Institute of Transport Economics
Norwegian Centre for Transport Research

Summary:

Emissions from Euro 6/VI vehicles
Test programme phase 2

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Tests show that the emissions of nitrogen oxides, NO_X, from future generations of vehicles can be dramatically reduced. This is positive news, since the late Euro 5/V regulations designed to reduce exhaust particulate, PM emissions, had the unintended drawback of increasing emissions of NO_2 (the toxic part of NO_X). According to our tests, the next generation of heavy-duty vehicles with the new Euro VI engine emits significantly lower amounts of NO_X in all kinds of driving cycles than did earlier generations of heavy-duty vehicles. While new Euro 6 light vehicles with diesel engines comply with the strict new Euro 6 limits for NO_X, the improvements in real-life traffic and at cold temperatures are not of the same magnitude as for heavy-duty vehicles. Modern conventionally petrol-engined cars and one hybrid petrol-engined light vehicle show to have very low and barely detectable emissions of NO_X.

The emission tests with diesel-engine cars show that in a Nordic city driving cycle and cold climate real-life emissions may be much higher than the approved certification levels. In a cold climate the number of cars and congestion increase, and there may be a risk of a layer of air leading to inversion, pollution and low air quality. Knowledge and understanding of new engine technology and exhaust-cleaning effects is important when action is being taken to combat future problems.

New and stricter limits on exhaust emissions will be mandatory for all new road vehicles from 2014-2015. The Institute of Transport Economics (TØI) is investigating whether new vehicles that comply with the forthcoming Euro 6/VI-legislations will reduce emissions from road traffic as much as expected, and/or whether new engines and new exhaust technology may lead to new problematic emissions.

The Norwegian Public Roads Administration has engaged TØI and VTT to measure emissions from vehicles with Euro 6/VI legislation. TØI report 1259 *"Emissions from vehicles with Euro 6/VI technology"* was the first indication that emissions of NO_X and NO_2 were lower from vehicles with Euro 6/VI technology than from similar vehicles with Euro 5/V technology. The results from the first phase of the emission test programme were confirmed in this second test phase, when we tested three additional type-approved Euro 6 diesel private cars, one petrol-engined car with new DI (direct injection) technology and three heavy-duty vehicles with Euro VI engines. The most significant findings were:

- NO_X and especially emissions of NO_2 from the new Euro 6 diesel cars are significantly lower than emissions from corresponding Euro 5 cars. *NO_X emissions in real traffic conditions, however, are still about 3-5 times higher than the requirement values for type approval.* At -7°C (winter conditions), emissions of NO_X are about 5-8 times higher than the legislation test values.

- Heavy-duty vehicles with Euro VI engines have impressively low emissions of NO_X and NO_2. The exhaust emissions of NO_X and PM are comparable with those of diesel Euro 6 private cars.

Euro 6 diesel cars and cars with new engine technology

Emissions from private cars when driven over a "Helsinki city cycle", which is 7.8 km, are measured at both -7°C (cold/warm start) and +23°C (cold/warm start).

Emissions of NO_X from Euro 6 diesel cars tested so far are significantly lower than from Euro 5 diesel cars, but still exceed the legislation level for the car model approval test (see figure S.1). Emissions in typical winter temperatures (-7°C) have been shown to be higher than in summer temperatures (+23°C is the type approval temperature).

NO_X emissions from conventional three way catalyst petrol-engined cars and a reference petrol-engined hybrid car that we tested in phase 1 of the test programme are well below those from diesel-engined cars.

