For Discussion on
26 May 2011

LEGISLATIVE COUNCIL
PANEL ON ENVIRONMENTAL AFFAIRS

SUBCOMMITTEE ON IMPROVING AIR QUALITY

Primary Nitrogen Dioxide Emissions from Vehicles

PURPOSE

Upon the request of Members, this paper sets out our response to the submission from Prof. Linwei TIAN entitled "Retrofit or renew the old diesel fleet: the NO_2 pollution in HK". It also provides an explanation on the roadside air pollution problem and our strategy to improve roadside air quality, including how best the nitrogen dioxide (NO_2) pollution at the roadside should be tackled.

ROADSIDE AIR POLLUTION

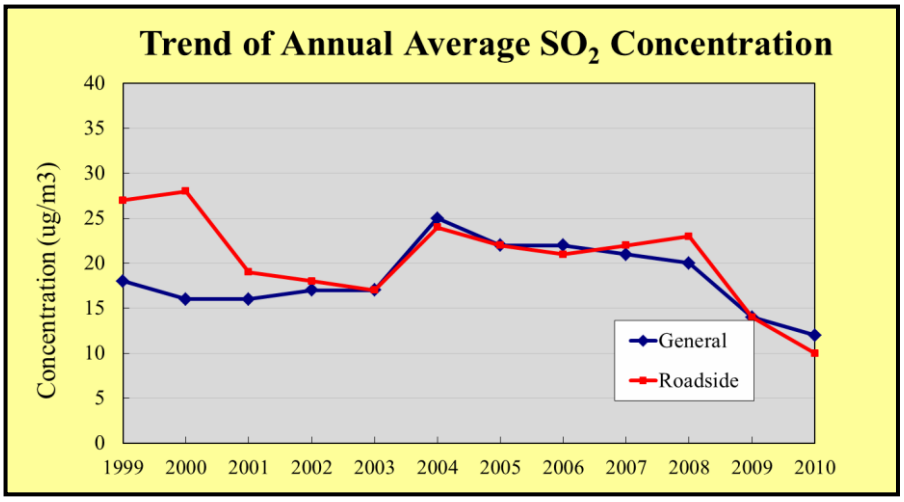
Key Air Pollutants at the Roadside

2. Vehicle emissions are the main air pollution source at the roadside. Sulphur dioxide (SO_2), respirable suspended particulates (RSP) and NO_2 are the key air pollutants emitted from vehicles. The SO_2 comes mainly from the sulphur content of motor vehicle fuels and the RSP are mainly emitted by diesel vehicles. NO_2 is however either emitted directly by vehicles (i.e. primary emission) or formed after the further oxidation of the nitric oxide (NO) emitted also by vehicles (i.e. via a secondary formation route involving volatile organic compounds (VOCs) and ozone (O_3)). All of the above air pollutants have adverse health effects.

Strategy to Improve Roadside Air Quality

Sulphur Dioxide

3. SO_2 is formed when the sulphur in the fuel is burnt during the combustion of the fuel. The SO_2 emission can be reduced by lowering the fuel sulphur content. Moreover, using fuel with low sulphur content is a pre-requisite for the successful operation of advanced equipment for tackling the emissions of RSP and nitrogen oxides (NOx), which is a collective name for NO and NO_2. Hence, the Government has been offering fuel duty concessions to encourage the early introduction of cleaner diesel. The statutory requirements for our motor vehicle petrol and diesel are among the most stringent in this region and on a par with advanced economies such as USA and the European Union. Our proactive action on reducing the sulphur content of motor vehicle fuels reduced the SO_2 level at the roadside by about 60% between 1999 and 2010 as shown in the following chart –



Respirable Suspended Particulates

4. Diesel vehicles are the main emitter of RSP at the roadside, much of which are fine particulates (i.e. $PM_{2.5}$). European Union and the USA started in the mid-1990s directing vehicle manufacturers to reduce the particulate emissions of their diesel vehicles, leading to the development of diesel oxidation catalysts (DOC) and diesel particulate filters (DPF)[1], etc. In addition, taking

[1] Diesel oxidation catalysts (DOCs) can reduce the particulate emissions of diesel vehicles by about 30%. Diesel particulate filters (DPFs) are more effective and can reduce the particulate emissions by over 80%.

advantage of these diesel particulate control technologies, many environmentally-conscious cities such as London, Brussels, Paris, Stockholm, Gothenburg, Tokyo, and Seoul, etc. have also undertaken retrofit programmes to reduce the particulate emissions from their aged diesel vehicles.

