Exhaust gas emissions and consumption tests are showing the advantages of E10

Keeping the air cleaner with E10

On the way to net-zero greenhouse gas (GHG) emissions by 2050, the European Union (EU-28) is on track to exceed its 2020 goal to reduce GHG emissions by 20%. According to Eurostat, in 2017 GHG emissions were down by 22% compared with 1990 levels.[1] However, limiting global warming to below 2°C and curbing climate change remains a significant challenge.

The transport sector is often seen as the "problem child" of climate change. Compared to 1990, the share of GHG emissions of most sectors decreased, while emissions in the transport sector increased, from 15.1% in 1990 to 24.6% in 2017.[2] The reasons for this development are the growing vehicle stock of passenger and freight transport, as well as the tendency to purchase heavier automobiles with more powerful engines. Meanwhile, however, technology-driven improvements and the use of biofuels, such as bioethanol and biodiesel, contributed to significantly reduce kilometre-related emissions and to counteract elevated traffic-emergence. In the near future, the transport sector will still depend on liquid biofuels in the European motor vehicle fleet, which is getting older year-on-year (passenger cars are now on average approximately 11 years old[3]). In both aviation and shipping, no established alternatives to combustion engines yet exist.

It is well known that bioethanol and other biofuels have the ability to reduce GHG emissions by replacing fossil fuels. The average certified GHG emission savings of renewable fuels have increased continuously. In 2018, European bioethanol achieved a GHG emission saving of 71% compared to fossil fuels.[4] Another substantial benefit of bioethanol is its ability to reduce exhaust emissions that are harmful to both the environment and human health. Recent tests commissioned by the German Bioethanol Industry Association confirmed these advantages once again.

The tests were carried out to assess the impact of bioethanol content over fuel consumption and regulated pollutants when running with Super E5 RON 95 (E5, a blend of 5% ethanol) and Super E10 RON 95 (E10, a blend of 10% ethanol). Five vehicles, approved according to Euro 6d-Temp standards and recent engine technology, were laboratory-tested on the Worldwide harmonised Light-duty vehicles Test Cycles (WLTC) class 3b cycle.

The chosen vehicles should be representative for the mid-size, compact and subcompact vehicle class. Furthermore, the tests should be performed on vehicles with direct as well as manifold injection. Considering these aspects and taking into account the most represented passenger car types in the German car stock, the following passenger cars were selected: Ford Fiesta, Opel Corsa, VW Golf, Renault Mégane and BMW 3-series. Regarding current debates on exhaust gases, as well

Exhaust emission and fuel consumption measurements (WLTP)	**Fiesta 1.1** (1)		**Corsa 1.4** (2)		**Golf Variant 1.0 TSI** (3)		**Mégane TCE160** (4)		**318i** (5)	
Petrol type	Super (E5)	Super E10	Super (E5)	Super E10	Super (E5)	Super E10	Super (E5)	Super E10	Super (E5)	Super E10
Consumption in L/100 km	5,29	5,38	5,87	5,74	5,27	5,24	5,69	5,68	6,19	6,23
Difference in %	1,70 %		−2,21 %		−0,57 %		−0,18 %		0,65 %	
NO_X* in g/km	0,0055	0,0049	0,0509	0,0355	0,0203	0,0180	0,0128	0,0132	0,0176	0,0084
Difference in %	−9,9 %		−30,3 %		−11,3 %		3,0 %		−52,3 %	
PN*/km	$1{,}6 \times 10^{12}$	$4{,}5 \times 10^{11}$	$1{,}6 \times 10^{12}$	$4{,}4 \times 10^{11}$	$7{,}1 \times 10^{10}$	$3{,}4 \times 10^{10}$	$6{,}9 \times 10^{10}$	$2{,}5 \times 10^{10}$	$7{,}9 \times 10^{11}$	$2{,}6 \times 10^{11}$
Difference in %	−71,8 %		−72,8 %		−52,1 %		−63,5 %		−67,1 %	
Car classification	subcompact car		subcompact car		compact car		compact car		mid-size car	
Displacement in cm^3	1084		1398		999		1332		1499	
Performance in kW	52		66		81		120		100	
Engine Design	intake-manifold fuel injection		intake-manifold fuel injection		direct fuel injection with turbocharger		direct fuel injection with turbocharger		direct fuel injection with turbocharger	

