

**Summary:**

# Exhaust emissions from vehicles with Euro 6/VI technology

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*In several major Norwegian cities exhaust emissions from vehicles is a problem and standards for air quality standard are expected to be exceeded in the years to come, if measures to reduce NO<sub>x</sub> and NO<sub>2</sub> emissions are not implemented. Modern particulate traps effectively decrease particulate emissions from diesel exhaust, but with these traps and oxidising catalysts Euro 5/V vehicles emit 5-10 times more NO<sub>2</sub> than without. It is important to investigate to what extent the Euro 6/VI regulations, which will be mandatory from 2014-2016, will reduce the emissions and if new exhaust cleaning technology will create new problems. For the Norwegian Public Roads Administration, TØI and VTT has performed emission testing of Euro 6/VI vehicles and vehicles with new engine technology.*

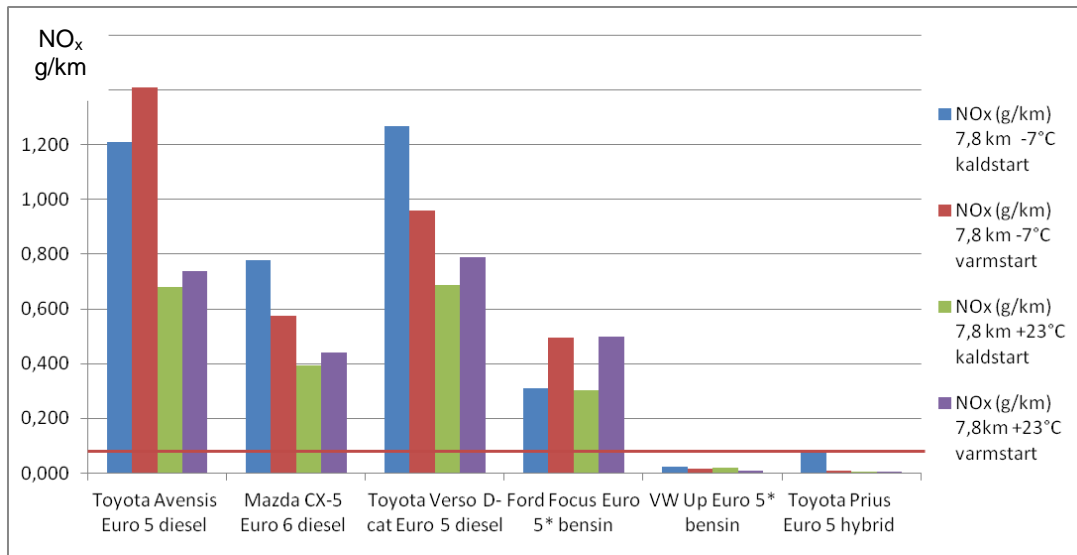
*Results from these tests show that the emissions of NO<sub>x</sub> from new Euro 6 light vehicles may be significantly lower than from corresponding Euro 5 light vehicles, but that they still at 23 °C in real life traffic may be about 2-4 times higher than the Euro 6 approval limits, and about 5-8 times higher at -7 °C (Nordic winter). Emission of unregulated emission components from Euro 6 cars and new engine concepts may be higher and different compared with what you traditionally have measured from diesel engine cars. The emissions of NO<sub>x</sub> and NO<sub>2</sub> from heavy duty vehicles with Euro VI engines may be so low that these vehicles emit less of these exhaust components than today's diesel engine cars with Euro 5 technology, and they can reach about the same level as Euro 6 diesel engine cars. New knowledge about real life exhaust emissions from new vehicles with Euro 6/VI indicates that authorities should be careful in taking actions based on emission figures from legislation or experience with Euro 5/V vehicles and yesterdays engine technology.*

This report present new results from emission testing of six light vehicles and two heavy duty vehicles with new and interesting engine technology. In addition we, as reference, present the emission values from three light vehicles tested in another TØI project. The emission tests have been performed at VTT's certified exhaust emission laboratory in Finland. It has been possible to get hold of two certified diesel cars with Euro 6 technology and two heavy duty vehicles with Euro VI engines for testing. Based on the emission tests we can estimate the possibilities and challenges with Euro 6/VI technology. We very much appreciate the positive attitude we have met from the international companies and importers of vehicles to Norway and Finland, who have contributed with vehicles for testing.

