Air quality impact assessment of changes in traffic management implemented by Paris City Council between 2002 and 2007

Summary

This document sets out the results of the changes between 2002 and 2007 in the amounts of nitrogen oxides released to the atmosphere by road traffic (emissions) and in the quality of air breathed in the streets (nitrogen dioxide concentrations), subsequent to the completion of road system alterations. Both parameters result largely from moving vehicles (number and category of vehicle, renewal of the vehicle stock) and changes in traffic management introduced in Paris between these dates.

The results of this survey demonstrate a 32% overall decrease in the quantities of nitrogen oxides emitted by road traffic in Paris and on the Paris Ring Road (Boulevard Périphérique) between 2002 and 2007. This trend, stemming notably from imposition of stricter vehicle emissions standards, is in any case being confirmed in Europe generally. This survey brings detailed evaluation of the strength of this trend and reveals the impact linked solely to changes in traffic management. In Paris intra-muros (within the bounds of the Boulevard Périphérique) 6% of the decrease is directly attributable to traffic movement changes.

In more detail, this survey also brings out evidence of inconsistent situations within central Paris itself with:

- An improved situation on the main thoroughfares that have undergone alterations, owing to a fall in traffic (both in the amount of nitrogen oxides emitted to the atmosphere and in nitrogen dioxide concentration-based air quality levels) and NO_2 concentrations decreasing over 780 km of the network. The street-level concentrations in nitrogen dioxide still exceed the air quality objectives; nevertheless the concentration decrease expected will allow the statutory limit value for 2007 (46 µg/m^3) to be complied with on 440 km of the road system.
- But also traffic increases on some routes, sometimes linked to traffic transfer pushed on to other sections of the network, which leads to a stagnation of nitrogen oxides emission levels and pollution by nitrogen dioxide (stagnation of NO_2 concentrations on 100 km of the road network); even increases of both parameters in some cases (on 20 km of the network concerning NO_2).

This Paris-scale survey is the first to be done and is particularly innovative. It concerns nearly 900 km of road network and 6900 different street sections.

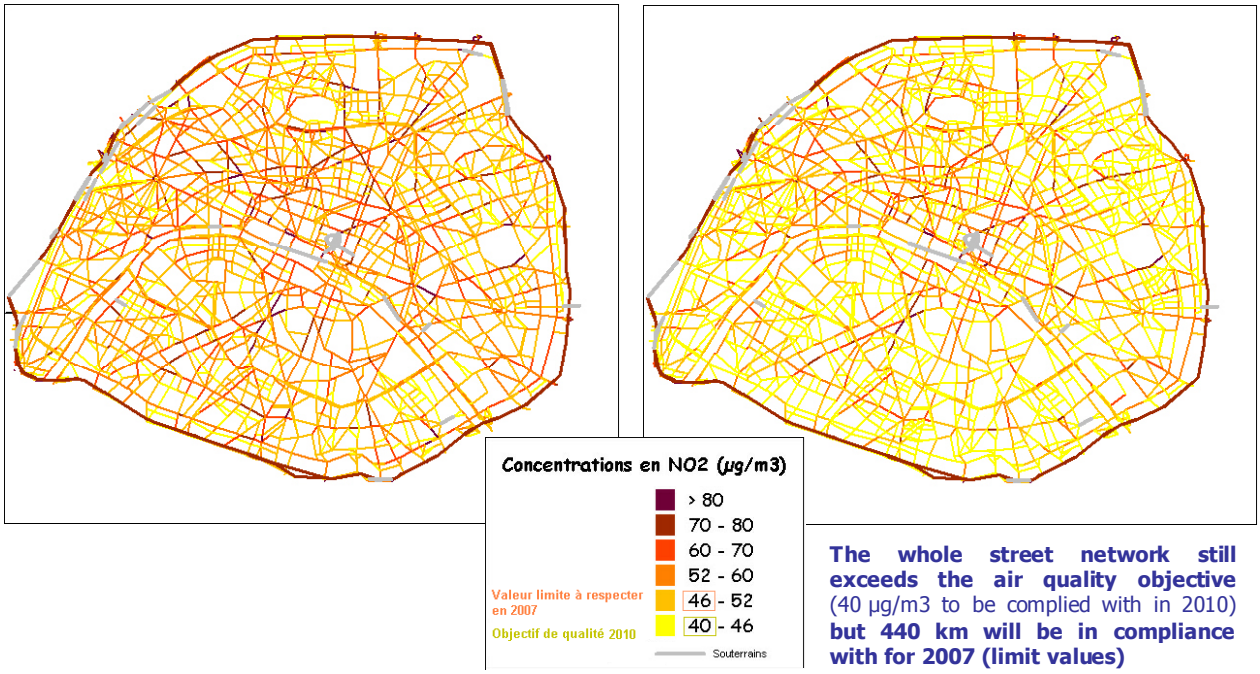
Nitrogen dioxide based air quality is improving on most of the major roads but remains unsatisfactory

The nitrogen dioxide-based street air quality maps for Paris in 2002 and 2007 depict an improvement of the situation during that period. This overall improvement stems from simultaneous changes in other factors: less polluting vehicles, a fall in ambient pollution at the scale of the whole Paris conglomeration, road management alterations and a fall in traffic in Paris.