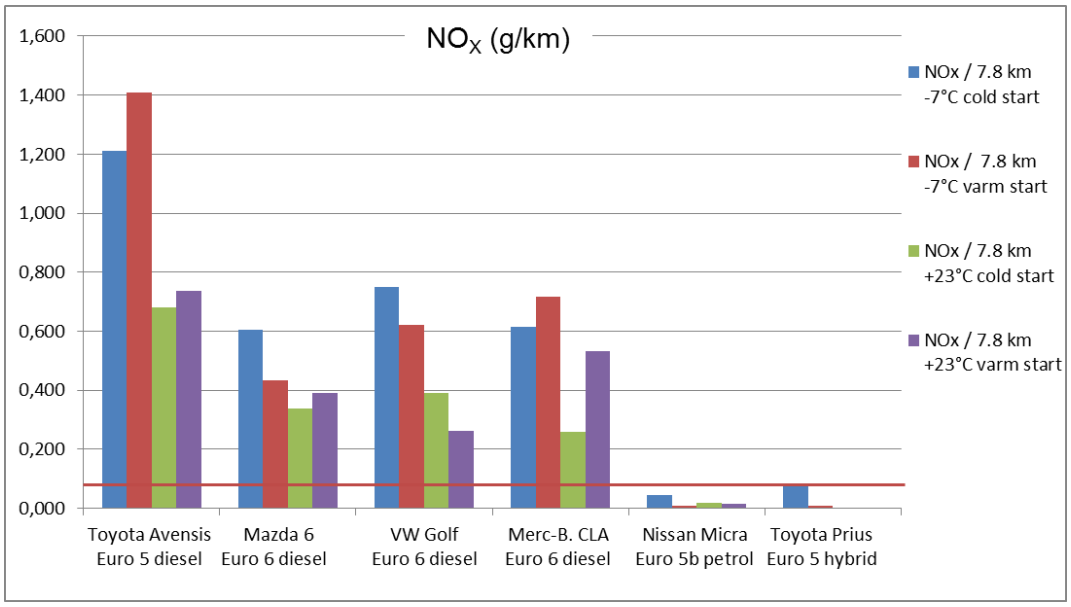

Figure S.1: NO_X emission from six light vehicles driving the Helsinki city cycle in -7°C and +23°C (cold-/warm start). The red line shows the requirement for the type approval of Euro 6 diesel cars (0.08 g/km).

The measured values of NO_2 and the NO_2-part of the total amount of NO_X emitted from the Euro 6 diesel cars tested was lower than from Euro 5 diesel cars (see figure S.2). NO_2 and some NO_X emissions vary between different cars and cold temperatures. Altogether, the ordinary petrol cars and the hybrid car had little or only insignificant emissions of NO_2.

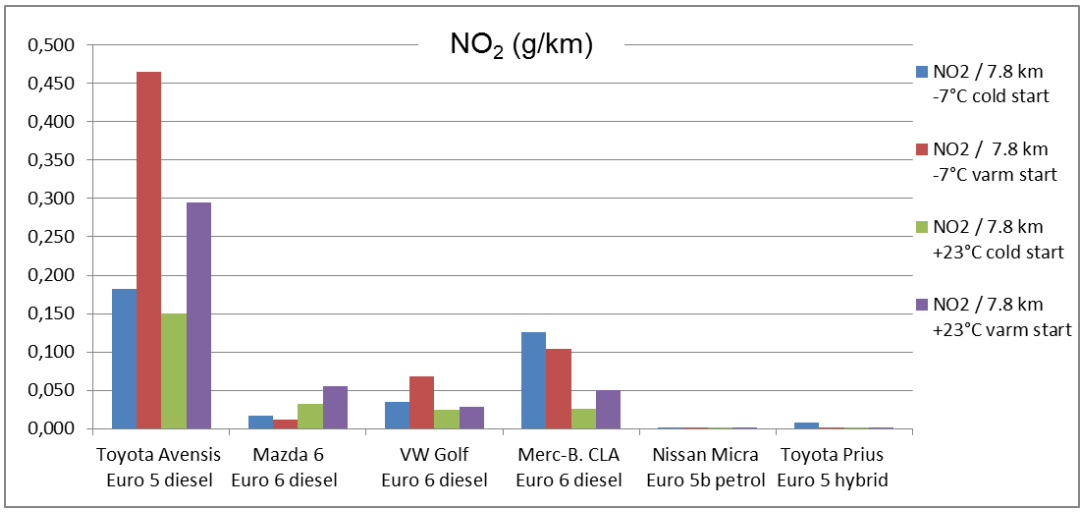

Figure S.2: NO_2 emission from six light vehicles driving the Helsinki city cycle in -7°C and +23°C (cold-/warm start).

The emissions of PM were low for all the Euro 6 diesel-engined cars tested as well as for Euro 5 diesel cars (see figure S.3).

In phase 2 of the emission test programme, the Euro 5 b petrol car (with DI, direct injection technology) had high emissions of PM at cold start and at -7°C. The same was the case with the Euro 5 DI petrol-engined car (i.e. with DI injection technology) tested during the first phase of the test programme.

