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PARTICULATE MATTER AND NITROGEN DIOXIDE IN THE BRUSSELS AMBIENT AIR. TO WHAT EXTENT LOCAL EMISSION REDUCTIONS NEED TO BE DRASTIC TO ENABLE COMPLIANCE WITH THE EU LIMIT VALUES

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Abstract

Over the past 40 years ambient air quality in Brussels improved significantly. This was especially true for sulfur dioxide, lead, nitrogen monoxide, carbon monoxide, benzene and Benzo a pyrene. With respect to the air quality objectives imposed by the most recent European directive on air quality, 2008/50/EC, two major problems remain: nitrogen dioxide (NO2) and particulates (PM10 and PM2.5). Although the air quality objectives are met at several measuring sites in Brussels, a thorough analysis of data shows that it will be impossible to become fully compliant, in due time, in all of the different urban environments. A comparison of the average concentration levels in the Brussels Capital Region with those in the surrounding regions, the interpretation of the average daily and weekly concentration profiles and some special observations (e.g. car free Sundays) make clear that drastic emission reductions will be needed if compliance is to be assured solely by measures on the local scale.

Keywords: *air quality, particulates (PM10 and PM2.5), air quality objectives*

Rezumat

Microparticulele şi dioxidul de azot din aerul mediului ambiant din Bruxelles. Măsura în care reducerile locale de emisii trebuie să fie drastice pentru a respecta valorile limită impuse de UE. În ultimii 40 de ani calitatea aerului din Bruxelles s-a îmbunătățit semnificativ. Acest lucru s-a remarcat mai ales la dioxidul sulfurat, plumbul, monoxidul de azot, monoxidul de carbon, benzenul şi benzo-pirenul. Obiectivele pentru calitatea aerului impuse de directivele europene recente referitoare la calitatea aerului, 2008/50/EC sunt dioxidul de azot (NO2) şi microparticulele (PM10 şi PM2,5). Deşi obiectivele referitoare la calitatea aerului sunt îndeplinite în câteva dintre locurile de măsurare din Bruxelles, o analiză minuțioasă a datelor indică faptul că este imposibil ca acestea să fie respectate. O comparație a nivelurilor medii de concentrație din regiunea capitalei cu cele din regiunile înconjurătoare, interpretarea profilelor concentrațiilor zilnice şi săptămânale medii şi a câtorva observații (ex. duminicile când circulația maşinilor este interzisă) reflectă clar faptul că reducerea emisiilor este necesară dacă trebuie asigurată respectarea doar prin măsurile luate la nivel local.

Cuvinte-cheie: *calitatea aerului, microparticule (PM10 şi PM2,5), obiective pentru calitatea aerului*

INTRODUCTION

The Brussels Capital Region, situated in the centre of Belgium, has a population of 1,048,000 people (2008) and a surface of 161,4 km^2 and it represents about 19% of the Belgian GDP (gross domestic product). Due to the political reform of the Federal State in 1988, the three Regions in Belgium, Flanders, Brussels and Wallonia, have obtained full responsibility over Environmental matters. Air quality objectives imposed by the European Directives have to be transposed by the Member States and, in the case of Belgium, the legislation has to be adopted by the three Regional Parliaments. Thus, since 1988, meeting the environmental objectives on their territory is the responsibility of the Regional Governments.

On May 21, 2008, the European Commission sorted a new directive on ambient air quality and a cleaner air for Europe (*2008/50/EC*), integrating the former frame directive on air quality (*1996/62/EC*) and the subsequent daughter directives on SO_2, NO_2, PM10 en Pb (*1999/30/EC*), benzene and CO (*2000/69/EC*) and O_3 (*2002/3/EC*). The new directive confirms all previous defined air quality objectives limit values as well as target values and, for PM2.5, new air quality objectives are imposed. The subtle difference between the two types of objectives is hat limit values must be attained within a given period and may not be exceeded again once attained and that target values are to be attained where possible. The target values for arsenic, cadmium, nickel and Benzo a pyrene, imposed by the directive *2004/107/EC*, will be integrated at a later stage.

The state of the art and the compliance with the European objectives in the Brussels Capital Region are described in this paper. Two major problems remain: limit values concerning nitrogen dioxide (NO_2) and Particulate Matter (PM10) are still not respected.

2. EVOLUTION OF AIR QUALITY IN BRUSSELS - COMPLIANCE WITH EC-DIRECTIVES

2.1 Air Pollution Network

Systematic measurements for air pollutants in Brussels started in 1968 with the realization of a semi-automatic network for SO_2 and "Black Smoke". In the year 1973 a second semi-automatic network for "heavy metals" (e.g. lead) was added. From 1978 on, the telemetric network for the surveillance of the ambient air quality in real time became operational. Actually the Brussels telemetric network counts for 11 sites, located in different types of urban environments, measuring a selection of several pollutants: nitrogen oxide and dioxide, ozone, sulfur dioxide, carbon monoxide, carbon dioxide, benzene, mercury vapor and the PM10 and PM2.5 fraction of the suspended particulates (particulates with an equivalent diameter up to 10 or 2.5 µm). The presence of nitrogen oxides is measured in all 11 measuring sites, PM10 and PM2.5 respectively in 6 and 5 locations. More recently, in 2002, the network was extended with 2 traffic road tunnel stations for measuring NO, NO_2 and CO. Other semi-automatic networks for other classes of pollutants were also installed: measurements for VOC (volatile organic components) started in the period 1987-1994 and for PAH (polycyclic aromatic hydrocarbons), a few years later in 1999.

2.2 State of the art: Air Quality in Brussels

In the period 1970-1990 the observed concentrations for certain pollutants, especially SO_2 and lead (Pb) decreased drastically. For SO_2 this was mainly due to the lowering in several stages, of the sulfur content in combustion fuels and the gradual replacement of coal and liquid fuels by sulfur free natural gas for domestic heating. For lead, this result was obtained by limiting the quantity of Pb-additives in gasoline and, from 1989 on, by the use of Pb free gasoline. The evolution of the Pb concentration since 1973 for different types of stations is given in Fig. 1.

