ONE YEAR ON: THE IMPACTS OF THE LONDON CONGESTION CHARGING SCHEME ON VEHICLE EMISSIONS

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ABSTRACT

The Central London Congestion Charging Scheme (CCS) began in February 2003 through the introduction of a daily charge of £5 for those vehicles entering a central zone that is approximately 22 km^2 or 1.3 % of the Greater London area. The hours of operation of the scheme are between 07:00 and 18:30, Monday to Friday. The effect of the scheme has been to reduce the vehicle km travelled within the charging zone by - 15 % and to increase the speed by about + 20 %. The impact of the scheme on traffic emissions has been assessed using the Environmental Research Group's (ERG) emissions model that has been used widely in London, for the production of the London Atmospheric Emissions Inventory (LAEI)[1] and for the assessment of traffic management schemes such as the London Low Emissions Zone [2]. Comparisons have been made between pre-CCS (2002) and post-CCS (2003) emissions using four scenarios, run separately for the CCS area and the Inner Ring Road (IRR). These were selected to estimate the impact of changes in speed, vehicle km travelled by different vehicle categories, and the role of new vehicle emission technology between pre and post CCS. The emissions model estimates have shown that congestion charging has reduced NO_X emissions by – 12.0 % in the charging area and has increased emissions on the inner ring road by + 1.5 %. The model has also shown that PM_{10} emissions have reduced by – 11.9 % in the charging area and by - 1.4 % on the inner ring road. With the benefit of the introduction of new vehicle technology between pre and post CCS years an additional reduction in emissions is estimated to be – 3.9 % and 5.7 % for the CCS area and IRR, respectively. Similarly the benefit brought about by new vehicle technology results in further improvements in PM_{10} of – 4.0 % and 5.4 % for the CCS area and IRR, respectively. Large benefits are also evident with a reduction in emissions of the greenhouse gas, CO_2 by - 19.5 % in the CCS area. Unlike the emissions of NO_X and PM_{10} however, additional CO_2 reduction, through the introduction of new vehicle technology is modest, at only - 0.4 %. Overall results have shown that an increase in speed brought about by demand management within the CCS are at least as effective at reducing emissions as changes to the numbers of vehicles on the roads or to improvements in vehicle technology between 2002 and 2003. Furthermore particle reduction technology, fitted to the London bus fleet has also reduced the incremental PM_{10} impact of increased number of buses to almost zero.

Keywords: Environment and Transport planning, exhaust after treatment, climate change targets

INTRODUCTION

The implementation of the London Congestion Charging Scheme (CCS), in February 2003, was aimed predominantly at the reduction of congestion within the centre of London. Tackling the problems of congestion, using a demand management approach, has had additional benefits for the environment, particularly the reduction of two key urban pollutants NO_X/NO_2 and PM_{10} and the greenhouse gas, CO_2. The CCS is shown as the area highlighted in the centre of London (see Figure 1) and although only 1.3 % of the greater London area has seen changes in what was considered to be the most congested part of the city. The report, 'Impacts Monitoring: Second Annual Report' [3] sets out the impacts of the CCS to date, for example, a reduction in traffic delays of - 30 %, a reduction in overall traffic of - 15 % and a large increase in bus vehicle km and passenger use.

