

Summary

Exhaust emissions from cars with GDI-technology

Results from the measurement program in EMIROAD 2016

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Petrol cars with gasoline direct-injection technology should provide lower fuel consumption and higher performance than traditional petrol engine technology. However, these savings may have a downside: Emissions of particles and nitrogen oxides can be relatively high from this car type.

In order to improve fuel economy, the injection of fuel directly into the cylinder (direct injection, DI), was introduced for diesel engines. In recent years, this technology has also been transferred to petrol engines (gasoline direct injection - GDI). Together with reduction of cylinder volume ("downsizing"), this technology offers potential for fuel saving, while at the same time maintaining high power-output levels. However, GDI-technology also has downsides. As conditions in the cylinder of petrol engines during combustion approach those found in diesel engines, the disadvantages of high particulate and nitrogen oxide emissions can also be transferred to petrol cars. While many are aware of this problem, few have performed studies that map the emissions during realistic driving conditions.

Since 2011, the Institute of Transport Economics (TØI) has investigated to what extent and why road traffic contributes to high levels of emissions of local pollutants. Since 2013, this measurement project has been funded by the National Road Administration's R & D program EMIROAD (EMISSIONS from ROAD transport vehicles).

This report presents the results of measurements from passenger cars with GDI-engines in realistic driving conditions, with cold and hot start of the engine at different temperatures. The measurements were carried out in VTT's emission-laboratory in Helsinki, Finland.

Petrol cars with GDI-engines emit more CO₂ than diesel cars

Petrol cars traditionally have an approx. 20-25 % higher fuel consumption and therefore exhibit higher CO₂-emissions than diesel cars. But the difference between the two engine technologies is decreasing. Figure S 1 shows the CO₂-emission of cars tested during the EMIROAD program. The emission figures are normalized based on kilometers driven using the Helsinki-cycle, and on the weight of the vehicles. At +23 °C, petrol cars emit on average 13.3 % more CO₂ per kilogram of vehicle-mass than diesel cars. However, as the report shows, this improvement comes at a high price in terms of the "local" emission factors, such as particulate matter (PM) and nitrogen oxides (NO_x). In this context, it is also important to mention that it is the total CO₂-emission of the whole vehicle, in a life-cycle perspective, that is important in a climate perspective.

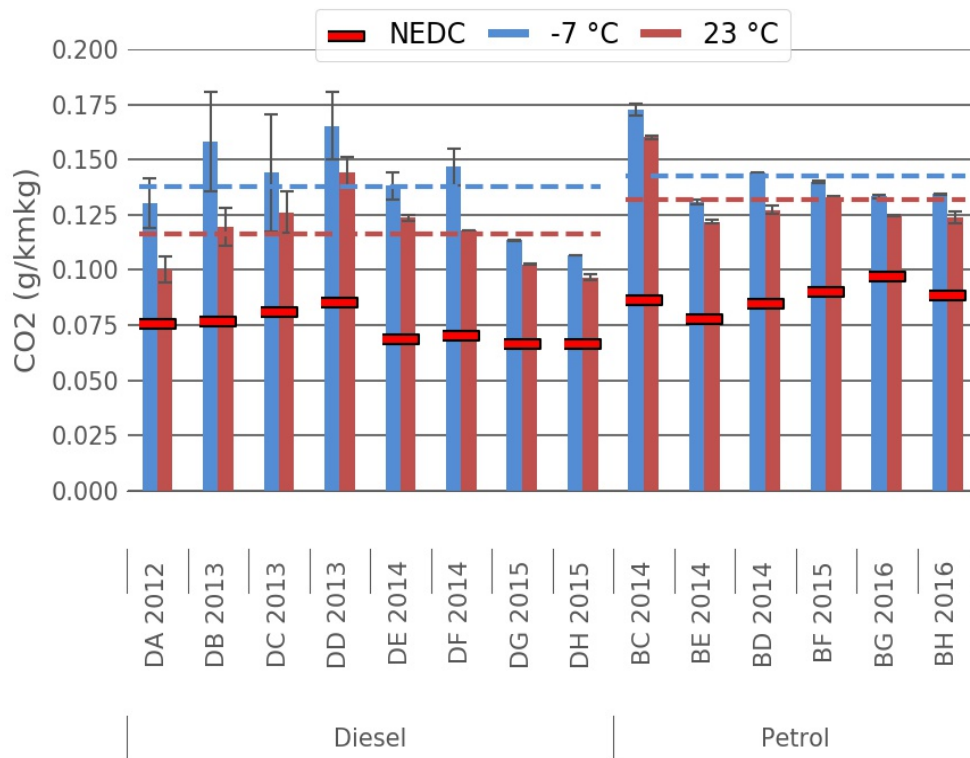


Figure S 1: CO₂-emissions from petrol cars (BC-BH), compared to those of diesel cars (DA-DH). The year indicates the production year of the vehicle. Helsinki-cycles, normalized based on weight of vehicles ((g/ km)/ kg). The red markers on the bars indicate the emissions reported by the manufacturer. The dotted red and blue lines show the average measured values for both vehicle types, and at two different temperature levels. The values for the diesel vehicles are collected from previous TØI reports in the EMIROAD program.