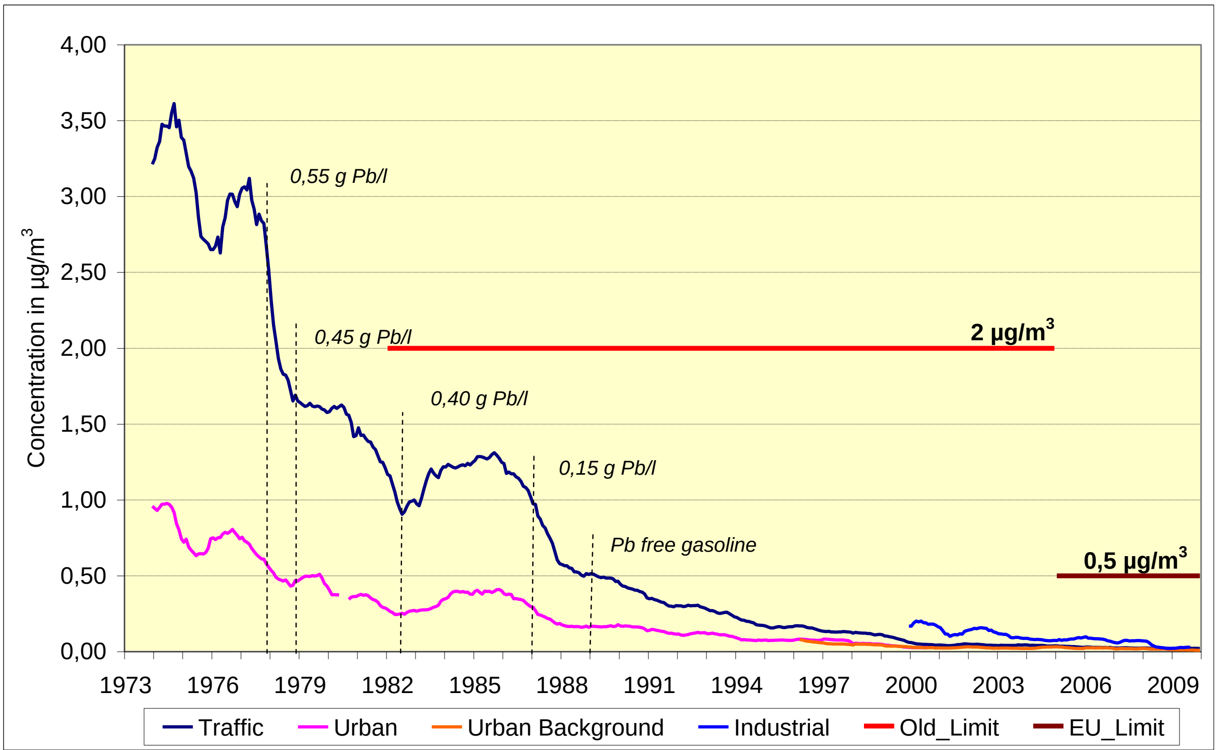

Fig. 1. Evolution of the Pb concentration [µg/m3] in Brussels between 1973 and 2009

Although these two problems seemed easily to solve, mainly by the systematic reduction of the pollutant content in the fuel, it took almost two decades to alter, on a large scale, the technology and production processes in use in some of the most important industrial and economic sectors such as power generation, refineries and the production of automotive engines.

In the same period traffic intensity increased significantly and the presence of traffic related air pollutants became the priority problem: nitrogen monoxide (NO), nitrogen dioxide (NO_2) and associated to it, ozone (O_3), volatile hydrocarbons (VOC) and suspended particulates. The pollutants are not necessarily present in the fuel, but may be formed as a by-product of the combustion processes. Nitrogen monoxide is formed by recombination, at high temperature, of small quantities of nitrogen and oxygen present in the combustion air. Other pollutants are generated by atmospheric reaction processes as it is entirely the case for ozone (secondary pollutant) and partially for NO_2 and particulates (secondary aerosol). Therefore, measures to reduce the concentration of these pollutants are not as easy to implement as it was the case for SO_2 and Pb. Moreover, the obtained concentration benefits will most certainly not be proportional to the local emission reduction efforts. For NO_2 and the related O_3 problem, a supplementary difficulty lies in the fact that NO_2 is thermodynamically the more stable component of the nitrogen oxides at ambient temperature and pressure.

Therefore NO_2 is always and anywhere present in sufficient quantities so that excessive ozone formation can take place when meteorological conditions are favorable to it. A decrease by more than 50% of the nitrogen oxides (NO_X) emissions from road traffic between 1990 and 2007, mainly due to the introduction of the 3-way catalyst on gasoline cars, and a concurrent shift towards diesel engines, led to a significant decrease of the NO-concentrations in traffic oriented measuring sites. Despite this favorable evolution, no clear tendency for the NO_2 concentrations (near status quo) has been observed so far.

Furthermore, the increasing number of diesel powered vehicles over the past decade did and does not help to reduce the ambient NO_2 concentration level. Up to now diesel engines do not have de-NO_X systems installed and, compared to gasoline engines, they have a higher NO_2/NO_X output ratio. In a Brussels road tunnel, the mean average NO_2/NO_X ratio (volume/volume) raised from 0.12 to 0.24 over the period 1989-2008.

In 1989, the year of introduction of the 3-way catalyst in Belgium, about 20% of the car fleet was composed of diesel cars. The increased prices for catalyst equipped gasoline cars and especially the continuation of the lower taxation on diesel fuel by the Federal State has led to a changeover to diesel cars. In 2008, about 80% of new sold cars were diesel cars and they now represent about 60% of the total car fleet.

A rough estimate based on the evolution of the composition of the car fleet between 1989 and 2008, the increase of the traffic volume and the total mileage, the relative importance of NO_X emissions from gasoline cars compared to those from diesel cars and the evolution of the NO_2/NO_X ratio measured in road tunnels, learns that an opportunity has been missed to lower significantly the NO_2 emissions originating directly from road traffic. If the composition of the car fleet would have stayed unchanged since the introduction of the 3-way catalyst in 1989, then the NO_2 traffic emissions should have been lowered by approximately 35% compared to the actual situation.

Over the period 1990-2007 the overall NO_X emissions in the Brussels Capital Region decreased from 10,388 to 4,848 tons/yr and the traffic related NO_X emissions from 6,974 to 2,391 tons/yr. The 3-annual average concentrations measured in a traffic oriented site, situated in a canyon street, respectively for the periods 1990-1992 and 2006-2008 showed a nearly proportional decrease for NO from 118 to 37 $\mu g/m^3$, but for NO_2 only a limited decrease from 58 to 54 $\mu g/m^3$ was observed. These evolutions are represented in Fig. 2. For the particulates (PM10 and PM2.5) the problem is even more complex. Besides the anthropogenic emissions (combustion, traffic, production processes, etc.), major contributions to the total mass concentration of the particulates in the Brussels ambient air are coming from airborne aerosol (formation of secondary particulates) and from the (re)suspension of the coarser PM fraction, particulates with an equivalent diameter between 2.5 and 10µm.

