality
Scrappage scheme for petrol and diesel vehicles
Fuel duty differential based on life-cycle emissions

Analysis techniques for ranking and prioritising options

In order to rank and prioritise the scenario options, two analysis techniques have been used: multi-criteria analysis (MCA) and cost-benefit analysis (CBA). The MCA technique allows

options to be assessed against a wide range of different performance criteria, and for this study the following performance criteria have been used:

- Capital costs
- Operating costs
- NOx emissions abatement performance
- Particulate emissions abatement performance
- Carbon dioxide emissions abatement performance
- Hydrocarbon emissions abatement performance
- Impact on ground level ozone
- Traffic noise
- Traffic congestion
- Accident rate
- Social cohesion
- Quality of life
- Distribution effects
- Public acceptability
- Practicality

The MCA technique requires that numerical scores are attached to each option to describe its performance against each criterion. Where quantitative data were available (e.g. costs and emissions abatement performance), these were used to score the options. Where only qualitative data were available, a scoring system ranging from "+3" (strong positive effect) to "-3" (strong negative effect) was used. The scores against each criterion were then normalised to a scale from 0 to 100, and sets of weighting factors were applied to indicate the relative importance of the different performance criteria. After applying the weighting factors, the analysis was completed by summing the weighted scores for each option; the option with the highest overall score out of 100 could then be identified as the "most preferred" option.

For each time period, five different sets of weighting factors were used, as provided by governmental policy experts, thereby enabling sensitivity analysis to be carried out on the options. Whilst changing the weighting factors was found to alter the overall ranking of options (and in some cases to alter the selection of the most preferred option), in general there was a broad level of agreement between different sets of weighting factors with regard to the selection of the most preferred and least preferred options. For this reason, the final ranking of options was carried out by averaging the scores obtained from each analysis run where a different set of weighting factors had been used.

For the **2005-2010 time period**, further analysis of options was carried out using cost-benefit analysis. The additional capital and operating costs associated with each option were set against the monetary value of emissions benefits (based on reductions in NOx, PM_{10}, and CO_2 emissions), in order to identify the options with the greatest net monetary benefits.

Ranking and prioritisation of individual options for further study

The results of the MCA process identified that for the **2005-2010 time period** the following options should be prioritised for further study (presented in rank order of importance):

1. Scrappage scheme for pre-Euro and Euro 1 passenger cars
2. Low emission passenger cars
3. Retrofit Selective Catalytic Reduction (SCR) with diesel particulate filter for heavy duty vehicles

For the 2005-2010 time period, (but not for the other time periods) a CBA approach was also used to identify and rank options for further study. The results of this analysis are presented in the table below (presented in rank order of importance with estimates of net monetary benefits).

Table 1.4: Prioritised options for the 2005-2010 time period as identified using Cost Benefit Analysis

Ranking	Option	Net Present Value of total implementation costs (2005-2010) in £millions	Net Present Value of changes in NOx, PM_{10}, and CO_2 emissions (2005-2010) in £millions	Net costs or benefits (2005-2010) in £millions
1	Increased uptake of low emission passenger cars	-£647.87 to -£115.51	-£199.93 to -£54.36	**-£847.80 to -£169.86**
2	Revised speed policy for motorways close to urban areas	£2.92 to £20.00	-£20.96	**-£18.04 to -£0.96**
3	Low Emission Zones	£188.45 to £325.53	-£195.78	**-£7.34 to £129.75**

It is clear that for the 2005-2010 time period, the prioritised list of options obtained using the MCA technique is different from that obtained using the CBA technique. This is to be expected as the MCA process takes into account a wider range of performance criteria. Further analysis has indicated that it was not appropriate to try to combine the outputs from the two analysis techniques to come up with an overall list of ranked options. However, the option for increased uptake of low emission passenger cars was ranked highly in both the MCA and CBA results, and hence this option has been given overall priority for further investigation. It is recommended that the remaining four options should also be investigated, but the rank order of preference for these remaining options depends on whether the MCA or CBA approach is used.

For the **2011-2025 time period**, the results of the MCA process identified the following options for further study (presented in rank order of importance):

1. Battery powered electric vehicles
2. New diesel formulations
3. Further integrated transport and land use planning

For the **2025-2050 time period**, the following options were identified for further study from the results of the MCA process (presented in rank order of importance):

1. Large-scale uptake of hydrogen fuel cell vehicles
2. Fuel duty differentials based on life cycle emissions
3. Scrappage scheme for petrol and diesel vehicles

Combinations of options for further study

For the **2005-2010 time period**, cost benefit analysis was used to rank and prioritise combinations of the prioritised individual options for further study. The results of this analysis indicated that combinations that included increased uptake of low emission passenger cars were favoured. The five option combinations with net monetary benefits are presented in the table below (ranked in order of priority).

