Report

Test of eFuels and HVO

Comparison of synthetic fuels with their mineral counterparts

Electricity-based fuels, so-called eFuels, have been promised for several years now. So far, production plants have not progressed beyond the experimental stage, but the first large-scale plants are expected to come on stream soon. Another alternative to mineral fuel is HVO as a diesel substitute, which is obtained from (vegetable) waste materials.

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Synthetic fuel as a climate-neutral fuel for the future

The debates about synthetic fuels are becoming increasingly energetic - on the one hand they are promoted as the saviour of climate-neutral mobility, on the other they are branded as a nonsensical waste of energy. As is so often the case, the truth lies somewhere between the poles. The energy consumption for production is undoubtedly high, so that production in Germany with its scarce resources is probably not feasible. However, there are remote regions in the world where a lot of electricity can be generated sustainably with sun and wind. There, the production of eFuels can make perfect sense, even if the efficiency is moderate. If the electricity were to be transported over long distances to Germany, the losses could be similarly high. In addition, the infrastructure for this would first have to be created. In contrast, the existing structures for transport and distribution can continue to be used for eFuels.

The production of liquid fuels from electricity, water and CO_2 is not a new invention, and the processes themselves are feasible in large-scale plants. The biggest challenge so far has been the cost, both for the investment and for the operation. However, due to the enormous increase in prices for mineral fuels, the calculation can be reopened, especially since the investment costs for sustainable power generation have dropped considerably. In addition, there is pressure from politicians to move quickly in the direction of CO_2 -neutral mobility.

Some test plants already exist, for example at CAC (Chemie Anlagen Chemnitz), at KIT in Karlsruhe or at some vehicle manufacturers. Currently, the first large-scale plants are being planned (CAC with Shell) or built (Porsche in Patagonia, Chile). The new plants will produce eFuels that burn more cleanly due to their optimised properties (e.g. very low aromatics content), but at the same time meet the proven EN 228 standard for petrol. This means that the fuels can be used in all standard petrol-engined vehicles - including classic cars. This complete compatibility is important to achieve the widest possible range of applications. eFuels and mineral counterparts can be mixed easily and in any ratio, so a steady production ramp-up can be well integrated into petrol and diesel sales.

The paraffinic fuel HVO is currently being produced on a large scale as a possible diesel substitute. This has two very important differences compared to the eFuels for petrol engines just described: the basis for HVO production is biomass, e.g. waste oils and fats, and it does not meet the EN 590 standard for mineral diesel. Paraffinic HVO fuels such as C.A.R.E diesel are not fully compatible with this, which is why they may only be used in diesel vehicles that are approved for the EN 15940 standard (also known as XTL). At least XTL is being allowed in more and more models, but in Germany in particular, vehicle manufacturers are still reluctant. BMW deserves a positive mention at this point. The manufacturer has approved all diesel models, even older existing vehicles, for operation with paraffinic fuels according to the EN 15940 standard.

So far, practically no measurement results on eFuels are known from manufacturer-independent sources. Therefore, it was important for ADAC to determine its own results in order to be able to provide expert answers in the eFuels and biofuels debate.

Definition of eFuels

Synthetically produced fuels are referred to as eFuels. Basically, a type of crude oil is produced first, which can then be further processed into petrol, diesel or paraffin, for example. The production of the raw material requires electricity, water and CO_2 . The CO_2 required can be filtered from direct sources (e.g. cement plant) or from the air; the latter involves more effort and thus more energy consumption.

Various conversion and refinement processes are used to obtain the desired fuel, which complies with the EN 228 petrol standard, for example. This artificial petrol can then be used in any standard petrol engine. This means that it can also be used without any problems in vintage cars without special approval or conversion.

Definition of paraffinic fuels

Biomass is usually used as a feedstock for paraffinic fuels. For example, waste materials such as used cooking oils or fat residues are refined into liquid fuel, known as HVO, with the use of energy. Animal fats can also be used to produce such fuels. Examples of paraffinic fuels are C.A.R.E. Diesel or NExtBTL from Neste. We examined this HVO in the test. The important difference compared to eFuels is that it does not comply with the standard diesel standard EN 590, but with DIN EN 15940. Diesel models must be explicitly approved for this fuel by the manufacturer in order to be able to use it. With HVO 100, balance sheet CO_2 emissions can be reduced by over 90 %.

Ecotest procedures and test models - the basis of the study

The different fuels were tested in five vehicle models on the test bench. In over 100 measurements – measured at one piece, this would mean over two months of continuous measurement - the exhaust emissions and fuel consumption were precisely determined and compared with each other. All vehicles had to pass through the proven cycles of the ADAC Ecotest, i.e. the registration cycles under different conditions as well as the demanding motorway test. In this way, it can be determined whether the test vehicles comply with the legal requirements and how they also behave in everyday life.

A six-year-old Ford Fiesta, a five-year-old VW Golf VII and a current Golf VIII with the latest engine technology were tested with the eFuel. The aim was to test whether older and new engine technology react differently to the artificial fuel. For the HVO tests, a nine-year-old BMW 320d and a current VW Touran TDI were measured. Both models are explicitly approved for paraffinic fuels.

The test products: eFuel petrol and HVO 100 as diesel equivalent

For the petrol models, E10 reference fuel and E10 petrol station fuel were used as mineral fuels. The manufacturers use the reference fuel for the type approval of a model, the petrol from the filling station is used in everyday life. The mineral petrol was compared with eFuel from the manufacturer CAC, which also contains 10 percent ethanol.

In the diesel study, diesel reference fuel with a standard 7 percent bio-content was used and compared with the paraffinic fuel HVO 100.

All fuels were subjected to a detailed fuel analysis in advance in an external laboratory.

The results at a glance

The tests have shown that the synthetic fuels work without any problems, as long as the models are approved for the respective fuel. With eFuels according to the EN 228 standard for petrol, the situation is simple because they can be used in any standard petrol engine. Diesel models, on the other hand, must be explicitly approved for HVO, but the number of approvals is growing steadily.

In all measurements, it could be confirmed that the pollutant emissions are not worsened by the alternative fuels. However, at the time of testing, only prototype eFuels were available, which are already of good quality but do not yet exploit the full potential of artificially produced fuels. The planned new production plants, e.g. those of Porsche, will continue to produce optimised fuels. Their aromatics content is to be significantly lower, so that, according to the current status, particulate emissions in particular should fall. Thus, with ideally designed fuel, even a positive effect on air pollution control can be expected.

Optimised eFuels therefore have the potential not only to improve the CO_2 balance sheet of the existing vehicle fleet, but also to reduce pollutant emissions. This would not require waiting for the renewal of the entire fleet. The CO2-neutral fuels would thus be a good complement to the market ramp-up of electromobility, because they can make a parallel contribution to environmental protection.

Potentials for future developments

It is possible to mix mineral and artificial fuels so that the eFuels share can be continuously increased depending on availability. From the ADAC's point of view, the argument to reject eFuels in general does not count because the total demand could not be covered at present anyway. Rather, the opportunity should now be seized to continuously reduce the fossil share by blending eFuels and thus make an important contribution to environmental protection.

The petroleum association UNITI confirms the drop-in capability for eFuels:

„E-Fuels, die die geltenden Kraftstoffnormen, wie z.B. die Anforderungsnorm EN228 für Ottokraftstoffe, erfüllen, sind technisch gleichwertig zu herkömmlichen Kraftstoffen. Diese E-Fuels sind damit „Drop-in“-fähig und können in beliebigen Anteilen herkömmlichen Kraftstoffen beigemischt werden oder können diese sogar zu 100 Prozent ersetzen. Technische Anpassungen an Fahrzeugen, die für die jeweilige Anforderungsnorm zugelassen sind, sind weder bei der Verwendung von E-Fuels in beigemischter Form noch in Reinform notwendig.“

The English translation follows on the next page.

"E-fuels that meet the applicable fuel standards, such as the EN228 requirement standard for petrol, are technically equivalent to conventional fuels. These e-fuels are thus "drop-in" capable and can be blended with conventional fuels in any proportions or can even replace them 100 percent. Technical adaptations to vehicles approved for the respective requirement standard are not necessary either when using e-fuels in blended form or in pure form."

Demands on politics

It is important to provide incentives and a perspective for eFuel manufacturers. The high investments and development efforts require planning security. In addition, Germany should finally give the go-ahead for the regular sale of HVO, as is already the case in other EU countries.

EU bodies are currently working on introducing a mandatory quota of 2.6 to 5.7 percent for green hydrogen and eFuels in the European transport sector by 2030. Such a regulation could significantly advance eFuels development and make large-scale production more attractive.

Demands on the vehicle manufacturers

Some manufacturers are still very reluctant to approve their diesel models for paraffinic fuels such as HVO. Technically, however, it is no problem to design modern diesel engines to meet the relevant standards.

After all, Peugeot and Citreon have now approved all Euro 5 and Euro 6 diesel models for operation with HVO. In the VW Group, diesel cars may be fuelled with HVO from production in mid-2021. However, it is incomprehensible why some manufacturers (e.g. Volvo) allow their vehicles in Scandinavian countries to run on paraffinic fuels, while the same models in Germany do not receive approval. There should be urgent improvements here and equal regulations should be introduced.

BMW can be a role model, because the manufacturer has approved all of its diesel models for HVO operation - even all of the older ones on the road.

Demands on the eFuel manufacturers

Our efforts around the procurement of eFuels have shown: there is a lack of transparency on the part of the manufacturers and a clearly recognisable will to advance the topic of synthetic fuels. Constructive communication and effective PR work are indispensable for the future success of eFuels. The eFuel Alliance is a good step in this direction, but it should not be limited to this.