## Euro 6 light vehicles and new engine technology

Some of the results from emission testing of light vehicles are shown in Figure S.1 (NO<sub>x</sub>), Figure S.2 (NO<sub>2</sub>) and Figure S.3 (CO<sub>2</sub>). The emissions relate to a "Helsinki city cycle" of 7,8 km at the temperatures -7 °C and +23 °C. Reference vehicles are a Toyota Avensis with 2,0 l Euro 5 diesel engine and a Toyota Prius (petrol engine and partly electric drive).

Figure S.1 show that the NO<sub>x</sub> emissions from light vehicles with Euro 6 technology may be significantly reduced compared with vehicles having Euro 5 technology. The reduction may be relatively high at +23°C, but low temperatures (-7°C) puts demand on heating before the systems for NO<sub>x</sub> reduction (SCR) are operative, making the exhaust treatment more complicated, and emissions higher.



\*Satisfy Euro 6 legislation emission limits

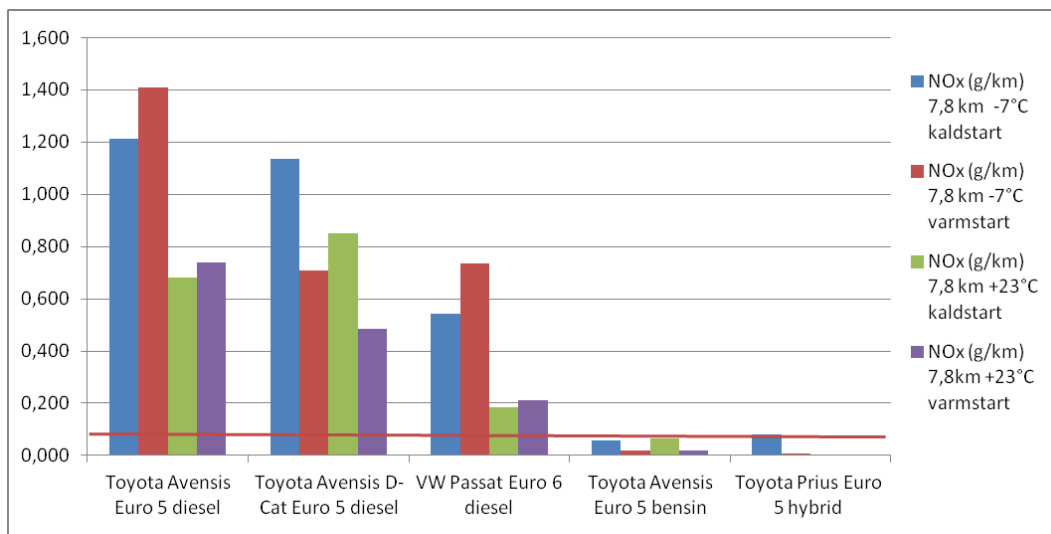


Figure S.1: Emissions of NO<sub>x</sub> from six light vehicles tested with the Helsinki city cycle at -7°C and +23°C with cold and warm engine start. The red line show the Euro 6 limit for NO<sub>x</sub> type approval of Euro 6 diesel engine cars 0,08 g/km).