5. We embarked on the following three key programmes to reduce the diesel particulate level at the roadside, making reference to the successful experience of other places and on top of our standing policy to tighten the emission standards for newly registered vehicles whenever practicable to do so –

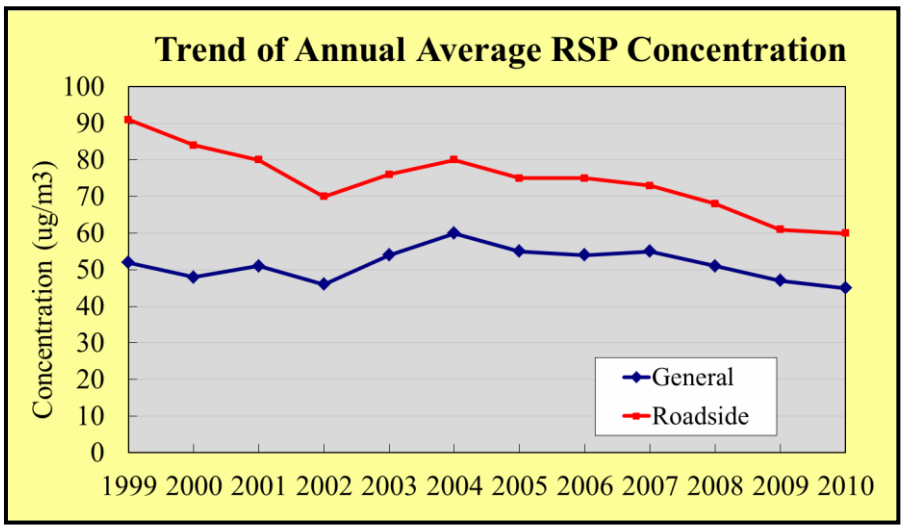
(a) the LPG taxi and light bus programme;

(b) the introduction of an advanced test to check diesel vehicle smoke emission; and

(c) the retrofit of pre-Euro diesel commercial vehicles with DOCs.

Franchised bus companies have also retrofitted their Euro I buses with DOCs and Euro II and III buses with DPFs.

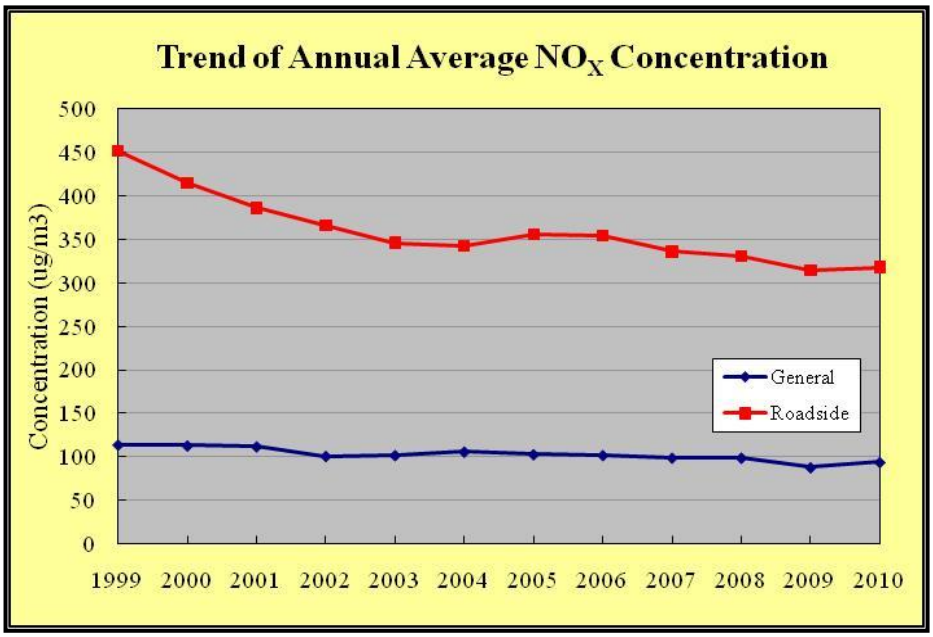
6. The above efforts have borne fruits. The roadside RSP level was reduced by about 30% and the gap between the RSP level at the roadside and at the ambient air was narrowed by about 65% between 1999 and 2010 as shown in the chart below –