The introduction of the 3-way catalyst had also beneficial effects on the CO concentration in a traffic environment, with a nearly 80% decrease between 1991 and 2008 (1.62 to 0.33 mg/m^3 CO). Together with a reformulation of the gasoline it also led, since 1997, to a 75% decrease of the benzene levels from 8.4 to 1.9$\mu g/m^3$ in a traffic station.

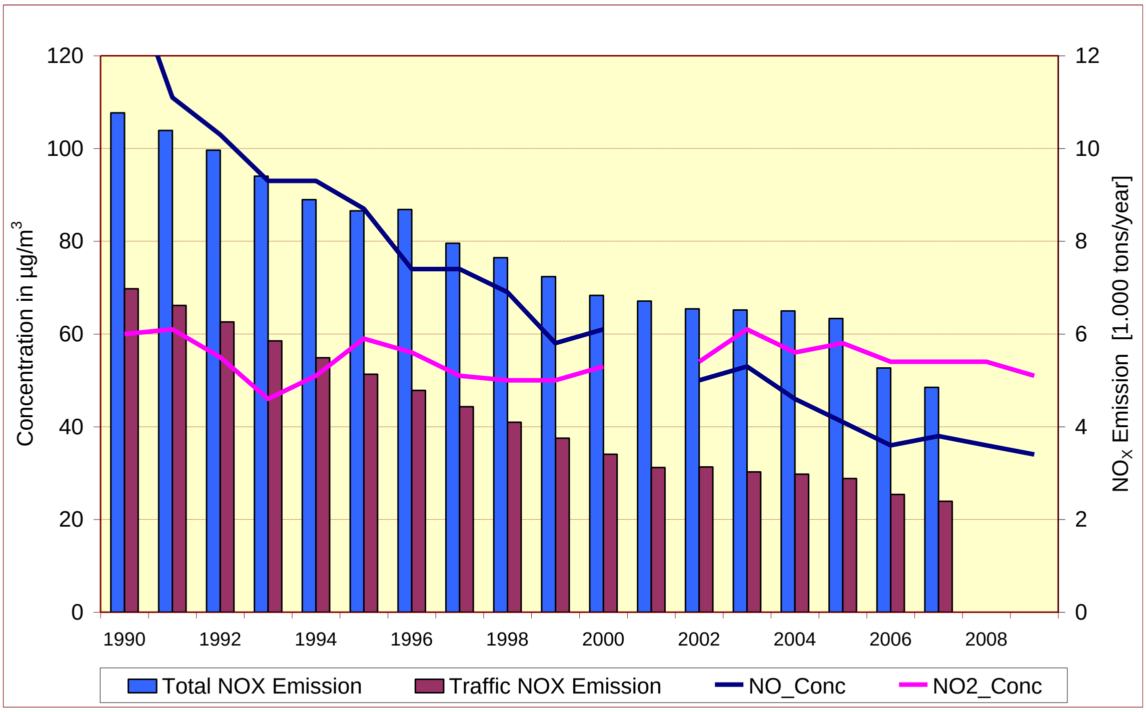

Fig. 2. NO and NO2 – Evolution of the annual average concentration in a street canyon (1990-2009) and of the total and the traffic NOX emissions in Brussels (1990-2007)

The evolution of the benzene concentration between 1987 and 2008, for some stations in Brussels, is given in Fig.3. Over the past years (1999-2008), a clear decrease in the PAH levels originating from traffic was also observed.

2.3 Compliance with EC-directives

In the Brussels Capital Region the limit values for SO_2, Pb, CO (all had to be attained by 2005) and benzene (by 2010) are respected and they will stay respected in the coming years. The target values for arsenic, cadmium, nickel and Benzo a pyrene (all to be attained by 2013) are also respected. Problems remain with one limit value for NO_2 and one target value for O_3, both to be met by 2010, and one limit value for PM10, which had already to be met by 2005. In agreement with the regulations of the directive 2008/50/EC, a request for a postponement of the attainment date up to 2011 was send to the Commission, but by lack of proof of the efficiency of the proposed measures, this postponement was not granted to Belgium.

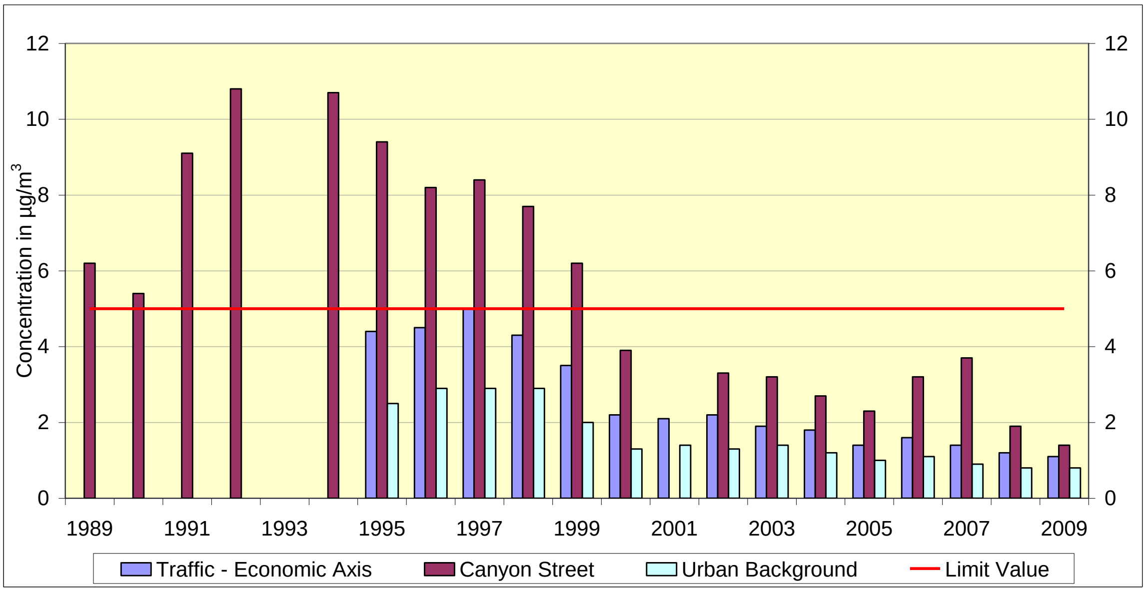

Fig. 3. Benzene concentration at different sites in Brussels

2.3.1 Nitrogen dioxide (NO_2)

The air quality directive specifies two limit values to be respected by 2010. First, the hourly value of 200µg/m^3 may not be exceeded more than 18 times during the calendar year. Second, the annual average concentration may not exceed 40µg/m^3. The limit value for the hourly values is respected up to now and it will probably stay so in the immediate future. The limit value for the annual average concentration however is not respected in all the measuring sites of the Brussels Capital Region. In 2010, the limit value will certainly be exceeded in at least 3 traffic oriented sites, while still no guarantee can be given for 5 other urban sites. The limit value will only be respected in 3 urban background sites that are protected from the direct influence of the local traffic.