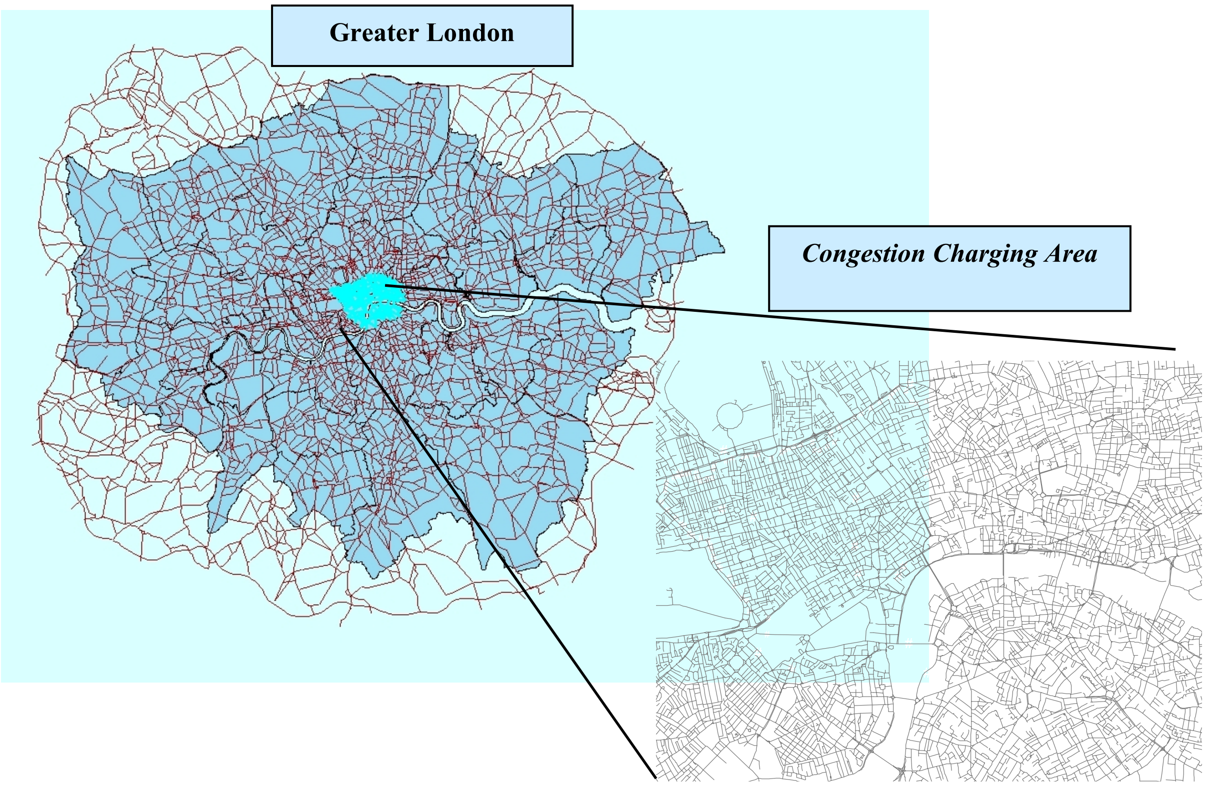

Fig.1 The extent of the congestion charging zone and position of traffic count sites used to evaluate the traffic impact of the scheme. Light grey and black circles represent the locations of manual and automatic count sites in the CCS.

Congestion charging is not a new idea and the first city to use this type of traffic control was Singapore, which has had a congestion charging zone since 1975. Since 1998 the system has been updated using automatic charging, the Electronic Road Pricing (ERP) scheme and from the inception of these systems, large reductions in road traffic and increases in speed have been achieved [4].

METHOD

The emissions model was run using four separate scenarios based upon an extensive measurement campaign by TfL of manual and automatic traffic counts as well as the 'floating car' to estimate changes in speed. Emissions have been calculated for each hour of the day, weekday and weekend, separately for the IRR and the CCS. Manual count data was taken from 282 locations, between the hours of 06:00 and 19:00 and automatic count data recording hourly data from 70 locations in central and inner London (see Figure 1). Manual counts were taken for the following vehicle types: Car, London taxi, Other taxi/minicab, Motorcycle/scooter, Van (car based), Van/light goods (2 axles), HGV (2 axles), HGV (3 axles), Large HGV (4+ axles), Public service bus, London double decker, London red arrow and other single deck London bus, Coach or private bus and Other. Automatic count data was averaged for each hour and given in three vehicle categories: short, medium and long. The pre and post-CCS changes were calculated for seven major vehicle types: motorcycles, buses, cars, taxis, light goods vehicles (LGVs) and rigid and articulated heavy goods vehicles (HGVs). Average road link speed was also applied to pre and post-CCS years by hour of the day and on a road by road basis. Speed data in the charging zone was surveyed every two months, the inner area, once a year and the IRR, four times a year. The results are aggregated over six time periods: 06:00-07:15, 07:45-09:15, 10:00-12:00, 14:00-16:00, 16:45-18:15 and 18:45-20:00. Changes in vehicle stock and technology characteristics have also been applied between pre and post-CCS years. For the vehicle categories cars, LGVs and HGVs these changes have been applied using the UK national vehicle stock model [5] and speed related emissions curves, (see http://www.naei.org.uk/emissions/index.php). However for important categories such as buses and taxis, specific London vehicle stock estimates have been made, including, in the case of buses, the percentage of vehicle fitted with new engines and exhaust particle traps.

The four emissions scenarios are described below and have been run to estimate the impact of changes in speed, vehicle km travelled by different vehicle categories, and the role of new vehicle emission technology between pre and post CCS. The scenarios can be summarised as follows:

Scenario 1: Pre CCS traffic flows, pre CCS speed and pre CCS vehicle stock – the base case from which all emissions changes were calculated. Scenario 2: Pre CCS traffic flows, post CCS speed and pre CCS vehicle stock – to quantify the significance of speed changes brought about by CCS. Scenario 3: Post CCS traffic flows, post CCS speed and pre CCS vehicle stock – to give an effect of both vehicle km changes brought about by CCS and changes in vehicle speed. Scenario 4: Post CCS traffic flows, post CCS speeds and post vehicle stock – the complete estimate of emissions in 2003 that allows the effect of improvements in vehicle emissions technology between 2002 and 2003 to be calculated.