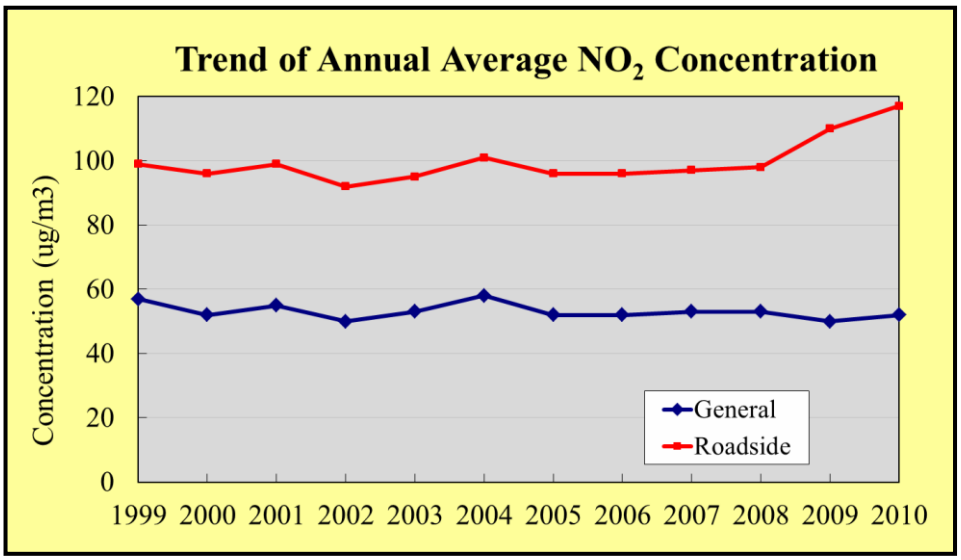


The RSP level at the roadside will be further reduced in coming years when aged diesel commercial vehicles are replaced by less polluting vehicles.

Nitrogen Dioxide

7. Unlike SO_2 and RSP, the level of NO_2 at the roadside increased by about 18% though the NOx level reduced by about 30% between 1999 and 2010 as shown in the following charts –