Over the past few years (2004-2009) the annual average NO_2 concentration level reaches about 50 to 55µg/m^3 in a street canyon, about 42 to 46µg/m^3 at sites exposed to the traffic but situated in a better ventilated environment and about 37 to 43µg/m^3 in urban sites. The annual average concentration at urban background sites is about 27 to 30µg/m^3. If the emission activities of all working days would be replaced by the activities of the 'average Saturday', then the annual mean concentration would be around 48 to 52µg/m^3 in the street canyon, about 38 to 42µg/m^3 in the exposed sites and about 24 to 28µg/m^3 at the urban background sites as it can be seen in Fig. 4.

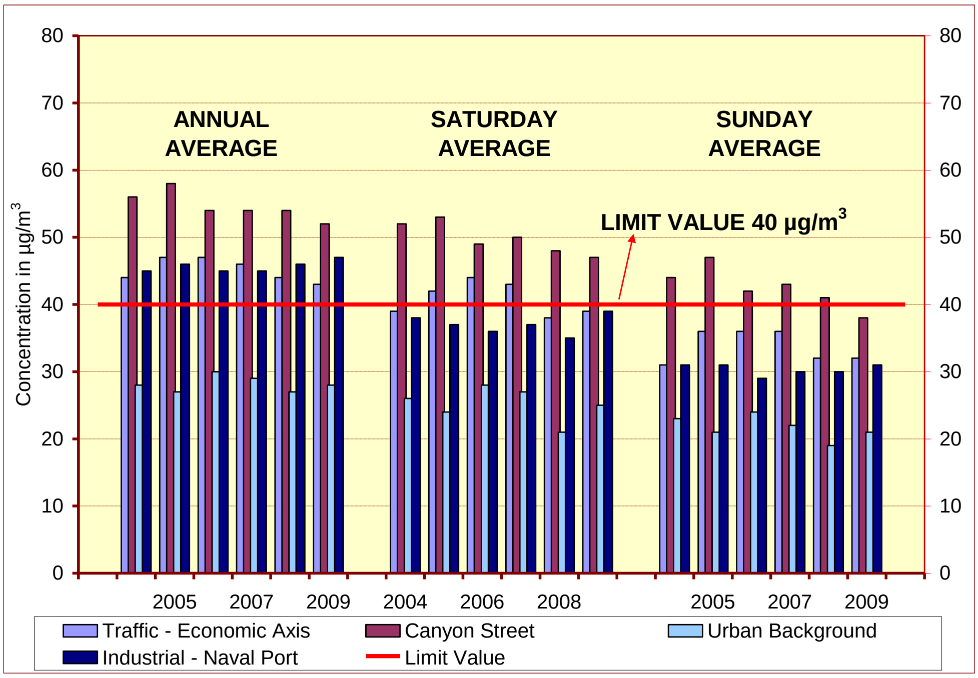

Fig. 4. NO2 at different stations in Brussels - Comparison between the annual average concentration (left) and the mean concentration for Saturdays (middle) and Sundays (right) for the period 2004-2009

For the 'average Sunday' situation, the mean concentration would still be around 40 to 42µg/m^3 in the street canyon, about 30 to 35µg/m^3 in the exposed sites and about 20 to 24µg/m^3 in the urban background sites. The experience with the car free Sundays, organized in the second half of September (2002-2009), introducing a nearly complete ban of all private motorized traffic over the entire Brussels Region between 9:00 and 19:00 h local time, has clearly demonstrated the potential of reducing NO_2 concentrations significantly. It is important to state that this result has been and can be obtained by a drastic emission reduction that has its application only inside the Brussels Capital Region (Vanderstraeten, 2009); (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006).

Nevertheless, the realization of a permanent equivalent to such drastic emission reductions (e.g. car fleet virtually free of NO_X emissions) in the near future seems not very realistic. The obligation of lowering the NO_X emissions from diesel cars (EURO 6) by 2014, combined with different measures to reduce the traffic and the related NO_X emissions gradually but in a sustainable way, could be the start of an evolution that may lead to a significant decrease of the NO_2 levels and hence to compliance with the EU directive in all types of urban stations, traffic as well as non traffic oriented locations. However, before such drastic reductions will be realized, the NO_2 problem will probably stay on the agenda for the next decade. Taking into account that the lowering of the NO_X emissions from diesel cars will start only by 2013/2014 (EURO 6) and that, considering an average lifetime of 10 to 12 years for the vehicles, a minimum period of 4 years is to be counted before a substantial part of the diesel cars are replaced, a significant decrease in the NO_2 levels leading to compliance may not be expected before 2017/2018.

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2.3.2 Ozone (O_3)

The European directive specifies two target values for ozone, both to be met by 2010. First, during the calendar year, there may not be more than 25 days, averaged over 3 consecutive years, with a maximum daily 8-hour value above 120µg/m^3 ozone. Second, the AOT40 value, computed from the 1 hour values in the period May till July may not exceed 18.000µg/m^3.h, averaged over 5 years. This second obligation is respected and will probably stay respected during the following years. Up to now there is no absolute guarantee for respecting the first target value. The evolution over the past years shows indeed a decrease in the frequency of the peak values, e.g. the evolution of the number of hourly values higher than the information threshold of 180µg/m^3, but a slight increase in the annual average concentration.

During the period 1994-2008, the number of days with a maximum 8-hour value higher than 120µg/m^3 assessed at the urban background stations indicating the highest ozone levels, ranges between 13 and 39, resulting in a 3-year average between 17 and 25 days as is illustrated in Fig. 5.