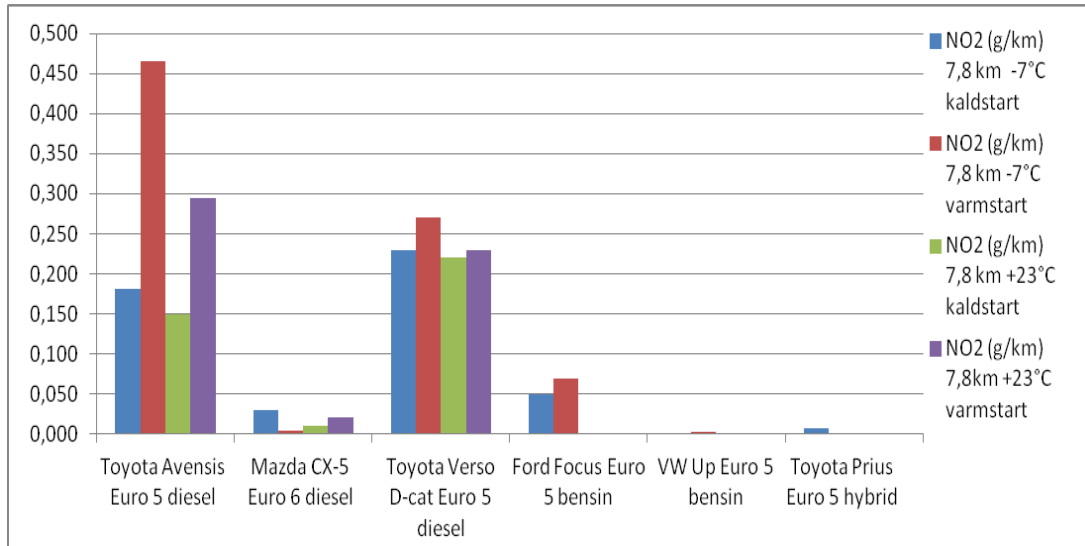


Figure S.2: Emissions of NO<sub>2</sub> from light vehicles tested with the Helsinki city cycle at -7°C and +23°C with cold and warm engine start.

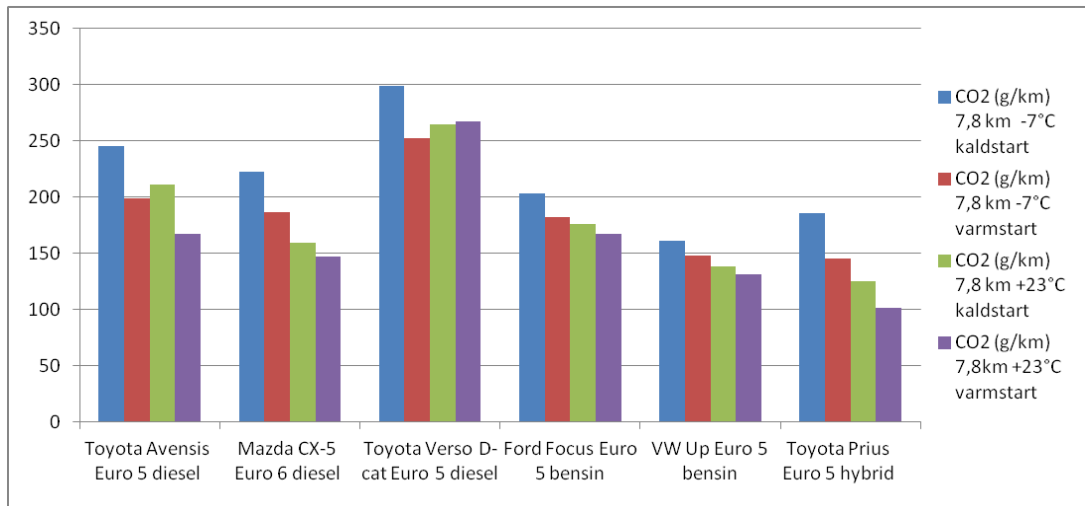


Figure S.3: Emissions of CO<sub>2</sub> from five light vehicles tested with the Helsinki city cycle at -7°C and +23°C and with cold respectively warm engine start.

