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Retrofitting Franchised Buses with Selective Catalytic Reduction Devices

PURPOSE

This paper reports on the Government's plan of retrofitting selective catalytic reduction (SCR) devices on Euro II and III franchised buses.

BACKGROUND

2. We need to improve roadside air quality to protect public health. At the roadsides, high concentration levels of respirable suspended particulates (RSP) and nitrogen oxides (NO_x), which is a collective term for nitric oxide (NO) and nitrogen dioxide (NO₂), are the main air pollution problems. These pollutants mainly come from motor vehicles, especially diesel vehicles.

3. After the introduction of a series of air quality improvement measures, the general air quality at the ambient level has been improving. As regards the air quality at roadsides, the concentration levels of RSP and NO_x were reduced by 29% and 12% respectively between 2006 and 2012. However, during the same period, the NO₂ level at roadsides increased by 23%, resulting in the number of days with air pollution index exceeding 100 (i.e. reaching very high level) at the roadside within a year rising from 51 days to 142 days.

4. To tackle the NO₂ problem at the roadsides, we need to further reduce NO_x emissions from major emission sources including franchised buses, diesel commercial vehicles and liquefied petroleum gas (LPG) taxis and public light

buses. We are tackling the air pollution problems from the latter two types of vehicles by new initiatives. For diesel commercial vehicles, we have earmarked \$10 billion for implementing a proposal to phase out progressively pre-Euro IV diesel commercial vehicles (excluding franchised buses) through an incentive-cum-regulatory approach. We are consulting the transport trades and relevant stakeholders on the proposal. Regarding LPG taxis and public light buses, we will subsidise their vehicle owners to replace their catalytic converters on a one-off basis for reducing emission. The replacement programme will start later this year. We will deploy remote sensing devices to identify those vehicles which emit excessively starting from 2014. In parallel, we are working with the Mainland to reduce the concentration levels of ozone, which can promote the conversion of the NO emissions from vehicles to NO₂ at the roadsides, in the Pearl River Delta region.

FRANCHISED BUS FLEET

5. As at end April 2013, there were some 5 700 franchised buses in Hong Kong which can account for up to 40% of the traffic flow in busy corridors. In 2011, franchised buses accounted for about 20% of NO_x emissions and 6% of RSP emissions amongst the whole vehicular fleet. To improve air quality at roadsides, we need to further reduce emissions from franchised buses.

6. A profile of the franchised bus fleet is at **Annex A**. Under the bus replacement programme, franchised buses will have to be replaced before reaching 18 years old. As a result, all Euro I buses will be replaced by Euro V or better buses by 2015. As for the remaining Euro II and III buses, they emit 7.5 to 5 times as much RSP and 1.75 to 1.3 times as much NO_x as compared with Euro IV buses. They will only be fully retired by 2019 and 2026 respectively.

7. To reduce the emissions of Euro II and III buses, the franchised bus companies have already retrofitted these buses, where technically feasible, at their own cost with diesel particulate filters (DPF). These DPF can reduce the particulate emissions of the buses by about 80%, thereby upgrading their particulate emission performance comparable to that of Euro IV buses. We need to tackle their NO_x emissions now.

SELECTIVE CATALYTIC REDUCTION DEVICES

8. SCR¹ is a proven technology in reducing NOx emissions. To meet the increasingly stringent emission standards for newly registered vehicles, vehicle manufacturers have started incorporating SCRs when producing Euro IV and Euro V vehicles. Some European countries and cities (e.g. Barcelona, Belgium and Sweden) have retrofitted some of their buses with SCR while others (such as London) are making preparations for a similar retrofit². Their experience suggests that SCR retrofit can reduce NOx emissions by some 60%, thereby upgrading the NOx emission performance of these buses comparable to that of Euro IV level. When retrofitting in-use vehicles with SCRs, the primary considerations are whether there is sufficient space to install the devices and whether they would unduly affect the performance of the vehicles. To improve air quality at roadsides, the Government announced in the 2010 Policy Address the plan to fully fund the retrofit of SCRs on Euro II and III franchised buses on a one-off basis subject to satisfactory trial results. Franchised bus companies will have to bear the subsequent recurrent expenditure including operational (urea and extra fuel costs), repair and maintenance costs, and future replacement of SCR filters³.

THE TRIAL

9. Together with three franchised bus companies⁴, we started in September 2011 a small-scale trial to ascertain the technical feasibility and effectiveness of retrofitting Euro II and III buses with SCRs and to assess the impact on their normal operation. The trial was completed in February 2013.

10. The trial involved three major bus models, namely Euro II and Euro III Dennis Trident, and Euro II Volvo Olympian. These three models have sufficient space to accommodate the SCR and together account for about 58% of Euro II and III franchised buses. Two SCR suppliers participated in the

¹ SCR is a system which is placed on the exhaust pipe. It can reduce NOx into nitrogen and oxygen. It uses a reagent, urea, to facilitate the chemical reaction.