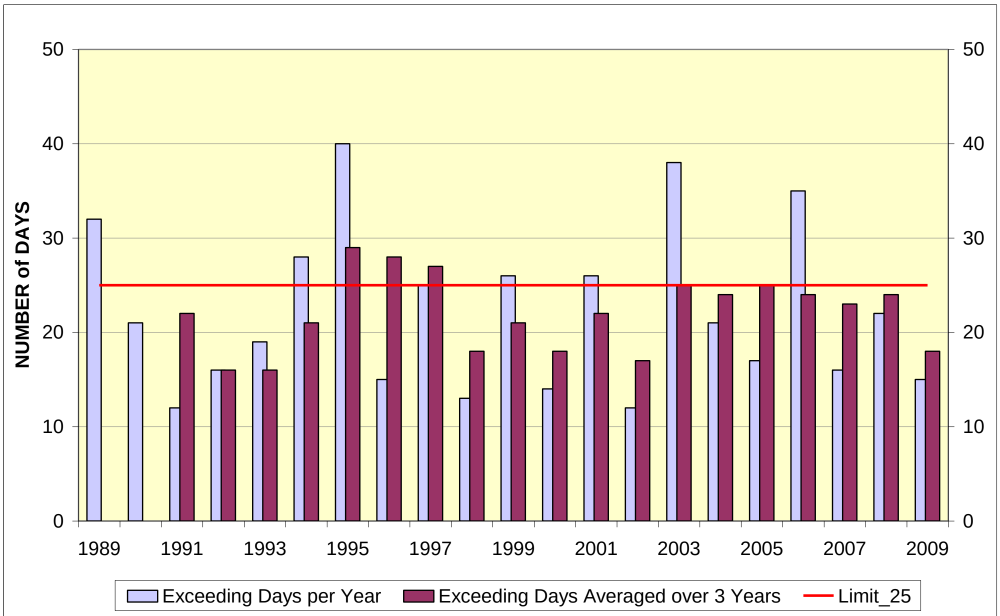

Fig. 5. Ozone at an Urban Background Site – Number of days, per Year and Averaged over 3 Years, with the maximum 8-hour value exceeding 120µg/m3 (Target Value)

In view of the threat of global warming, with the risk for more frequent hot summer periods, and considering the already increasing average ozone concentration, some non compliances may eventually be expected in the forthcoming years. Because of the link with NO_2 and due to the non linearity of the ozone formation process, a solution for this problem will only be possible if the emissions of the ozone precursors (NO_2, VOC) are reduced significantly, on a large scale, and in a sustainable way. 2.3.3 Particulate Matter (PM10).

The air quality directive foresees two limit values for PM10 in ambient air, both of them had to be met by 2005. First the annual average concentration may not exceed 40µg/m^3. Second, during a calendar year, there may be no more than 35 days with a daily average concentration higher than 50µg/m^3. The limit value for the annual average is respected at all Brussels measuring sites since 2005. The limit value for the daily average is not respected now and it will probably remain so during the following years. This daily limit value is respected in the typical urban background sites, but it is systematically exceeded in the two measuring sites located along the industrial and economic axis of the Region. For these sites the annual number of exceeding days is ranging between 45 and 65. For the urban background site the number is between 15 and 40 and for the urban sites it is between 25 and 40.

For 2005, 2006, 2007 and 2009 it seems that the weekend days are well represented amongst the exceeding days, indicating that the limit value could eventually not be respected even for a year having a permanent weekend emission regime. For a selection of measuring sites and for the calendar years 2005 till 2009, the real number of exceeding days is represented at the left side of Fig. 6.

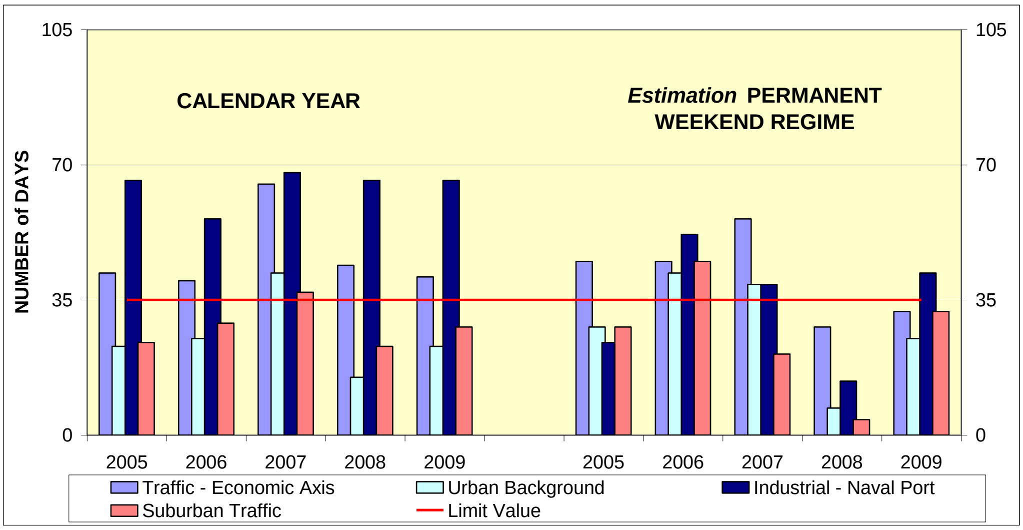

Fig. 6. PM10 – Number of exceeding days (left) for different measuring sites and the estimated result (right) for a permanent weekend emission regime (2005-2009)

These results are compared with, at the right of the graph, the number of exceeding days expected under a permanent weekend emission regime, as estimated by extrapolating the number of weekend exceeding days. In the Brussels Capital Region at least 3 different phenomena may lead, separately or by combination, to elevated PM10 concentrations and to an increased risk of exceeding the 50µg/m^3 limit value for the daily mean concentration.

- Meteorological conditions with poor dispersion, due to a temperature inversion and low wind speed, are a common factor resulting in high concentration levels for different pollutants. Under these conditions, mainly occurring in winter time, between December and February, high concentration levels are detected at all sites, inducing simultaneous PM10 exceeding values at several locations. In these cases the temporal evolution of the mass concentration for PM10 and for the gaseous pollutants (NO, NO_2) are quite similar.
- A second phenomenon, very important and still largely underestimated, is the formation of secondary aerosol during the period March-April and, to a lesser extent, September-October. The spreading of manure on a large scale, in the surrounding regions, before and after the agricultural season, releases a massive source of ammonia coming from the agricultural fields. At conditions of moderate temperature (8-20°C) and high Relative Humidity (80-90% RH) a stable secondary aerosol (Stelson, Seinfeld, 1982, pp. 983-992) is formed with ammonium nitrate as a main component. In these cases nearly 80 to 90% of the total PM10 mass concentration consists of

PM2.5, including volatile and/or possibly dissociating components that are mainly present within the PM2.5 fraction (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006). The concentration increases gradually and high PM10 concentrations, exceeding the daily limit value, are detected simultaneously over an extended area, much larger than the Brussels Capital Region. Furthermore, the temporal evolution of the PM mass concentration may be quite different from the temporal pattern followed by components that are more directly linked with the local traffic emissions, such as NO and NO_2 (Vanderstraeten, 2009); (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006). In April 2007, and again in April 2009, between 8 and 16 exceeding days were counted at the different measuring sites in Brussels, with secondary aerosol as a main contributor. Since the application of the daily limit value in 2005, PM10 exceeding values are most frequently observed (Fig. 7) during the spring, especially during the months March and April.

