Air quality trends in London confirm predictions

In response to growing concern over urban air quality in the European Union, the 90s saw an unprecedented legislative focus on reducing emissions from road transport. The Consolidated Vehicles Directive (CVD) and its revision (Council Directives 91/441/EEC and 94/12/EC) set new emission limits for vehicles registered after 31 December 1992 with a further tightening of these limits for vehicles registered after 31 December 1995. The revised sulphur in gas oil Directive (Council Directive 93/12/EEC) was, in part, designed to ensure that the sulphur level in diesel fuel was suitable for the diesel vehicle technology anticipated to be required to meet the post '95 emission limits of the CVD.

The first European Auto/Oil Programme, with its 'air quality driven' rather than 'technology driven' approach, was designed to determine the least cost mix of further vehicle technology and fuel measures required to deliver the road transport contribution to the attainment of European Air Quality Targets. This programme resulted in the mandating of tougher fuel specifications and vehicle emission limits for 2000 and 2005 (Council Directives 98/70/EC and 98/69/EC).

Traffic remains with us—but is air quality improving?

Along with this focus on road transport, the EU Air Quality Framework Directive has resulted in a significant increase in the number of air quality monitoring stations in European cities during the 90s. As the Commission's Second European Auto/Oil Programme draws to a close and they embark on their wider CAFE initiative, are the predicted emission reductions resulting from mandated measures already resulting in noticeable improvements in actual air quality? Positive signals are surely crucial to maintain stakeholder's confidence in environmental quality driven approaches to future legislation inasmuch as it relies on emission forecasting and air quality modelling. In this article we seek to address this question by looking at the 'Example City' of London.

ESTIMATING EMISSIONS AND AIR QUALITY TRENDS

CONCAWE used its in-house forecasting tool, *STEERS[1] for Europe,* to estimate emission trends for UK urban road transport. This incorporates the methodologies developed for the latest release of COPERT[2] together with the UK fleet composition, turnover data and driving characteristics used in Auto/Oil II. During the second Auto/Oil Programme, STEERS was extensively benchmarked against the FOREMOVE[3] and TREMOVE[4] tools used by the Commission. Given that all three tools utilize essentially the same methodology and databases, emission forecasts from all three emission models were predictably found to be in close agreement.

[1] *Strategic Toolkit For Evaluating Emission Reduction Scenarios*
[2] *COmputer Programme to calculate Emissions from Road Transport, Version III*
[3] *Forecast of Emissions from Motor Vehicles, LAT, Aristotle University Thessaloniki*
[4] *TREMOVE, developed for the European Commission as part of Auto/Oil II, is a behavioural model designed to analyse the cost-effectiveness of a wide range of technical and non-technical measures aimed at reducing emissions from road transport.*

The emission trends from non-road transport sources were based on the data generated by SENCO[5] for the European Commission as part of the second Auto/Oil Programme.

The air quality data were obtained from the extensive UK National Air Quality Information Archive[6] web site. Hourly data were used to build the compliance picture from a 'bottom up' approach for each pollutant.

To relate predicted emission trends to air quality, a 'reference year' was first selected for each measuring station/pollutant combination. For this reference year, the relative contribution of road transport emissions to overall measured concentration was estimated. For road-side stations this was assumed to be 100%. For urban background stations it was estimated from published air quality modelling results such as Auto/Oil I. By setting the 'emissions-based air quality' equal to the measured air quality in the reference year, the relative change in air quality due to emission reductions could then be determined for the whole period. The results for the three pollutants: benzene, PM_{10} and NO_2 are presented in this article.

MEASURED AIR QUALITY TRENDS IN LONDON CONFIRM EMISSIONS-BASED MODEL PREDICTIONS

The modelling protocols described above have been used to predict air quality trends in the London area, in particular for specific spots where measuring stations are located. Examples of results for three pollutants, namely, benzene, PM_{10} and NO_2 are discussed below. The analysis was undertaken for a number of measuring stations, all of which showed good agreement between modelled and measured air quality. However, this article focuses on two stations for each pollutant.

Benzene

Figure 1 indicates that the measured benzene concentrations in two London locations are consistent with the substantial reductions in benzene emissions from road transport that were predicted to occur over the period. In particular, the effect of the mandatory introduction of a maximum content of benzene in gasoline from 1 January 2000, is clearly reflected in these data.