Difficult procurement situation for eFuels

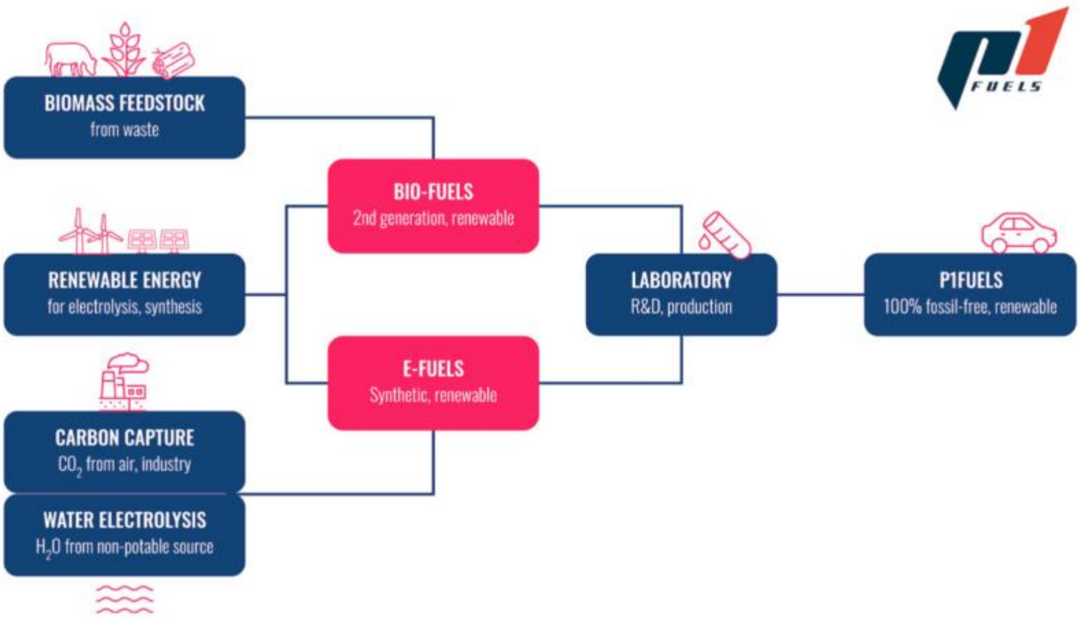
The biggest challenge for the test was obtaining the eFuels. Despite intensive efforts over a year, it was not possible to obtain synthetic, electricity-based diesel fuel. The company Mabanaft, which had initially held out the prospect of such a fuel, put off for months with the indication of plant repairs and has not been available at all since July 2022. This meant that a test with the VW Golf I 1.6 Diesel, which had already been organised, was unfortunately not possible.

The CAC fuel could also only be procured in a roundabout way - the petroleum association UNITI helped with this; initially, no eFuel could be obtained from the actual manufacturer itself.

P1 Racing Fuels Eco100 Pro - the special case in the test

Fortunately, a larger quantity of eFuel could be obtained from the company P1 Racing Fuels at the beginning of 2022. The 98 octane fuel without ethanol content is particularly well suited for classic cars that cannot tolerate ethanol. Therefore, the ADAC Classics Department started a long-term test with this fuel on their VW T1 in order to gain experience over many thousands of kilometres.

Measurements with both VW Golf VII and VIII could also be carried out. Although P1 had initially confirmed that it was eFuel, further research revealed that in addition to electricity-based feedstock, biomass was also used to produce the Eco100 Pro petrol. This was confirmed in talks, but no precise details were given on the mixing ratio. Only this much: at the moment, the biomass share is probably still well over 50 percent. The following graphic shows the sources and composition of the P1 eFuel:



©P1 Fuels

This means that the original requirement for eFuel fuels in the test is not met. In order to avoid a "tank or plate" discussion from the outset, the eFuels tested should be largely generated from electricity.

The endurance test with Eco100 Pro will be continued for the time being due to the lack of an alternative without ethanol content. The ADAC Klassik department describes its experiences in its own publications, a first report can be found under this link. However, the P1 fuel was separated from the comparison of the measurement results in the test. For the sake of completeness, the results with the P1 Racing fuel are summarised on page 26.

This is how we tested

Fuel analyses of all fuels in the test were first carried out in an external laboratory. This allowed compliance with the respective standards to be checked and the exact composition to be determined. The following table shows the results of the diesel fuels:

Auszug Kraftstoffanalysen	Einheit	Diesel B7 Referenzkraftstoff	HVO 100
Chemische Eigenschaften			
Cetanzahl	-	52,1	77,5
Dichte bei 15°C	kg/m³	833,8	780,8
Fettsäuremethylester (FAME)	%	6,4	0,0
Schwefelgehalt	mg/km	< 3,0	< 3,0
Heizwert	MJ/kg	42,9	47,2
Destillationsendpunkt	°C	366,5	309,2
Kraftstoffzusammensetzung			
Kohlenstoffanteil	%	85,64	84,7
Wasserstoffanteil	%	13,63	15,10
Sauerstoffanteil	%	0,73	0,00

The differences between mineral diesel and HVO from biomass are more pronounced than for petrol fuels. Depending on the engine, the higher ignition willingness and the different burn-off behaviour can also have an effect on the response behaviour and the turning willingness of the diesel drive.

The following are the results for the petrol types:

Auszug Kraftstoffanalysen	Einheit	E10 Referenzkraftstoff	E10 Tankstellenkraftstoff	E10 eFuel CAC	E0 Referenzkraftstoff	P1 Eco100 eFuel
Chemische Eigenschaften						
Oktanzahl	-	97,1	95,0	95,7	100,3	97,5
Dichte bei 15°C	kg/m³	744,0	749,6	756,4	751,0	758,4
Aromaten Gehalt	%	25,6	37,6	32,0	32,2	34,8
Ethanol Gehalt	%	9,3	10,1	10,0	0,0	0,0
Schwefelgehalt	mg/km	6,5	< 3,0	< 3,0	1,8	< 3,0
Heizwert	MJ/kg	42,2	41,9	42,0	42,8	41,9
Destillationsendpunkt	°C	195,0	168,0	175,8	196,1	206,7
Kraftstoffzusammensetzung						
Kohlenstoffanteil	%	82,94	83,23	83,17	86,89	82,91
Wasserstoffanteil	%	13,60	13,23	13,35	13,11	13,30
Sauerstoffanteil	%	3,46	3,54	3,48	0,00	3,79

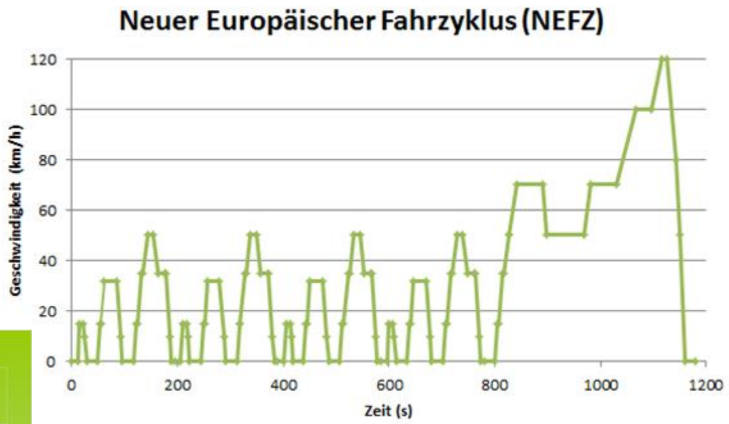
The differences in the aromatics content of mineral and synthetic petrol grades are striking. Aromatics, especially long-chain aromatics, promote the formation of particles in the exhaust gas, but also ensure the desired anti-knock properties. One goal of further eFuels developments is to reduce the aromatics to zero in order to minimise particle emissions; the necessary anti-knock properties can still be ensured by using appropriate additives.

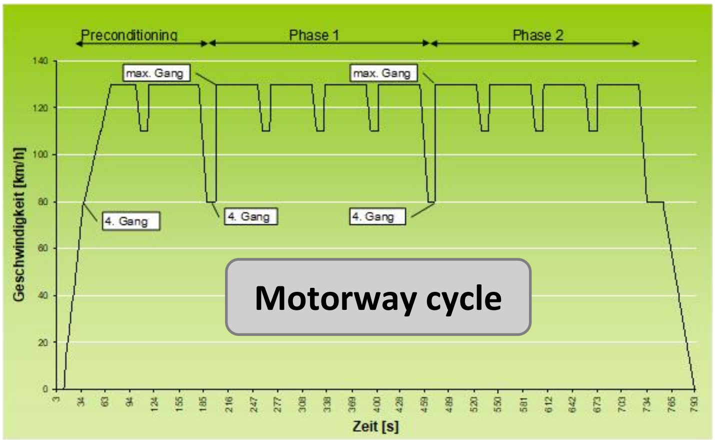
The test cars were selected on the basis of the technology installed. The aim was to examine how older and current injection systems and exhaust gas purification systems behave with the respective fuels and whether the pollutant limits are met with all types of fuel. For the petrol vehicles, the choice fell on a Ford Fiesta 1.0 EcoBoost and a VW Golf VIII 2.0 TSI DSG, for the diesel variants on a BMW 320d touring BluePerformance and a VW Touran 2.0 TDI DSG.

All test vehicles were measured on the test bench with the respective permissible fuels. For this purpose, the cycles of the ADAC Ecotest were run. For the older models homologated according to the NEDC, this includes an NEDC cold start, a WLTC warm start and the motorway cycle. With the new models, the WLTC was run once with a cold engine and once with a warm engine, and the motorway cycle was measured.