² More than 400 buses have been upgraded by SCR retrofit in Barcelona, Spain. In Belgium and Sweden, about 250 and 300 buses have been retrofitted with SCR respectively. After conducting successful trials recently, London has decided to retrofit about 900 buses with SCR by March 2014.

³ According to SCR suppliers, the expected life of the filter of the SCR could be about 5-6 years, depending on usage and maintenance condition of the vehicle.

⁴ Participating franchised bus companies include The Kowloon Motor Bus Company (1933) Limited (KMB), Citybus Limited (CTB) and New World First Bus Services Limited (NWFB).

trial which commenced in September 2011 and February 2012 respectively. Six buses from these three models took part in the trial during which their emission and operational performance were monitored.

11. By end-February 2013, all six buses had been in operation with the SCRs for 12 months or more. The trial results have demonstrated that the SCR retrofit is technically feasible for the three selected bus models though some maintenance and operation problems emerged which required remedial actions and more frequent maintenance/servicing. As for the remaining major Euro II and III bus models, we have also completed an assessment with the franchised bus companies and SCR suppliers on whether they have sufficient space for the retrofit. The assessment has identified another four potential bus models for the retrofit.

Emission Performance

12. For the buses on trial, the SCR retrofit can on average reduce the NO_x emissions by about 63% to 81%. There were occasions that the emission requirement was not met because of pre-mature equipment failure such as damaged filters. After replacement of the defective parts, the emission performance has resumed to the normal level. The NO_x emission reduction level could raise the emission performance of the retrofitted Euro II and III buses to level comparable with that of Euro IV buses. In addition, there are no unacceptable emissions of other pollutants such as carbon monoxide and total hydrocarbons. In terms of particulate emissions, they were very low since all trial buses were retrofitted with DPF. There were occasions during the trial when ammonia was excessively emitted and the contractor has already rectified the problem.

Operational Performance

13. A number of incidents occurred during the trial period, such as broken heat shield and mounting rubber, excessive filter movement/uncontrolled regeneration of DPF causing damages to the filters, blockage of exhaust pipe due to crystallization of urea, urea leakage, high backpressure alarm warnings due to blockage of DPF, insufficient urea solution dosing caused by blockage of urea tank filter and exhaust gas leakage resulting in the thermal lagging material being burnt, etc. These teething problems are mainly due to the improper design and construction of individual SCR systems. Modification

(including replacement of damaged parts) and necessary adjustments had been made to rectify the problems.

14. Franchised bus companies reported that the retrofit would require more intensive maintenance efforts for preventive and remedial purposes, including more frequent clean-up of the soot built-up in the DPFs, regular clean up of the urea crystal deposits in the SCR and piping joints, and regular clean up of the urea injector nozzles, etc. There could also be more incidents of bus breakdown, which could affect bus availability. However, the implication should be insignificant and can be resolved through suitable deployment of buses.

Urea and Fuel Consumption

15. The average urea consumption rates for the trial buses range from about 3% to 7% of the corresponding fuel consumption rates, which are in line with the findings of overseas studies of SCR retrofitting. There is also an average increase in fuel consumption⁵ of about 3.9%. The urea and additional fuel consumption would have recurrent cost implications for the franchised bus companies.

Implications on Operating Cost

16. On the basis that the large-scale retrofit will cover some 1 400 buses from KMB, CTB, NWFB and Long Win Bus Company Limited (LW), the urea consumption and extra fuel as well as increased maintenance could cost about \$131 million and \$19 million for KMB/LW and CTB/NWFB respectively over the remaining serviceable life of the buses to be retrofitted. While the franchised bus companies will absorb these costs as part of their operating costs, there could be pressure on bus fare increases, as operating cost is one of the six factors under the Fare Adjustment Arrangement for franchised buses that the Government would take into consideration.

NUMBER OF BUSES FOR LARGE-SCALE RETROFIT

17. After discounting those buses with a remaining service life less than

⁵ This is by comparing the fuel consumption rate of the trial bus and a number of buses running on the same route before and after the retrofit of the SCRs.

two years⁶ and bus models that are not technically feasible for retrofit or with a relatively small number (i.e. below 100 buses for each model), we have identified six bus models for the large-scale retrofit, involving a total of some 1 400 buses. They come from four franchised bus companies including KMB, CTB, NWFB and LW. Details of these bus models are at **Annex B**.

AIR QUALITY BENEFITS

18. If these 1 400 eligible Euro II and III buses are retrofitted with SCRs, we expect that the NO_x emissions of the whole franchised bus fleet could be reduced by about 14%. The SCR retrofit, together with other air quality improvement measures under planning such as strengthening the emission control programme for LPG and petrol vehicles and mandating the replacement of heavily polluting diesel commercial vehicles, etc., can reduce the NO₂ level at the busy corridors by about 40%, and the NO₂ level will broadly meet the new AQO at the ambient level by 2020. The retrofitted Euro II and III buses will also be deployed to routes serving the pilot low emission zones in Causeway Bay, Central and Mong Kok to help meet the target of having only low emission franchised buses operating there by end 2015.