Standardised exhaust emission and fuel consumption measurements in acc. with regulation (EU) 2015/1151 WLTP with test fuel Euro-6 fuel E5 and E10 (5 % and 10 % bioethanol content) in five cars with petrol engines; *NO_X: nitrogen oxides; PN: particle number

Figure 1. Standardised exhaust emission and fuel consumption measurements

as common misconceptions about a highly increased fuel consumption using E10, the main goal was to measure the influence of the bioethanol content on fuel consumption, as well as particle number and nitrogen oxides emissions. The main technical data and results are shown in Figure 1.

E5 vs E10: fuel consumption

The fuel consumption of vehicles 2-4 was lower with E10 than with E5. The difference in consumption for VW Golf (3) and Renault Mégane (4) is < 1%, and can be seen as measurement uncertainty due to driver handling. In contrast, the fuel consumption in vehicles 1 and 5 is slightly higher with E10 than with E5. Therefore, it can be concluded that there is no significant difference in fuel consumption between E5 and E10. A meta-analysis carried out by the Institute for Powertrains and Automotive Technology in Vienna (2014)[5] showed that fuel consumption when using ethanol blends is, as expected, rising with the increasing share of ethanol, due to the lower heating value of the alcohol.

"In the performed tests, particle emissions, particulate number and particulate matter were measured and compared when running the test vehicles on E5 and E10"

However, the increase is lower than the theoretical fuel consumption. For E20/E25 blends the meta-analysis reports an average increase in fuel consumption of 3.1% (theory: 7.7%) compared to fossil fuel, and for E5/E10 a rise of 1.0% (theory: 2.9%). The observed fuel economy improvements of 4.6% for E20/E25 and 1.8% for E5/E10, respectively, result from the thermodynamic advantage due to the use of ethanol.

E10 lowers particle emissions

Particle emissions are caused by inhomogeneous fuel/air mixtures and fuel-wall interactions in the combustion chamber. Furthermore, their formation is strongly related to the content of aromatic compounds. The share of these high-boiling components, and hence the production of soot precursors, can be reduced with ethanol blends. The benefit of ethanol as a clean, high-octane blend shouldn't be overlooked.

In the performed tests, particle emissions, particulate number (PN) and particulate matter (PM) were measured and compared when running the test vehicles on E5 and E10. In general, it has been shown that using E10 significantly reduces particle emissions compared to E5. A reduction of PN of around 52–73 % was observed with E10. It should be mentioned that vehicles 1, 2 and 5 are only meeting the Euro-6 standard requirements when running on E10 (threshold: 6 x 1011 PN/km).

E10 reduces nitrogen oxides emissions

During combustion, nitrogen oxide (NO) and nitrogen dioxide (NO_2), summarised as nitrogen oxides (NO_x), are formed in large quantities. The formation of these compounds depends, among other things, on the temperature range of combustion and the stoichiometric ratio of nitrogen and oxygen in the combustion zone. Most present-day vehicles are equipped with a catalytic converter to reduce NO_x, consequently lowering air pollutants and their adverse health effects. Four of the tested vehicles (1-3, 5) showed NO_x emission reductions between 10% and 52% using E10, compared to E5. For Renault Mégane (4), emissions were slightly higher when running on E10 than on E5 (+3%).

E5 vs E10: conclusion

To get reliable results and to avoid measurement uncertainties, it is recommended to perform the tests repeatedly with E5 and E10, always using the same vehicle. However, the results of the exhaust emission and consumption tests are clearly showing the advantages of E10 over E5. ●

Figure 2: Roller dynamometer test bench used in the measurement of exhaust emissions and fuel consumption

References:

1. https://ec.europa.eu/eurostat/statistics-explained/pdfscache/1180.pdf
2. https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-4a.html
3. https://www.acea.be/statistics/tag/category/average-vehicle-age
4. https://epure.org/media/1920/190828-def-data-statistics-2018-infographic.pdf
5. B. Geringer, J. Spreitzer, M. Mayer, Ch. Martin, Meta-analysis for an E20/25 technical development study - Task 2: Meta-analysis of E20/25 trial reports and associated data, 2014, TU Wien.

For more information:

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