To ensure that the vehicles always behaved in the same way in all cycles and to exclude extraneous influences on the results, the automatic start-stop system and the air conditioning system were deactivated, the ventilation was set to level 2 and its air outlets to the middle and bottom, and the desired temperature was set to 20 °C. Each time the fuel was changed, the tanks of the test cars were emptied, the fuel lines were flushed and the new fuel was first used to drive at least 25 km.

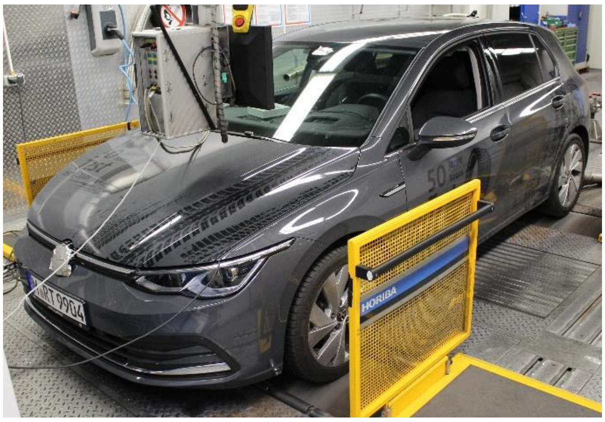
The following figures show the speed profile over time in the NEDC cycle, the WLTC cycle and the ADAC motorway cycle:





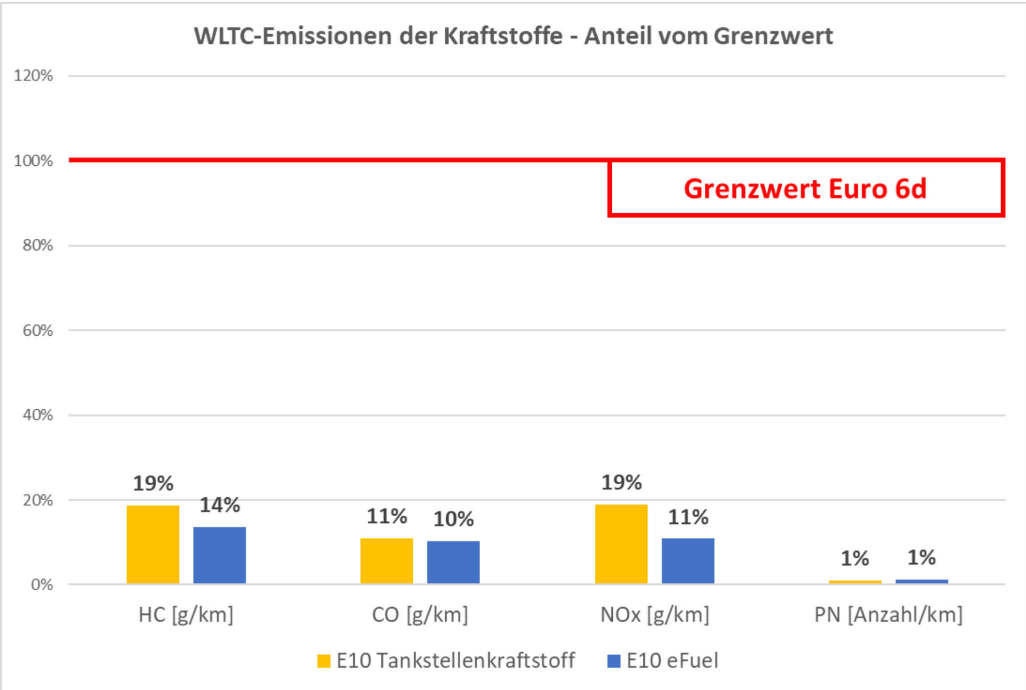
Test vehicle VW Golf VIII 2.0 TSI

Year of Production	2022
Motor	1984 cc, four-cylinder petrol engine, turbo
Power	140 kW / 190 PS, 320 Nm
Gearbox	7-speed dual clutch transmission
Emission control	3-way catalytic converter, particle filter
Pollutant standard	Euro 6d-ISC-FCM (AP)
Mileage	14,000 km



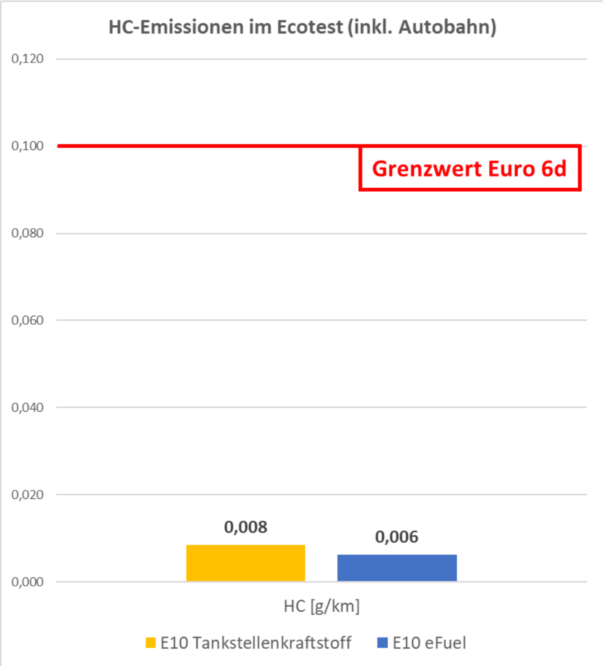
The Golf 2.0 TSI tested here represents the current petrol engine generation with turbocharging, direct injection and petrol particle filter. It meets the final Euro 6d emissions standard. All test results confirm the very low pollutant emissions of the engine, regardless of the fuel used. In all cycles, the emissions are far below the limit values, even in the very demanding motorway cycle of the ADAC Ecotest.

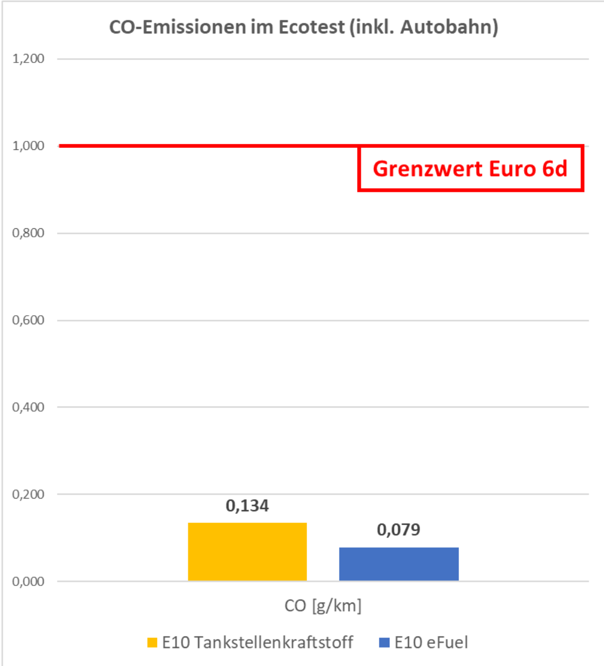
The following diagram shows the percentage of the respective pollutants from the limit value, measured in the WLTP cycle with E10 reference fuel and E10 eFuel from CAC:

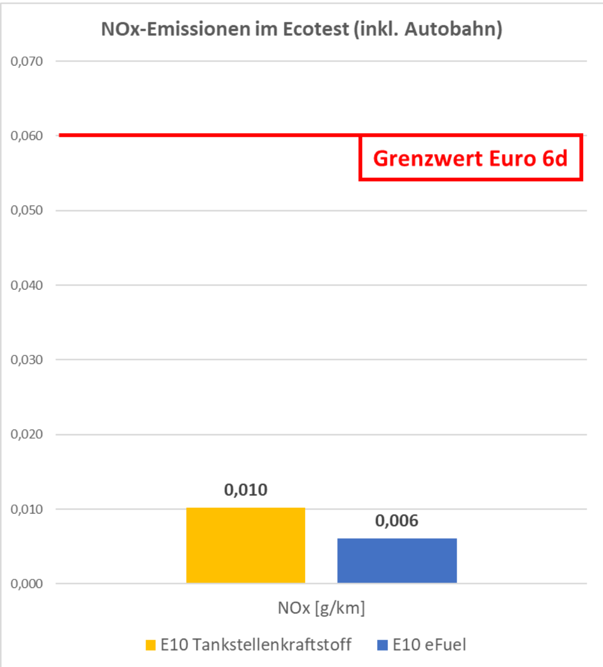


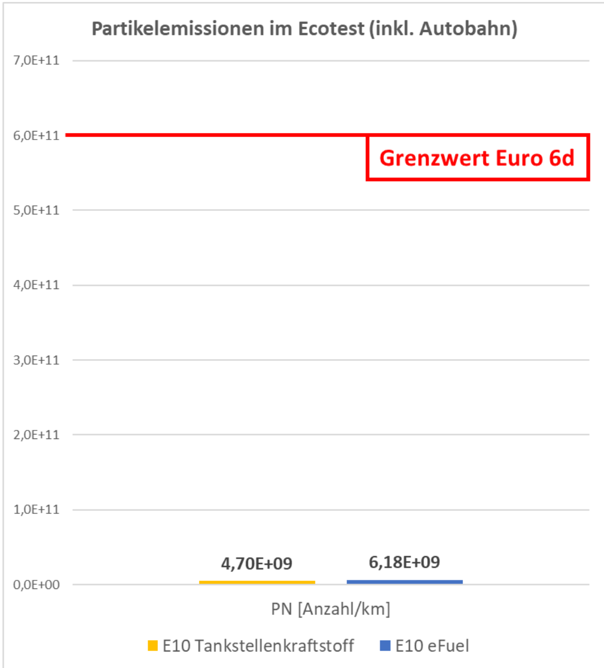
Result: Particulate emissions in particular are extremely low with both fuels. NOx emissions are reduced by about 40 % with the electricity-based fuel.