Table 1.5: Recommended option combinations for the 2005-2010 time period

Ranking	Combination of options	Net costs or benefits (2005-2010) (Low estimate for option cost) in £millions	Net costs or benefits (2005-2010) (High estimate for option cost) in £millions
1	Low emission passenger cars + Revised speed policy for motorways in urban areas	-£284.12	-£170.82
2	Low emission passenger cars + Revised speed policy for motorways in urban areas + Low Emission Zones	-£291.45	-£41.07
3	Low emission passenger cars + Low Emission Zones	-£273.41	-£40.11
4	Retrofit SCR for heavy duty vehicles + Low Emission passenger cars	-£208.99	£73.85
5	Revised speed policy for motorways in urban areas + Low Emission Zones	-£25.38	£128.79

For the **2011-2025 time period**, it is not clear that combinations of the three prioritised options (battery-electric vehicles, new diesel formulations, and further integrated transport/land use planning) will necessarily work well together. An initial examination of some of the other, less favoured, options for this time period has indicated that it may be better to include some of them in any combinations that are proposed. In particular, packages of options that combine incentives with new transport restrictions or financial penalties may work particularly well. Particular examples that should be considered for further investigation include combinations based around the proposed national road-pricing scheme and extended Low Emission Zones. A list of recommended combinations for further investigation is presented in the table below. It should be noted that these combinations are **not** presented in rank order of priority.

Table 1.6: Recommended option combinations for the 2011-2025 time period

Combinations of options for further investigation
* National road pricing scheme + Integrated land use and transport planning
* National road pricing scheme + Emissions trading scheme for HGVs/taxis
* National road pricing scheme + Personal Carbon accounts
* National road pricing scheme + Integrated land use and transport planning + Emissions trading scheme for HGVs/taxis + personal carbon accounts
* Extended LEZs + increased use of freight distribution centres
* Extended LEZs + + Emissions Trading Scheme for HGVs
* Extended LEZs + battery electric heavy duty vehicles + H_2 fuel cell vehicles for captive fleets
* Extended LEZs + battery electric heavy duty vehicles + H_2 fuel cell vehicles for captive fleets + Emissions Trading Scheme for HGVs

For the **2025-2050 time period**, the three prioritised individual options (large-scale uptake of hydrogen fuel cell vehicles, fuel duty differentials based on life-cycle emissions, and a scrappage scheme for petrol and diesel vehicles) are all targeted at reducing the use of fossil fuels. During this time period, options that can help mitigate climate change impacts (such as those that are based on encouraging or increasing the use of renewable and non-petroleum fuel sources) are likely to become increasingly important. It is recommended that the three prioritised options for this time period could be combined to form a mutually beneficial package to accelerate the uptake of hydrogen-based transport, and to speed the removal of conventional petrol and diesel fuel.

Table 1.7: Recommended option combination for the 2025-2050 time period

Combination of options for further investigation	
1	Large-scale uptake of hydrogen fuel cell vehicle + fuel duty differentials based on life-cycle emissions + scrappage scheme for petrol and diesel vehicles

Modelling the air quality benefits of urban transport measures

The study has contributed to the review of the Air Quality Strategy by prioritising measures based on their costs, emissions abatement performance, and wider impacts in order that further analysis can be carried out on the most promising options. However, it is important to reiterate that the reason why additional road transport measures are required is to help improve local air quality by reducing *pollutant concentrations*, particularly in urban areas. This study has necessarily focused on prioritising options based on their emissions abatement performance, but further work will be required to identify the air quality benefits associated with the prioritised options.

Estimates of the emissions abatement performance of different options can be used as input data for air quality modelling to quantify the effects that specific options would have on pollutant

concentrations. Typically, such modelling would use, as part of the input data, emission projections based on average vehicle emission factors for future years (taking into account new technologies and future vehicle emission standards), and traffic growth parameters for future years obtained from the Department for Transport's (DfT's) National Transport Model (NTM). These traffic growth parameters relate to specific "area types" within the NTM, and hence cover relatively large geographical areas that may not provide the required level of resolution for some urban transport measures. Furthermore, air quality modelling at the national scale makes use of a modelling grid with a 1 km x 1 km resolution, which combined with the emissions projection methodology described above, may not give a high enough level of resolution to fully quantify the air quality benefits of some options in urban areas. In particular, it is thought likely that reductions in urban pollutant concentrations associated with measures such as Low Emission Zones, access control measures, and measures to improve the emissions performance of urban buses may be underestimated using the above methodology. Further research will be required to resolve this issue.

Other recommendations

The study has also highlighted the need to carry out a more detailed investigation into the issue of primary NO_2 emissions and their impacts on air quality. Current air quality modelling techniques either assume that a fixed proportion of NOx is directly emitted from vehicles as NO_2 (typically 5%), or empirical data from monitoring sites regarding the proportion of NO_2 in roadside NOx is used as input data for predictive air quality modelling. The limitation with these approaches is that at best, the modelled pollutant concentration values for future years will reflect the *current* ratio of NO_2:NOx. However, it is known that some new technologies (in particular, Continuously Regenerating Traps (CRTs)) can significantly increase the proportion of primary NO_2 in NOx emissions; Previous work has indicated that increased primary NO_2 emissions would lead to an increase in roadside NO_2 concentrations. A number of the options investigated for this study include the likely fitment of CRT-type diesel particulate filters, and hence there is a need for a more detailed study to investigate the impact that increased use of such filters would have on primary and total NO_2 emissions (particularly in urban areas), and the consequent impacts on roadside NO_2 concentrations.