The fall in concentrations will allow compliance with the statutory maximum value for 2007 (46 µg/m^3) over 440 km of thoroughfares (among the 900 km taken into account in the survey). For comparison, only 160 km gave figures below this concentration of 46 µg/m^3 in 2002. **However, in 2007 as in 2002, all the roads will exceed 40 µg/m3, the quality objective fixed by the regulations and which must be complied with in 2010.**

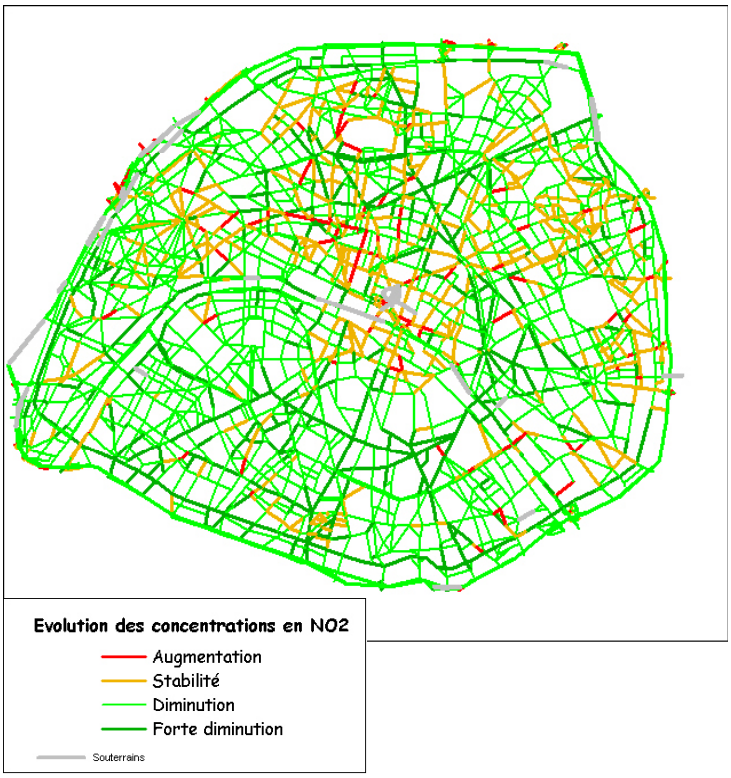
For some streets where concentrations were already particularly high in 2002 (up to twice the target quality value), the 2007 situation is identical. This is so both for the major thoroughfares where traffic has remained dense as for small narrow streets. In the latter pollution is dispersed with greater difficulty and the smallest traffic increase has a large impact.

➢ *Nitrogen dioxide concentrations in the streets of Paris in 2002 and 2007*



The whole street network still exceeds the air quality objective (40 µg/m3 to be complied with in 2010) **but 440 km will be in compliance with for 2007 (limit values)**

➢ *Variations in nitrogen dioxide concentrations in the Paris streets between 2002 and 2007*



- This map shows the large decreases in nitrogen dioxide on some thoroughfares (140 km), in particular on those that have undergone alteration. On 40 km of these roads, decrease can reach almost 10 µg/m^3.
- The streets in light green (640 km) correspond to the expected average fall of the ambient pollution level (4 µg/m^3).
- This map also shows a stagnation in the nitrogen dioxide level in some streets in central Paris and in the North-West of the city (100 km).
- A rise in nitrogen dioxide concentrations was nevertheless detected in some central Paris streets and in the North-West of the city (20 km).

For these 20 kilometres of thoroughfare subjected to the strongest impact (sections in red) this increase is higher than 2 µg/m^3 and can reach 15 µg/m^3. The rise in nitrogen dioxide levels in these streets is linked to increases in traffic.

Fall in NOx pollutants emitted into the Paris atmosphere: -32% between 2002 and 2007, -6% of which are linked solely to traffic changes in Paris intra-muros

In order to explain the changes in concentration, the results on emissions are presented in the following paragraphs.