The other four diagrams compare the fuels according to pollutants in the Ecotest:









Results of the VW Golf VIII 2.0 TSI DSG.

The detailed results with E10 reference fuel:

VW Golf VIII 2.0 TSI DSG

Schadstoffe	Grenzwerte	E10 Ref WLTP kalt	WLTP warm	BAB130	Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,014023	0,001078	0,002470	0,006026	14,0%
CO [g/km]	*1,000*	0,099620	0,069881	0,136525	0,100283	10,0%
NOx [g/km]	*0,060*	0,007613	0,004918	0,007573	0,006658	12,7%
CH4 [g/km]	---	0,001893	0,000259	0,000430	0,000882	
NH3 [g/km]	---	0,003560	0,005957	0,008360	0,005839	
PN [Anzahl/km]	*6,00E+11*	2,81E+09	8,19E+08	7,38E+09	3,48E+09	0,5%
PM [g/km]	*0,0045*	0,0000676	0,0003678	0,0019044	0,000724	1,5%
CO2 [g/km]	---	143,06	141,3	169,76	150,45	
Verbrauch [l/100 km]	---	6,34	6,26	7,52	6,67	

The detailed results with E10 petrol station fuel:

VW Golf VIII 2.0 TSI DSG

Schadstoffe	Grenzwerte	E10 Tankstelle WLTP kalt	WLTP warm	BAB130	Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,018626	0,000988	0,005234	0,008435	18,6%
CO [g/km]	*1,000*	0,110131	0,058653	0,250186	0,134130	11,0%
NOx [g/km]	*0,060*	0,011347	0,005067	0,014837	0,010196	18,9%
CH4 [g/km]	---	0,002227	0,000258	0,000809	0,001112	
NH3 [g/km]	---	0,002734	0,008253	0,342800	0,106685	
PN [Anzahl/km]	*6,00E+11*	5,80E+09	4,81E+09	3,29E+09	4,70E+09	1,0%
PM [g/km]	*0,0045*	0,0000774	0,0000388	0,0026791	0,000844	1,7%
CO2 [g/km]	---	141,5	141,25	172,17	150,61	
Verbrauch [l/100 km]	---	6,22	6,21	7,58	6,62	

The detailed results with E10 eFuel CAC:

VW Golf VIII 2.0 TSI DSG

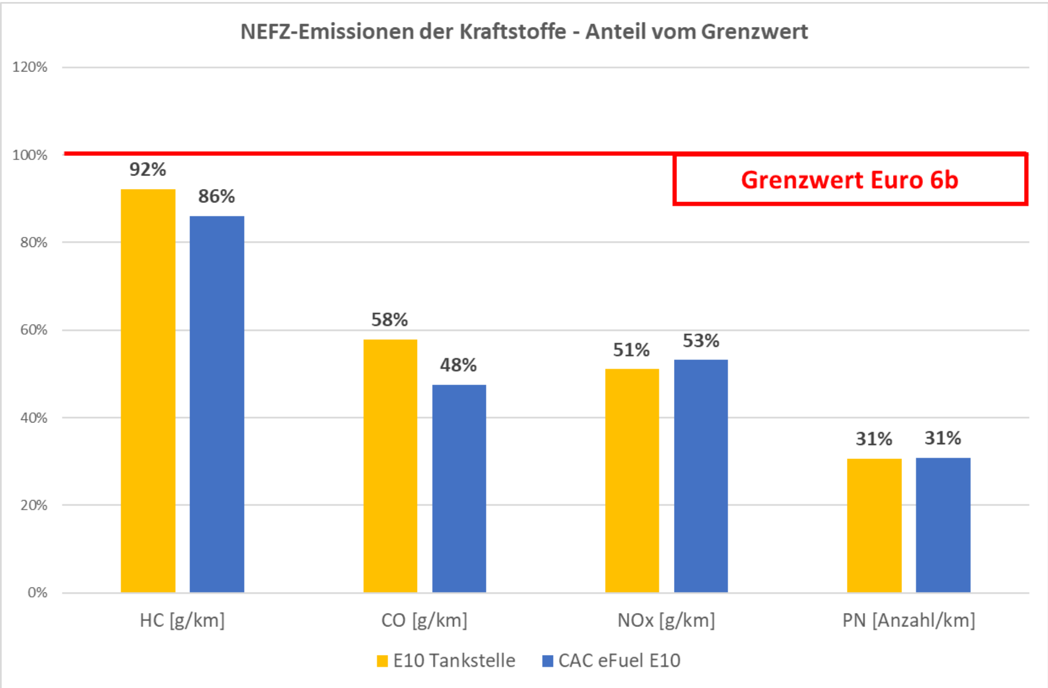
Schadstoffe	Grenzwerte	E10 CAC WLTP kalt	WLTP warm	BAB130	Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,013671	0,001376	0,003387	0,006283	13,7%
CO [g/km]	*1,000*	0,103265	0,025706	0,111985	0,078735	10,3%
NOx [g/km]	*0,060*	0,006492	0,004041	0,008064	0,006106	10,8%
CH4 [g/km]	---	0,002193	0,000129	0,000538	0,000974	
NH3 [g/km]	---	0,003176	0,002058	0,005851	0,003587	
PN [Anzahl/km]	*6,00E+11*	7,11E+09	1,95E+09	1,00E+10	6,18E+09	1,2%
PM [g/km]	*0,0045*	0,0004050	0,0003664	0,0014551	0,0007065	9,0%
CO2 [g/km]	---	143,21	138,97	170,34	149,87	
Verbrauch [l/100 km]	---	6,24	6,05	7,42	6,53	

Test vehicle Ford Fiesta 1.0 EcoBoost

Year of production	2016
Motor	998 cc, three-cylinder petrol engine, turbo
Power	92 kW / 125 PS, 170 Nm
Gearbox	6-speed manual gearbox
Emission control	3-way catalytic converter
Pollutant standard	Euro 6b (W)
Mileage	51,000 km

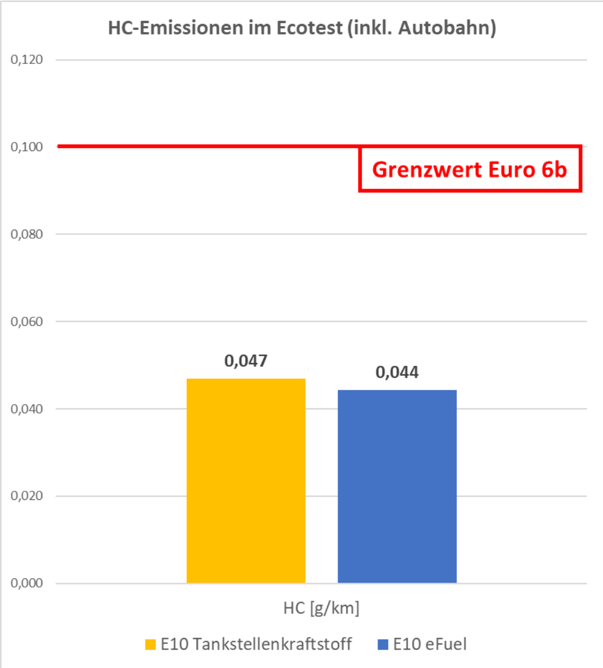
The 1.0 EcoBoost engine in the Ford Fiesta was one of the first Euro 6 engines in the model. It is equipped with direct injection and turbocharger. Ford designed the engine for the best possible fuel consumption values; according to NEDC, a manufacturer consumption of 4.3 l/100 km or 99 g/km CO2 was promised. The pollutant emissions are close to the limit values. The prioritisation of the lowest possible CO2 values is obvious. In the test, the pollutant emissions are partly within the limit values, and with the prototype eFuel from CAC there is no deterioration. Operation with optimised eFuels can lower the particulate values, which would have a measurable effect on models without particulate filters such as the Fiesta.

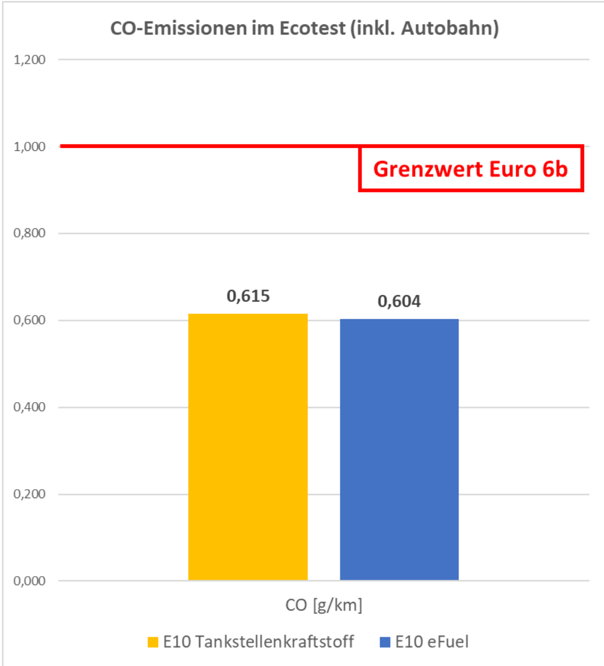
The following diagram shows the proportion of the respective pollutants from the limit value, measured in the NEDC cycle with E10 reference fuel and E10 eFuel from CAC:

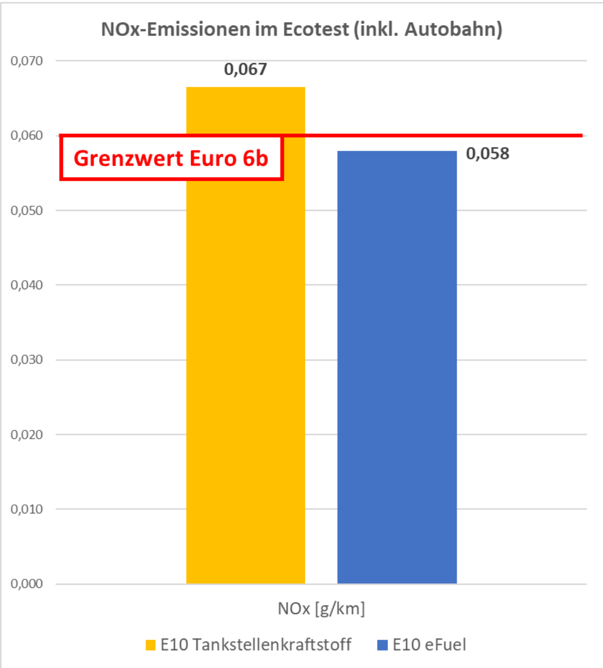


Result: Hardly any changes in pollutant emissions, the slight deviations between the fuels are within the range of measurement fluctuations.