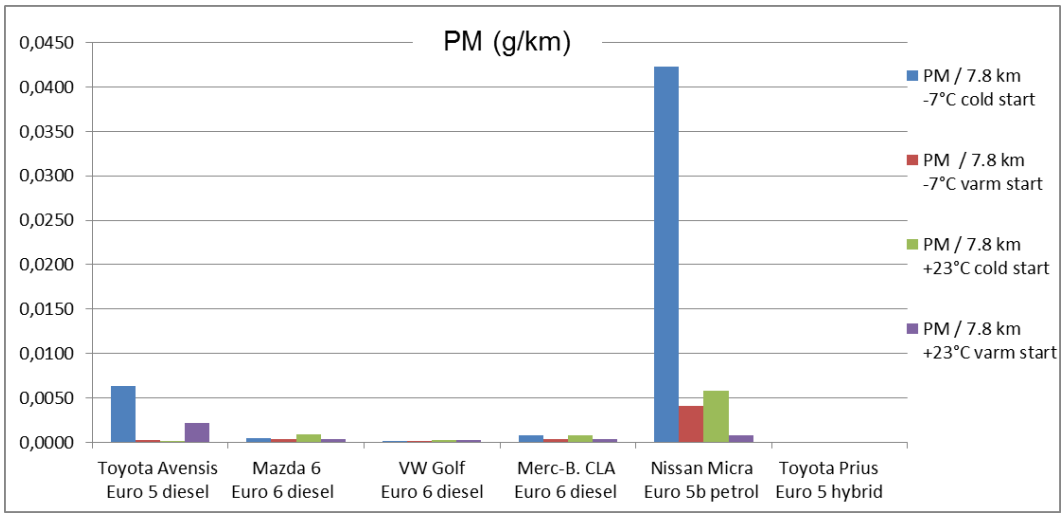

Figure S.3: PM emission from six light vehicles driving the Helsinki city cycle in -7°C and +23°C (cold-/warm start).

In city traffic, the CO_2 emissions from Euro 6 diesel cars were high and probably at least the same level as corresponding Euro 5 diesel cars (see figure S.4). Under the same conditions, emissions of CO_2 correlate strongly with the weight of the car. Large heavy cars have a higher fuel consumption and higher CO_2 emissions than small cars. In city driving, small petrol-engined cars have emissions of CO_2 that are lower or at the same level as bigger new Euro 5 and Euro 6 cars with diesel engines. Figure S.4 clearly shows the increase of CO_2 emissions at cold start.

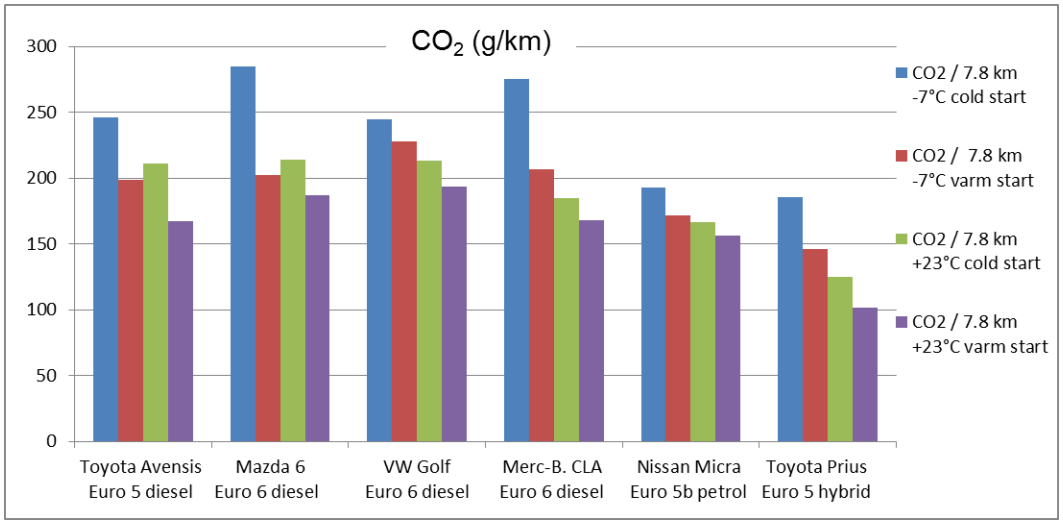

Figure S.4: CO_2 emission from six light vehicles driving the Helsinki city cycle in -7°C and +23°C (cold-/warm start).

Heavy-duty vehicles with Euro VI engines

Heavy-duty vehicles are tested over various vehicle driving cycles typical for the vehicles tested. NO_X and PM emissions from heavy-duty vehicles with Euro VI engines are very low and greatly reduced compared to emissions from corresponding vehicles with Euro V engines. The NO_X emissions from the tested heavy-duty vehicles with Euro VI engines are shown to be comparable with, or lower than, the emission from Euro 6 diesel private cars (figure S.5).