➢ *Overall trends in nitrogen oxides emissions in Paris between 2002 and 2007*

	Total change %	**Change linked solely to traffic changes**	**Change linked to technical improvements to vehicles**
NO_x emissions in Paris intra-Muros	**- 32 %**	**- 6 %**	**-26 %**
NO_x emissions on the Paris ring road	**-32 %**	**No change**	**- 32 %**

The decrease of –6% resulting from traffic movement changes come essentially from the fall in traffic volume in Paris. It is also explained by modification of the distribution of vehicle categories (cars, delivery vehicles, motorized two-wheeled vehicles, heavy goods, buses) and for transport movement conditions in Paris, due notably to road system management changes.
In the case of the Boulevard Périphérique, the change in traffic is not influential on these results. The decrease stems solely from technological changes and changes in the vehicle stock. This technologically-linked decrease is more prominent on the Paris Ring Road, because the gain in terms of pollution for new generation vehicles is higher at around 40 km/h, the average speed on that road, than at 15 km/h, the speed in Paris within the Paris intra-muros.

The survey results show a significant fall in NO_x emissions in Paris between 2002 and 2007, for all vehicle categories except motorized two-wheel vehicles. The strongest decrease is that of private vehicles (about 50%) linked to improvements in the vehicle stock and the fall in traffic volume. The NO_x emissions produced by this category remain however the largest proportion in 2007 (i.e. 43 % of total NO_x emissions). For the motorized two-wheel vehicles, technical improvement to the stock does not compensate for the increase in traffic. Emissions form this category have doubled. Nevertheless, the contribution of motorized two-wheel vehicles to total emissions is still the smallest (4% in 2007).

NO_x emissions from utility vehicles are practically stable, in spite of a 25% rise in traffic. They represent about 21% of total emissions. Emissions from buses were slightly lower, in spite of a 10% increase in traffic. They represent about 17% of total emissions.

On the Boulevard Périphérique, whereas in 2002, private vehicles were the primary contributors to NO_x emissions, in 2007 heavy goods vehicles are becoming the main contributors with 41%. This ties in principally with technological improvements to private vehicles, whose emissions fell 54% between 2002 and 2007. Heavy goods vehicles have however lowered their emissions by 20% in spite of a 10% increase in traffic. As in Paris intra muros, motorized two-wheel vehicles have seen their emissions doubled but they represent only 1% of all emissions. Finally, the emissions from utility vehicles remained stable even though their traffic increased by 17%.

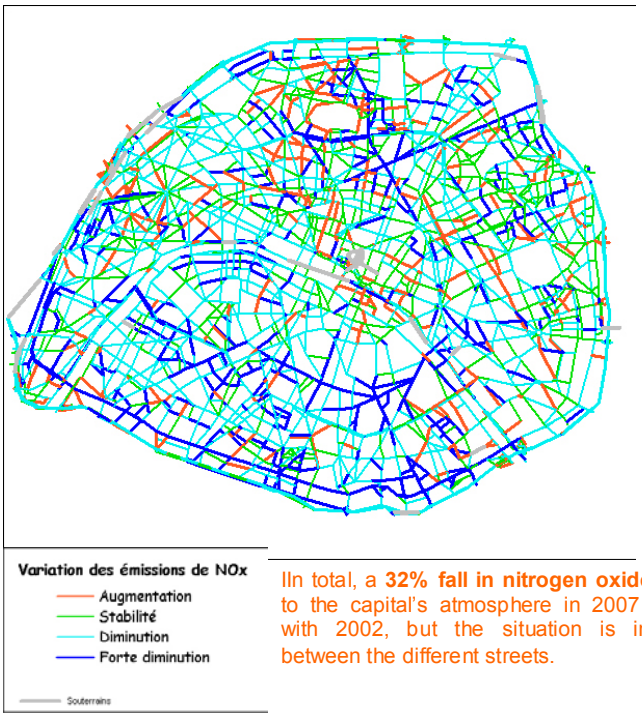
Inconsistent change in emissions between different streets

Although the general trend is one of decreasing emissions, wide variations are seen in different parts of the city of Paris. Those variations are directly limited with traffic movement changes. These differences can be directly linked to developments in traffic patterns.

➢ *Total variation of nitrogen oxides emissions between 2002 and 2007*

This map depicts the overall 32% decrease in NO_x emissions produced by road traffic in Paris between 2002 and 2007.