The other four diagrams compare the fuels by pollutant in the Ecotest:







Results of the Ford Fiesta 1.0 EcoBoost.

The detailed results with E10 reference fuel:

Ford Fiesta 1.0 EcoBoost

		E10 Ref				Anteil vom
Schadstoffe	***Grenzwerte***	**NEFZ kalt**	**WLTP warm**	**BAB130**	**Gesamt**	**Grenzwert**
HC [g/km]	*0,100*	0,086342	0,013889	0,024762	0,042509	86,3%
CO [g/km]	*1,000*	0,504403	0,295810	0,930146	0,559118	50,4%
NOx [g/km]	*0,060*	0,040942	0,048261	0,123327	0,068219	68,2%
CH4 [g/km]	---	0,014284	0,005231	0,005868	0,008591	
NH3 [g/km]	---	0,024048	0,002252	0,016066	0,014025	
PN [Anzahl/km]	*6,00E+12*	1,69E+12	9,56E+11	2,31E+12	1,62E+12	28,1%
PM [g/km]	*0,0045*	0,0011908	0,0003397	0,0022058	0,0011974	26,5%
CO2 [g/km]	---	110,48	106,05	147,88	120,15	
Verbrauch [l/100 km]	---	4,94	4,72	6,61	5,36	

The detailed results with E10 petrol station fuel:

Ford Fiesta 1.0 EcoBoost

		E10 Tankstelle				Anteil vom
Schadstoffe	***Grenzwerte***	**NEFZ kalt**	**WLTP warm**	**BAB130**	**Gesamt**	**Grenzwert**
HC [g/km]	*0,100*	0,092142	0,019173	0,026383	0,046875	92,1%
CO [g/km]	*1,000*	0,577748	0,381403	0,931275	0,615085	57,8%
NOx [g/km]	*0,060*	0,030623	0,062684	0,112910	0,066530	51,0%
CH4 [g/km]	---	0,014903	0,006610	0,005007	0,009032	
NH3 [g/km]	---	0,025167	0,029173	0,016300	0,023909	
PN [Anzahl/km]	*6,00E+12*	1,84E+12	9,50E+11	2,04E+12	1,59E+12	30,6%
PM [g/km]	*0,0045*	0,0012559	0,0003982	0,0020977	0,0012082	27,9%
CO2 [g/km]	---	108,81	106,51	148,4	119,88	
Verbrauch [l/100 km]	---	4,83	4,71	6,59	5,32	

The detailed results with E10 eFuel CAC:

Ford Fiesta 1.0 EcoBoost

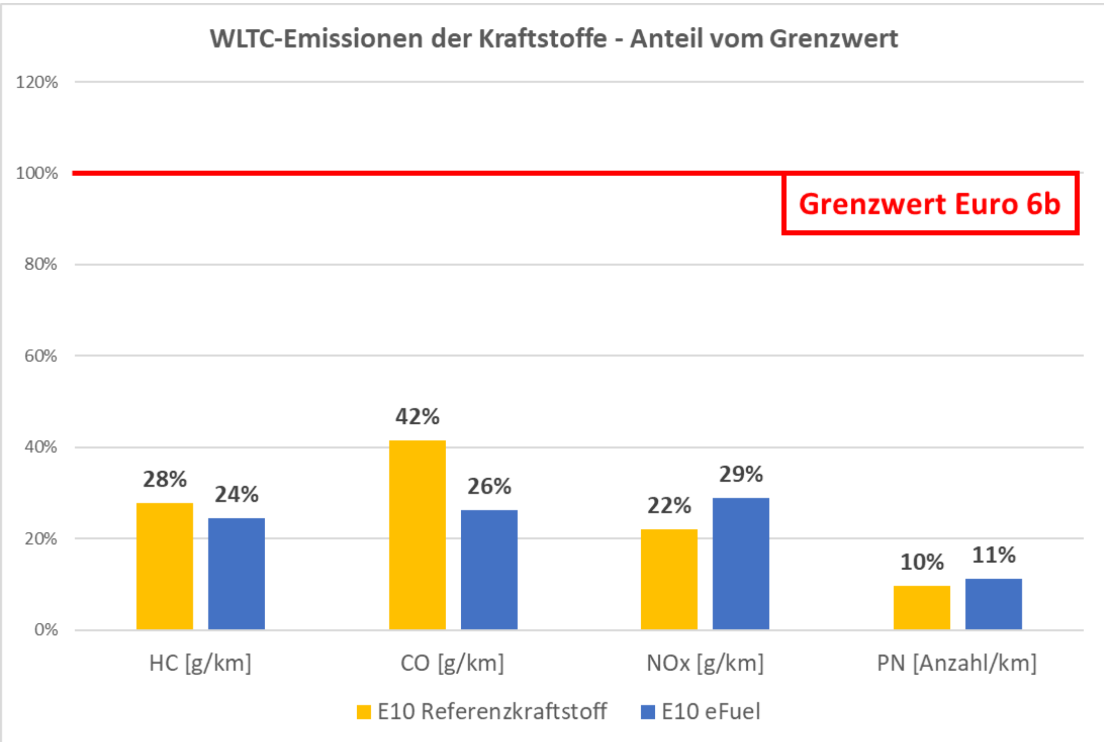
		E10 CAC				Anteil vom
Schadstoffe	***Grenzwerte***	**NEFZ kalt**	**WLTP warm**	**BAB130**	**Gesamt**	**Grenzwert**
HC [g/km]	*0,100*	0,086037	0,015683	0,028937	0,044283	86,0%
CO [g/km]	*1,000*	0,475518	0,319288	1,085500	0,603832	47,6%
NOx [g/km]	*0,060*	0,031889	0,036067	0,114077	0,058008	53,1%
CH4 [g/km]	---	0,015445	0,006018	0,005927	0,009290	
NH3 [g/km]	---	0,024237	0,024752	0,018385	0,022662	
PN [Anzahl/km]	*6,00E+12*	1,85E+12	9,74E+11	2,56E+12	1,76E+12	30,9%
PM [g/km]	*0,0045*	0,0015307	0,0004851	0,0016083	0,0011880	34,0%
CO2 [g/km]	---	107,27	104,08	150,42	119,10	
Verbrauch [l/100 km]	---	4,71	4,55	6,63	5,23	

Test vehicle VW Golf VII 1.4 TSI

Year of production	2018
Motor	1395 cc, four-cylinder petrol engine, turbo
Power	92 kW / 125 PS, 200 Nm
Gearbox	6-speed manual gearbox
Emission control	3-way catalytic converter
Pollutant standard	Euro 6b (W)
Mileage	47,000 km

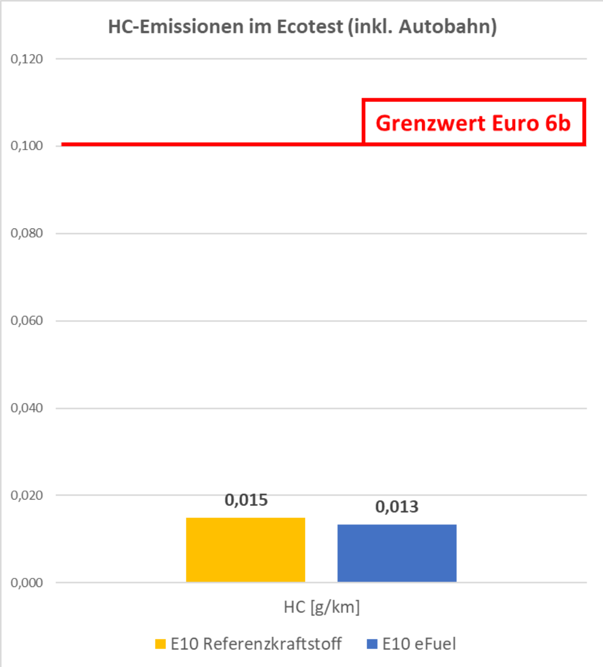
As part of a cooperation with the ZDK, a VW Golf VII with a 1.4 l turbo petrol engine was also measured. It does not yet have a particulate filter, but is one of the more technically complex direct injection engines, in which particulate emissions are reduced by means of internal engine measures. Although still homologated according to the less stringent NEDC, the Golf can easily stay well below the WLTC limits. Even in the demanding Ecotest as a whole, the turbo four-cylinder remains below the legal limits. With CAC's E10 eFuel, the emissions change only slightly and remain legally compliant even then.