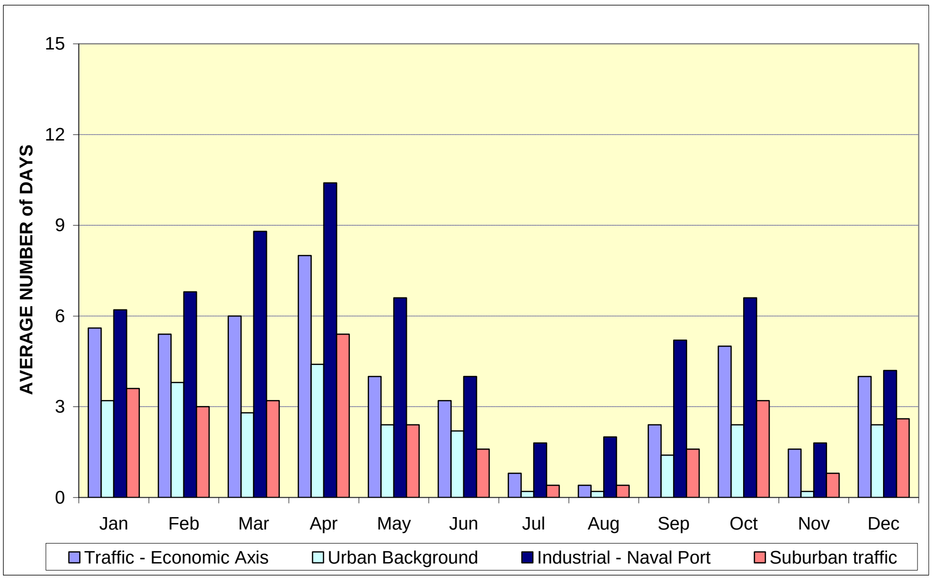

Fig. 7. PM10 – Averaged number of exceeding days per month. Period 2005-2009

- The third phenomenon, (re)suspension of the coarser fraction, is linked with the advection of dry air coming from the large sector East. Under these conditions and in the presence of a local source of the coarser fraction, these particulates (2.5 to 10µm) are suspended by a local activity, by the wind and/or by the turbulences created by the traffic. This may lead to the detection of high PM10 concentrations at a limited number of sites, situated close to the street or to a local source. In these cases PM2.5 represents only 40 to 50% of the total PM10 mass concentration and no volatile or dissociating material is detected. In the Brussels Capital Region, the second limit value for PM10, not more than 35 days with a daily concentration higher than 50 µg/m^3, is systematically violated at two different sites, the industrial site at the Brussels naval port (N043) and the traffic site (R001 - Molenbeek) located along the industrial and commercial axis. An analysis of the wind direction and classes of relative humidity, corresponding to the exceeding days, makes clear that, for these two sites, the excess of exceeding values is strongly correlated with the presence of dry air coming from the sector East. In Fig.8, for all six measuring sites and all exceeding days for the period 2006-2008, the percentage of the exceeding time for each of the main wind sectors is represented by the solid lines. The results are quite similar for four of the six PM10 stations, but they are much higher, for the large sector East, at the two sites situated along the commercial and industrial axis. Results much closer (hashed lines) to those of the four other sites are obtained when recalculating the percentages with omission of the exceeding days that are exclusive for one or both of these two sites, meaning that the additional number of exceeding days are strongly correlated with the large sector East. A similar exercise also reveals a strong correlation with the lower classes of Relative Humidity. The local presence of the coarser fraction is related to the storage and the handling of bulk material for construction purposes.

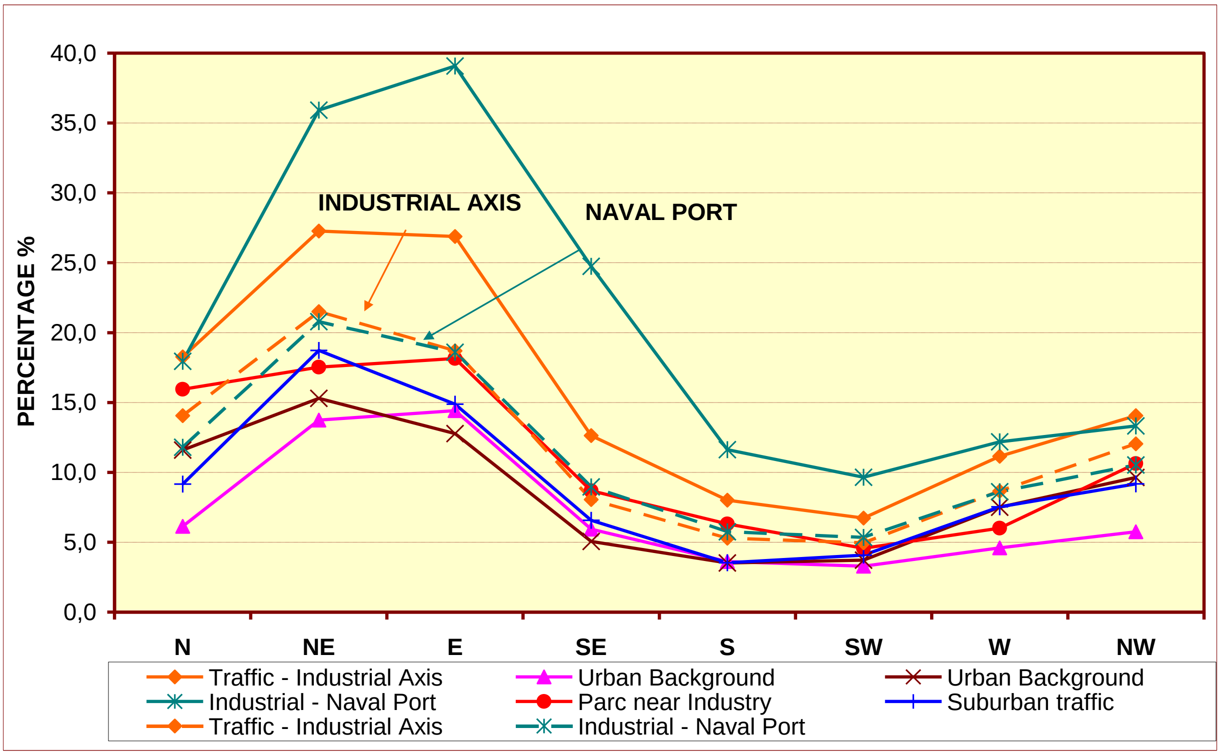

Fig. 8. PM10 – Percentage of Exceeding Time for the main Wind Sectors, computed at all six stations for all exceeding days during the period 2006-2008 (solid lines) – Percentage at the two sites along the industrial axis with omission of the exceeding days that are exclusive for these two sites (hashed lines)