- Some main roads have seen a very marked fall in their emissions (over –50%, routes in dark blue). This striking fall goes beyond that which can be attributed solely to technological improvements to traffic (-26%). It can be explained essentially by significant decreases in traffic, notably on thoroughfares where road layout and management works have been done.
- The decrease in nitrogen oxides emissions on the roads indicated in light blue is equivalent to that linked to the technological improvement of vehicles.
- This map also shows a stagnation of emission levels for certain traffic routes and streets.
- An increase in emissions (greater than 15%) for several roads which again is explained by traffic changes and, in some cases, by transfer of traffic on to these major road links.



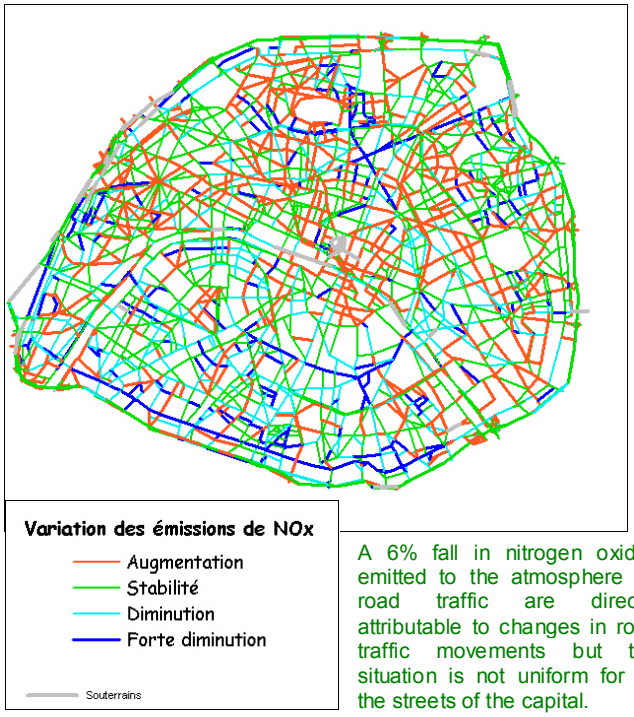
In total, a **32% fall in nitrogen oxides emitted** to the capital's atmosphere in 2007 compared with 2002, but the situation is inconsistent between the different streets.

➢ ***In the absence of technological changes to the vehicle stock,*** *variations in nitrogen oxides emissions between 2002 and 2007 would have been as follows :*

This map serves to explain the previous one. It shows the changes in nitrogen oxides emissions that are directly attributable to road layout and management alterations. It highlights:

- a positive effect on the nitrogen oxide emissions on the roads of the system that have undergone alterations,
- no effect on emissions on thoroughfares depicted in green,
- a negative effect on emissions concerning routes that have experienced increase in traffic.

Comment :
It corresponds to an exercise aiming to show the specific impacts of traffic changes on nitrogen oxidesemissions. Only the previous map depicts the effective variations of these emissions..



A 6% fall in nitrogen oxides emitted to the atmosphere by road traffic are directly attributable to changes in road traffic movements but the situation is not uniform for all the streets of the capital.

Traffic data used:

A stable speed, fewer cars and heavy goods vehicles but more motorized two-wheeled vehicles, delivery vehicles and buses

This survey as a whole is based on traffic data provided by the Paris City Council's Roads and Traffic Department. The changes between 2002 and 2007 of the vehicle categories are as follows for Paris intra muros (expressed as kilometres travelled) :

- Private cars : - 15%
- Motorized two-wheeled vehicles : + 25%
- Buses (public transport): + 10%
- Delivery vehicles : + 25%
- Heavy goods : - 11%
- Tourist coaches : - 11%

These data originate from traffic data used for calculation of emissions.

On the *Boulevard Périphérique*, the following changes in vehicle categories occurred :

- Private cars : - 5%
- Motorized two-wheeled vehicles : + 31%
- Delivery vehicles : + 17%
- Heavy goods : + 10%
- Tourist coaches : - 5%

On average, the speed stayed stable between 2002 and 2007, but this overall tendency covers some widely inconsistent situations between different streets.

The situation concerning carbon dioxide

Carbon dioxide (CO_2), unlike nitrogen dioxide, has no effect on local atmospheric pollution or on health. It is, however, a greenhouse gas: the large quantities of this gas emitted into the atmosphere by human activities are responsible for global warming.