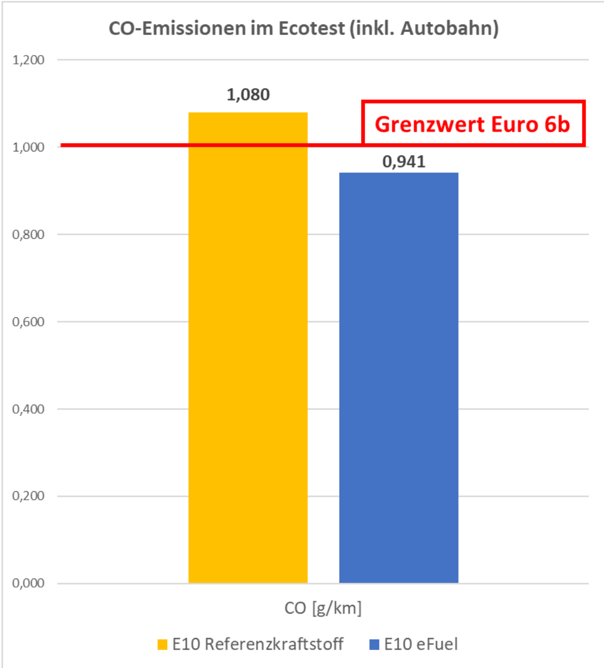
The following diagram shows the percentage of the respective pollutants from the limit value, measured in the WLTP cycle with E10 reference fuel and E10 eFuel from CAC:

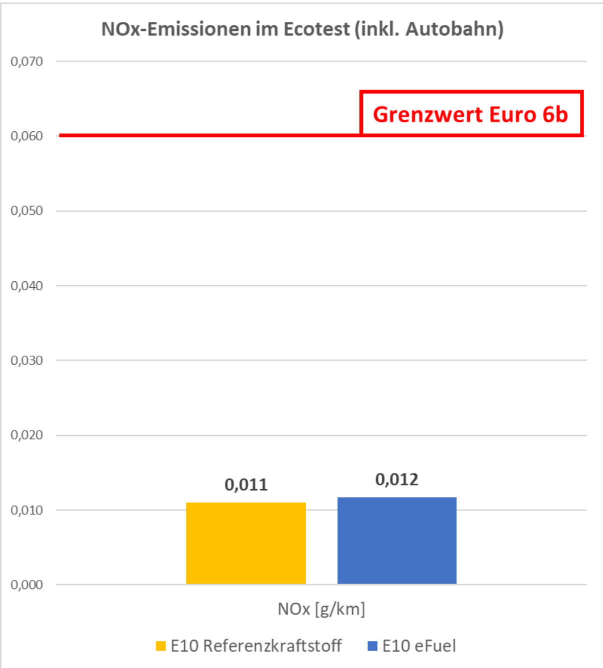


Result: Little change in pollutant emissions, no overall deterioration in practice due to the electricity-based fuel.

The other four charts compare fuels by pollutant in the Ecotest. Please note: As the vehicle was only available for a short time, tests could only be carried out with reference fuel and E10 eFuel from CAC, but not with E10 petrol station fuel as with the other models.







Results of the Golf VII 1.4 TSI.

The detailed results with E10 reference fuel:

VW Golf 1.4 TSI Handschalter

Schadstoffe	*Grenzwerte*	E10 Ref WLTP kalt	E10 Ref WLTP warm	E10 Ref BAB130	E10 Ref Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,027873	0,002655	0,014083	0,014910	27,9%
CO [g/km]	*1,000*	0,416004	0,249226	2,823000	1,079731	41,6%
NOx [g/km]	*0,060*	0,01323	0,014257	0,004496	0,010969	22,1%
CH4 [g/km]	---	0,004196	0,000985	0,006066	0,003633	
NH3 [g/km]	---	0,040491	0,033131	0,058469	0,043308	
PN [Anzahl/km]	*6,00E+12*	5,78E+11	5,99E+11	1,37E+12	8,22E+11	9,6%
PM [g/km]	*0,0045*	0,0002006	0,0001557	0,0008467	0,000379	4,5%
CO2 [g/km]	---	128,35	130,33	148,65	135,13	
Verbrauch [l/100 km]	---	5,71	5,79	6,78	6,059000	

The detailed results with E10 eFuel CAC:

VW Golf 1.4 TSI Handschalter

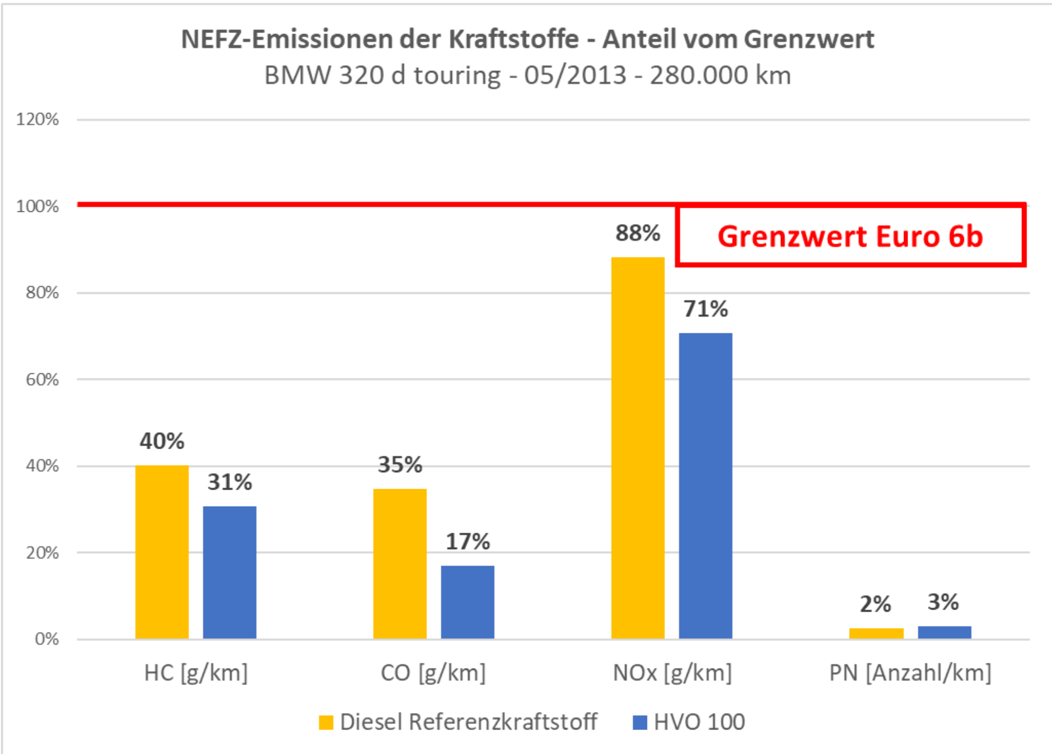
Schadstoffe	*Grenzwerte*	E10 CAC WLTP kalt	E10 CAC WLTP warm	E10 CAC BAB130	E10 CAC Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,024424	0,001763	0,014171	0,013417	24,4%
CO [g/km]	*1,000*	0,262601	0,156558	2,649000	0,941406	26,3%
NOx [g/km]	*0,060*	0,017372	0,010965	0,005873	0,011680	29,0%
CH4 [g/km]	---	0,003655	0,000817	0,006358	0,003473	
NH3 [g/km]	---	0,025704	0,018437	0,045732	0,029169	
PN [Anzahl/km]	*6,00E+12*	6,71E+11	5,68E+11	1,54E+12	8,97E+11	11,2%
PM [g/km]	*0,0045*	0,0002817	0,0001683	0,0005035	0,000309	6,3%
CO2 [g/km]	---	125,04	123,15	147,08	130,99	
Verbrauch [l/100 km]	---	5,46	5,37	6,58	5,76	

Test vehicle BMW 320d touring BluePerformance

Year of production	2013
Motor	1995 cc, four-cylinder diesel, turbo
Power	120 kW / 163 PS, 380 Nm
Gearbox	8-speed torque converter automatic transmission
Emission control	Oxi-cat, particulate filter, NOx storage catalytic converter
Pollutant standard	Euro 6b
Mileage	280,000 km

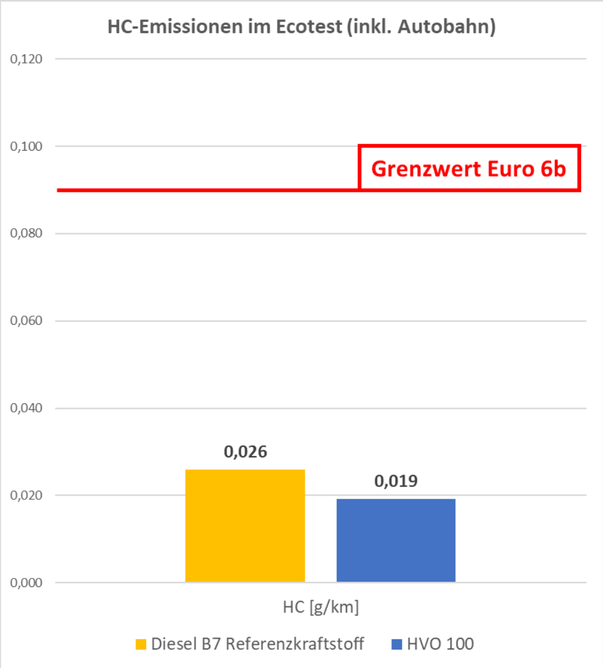
Since BMW has approved its entire diesel fleet, including older existing vehicles, for paraffinic fuels such as HVO, it was possible to use a 320d touring from 2013, which was used as a service vehicle in the ADAC, for the test. The vehicle has now driven 280,000 km - which makes the results all the more astonishing: With both mineral and paraffin diesel, the BMW still complies with the legal limits in the test cycle. A minimum of 160,000 km is prescribed. BMW has obviously not "sewn the system on the edge". Due to the lower energy density of HVO, consumption increases slightly, but CO2 emissions remain the same.