The emission tests at VTT has given us the following indications and conclusions about Euro 6 cars and new engine technology:

- New Euro 6 light diesel engine vehicles comply with Euro 6 legislation
- Emissions of NO<sub>x</sub> from new Euro 6 light diesel vehicles may in real life traffic and at 23 °C be significantly lower than from Euro 5 light diesel vehicles, but they may be 2-4 times higher than the limit for type approval (measured in g/km).
- Emissions of NO<sub>x</sub> from new Euro 6 light diesel vehicles may in real life traffic and at -7 °C be 5-8 times higher than the limit for type approval.
- Emissions of NO<sub>2</sub> from new Euro 6 light diesel vehicles may in real life traffic be 30-50 percent of the total emissions of NO<sub>x</sub>.
- Emissions of Particulate Matter (PM) from Euro 5 and Euro 6 light vehicles seems to very small from diesel vehicles having efficient Particulate Traps

- Emissions of unregulated exhaust components from Euro 6 light vehicles may be higher, and somewhat different compared with older diesel engines.
- Emissions of CO<sub>2</sub> from new Euro 6 diesel light vehicles may in real life traffic be relatively high, because of energy use for chemical reduction of NO<sub>x</sub>.
- New light Euro 6 vehicles with small petrol engines and new technology may give us new challenges with emissions of NO<sub>x</sub> and PM in real life traffic.
- New light Euro 6 vehicles with small petrol engines and new technology may in real life traffic have so low emissions of CO<sub>2</sub> that they come down to the same levels as cars with diesel engines.
- A petrol car with hybrid drive had the lowest emissions of both CO<sub>2</sub> and local pollutants in real life city traffic among the cars tested in this project.

## Heavy duty vehicles with Euro VI engines

NO<sub>x</sub> and NO<sub>2</sub> emissions from two heavy duty vehicles with Euro VI engines are shown in Figure S.3 and S.4. The vehicles are tested at VTT's heavy duty vehicle laboratory, with different driving cycles typical for the use of heavy (over 3 500 kg) vehicles. For the vehicle with a 13 l engine VTT had in its database a comparable set of emission data for three of the driving cycles with a corresponding vehicle with Euro V engine.

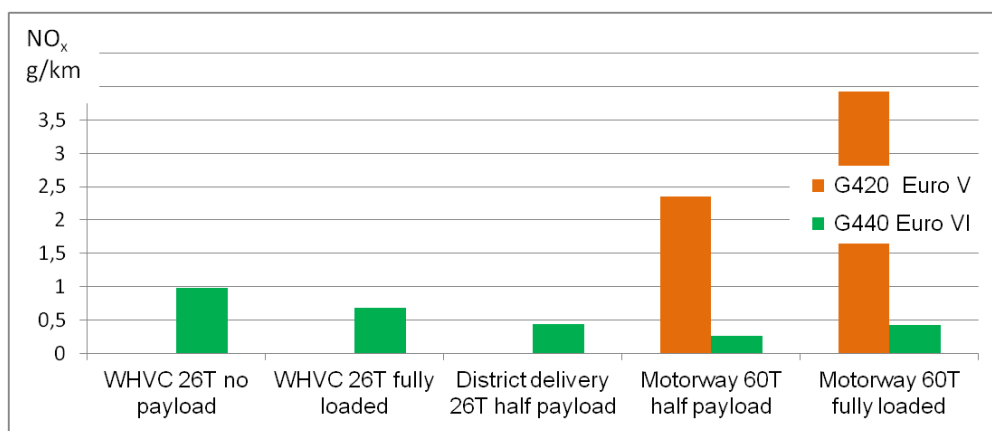


Figure S.4: Emissions of NO<sub>x</sub> from a heavy duty vehicle with a 13 l Euro VI motor, and as a reference a corresponding vehicle from the same producer with Euro V engine, at different driving cycles and different payloads.

The emission of NO<sub>x</sub> with an Euro VI engine were found to be only a fraction compared with what they were with an Euro V engine (Figure S.3). NO<sub>x</sub> from a heavy duty vehicle with an Euro VI 9-l Euro VI-engine were very low, when it is driven as a city bus and in other driving cycles (Figure S.4). The nitrogen oxide (NO<sub>x</sub> and NO<sub>2</sub>) emissions from this vehicle in city driving can be compared with corresponding emissions from city driving of a typical light diesel Euro 5 car. The comparison shows that the emissions are lower from this heavy duty vehicle than from the light Euro 5 vehicle. Comparisons indicate that it even may be possible to get NO<sub>x</sub> and NO<sub>2</sub> from heavy duty vehicles down to the same level as from light Euro 6 diesel vehicles.