These comprehensive observations do accentuate the complexity of the PM10 problematic. Due to the frequent formation of secondary aerosol, meeting the daily limit value in the near future, in all urban sites, may probably not be attainable solely by local emission reductions.

2.4 Traffic Impact on Concentration Levels for NO, NO_2 and PM10

From 1997 till 2007, the overall PM10 emissions from the Region have decreased from 496 to 280 tons/yr and the traffic related PM10 emissions from 345 to 202 tons/yr. During the same period the 3-annual average PM10 concentration in a traffic oriented station, situated in a well ventilated area, respectively for the period 1997-1999 and 2006-2008 has dropped from 46 to 32 µg/m^3. The emission inventory attributes 72% (in 2007) of the local PM10 emissions originating from traffic. However, the analysis of the measured concentrations, showing no linear link with the local emissions, indicates that the PM problematic is much more complex: major contributions are coming from anthropogenic emissions (traffic, combustion processes) but also from natural sources, from the suspension of the coarser PM fraction and from airborne aerosol (secondary particulates).

Figure 9 represents the normalized weekly pattern for the NO, NO_2, PM10 and PM2.5 concentrations during the period 2006-2008, averaged over 5 different measuring sites, excluding the results from the industrial site at the naval port. The result is obtained by dividing the mean concentration for each day of the week by the average concentration for working days. Compared to the situation for the working days of the week (Monday to Friday), the NO concentration falls by 40% on Saturday and by 60% on Sunday, corresponding to the order of magnitude of the decrease in traffic intensity. The NO_2 concentration falls only by 20 to 30% and the PM10 and PM2.5 concentrations only by 7 to 15%. The decrease of the concentration for NO_2 and PM during the weekend confirms that there is no proportionality with the local traffic emission reductions.

From the experience with the car free Sundays it became obvious that there was no clear sink in the concentration for PM10 or PM2.5 during the traffic ban hours and, unlike it is the case for the gaseous pollutants related to traffic, one could not observe a sharp and sudden concentration change at the begin nor at the end of the traffic ban period (Vanderstraeten, Forton, Lénelle, Meurrens, Carati, Brenig, Offer and Zaady, 2006).

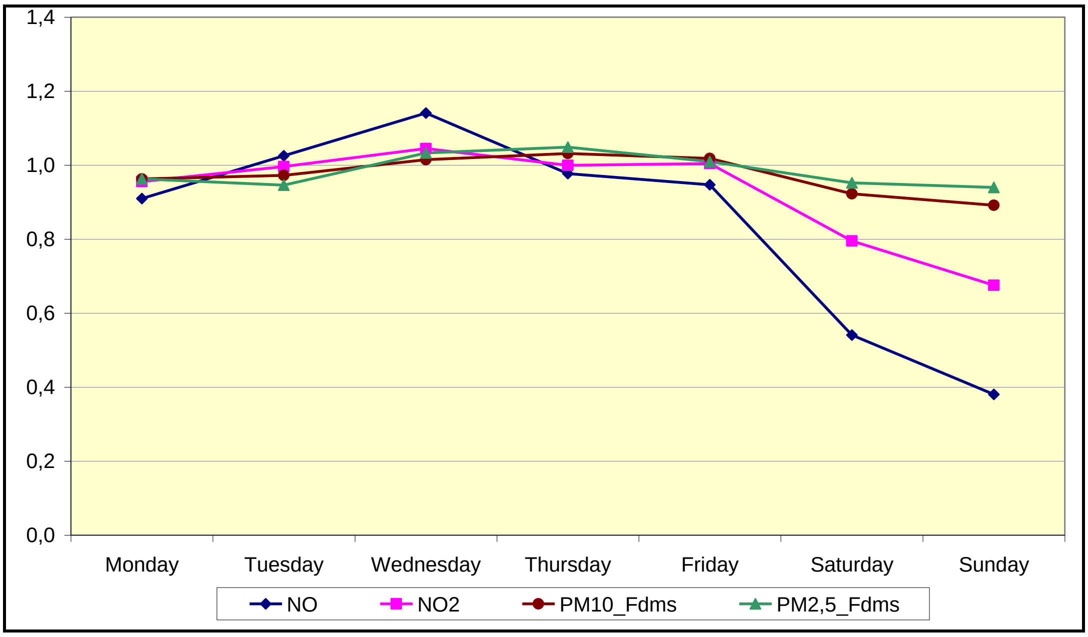

Fig.9. Average Weekly pattern for NO, NO2, PM10 and PM2.5 – Average situation over 5 different measuring sites and 3 calendar years (2006-2007-2008)

The average concentration during the interdiction period (09:00-19:00 h local time) of the car free Sundays stayed at the same level as on an average Sunday.

The concentration difference between the more exposed sites close to the city centre and the urban background sites gives an indication of the PM10 quantity originating from the activities inside the city (about 30% coming from local activity). A comparison, over the past few years, of the average concentrations obtained at rural background sites and regional stations outside Brussels with those of the urban background and traffic stations inside the Brussels Capital Region enables to estimate the relative contributions to the local measured overall NO_2 and PM10 values. Estimated results for the average situation as well as for a winter pollution peak of poor dispersion are given in Tables 1 and 2.

On an average, for a canyon street, about 50% of the NO_2 concentration is related to the traffic inside the city and, at a well ventilated traffic environment, about 37% is from local origin. For PM10 this represents respectively 34.2% and 15.6%. For a pollution peak during the winter period, related to poor dispersion conditions of temperature inversion and low wind speed, the part of the PM10 concentration explained by local PM emission may increase, due to the accumulation effect, to about 42.3 and 22.7% respectively.