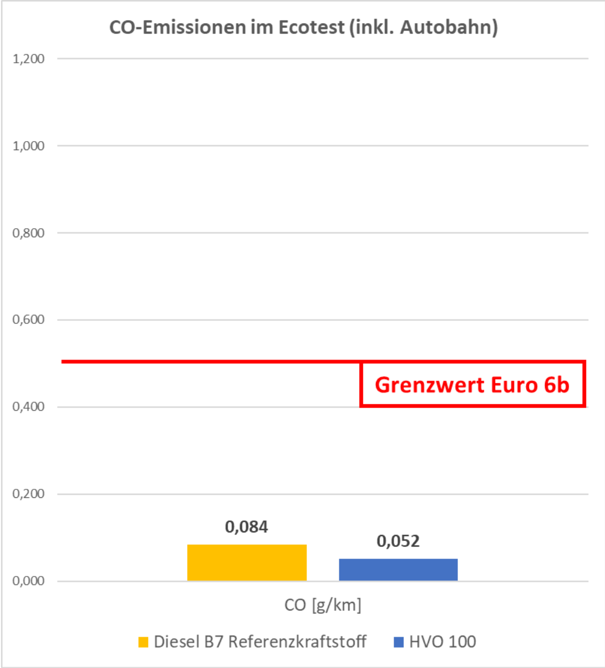
The following diagram shows the proportion of the respective pollutants from the limit value, measured in the NEDC cycle with diesel B7 reference fuel and HVO 100:

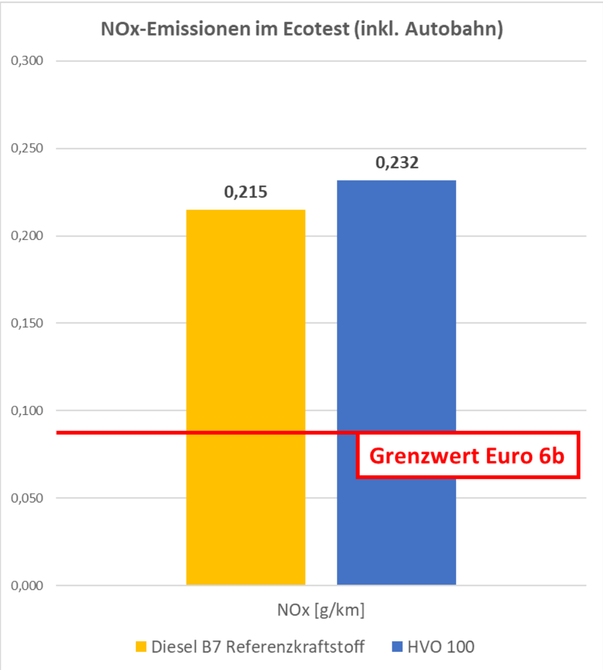


Result: The pollutant emissions drop slightly with HVO compared to mineral diesel. The better ignition propensity of HVO improves the response behaviour and the revving pleasure.

The other four diagrams compare the fuels according to pollutants in the Ecotest:







Results of the BMW 320d touring BluePerformance.

The detailed results with diesel B7 reference fuel:

BMW 320d touring Efficient Dynamics Edition

Schadstoffe	*Grenzwerte*	Diesel B7 Ref				Anteil vom Grenzwert
		NEFZ kalt	WLTP warm	BAB130	Gesamt	
HC [g/km]	*0,090*	0,036207	0,018738	0,022310	0,025924	40,2%
CO [g/km]	*0,500*	0,173592	0,025600	0,048320	0,084213	34,7%
NOx [g/km]	*0,080*	0,070484	0,166534	0,439972	0,214948	88,1%
CH4 [g/km]	---					
NH3 [g/km]	---	0,000465	0,000717	0,003310	0,001407	
PN [Anzahl/km]	*6,00E+11*	1,47E+10	1,81E+09	3,73E+09	6,89E+09	2,4%
PM [g/km]	*0,0045*	0,0000619	0,000158	0,0007825	0,0003117	1,4%
CO2 [g/km]	---	134,06	130,79	150,29	137,78	
Verbrauch [l/100 km]	---	5,09	4,95	5,69	5,22	

The detailed results with HVO 100:

BMW 320d touring Efficient Dynamics Edition

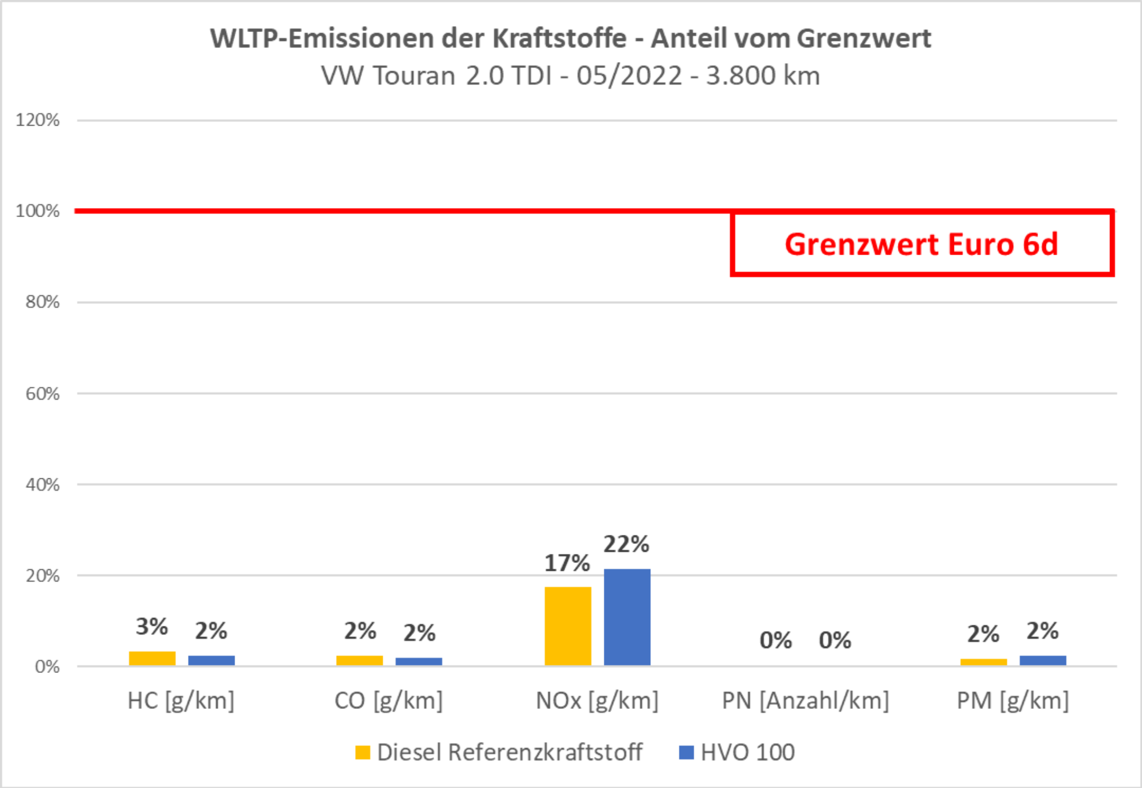
Schadstoffe	*Grenzwerte*	HVO 100				Anteil vom Grenzwert
		NEFZ kalt	WLTP warm	BAB130	Gesamt	
HC [g/km]	*0,090*	0,027638	0,025674	0,002024	0,019266	30,7%
CO [g/km]	*0,500*	0,084718	0,030835	0,037947	0,051828	16,9%
NOx [g/km]	*0,080*	0,056589	0,199173	0,473670	0,231618	70,7%
CH4 [g/km]	---					
NH3 [g/km]	---	0,000573	0,000499	0,001997	0,000974	
PN [Anzahl/km]	*6,00E+11*	1,78E+10	2,83E+09	4,81E+09	8,67E+09	3,0%
PM [g/km]	*0,0045*	0,0002475	0,0001289	0,0002984	0,0002213	5,5%
CO2 [g/km]	---	125,89	126,21	147,43	132,46	
Verbrauch [l/100 km]	---	5,15	5,11	5,96	5,38	

Test vehicle VW Touran 2.0 TDI DSG

Year of production	2022
Motor	1968 cc, four-cylinder diesel, turbo
Power	110 kW / 150 PS, 360 Nm
Gearbox	6-speed dual clutch transmission
Emission control	Oxi-cat, particulate filter, 2 SCR-cats
Pollutant standard	Euro 6d (AP)
Mileage	4,000 km

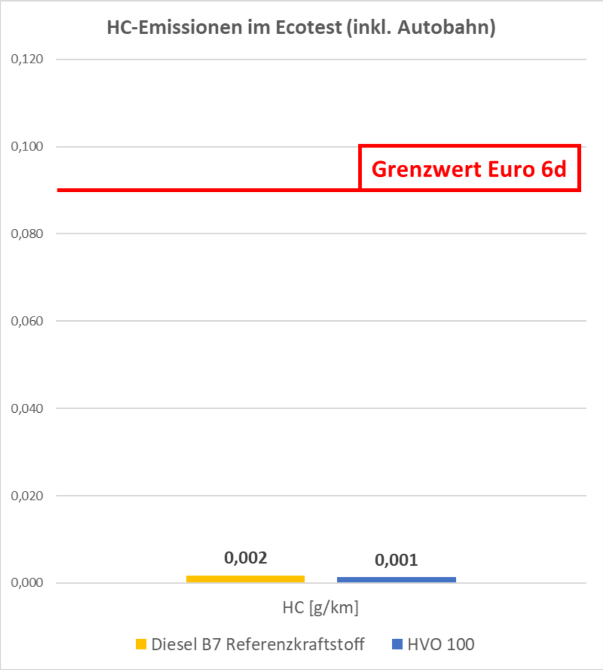
VW is finally releasing its diesel models for paraffinic fuels since mid-2021 - but not retroactively like BMW. The latest four-cylinder diesel generation has, among other things, a double SCR system with AdBlue injection. This keeps pollutant emissions very low in all situations. Even with HVO 100, the emissions practically do not change, all limits are far undercut.