➢ **Overall change in carbon dioxide emissions in Paris intra muros and on the Paris Ring Road between 2002 and 2007:**

	Total change %	Change linked solely to traffic changes	Change linked to technical improvements to vehicles
CO_2 emissions in Paris Intra-Muros	-9 %	-11 %	+2 %
CO_2 emissions on the Paris ring road	+ 6 %	/	+ 6 %

In Paris intra muros, the expected overall change for carbon dioxide in 2007 compared with 2002 is a 9% decrease. Unlike nitrogen oxides, **the fall linked to road system alterations and to the fall in road traffic in Paris is dominant in this overall decrease: - 11%. In this case, technical changes to vehicles lead to a 2% increase in carbon dioxide emissions.**
The increase in CO_2 emissions on the Paris Ring Road is mainly linked to the increase in the proportion of heavy goods and utility vehicles in the total traffic.

The proportion of CO_2 emissions stemming from private vehicles is greater within Paris itself. Its respective figures are 79 and 74% for 2002 and 2007. As for utility vehicles, the contribution to CO_2 emissions is 9% and 12% for 2002 and 2007. The other vehicle categories contribute less than 5% during the two years studied. The fall in CO_2 emissions is linked exclusively to the decrease in traffic in Paris intra muros. Again, correspondence is found between the change in the number of kilometres travelled and the changes in the emissions by vehicle type. Only the motorized two-wheel vehicles and utility vehicles show a different trend. The 25% increase in kilometres travelled by motorized two-wheel vehicles is linked to the rise in the number of powerful motorcycles with higher fuel consumption, and notably those with 4-stroke engines. However, it should be recalled that the proportion of emissions from motorized two-wheel vehicles is low compared with total CO_2 emissions (2% in Paris intra muros).
The increase in CO_2 emissions on the Paris Ring Road is mainly connected with the rise in the proportion of heavy goods vehicles in the traffic (+ 10%) and, to a lesser extent, to that of utility vehicles (+ 17%).

APPENDIX : context of the survey

Only a detailed study conducted using modelling tools could show specifically the impact of alterations and changes in traffic management implemented on the road system of Paris :

- between 2002 and 2007,
- around 900 km of streets in the capital.
- while removing meteorological effects from considerations and distinguishing the effects due to technological improvements to vehicles.

Modelling tools also provide a means to take into account the effects of parameters -such as the composition of the vehicle stock (type and age of the vehicles), the number of vehicles or the type of thoroughfare (a large boulevard or a small enclosed street), and also variations in the speed of traffic observed on each main roadway depending on the time of day- that observations from measurement stations do not permit. At the scale of the Paris conglomeration, the atmospheric pollution levels measured by Airparif monitoring stations result mainly from the combined effects of two parameters: the quantity of pollutants produced (emissions) and meteorological conditions (producing varying degrees of dispersion from one year to another or from one day to another), without the possibility of distinguishing them and therefore identifying the exact trends. However, these measurements are essential for comparing the results of model-derived calculations with the real situations.

In the streets, pollution coming from traffic adds to the background pollution present in Paris and its conurbation. For a given street, the strength of the impact of traffic on its pollution level will depend on :

- its immediate environment (an open or enclosed area),
- the intensity of traffic movements,
- the type of vehicles,
- their speed.

It is this local impact of traffic which is influenced directly by changes in road layout and management consequent on traffic and transportation policies implemented by the City Council of Paris over the past few years.

Two scenarios have been studied, with the aim of interpreting the trends in emissions of nitrogen oxides and carbon dioxide in Paris, as follows :

1- **The overall trend in quantity of these pollutants emitted into the atmosphere which takes into account both**
   - the effects of technological improvement to vehicles and therefore of the stock of vehicles (the new EURO IV vehicles are about 10 times less polluting than previous models)
   - and the impact of road layout and management alterations on traffic

   This corresponds to the real changes taking place in emissions and traffic.

2- Within this overall trend, **the changes linked solely to modifications in traffic movements (road system alterations and reduction in traffic) in Paris.**
   This trend can be calculated by taking for 2007 the same vehicle stock with its technological attributes as for 2002.

The total trend = effects of improvements to vehicles + impact of changes in traffic

The choice of pollutants studied

The oxides of nitrogen (NOx), to which nitrogen dioxide belongs, were chosen because they are indicators of atmospheric pollution produced by vehicles. Moreover, nitrogen dioxide comes under statutory control owing to its effects on health. In Paris, this pollutant exceeds the levels stipulated by regulations, both for background pollution and places near traffic where concentrations are even more of a problem (reaching figures twice as high as statutory maxima).

Furthermore, these are the pollutants for which modelling tools are the most robust because we have available a large amount of data on their emission and dispersion. Conversely, for dusts, modelling yields less precise descriptions of their emissions. Furthermore, as the processes of their formation in the atmosphere are complex (direct production, trans-border influx, suspension formation and chemical formation), calculation tools for determining their levels are subject to large degrees of uncertainty.