RESULTS

Table 1 shows the average changes in AADT flows for different vehicle types as a result of the CCS. Bus and coach information was based on changes in vehicle km estimates provided by Transport for London. The remainder was calculated on the basis of both the ATC and MCC information described above. The most notable changes in vehicle km in the CCS area were an increase in buses (+ 20 %), an increase in taxis (+ 13 %), associated with the transfer to alternative modes of transport for work journeys and a reduction in cars (- 29 %) and in goods vehicles (- 11 %). On the inner ring road larger increases in bus use (+ 25 %) were evident, but because the IRR is the boundary of the charging zone similar changes to taxis and car travel were not seen. Finally, LGV and HGV vehicle km increase by 8 % and 5 %, respectively on the IRR. It should be noted that estimates of traffic volume and speed changes quoted below will differ slightly from those already published by TfL, owing to necessary assumptions made in applying the TfL count and speed survey data to the specific requirements of the emissions model.

	Motorcycles	Taxis	Cars	Bus and coaches	LGV	Rigid	Artic
Inner ring road	5	- 2	1	25	8	5	5
CCS	3	13	- 29	20	- 11	- 11	- 11

Table 1. The percentage change in vehicle km travelled for 7 vehicle types between 2002 and 2003.

The introduction of the CCS also led to an increase in average vehicle speed across central London. The average speed over the whole of the speed survey network (which extends outside of the charging zone) in 2003 was 24.8 $kmhr^{-1}$, compared with the average speed, in 2002, of 22.1 $kmhr^{-1}$. The mean speed between 2002 and 2003 increased by 2.0 $kmhr^{-1}$ in inner London, 2.8 $kmhr^{-1}$ on the inner ring road and 4.0 $kmhr^{-1}$ in the charging area. The results from the MCO speed survey show a shift towards increasing speed, however, a wide range of positive and negative speed changes road by road is also evident and over the entire network speed changes are within the range + 2.6 ±8.9 $kmhr^{-1}$ (1σ). Fig.2 shows a distribution of the change in speed (within 5 $kmhr^{-1}$ speed bins), and points to significant changes occurring at the slowest speeds < 30 $kmhr^{-1}$. Because, in the emissions model, speed is applied on a road by road basis large speed changes and changes at very low speeds can disproportionately affect emissions on individual roads and throughout the CCS road network.

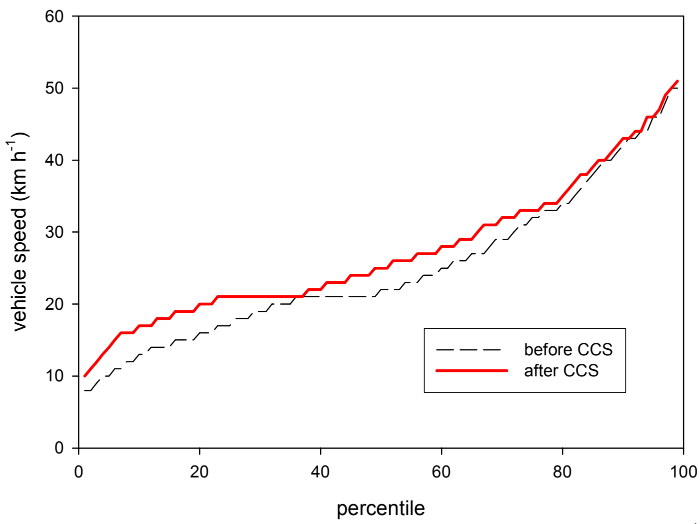

Fig. 2. The profiles of average road link speed ($kmhr^{-1}$) in central London before and after the introduction of the CCS.

For NO_X, all vehicle types, except motorcycles (which show an increase in emissions), the predicted increase in vehicle speed reduces emissions by - 4 % for the inner ring road and - 8 % for the charging zone. For PM_{10}, all vehicle types, except motorcycles (where speed related emission factors are not available), the predicted increase in vehicle speed reduces emissions by - 4.8 % for the inner ring road and - 8.5 % for the CCS. These results indicate that increasing speed has at least as great an effect on emissions as do changes in vehicle km as a result of congestion charging.

Overall the effect of the CCS was to reduce NO_X emissions by – 12.0 % in the charging zone and increase NO_X emissions by + 1.5 % on the Inner ring road (see Table 2). The change in emissions is a combination of the benefits brought about by an increase in vehicle speed and the benefits or disbenefits of changes to vehicle km.