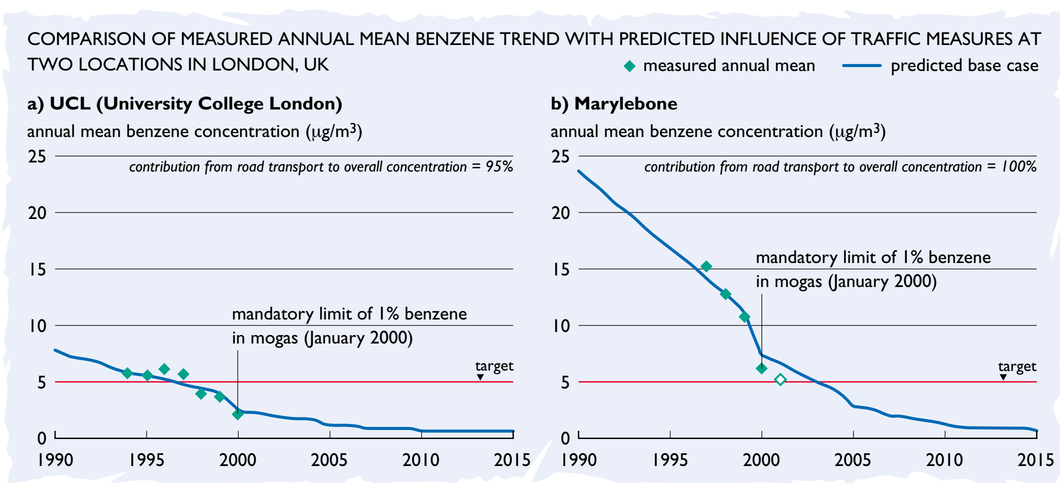


Figure 1a/b
Benzene air quality trends in London. The 2001 data point for Figure 1b is based on only two months of measurement data in 2001.

[5] *Sustainable Environment Consultants*

[6] *The UK National Air Quality Information Archive is sponsored by the Department of Environment, Transport and the Regions, the National Assembly for Wales and the Scottish Executive and maintained by the National Environment Technology Centre, NETCEN.*

This provides confidence in the validity of the emissions predictions that underlie the emissions-based air quality trends. Further, it provides justification for extrapolating these trends using the emission forecasting tool to obtain a robust view of future air quality. The anticipated further improvements, resulting from the tightening of VOC emission standards for vehicles and fuel specifications changes post 2000, are also shown on the charts. This indicates that, even for a roadside station such as Marylebone, the recently adopted EU benzene annual mean air quality standard of 5 µg/Nm^3 will be met before 2005.

This ability to relate emission trends to measured air quality also means that any potential further emissions changes e.g., due to a vehicle technology or fuel specification change, may be expressed in air quality terms. Such 'what if' analysis is explored in the air quality trends for PM_{10} discussed below.

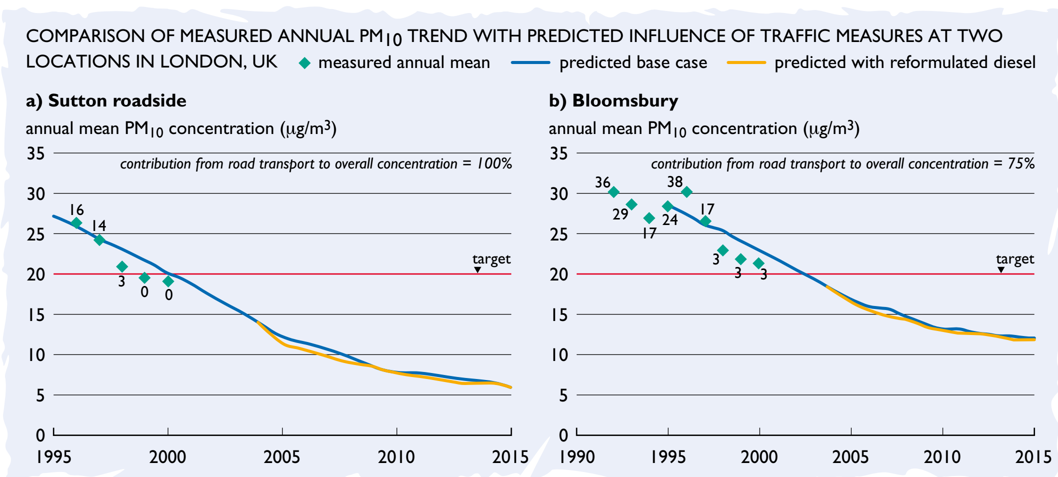
PM_{10}

Figure 2 shows that the measured concentrations of PM_{10} are in good agreement with the emissions-based trend for two London measurement stations. This facilitates the extrapolation of the expected trend resulting from emission reductions from already mandated transport measures, the so-called 'Base Case'. For these stations this indicates compliance with both the annual mean air quality standard and the 24-hour air quality standard exceedance target, before 2005.

Confirmation of the robustness of using the emissions to provide a forecast of future air quality also permits a reliable assessment of the effect of further measures on this trend. Here one such case is shown. This is the introduction in 2005 of one of the reformulated diesel fuels examined under the second Auto/Oil programme[7]. As may be seen, this measure offers a very small further reduction on PM_{10} levels. Indeed, since such a new fuel only benefits the existing fleet in 2005, with time, as these vehicles are replaced with new vehicles (which use the new fuel to conform to their emission standard), this small impact reduces to zero.