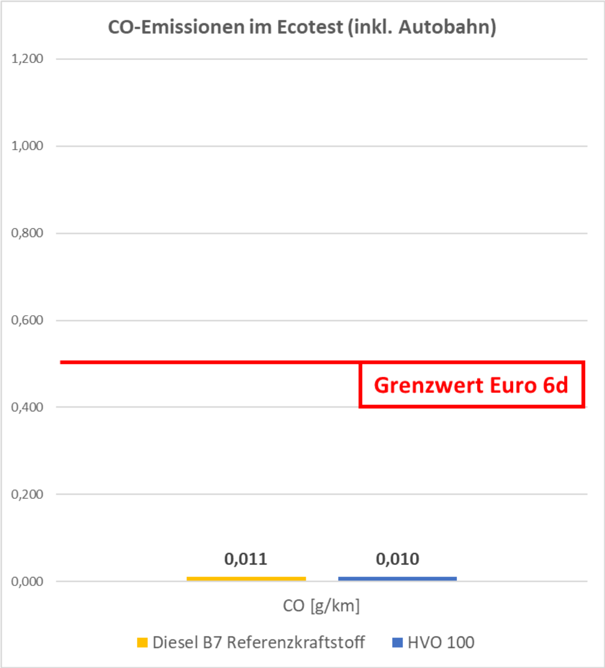
The following diagram shows the proportion of the respective pollutants from the limit value, measured in the WLTP cycle with diesel B7 reference fuel and HVO 100:

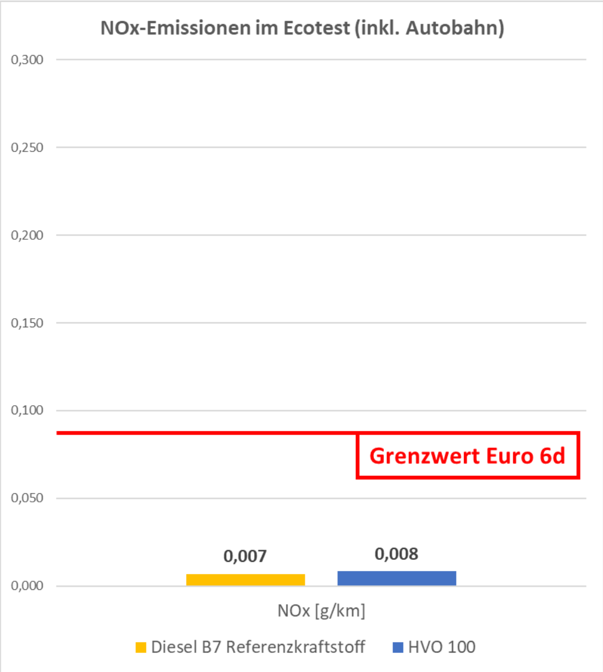


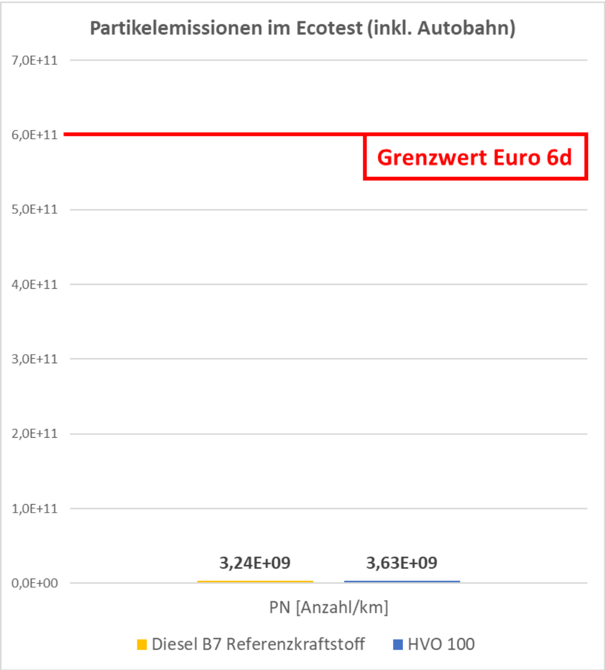
Result: In all cycles, even in the demanding motorway cycle, all emissions remain far below the limit values. The fuel, whether diesel or HVO, is irrelevant. The differences in NOx lie within the range of the measurement tolerance.

The other four diagrams compare the fuels according to pollutants in the Ecotest:









Results of the VW Touran 2.0 TDI DSG.

The detailed results with diesel B7 reference fuel:

VW Touran 2.0 TDI 110 kW DSG

Schadstoffe	Grenzwerte	Diesel B7 Ref				Anteil vom
		NEFZ kalt	WLTP warm	BAB130	Gesamt	Grenzwert
HC [g/km]	*0,090*	0,002921	0,001203	0,000808	0,001686	3,2%
CO [g/km]	*0,500*	0,011556	0,008271	0,012601	0,010720	2,3%
NOx [g/km]	*0,080*	0,013876	0,001804	0,004523	0,006845	17,3%
CH4 [g/km]	---					
NH3 [g/km]	---	0,000517	0,000348	0,000496	0,000452	
PN [Anzahl/km]	*6,00E+11*	1,07E+09	7,40E+08	8,68E+09	3,24E+09	0,2%
PM [g/km]	*0,0045*	0,0000770	0,0000771	0,0009359	0,0003347	1,7%
CO2 [g/km]	---	151,75	150,69	181,09	160,18	
Verbrauch [l/100 km]	---	5,74	5,70	6,86	6,06	

The detailed results with HVO 100:

VW Touran 2.0 TDI 110 kW DSG

Schadstoffe	Grenzwerte	HVO 100				Anteil vom
		NEFZ kalt	WLTP warm	BAB130	Gesamt	Grenzwert
HC [g/km]	*0,090*	0,002061	0,001159	0,000538	0,001288	2,3%
CO [g/km]	*0,500*	0,009874	0,009271	0,011781	0,010235	2,0%
NOx [g/km]	*0,080*	0,017216	0,001588	0,005702	0,008292	21,5%
CH4 [g/km]	---					
NH3 [g/km]	---	0,000716	0,000414	0,001174	0,000748	
PN [Anzahl/km]	*6,00E+11*	1,80E+09	1,24E+09	8,54E+09	3,63E+09	0,3%
PM [g/km]	*0,0045*	0,0001063	0,0000673	0,0002237	0,0001279	2,4%
CO2 [g/km]	---	140,64	140,81	178,07	151,93	
Verbrauch [l/100 km]	---	5,69	5,69	7,20	6,14	

Special case P1 Racing Fuels Eco100 Pro

The detailed results for the VW Golf VIII 2.0 TSI DSG with Eco100 Pro:

VW Golf VIII 2.0 TSI DSG

Schadstoffe	*Grenzwerte*	E0 P1 WLTP kalt	E0 P1 WLTP warm	E0 P1 BAB130	E0 P1 Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,014616	0,000645	0,003760	0,006469	14,6%
CO [g/km]	*1,000*	0,072177	0,066395	0,099750	0,078425	7,2%
NOx [g/km]	*0,060*	0,007265	0,002752	0,006983	0,005601	12,1%
CH4 [g/km]	---	0,001848	0,000172	0,000698	0,000916	
NH3 [g/km]	---	0,001365	0,003187	0,004230	0,002862	
PN [Anzahl/km]	*6,00E+11*	3,65E+10	1,17E+10	1,34E+10	2,09E+10	6,1%
PM [g/km]	*0,0045*	0,0003658	0,0001543	0,0019355	0,000763	8,1%
CO2 [g/km]	---	143,72	139,89	169,24	150,04	
Verbrauch [l/100 km]	---	5,98	5,82	7,04	6,24	

Result: With P1 fuel, which is predominantly derived from biomass, there are no anomalies; all emissions remain well below the limit values.

The detailed results for the VW Golf VII 1.4 TSI with Eco100 Pro:

VW Golf 1.4 TSI Handschalter

Schadstoffe	*Grenzwerte*	E0 P1 WLTP kalt	E0 P1 WLTP warm	E0 P1 BAB130	E0 P1 Gesamt	Anteil vom Grenzwert
HC [g/km]	*0,100*	0,040812	0,002953	0,021509	0,021770	40,8%
CO [g/km]	*1,000*	0,417953	0,277602	3,0405	1,155594	41,8%
NOx [g/km]	*0,060*	0,013905	0,01087	0,006285	0,010557	23,2%
CH4 [g/km]	---	0,004249	0,000984	0,008614	0,004416	
NH3 [g/km]	---	0,035211	0,027541	0,053986	0,038159	
PN [Anzahl/km]	*6,00E+12*	1,20E+12	8,24E+11	1,94E+12	1,29E+12	20,1%
PM [g/km]	*0,0045*	0,0006458	0,000333	0,0009753	0,000635	14,4%
CO2 [g/km]	---	127,27	128,12	146,35	133,29	
Verbrauch [l/100 km]	---	5,32	5,35	6,29	5,62	

Result: There is nothing to criticise about the measurement results with P1 fuel, which is predominantly obtained from biomass. The limit values are undercut across the board.