	NO_X emissions		PM_{10} emissions	
	Inner ring road	CCS area	Inner ring road	CCS area
2002 base case				
CCS speed changes	-4.1	-7.9	-4.8	-8.5
Motorcycles	0.0	0.0	0.5	0.6
Taxi	0.0	1.4	-0.1	3.1
Car	0.7	-6.4	0.5	-3.8
Bus and coach	3.3	4.0	0.3	0.3
LGV	0.8	-1.2	1.7	-2.4
Rigid HGV	0.7	-1.8	0.4	-1.1
Articulated HGV	0.2	-0.3	0.1	-0.1
2003 post CCS	1.5	-12.0	-1.4	-11.9
Additional benefit of emission factors	-5.7	-3.9	-5.4	-4.0
2003 post CCS + emission factors	-4.2	-15.9	-6.8	-15.9

Table 2. The percentage change in NO_X and PM_{10} emissions on major roads in the congestion charging zone and on the inner ring road.

Each vehicle type has contributed differently to this total. For the CCS area NO_X emissions from cars, light goods vehicles (LGVs) and rigid and articulated heavy goods vehicles (HGVs) have reduced by – 6.4 %, - 1.2 %, - 1.8 % and – 0.3 %, respectively. However, NO_X emissions from buses and taxis have increased by 4.0 % and 1.4 %, respectively. For the inner ring road the increase in vehicle km has resulted in an increase in NO_X emissions from all vehicle categories. However, all the changes are small (< 1 %), except for buses, which show increases of 3.3 %. The two most important vehicle categories in terms of changes in NO_X emissions are therefore cars and buses. If the changes include those benefits brought about by improvements in vehicle technology between 2002 and 2003 then NO_X is reduced by an additional - 5.7 % for the inner ring road and - 3.9 % for CCS area. Overall the resulting emissions reduction between 2002 and 2003 is - 15.9 % for the CCS area and - 4.2 % for the inner ring road.

The combined effect of the CCS would be to reduce PM_{10} by - 11.9 % in the CCS zone and by + 1.4 % on the inner ring road. Here too speed increases were beneficial at reducing PM_{10} and mitigate against the effect of increasing vehicle km. Once again each vehicle type has contributed differently to this total. For the CCS area PM_{10} emissions from cars, LGVs and rigid and articulated HGVs have reduced by - 3.8 %, - 2.4 %, - 1.1 % and – 0.1 %, respectively. However, buses and taxis have increased by + 0.3 % and + 3.1 %, respectively. Note that the small impact of buses is due to new buses fitted with particle traps, which are highly effective at reducing PM_{10} emissions. For the inner ring road all vehicle emissions, except taxis, have increased. Each vehicle represents a small emissions change (< 1 %) however, except light goods vehicle, where there is an increase in emissions of + 1.7 %. The three most important vehicle categories in terms of changes in PM_{10} emissions are therefore cars, LGVs and taxis. If the changes include those benefits brought about by improvements in vehicle technology between 2002 and 2003 then the emissions are reduced by a further - 5.4 % for inner ring road, - 4.0 % for the CCS area. The resulting emissions reduction between 2002 and 2003 is - 15.9 % for the CCS area and - 6.8 % for the inner ring road.

Large benefits are also evident with a reduction in emissions of the greenhouse gas, CO_2 by - 19.5 % in the CCS area. Unlike the emissions of NO_X and PM_{10} however, additional CO_2 reduction, through the introduction of new vehicle technology is modest, at only - 0.4 %.

CONCLUSIONS

The introduction of a congestion charging zone in central London has had a large effect on both the total vehicle km travelled in the CCS area, down by approximately - 15 %, as well as an increase in average speed of about + 20 %, both during charging hours. To balance the large reductions in passenger car vehicle km (-29 %) a large increase in bus use has been evident. The impact of replacing cars with large diesel engine vehicles has been reduced through the widespread use of particle traps on these vehicles. Increases in speed have been a key factor in the CCS and have been at least as effective in changing vehicle emissions as the change in vehicle km travelled or the introduction of new vehicle technology between 2002 and 2003. Finally, whilst vehicle technology can assist in reducing pollutants such as NO_X and PM_{10} from vehicles it has a much smaller effect on emissions of CO_2. Here too the effect of the CCS has shown a large reduction in emissions (-19.5 %) and provides a good example of how traffic management can potentially contribute to the achievement of air quality or climate change goals, as part of a wider range of measures.

The emissions changes described above would not be expected to translate directly into improvements in measured air quality, for a variety of reasons. Indeed, provisional analysis of measured air quality data in and around the charging zone for 2003 (an unusual meteorological year) does not yet allow a 'congestion charging effect' to be distinguished.

Acknowledgements

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