A tested hybrid bus with Euro V engine has higher NO_X emissions than the tested heavy-duty vehicles with Euro VI diesel engines. However, according to corresponding tests with ordinary diesel buses with Euro V engines, the hybrid bus emits less than half the NO_X emissions.

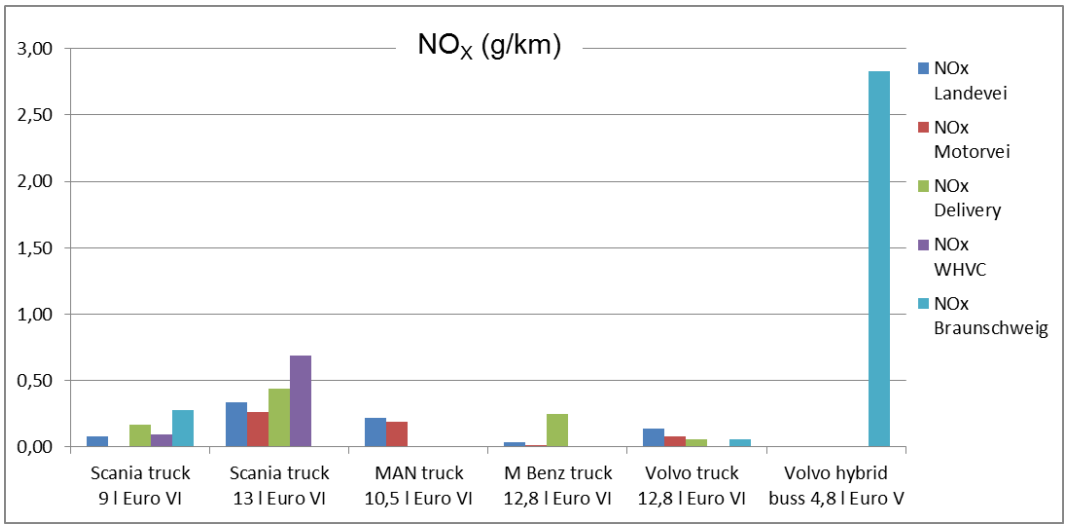

Figure S.5: NO_X emission from six heavy-duty vehicles tested using five different driving cycles (note that the bus to the right has a Euro V engine).

The emissions of CO_2 from the hybrid bus in city traffic (Braunschweig cycle) were higher than expected and may be explained by the fact that the Braunschweig cycle is extremely demanding and that the hybrid system was probably optimized to a less energy demanding driving pattern. With a somewhat less demanding driving cycles (SORT 1-3) used in addition, CO_2 was much lower.

In a few tests with heavy-duty vehicles, emissions of the powerful greenhouse gas N_2O were high, and in one case particularly high. The measured 0.6-0.9 g N_2O/km corresponds to 180-270 g CO_2/km, and under these conditions the N_2O emissions may seriously contribute to the global warming emissions from the vehicle.

Discussion

The results from the two test phases are not enough for solid conclusions to be drawn about Euro 6/VI-technology and future exhaust emissions, but they do tell us that it is possible to achieve low levels of regulated and unregulated locally harmful exhaust pollution. At the same time, though, we can see new problems that could arise.

Private cars have emissions from the legislation test (NEDC driving cycle) that are lower than the emissions TØI has measured at VTT. The CO_2 emissions are measured 10-30% higher than comparable legislation values. From new diesel engine cars the emissions of NO_X are often several hundred percent higher than what is shown from the legislation data. A possible explanation may be that new cars with diesel engines are optimized for low emissions of CO_2 at the legislation test but only to pass the test with respect to NO_X.

Heavy-duty vehicles with new Euro VI engines show impressively low emissions of NO_X and PM that are a result of advanced and well tested PM traps and Selective Catalytic Reduction SCR (with AdBlue) of NO_X.

Rather than focus on specific producers of engines or specific new car models, we want to find out more about Euro 6/VI technology, possibilities for reducing emissions, and show the need for objective testing.

A focus on measurements of unregulated emission components such as NO_2, N_2O, NH_3 (Ammonia) and PM, not just from diesel engines but also from petrol-engined cars, is necessary if we are to avoid unexpected surprises with greenhouse gases and local pollutant emissions.

Knowledge about Euro 6/VI emissions can be achieved efficiently through cooperation among researchers, authorities and vehicle producers, and is essential if we are to come to the right decisions about future vehicle technology, fuels, emissions and action to improve air quality.