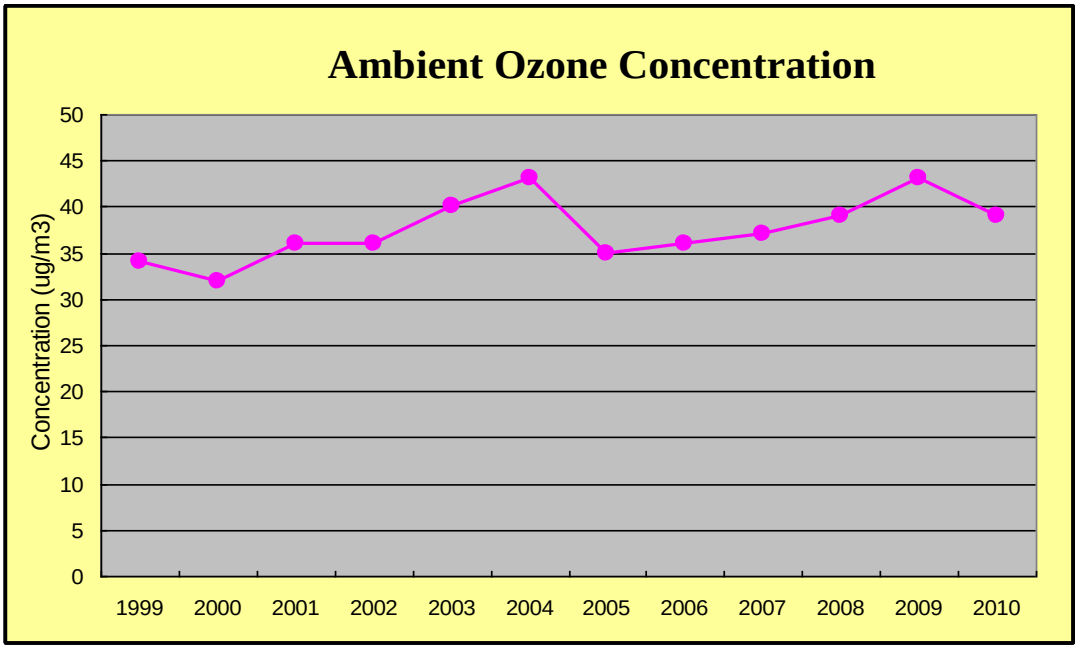


8. As explained in paragraph 2, NO_2 is emitted directly by vehicles or formed by further oxidation of the NO emitted by vehicles in the presence of VOCs and O_3. There are thus a combination of factors accounting for the increasing trend of NO_2, which are as follows –

(a) some of the technologies, particularly the more effective ones such as DPFs, which are equipped in some of the Euro IV or more advanced vehicles for reducing the RSP emissions from diesel vehicles, could increase the direct emissions of NO_2. The strategy of the advanced economies (including the European Union, the USA and Japan) is to reduce the emissions of both RSP and the nitrogen oxides (i.e. NOx, which includes both NO and NO_2) of new vehicles at the same time. Owing to the constraint of the control technology for both NO and NO_2, the reduction in the NOx emission is limited until the recent years when vehicle manufacturers have started to adopt for their new vehicles the selective catalytic reduction (SCR) technology, which can reduce both NO and NO_2 in the vehicle exhaust;

(b) petrol vehicles and LPG vehicles rely on their catalytic converters to reduce their NOx emissions. The converters need to be regularly replaced, particularly for high-mileage vehicles such as taxis and light buses. Otherwise, the vehicles will emit a lot more NOx alongside other pollutants including VOCs. Our observation is that many of these high-mileage vehicles have their catalytic converters significantly depleted; and

(c) the ambient concentrations of ozone, which can promote the photochemical oxidation of NO to NO_2 at the roadside, are still at a high level are shown in the chart below –



9. To improve the roadside NO_2 problem, we are taking the following multi-pronged approach –

(a) we will soon consult the transport trades about tightening the emission standard for newly registered vehicles to the Euro V level and will further tighten the standard[2] as soon as practicable so as to take advantage of the latest technological developments in reducing vehicle emissions including NOx and NO_2;

(b) in consideration of franchised buses accounting for up to 40% of the traffic flow along busy corridors (such as those in Causeway Bay, Central and Mong Kok), we are making preparation with the franchised bus companies to launch a trial of retrofitting on Euro II and III buses with SCRs. Subject to satisfactory results of the trial, the Government will fully fund the retrofitting of Euro II and III buses with SCRs;

(c) we are developing a proposal to strengthen the control of excessive

[2] As compared with Euro IV vehicles, Euro V and VI heavy duty diesel vehicles (i.e. of vehicle weight over 3.5 tonnes) emit about 40% and 90% less NOx. Euro VI models will emit 50% less RSP than Euro IV and V models. As for light duty diesel vehicles, Euro V models and Euro VI models emit about 90% and 93% less respirable suspended particulates respectively; and 30% and 70% less NOx respectively. The European Union will add to Euro VI emission requirements a cap on NO_2, the size of the cap is being worked out and would be introduced at a later stage.

exhaust emission from in-use petrol and LPG vehicles, including the use of roadside remote sensing device and chassis dynamometer to test the exhaust emission from vehicles. When ready, we will consult the stakeholders including this Subcommittee, the transport trades and others. Meanwhile, we are also developing guidelines on the essential vehicle maintenance for preventing excessive emissions; and

(d) we will continue our joint efforts with Guangdong to reduce the ozone concentrations in the whole Pearl River Delta Region by cutting the VOCs and NOx emissions in the Region.

The above efforts will effectively address the NO_2 pollution problem at the roadside.

RESPONSES ON SPECIFIC SUGGESTIONS

Designed to control NOx, SCR may also increase NO_2 emissions due to an increased share of NO_2 in NOx.

10. SCRs are well proven to be effective in reducing both NO and NO_2. SCR technology has been applied to Euro IV and Euro V diesel commercial vehicles, including buses. Retrofitting vehicles that have already been installed with DPFs with SCRs can surely reduce both of their primary and secondary NO_2 emissions at the same time, as vindicated by the retrofit programmes conducted in some European cities. Moreover, our understanding from vehicle manufacturers is that SCRs will continue to be a key emission control technology to help vehicles meeting the much tightened NOx emission standard of Euro VI.