NEXT STEPS

19. Subject to the agreement of the Legislative Council, we plan to fully fund the franchised bus companies for the capital costs of retrofitting SCRs for some 1 400 Euro II and III franchised buses, including the buses selected for the pre-qualification trial. The franchised bus companies will be responsible for the subsequent operational and maintenance costs and absorb them in their operating costs. The franchised bus companies will also be responsible for taking forward the retrofit with a view to starting the large-scale retrofit in April 2015 and completing it on a best endeavour basis by the end of 2016. The retrofit programme will be monitored by the Environmental Protection Department (EPD) and the Transport Department (TD), including conducting emission tests on selected retrofitted buses.

⁶ In consideration of the cost effectiveness of the retrofit and the seriousness of roadside air pollution, we suggest that a bus should have at least two years of remaining service life after the retrofit. The buses identified for the retrofit will have remaining service lives ranging from two to eight years after retrofit.

20. To ensure that the SCRs are of the right design for individual bus models which is critical to their satisfactory performance afterwards, it is prudent to identify qualified SCR suppliers through a pre-qualification trial on the selected bus models before inviting tenders for the large-scale retrofit. This prudent approach has also been adopted elsewhere such as London⁷. To expedite the process, the franchised bus companies have already started initial contacts with potential SCR suppliers for the large-scale retrofit on a non-committal basis. Tentatively, the pre-qualification trial would last for about twelve months. At the end of the pre-qualification trial, the franchised bus companies will undertake a tender exercise to select suitable SCR suppliers. A tentative timetable for the retrofit exercise is at **Annex C**.

21. Given that the large-scale SCR retrofit programme is a new initiative that has not been pursued locally before, we consider it reasonable to ask the suppliers to provide a firm commitment on its product quality. In this regard, a 4-year warranty will be provided by the SCR suppliers and the actual warranty period for individual SCR units will depend on the remaining service life of individual buses upon retrofit, and be finalized prior to undertaking a tender exercise.

FINANCIAL IMPLICATIONS

22. The latest estimated cost of retrofitting a bus with SCR is about \$250,000, having regard to the current prices of precious metals which are essential ingredients of SCR components, the complexity of the work in the congested engine compartment, and the 4-year warranty arrangement. Since there would be some 1 400 buses eligible for retrofit, about \$350 million will be required. To allow for about 15% contingency to cater for inflation and fluctuations in foreign currencies and prices of precious metals, the total budget for the proposed large-scale retrofit programme for Euro II and Euro III franchised buses is about \$400 million.

⁷ After an initial trial on SCR retrofit in around 2004, Transport for London (TfL) conducted another trial in 2011 on a wider variety of routes with SCRs from different suppliers. Based on its outcome, TfL identified several qualified suppliers for retrofitting 900 buses with SCR systems by March 2014.

IMPLEMENTATION

23. Subject to the support of the Panel on Environmental Affairs of the Legislative Council and the approval of funding from the Finance Committee, our plan is to start the pre-qualification exercise by the end of October 2013 and the large-scale retrofit in April 2015, and completing it by the end of 2016.

ADVICE SOUGHT

24. Members are invited to comment and support the retrofit proposal as set out in paragraphs 19 to 22 above.

Environmental Protection Department
June 2013

Profile of Franchised Buses according to Emission Standards as at end April 2013

Emission Standard	Total
Euro I	749
Euro II	2 612
Euro III	1 265
Euro IV	221
Euro V	859
Electric Bus	1
Total	5 707

Profile of Franchised Buses Selected for the SCR Retrofit

Bus Model	No. of Buses as at April 2013	Estimated no. of buses with a remaining service life of two or more years after retrofit
Euro II Trident 12m	856	237
Euro II Trident 11m/10.3m/10.6m	178	177
Euro II Super Olympian 12m	198	198
Euro III Trident 12m	101	101
Euro III Trident Enviro500 12m	278	278
Euro III Super Olympian 12m	393	393
Total	2 004	1 384

Remarks:

- (1) Total no. of buses selected for retrofit: 1 384
- (2) Based on bus fleet information as at April 2013.
- (3) Disposal year is based on bus life of 18 years.
- (4) Buses are under the following four franchised bus companies:
 - The Kowloon Motor Bus Company (1933) Limited (KMB)
 - Citybus Limited (CTB)
 - New World First Bus Services Limited (NWFB)
 - Long Win Bus Company Limited (LW)
- (5) Estimated no. of buses selected for the SCR Retrofit:
 - KMB: 1 103 buses
 - CTB: 18 buses
 - NWFB: 254 buses
 - LW: 9 buses

Tentative Timetable for SCR Retrofit Programme

	Milestone
July 2013	The Administration to seek funding approval from the Finance Committee (FC) of Legislative Council for the retrofit programme.
End of October 2013	Subject to FC's approval, franchised bus companies (FBCs) to start the pre-qualification (PQ) exercise.
End of October 2014	FBCs to complete the PQ exercise and tender for the large-scale retrofit.
1 April 2015	FBCs to start the large-scale retrofit.
End of 2016	Complete the large-scale retrofit.