In cold-starts at low temperatures, cars with GDI-engines emit more particle mass than diesel cars

The diesel car has had a bad reputation for particle emissions for many years. However, with the introduction of diesel particulate filters (DPF), particulate matter emissions have become very low, and for new diesel cars, the level is well below the Euro 6 type approval limit (Figure S 2). For petrol cars with GDI-technology, however, cold-start PM emissions (at low temperatures) can be high, and reach up to 8.6 times above approved limits. With the further reduction of the approved limit value for PM in 2017, it is expected that petrol cars with GDI-engines will also be equipped with particle filters. It is reasonable to expect then that the PM-emissions will become as low as they are for diesel cars, but it will be important to monitor this development with independent measurements. It will be especially important to check developments in emission levels in Nordic climates (winter temperatures).

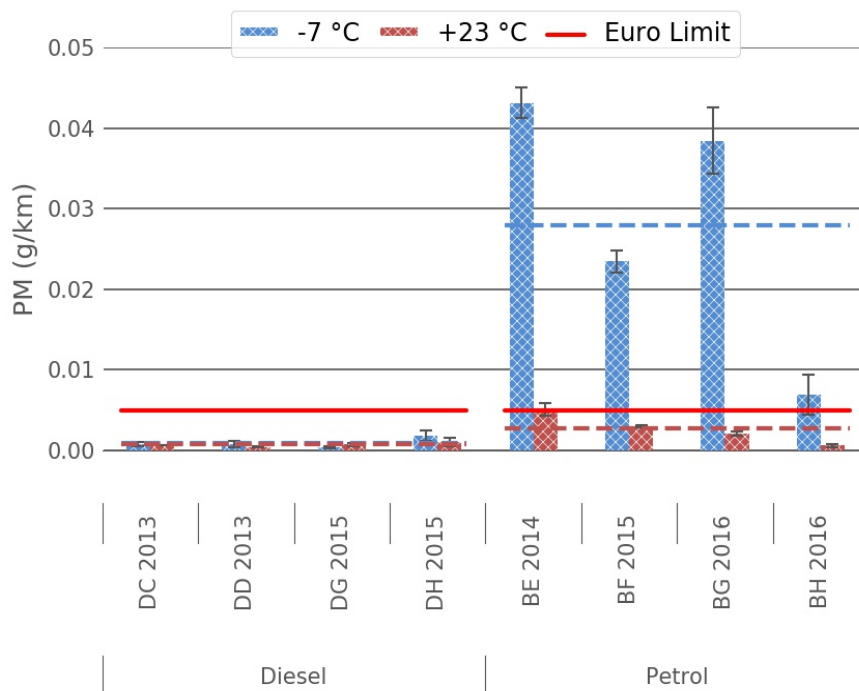


Figure S 2: PM-emission for tested cars with diesel engines (DC, DD, DG, DH) and petrol engines (BE, BF, BG, BH) at cold-start conditions during the Artemis Urban-cycle. The year indicates the vehicle's year of production. The red line shows the Euro 6 type approval limit-value (European Parliament, 2007). The dotted red and blue lines show the average measured values for both vehicle types, and at two different temperature levels. The values for the diesel vehicles are collected from previous TOI reports in the EMIROAD program.

Some cars with GDI-engines have relatively high emission of NO_x, but the emission level is still considerable lower than that of modern diesel cars

Half of the tested cars with GDI-engine showed NO_x-emissions that were significantly above the Euro 6 limit value for type approval (Figure S 3). This observation also requires follow-up, especially since the introduction of particulate filters for petrol cars potentially can lead to increased NO₂-emissions. Nevertheless, NO_x-emissions from petrol cars with GDI-engines in cold temperatures are significantly lower than that of new diesel cars.

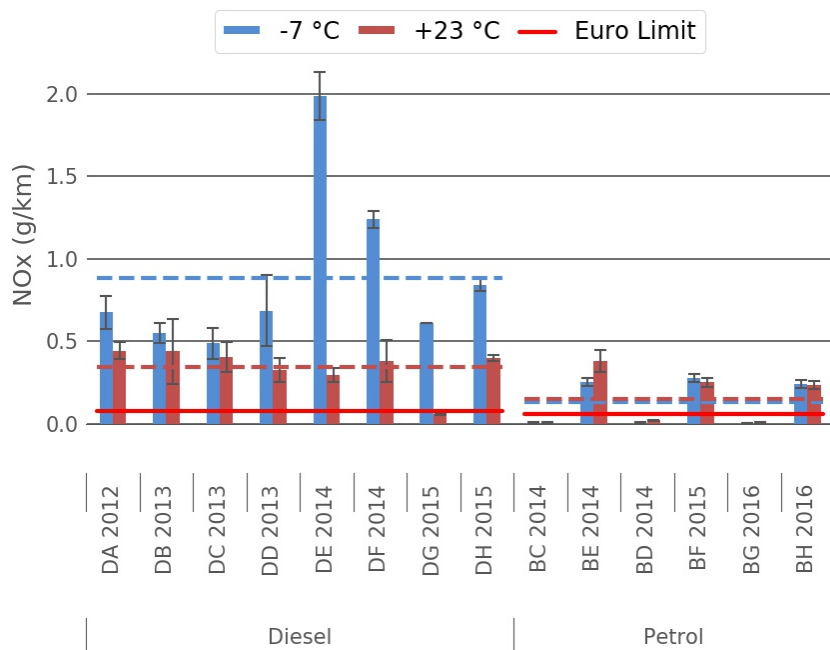


Figure S 3: NO_x-emission for petrol cars (BC-BH), compared to diesel cars (DA-DH). Emission during the Helsinki-cycle. The year indicates the production year of the vehicle. The red line show the Euro 6 type approval limit-value (European Parliament, 2007). The dotted red and blue lines show the average measured values for both vehicle types, and at two different temperature levels. The values for the diesel vehicles are collected from previous TOI reports in the EMROAD-program.