11. In the design of an SCR system for vehicle applications, it is desirable to have a high ratio of NO_2 in NOx at the inlet of SCR so as to attain a high reduction efficiency of both NO and NO_2. Placing a DPF or DOC ahead of an SCR can serve at the same time the purposes of reducing the harmful diesel particulates emissions and providing a favourable working condition for the SCR to function. As long as the design is in good order, there should be significant reduction in both NO and NO_2 emissions. That also explains why SCRs will still be a key emission control technology for vehicles to meet with

Euro VI emission standards.

Euro IV or V buses performs no better than Euro III buses in terms of NO_2 emissions. What is the point of retrofitting Euro III vehicles to meet Euro IV standard?

12. As compared with Euro II buses, Euro III, Euro IV and Euro V buses emitted about 30%, 50% and 70% less NOx respectively. Retrofitting Euro II buses with SCRs could upgrade their NOx emission performance to Euro IV level and Euro III buses to Euro V level. As it is, NOx but not NO_2 is a regulated pollutant in all leading vehicle emission standards such as those adopted by the European Union, USA and Japan. To certify the emission performance of a vehicle against the prevailing emission requirements, vehicle manufacturers need to submit NOx but not NO_2 emission figures to the relevant emission control authorities. There are thus no vehicle certification data showing that Euro IV or V buses perform no better than Euro III buses in terms of NO_2 emissions. Nor are we aware of any comprehensive studies on the relative NO_2 emission performance of these Euro vehicles. It is however certain that retrofitting a diesel vehicle with SCR can reduce its emissions of both NO and NO_2. The reduction in the NO can reduce the formation of NO_2 at the street level, which is also a significant source of roadside NO_2.

13. Furthermore, as explained in paragraph 2, we are facing the problem of both RSP and NO_2 pollution at the roadside. We have taken prompt action to make use of the available technologies to reduce the exposure of the public to the adverse health effects of RSP by retrofitting pre-Euro diesel vehicles with DOCs or low-cost filters. The franchised bus companies have also retrofitted their pre-Euro II buses with DOCs and Euro II and III buses with DPFs. The emission control technology has now evolved to the stage that it is technically feasible to retrofit buses with SCRs to reduce their NOx (including NO_2) emissions, subject to the availability of space. We have therefore joined hands with the franchised bus companies to retrofit these DPF-equipped buses with SCRs to reduce their NOx (including NO_2) emissions. This approach is in line with the suggestion made in the Press Release of the Chinese University of Hong Kong about this research of Prof. Tian and Prof. Ignatius Yu – "***The combined use of DOCs and SCR in diesel vehicles should help reduce NO_2 in the near future***."

It is NO_2 that is of public health relevance, not NOx as regulated by Euro emission standards. In Euro VI, a separate NO2 cap may be specified.

The right way to control NO_2 is to drastically reduce NOx to Euro VI level and the increased share of NO_2 in NOx would be of less consequence.

No more retrofit; quick replacement please.

14. No doubt, Euro VI vehicles are better than Euro IV or Euro V vehicles in respect of both NOx and RSP emissions. However, there has yet to be any country in the world which adopts Euro VI as the statutory vehicle emission standards. As a matter of fact, vehicle manufacturers are still making preparations for developing Euro VI diesel vehicles, which will not be commercially available from Japan (a major source of local commercial vehicles) until 2016 and Europe until 2014 at the earliest. We are not aware of any double-deck buses meeting Euro VI standards which are for sale on the market at the moment. It is unrealistic to replace the entire franchised bus fleet, which comprises some 5,700 buses[3], with Euro VI models in the coming few years. In contrast, it is much more prudent and practicable to make use of the existing bus replacement arrangement to phase out all pre-Euro I buses by around 2015 and seek to upgrade the Euro II and III buses to Euro IV level by retrofitting them with SCRs.

Environment Bureau/Environmental Protection Department
May 2011

[3] As at end February 2011, the franchised bus fleet had 92 pre-Euro, 1,261 Euro I, 2,649 Euro II, 1,269 Euro III, 211 Euro IV and 216 Euro V, buses.