Figure 2 a/b
PM_{10} trends in London

Note: The numerical value attached to each data point denotes the number of days for which the 24-hour average standard of 50 µg/m^3 has been exceeded. Measured data are shown for each measurement year.



NO_2

Figure 3 provides a comparison between measured annual mean concentrations of NO_2 and the emissions-based annual mean trend. The availability of measurement data on an hourly basis permitted the emissions-based annual mean air quality trend to be related to the exceedances of

[7] *The so-called DQ3 case: 'market-average' diesel fuel with a density of 825 kg/m^3, a T95 of 355°C and polyaromatic content of 3% m/m.*

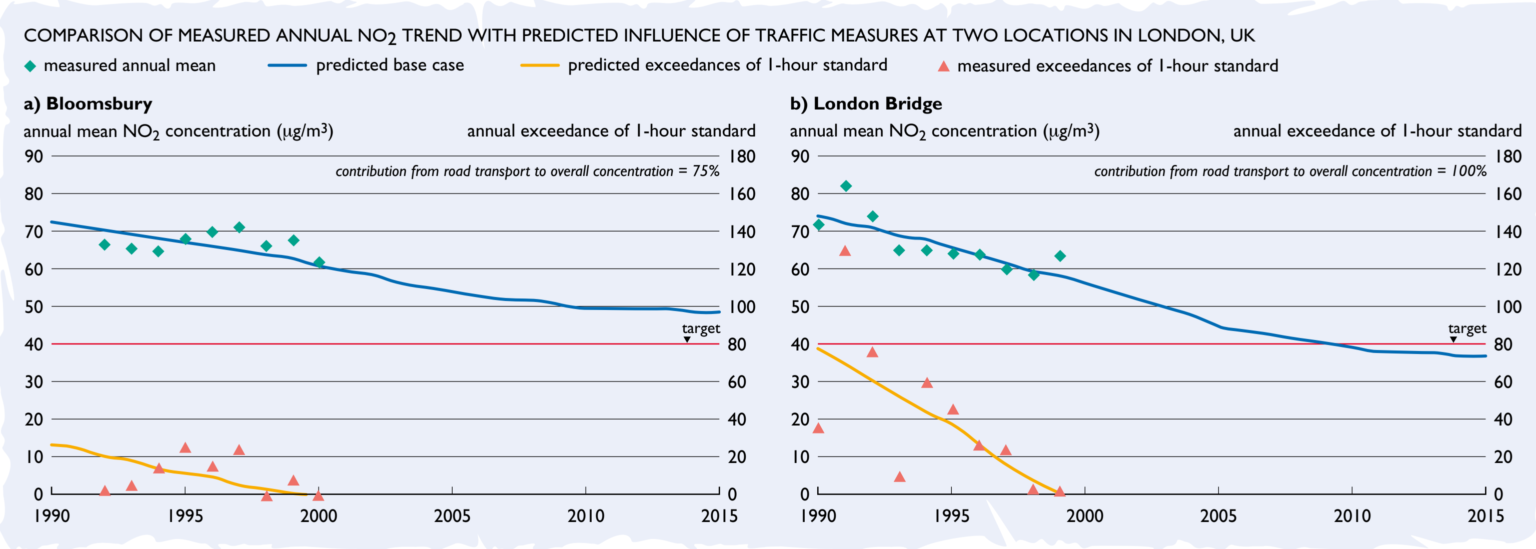


Figure 3 a/b
NO_2 trends in London

Note: NO_x emitted from motor vehicles is almost all in the form of NO which reacts in the atmosphere with ozone to form NO_2. To account for this, the measurements of both NO and NO_2 were used to develop the emissions-based trends shown in the figure.

the 200 µg/m^3 1-hour standard. Again this shows close agreement with the exceedance trend based on measured data.

The trends show that the annual mean standard of 40 µg/m^3 is a more challenging target than the exceedance criteria for the 200 µg/m^3 target. This is especially so for the Bloomsbury measuring station where the emissions from non-transport sources play a more important role in overall measured levels, especially post 2000. The London Bridge Road site, being much more traffic-dominated, benefits from the significant transport emission reduction over the period. These different characteristic responses at the two sites are reflected in the exceedances of the short-term standard. Where traffic dominates, the exceedances are much higher but decline rapidly as transport emissions reduce.

CONCLUSIONS

This analysis of air quality measurement data in the London area shows that forecast air quality trends are already reflected in measured data. This reinforces confidence in the current forecasting methodologies both for emissions and resultant air quality. It also upholds the validity of the technical analysis of the second European Auto/Oil Programme for which such forecasts are the cornerstone. This should provide further assurance regarding the robustness of underlying technical analysis to those involved in finalizing the conclusions of the Programme. Finally it vindicates concepts such as Integrated Assessment Modelling that depend on emissions forecasting and will be at the heart of the technical input to the development of future programmes such as CAFE and future air quality policies.