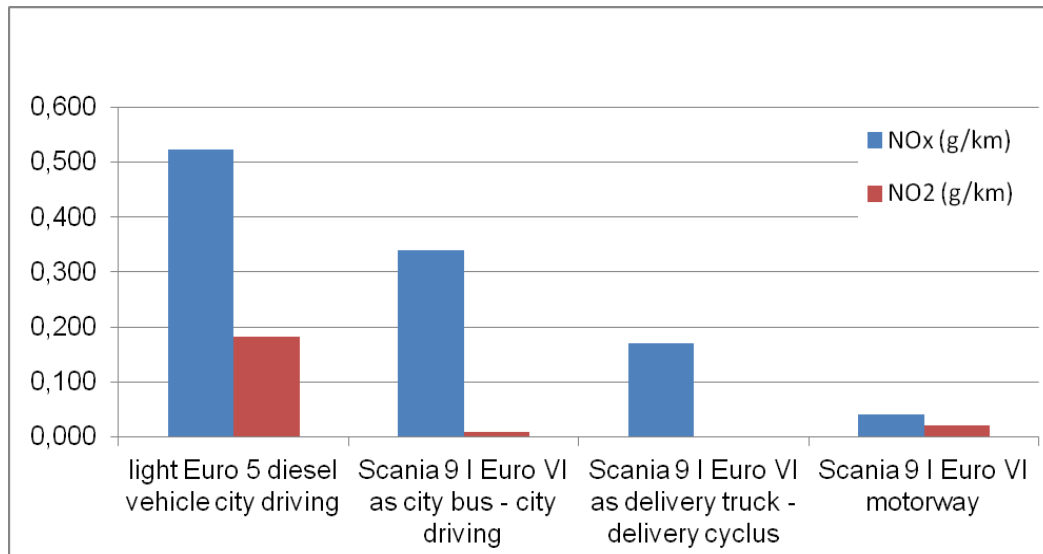


Figure S.5: Real life emissions of NO<sub>x</sub> and NO<sub>2</sub> from a heavy duty vehicle with a 9 l Euro VI engine, in comparison with a typical Euro 5 car with diesel engine.

The emission tests at VTT has given us the following indications and conclusions about heavy duty vehicles with Euro VI engines:

- Heavy duty vehicles with Euro VI engines may in all kinds of driving cycles have low emissions of NO<sub>x</sub> and PM.
- For one of the heavy duty vehicles with Euro VI engine were the emissions of NO<sub>x</sub> and PM 5-10 times lower than from a corresponding vehicle with Euro V engine.
- One of the two heavy duty vehicles had in one driving cycle low emissions of NO<sub>2</sub> but relatively high emissions of N<sub>2</sub>O (Laughing gas) which has a strong global warming effect.
- The demand for low levels of local emission from heavy duty vehicles, their engines and exhaust cleaning systems are now with Euro VI so strict that it is necessary to tune the engine and exhaust cleaning systems according to the use of the vehicle.

## **Focus and conclusion**

The results from the few tests we have done and presented is not enough to draw solid conclusions about Euro 6/VI-technology and about future exhaust emissions. The results tell us at that it is possible to achieve low levels of regulated and unregulated locally harmful exhaust pollution, at the same time as we can see that new problems may arise. We want in this report not to focus on specific producers of engines or specific new car models. We want to find out more about Euro 6/VI technology, possibilities to reduce emissions and show the need for objective tests. The presented exhaust tests of vehicles with new Euro 6/VI technology give us new information about possibilities and challenges to reduce air pollution and emissions of CO<sub>2</sub>.

There is a strong need for additional emission testing and cooperation between independent research institutes, authorities and vehicle producers. More knowledge is essential for authorities to be able to make the right decisions about vehicles, emissions and air quality.