Table 1 Estimation of the relative contribution to the overall NO2 concentration

Origin NO_2	Average situation	Winter Pollution Peak
Rural background	16.4%	15.7%
Trans regional	23.6%	39.2%
Urban background	10.9%	10.8%
Urban traffic	29.1%	31.4%
Street Canyon	20.0%	2.9%

Table 2 Estimation of the relative contribution to the overall PM10 concentration

Origin PM10	Average situation	Winter Pollution Peak
Rural background	39.0%	26.3%
Trans regional +Urban background	26.8%	31.4%
Urban traffic	12.2%	16.9%
Street Canyon	22.0%	25.4%

3. ACHIEVING COMPLIANCE BY LOCAL EMISSION REDUCTIONS?

Analysis of the NO_2 concentration levels in the city shows the relative importance of the local NO_X emissions, but it confirms also the relative high percentage already present in the incoming air masses. Therefore solutions to the problem should be shared by the different actors and authorities concerned. However a strict interpretation of the air quality directive by administrators risks to put the entire responsibility at the zone where a non compliance is established.

Analysis of the weekend situations have made clear that, in order to respect the limit values at all Brussels sites, NO_X emissions should be reduced permanently to those of the average Sunday activities, inside the city (~60% traffic reduction), as well as in the surrounding areas. If compliance is to be attained solely based on local emission reductions, then the local traffic, representing about 50% of the yearly average NO_X emissions (a higher percentage during summer) and probably more in a typical traffic environment, should become virtually free of NO_X emissions. With the introduction of EURO 6 by the year 2013/2014, NO_X emissions from diesel cars should start to decrease. Taking into account that the car fleet is renewed by approximately 10% each year, significant improvements of the annual average NO_2 concentration may only be expected beyond the year 2017/2018.

Analysis of the PM10 concentration showed that only about 30% of the total PM10 mass concentration in the Brussels urban area is related to the local particulate emissions. Assuming that the differences between the centre of the city and the cities background, for both the average concentration and the number of exceeding days, are mainly due to the local emissions activity, for which about 70 to 75% is originating from traffic, a reduction of at least 70 to 80% of the local traffic emissions should be realized in order to become compliant with the daily limit value. This is illustrated in Figure 10, comparing the number of exceeding days and the average PM10 concentrations between an urban background station (R012 – Uccle) and the traffic station situated near the city centre and along the economic axis (R001 – Molenbeek). Since particulate emissions from traffic are not limited to the direct emissions by the tailpipe, even such drastic reductions may not give full guarantee.

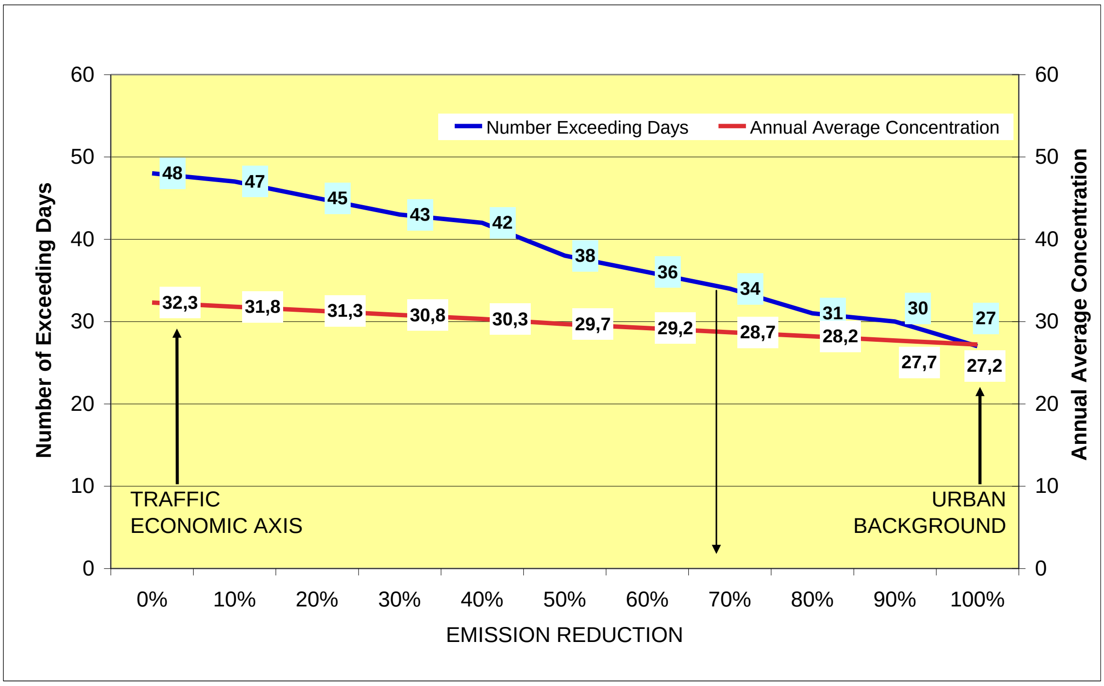

Fig. 10. Estimation of Local PM10 Emission Reduction needed for compliance at the traffic site along the commercial and industrial axis of Brussels

4. CONCLUSION

Considering the related health effects and its important role in the formation of ozone and secondary aerosol, together with the nearly unchanged concentration levels after 20 years of NO_X emission reductions, NO_2 can be seen as a key pollutant and meeting its air quality objectives as a major problem. Lowering the NO_2 concentration levels will be the challenge for the next decade. Compliance with the air quality objectives for NO_2 in all kinds of urban environments will hopefully be in reach by the end of the next decade. However lowering the NO_2 concentrations much further will probably be needed to meet the objectives for the related problems such as ozone and PM10. Up to now, no clear decrease of the NO_2 concentrations could be achieved. Therefore, drastic emission reductions, equivalent with a tendency to move towards a car fleet free of NO_X emissions, will be needed everywhere. In the Brussels Capital Region several measures have already been taken, but additional actions will be needed in order to limit the traffic related emissions.

To enable compliance with the EU limit values for NO_2 and PM10 in the future, solely based on local emission reductions, the Brussels NO_X emissions should be lowered by at least 60% and the PM emissions by 70 to 80%. A realization of such drastic emission reductions in the short term seems unrealistic because of the associated socio economic consequences. Nevertheless, a more ambitious emission reduction plan should be prepared. But in the attendance, one should be aware of the shared responsibility, especially when assessing non compliancy. Considering the significant role played by the background concentrations, even important local emission reductions will probably not be sufficient to meet the air quality objectives in the near future. Therefore drastic emission reductions on the national and international scale should also be considered in order to lower significantly the contribution of medium and long range transport of pollutants.

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