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Effect of GTL Diesel Fuels on Emissions and Engine Performance

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Effect of GTL Diesel Fuels on Emissions and Engine Performance

Results from a joined research effort of Sasol / SasolChevron and DC into the benefits of GTL Diesel for vehicles without any hardware adaptation The work was carried out in the RT Labs of DaimlerChrysler Stuttgart

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Outline

- Motivation
- Fuel and Engine Characteristics
- Results from Dynamometer Tests
- Results from Engine Bench Tests
- Conclusions

Motivation (1)

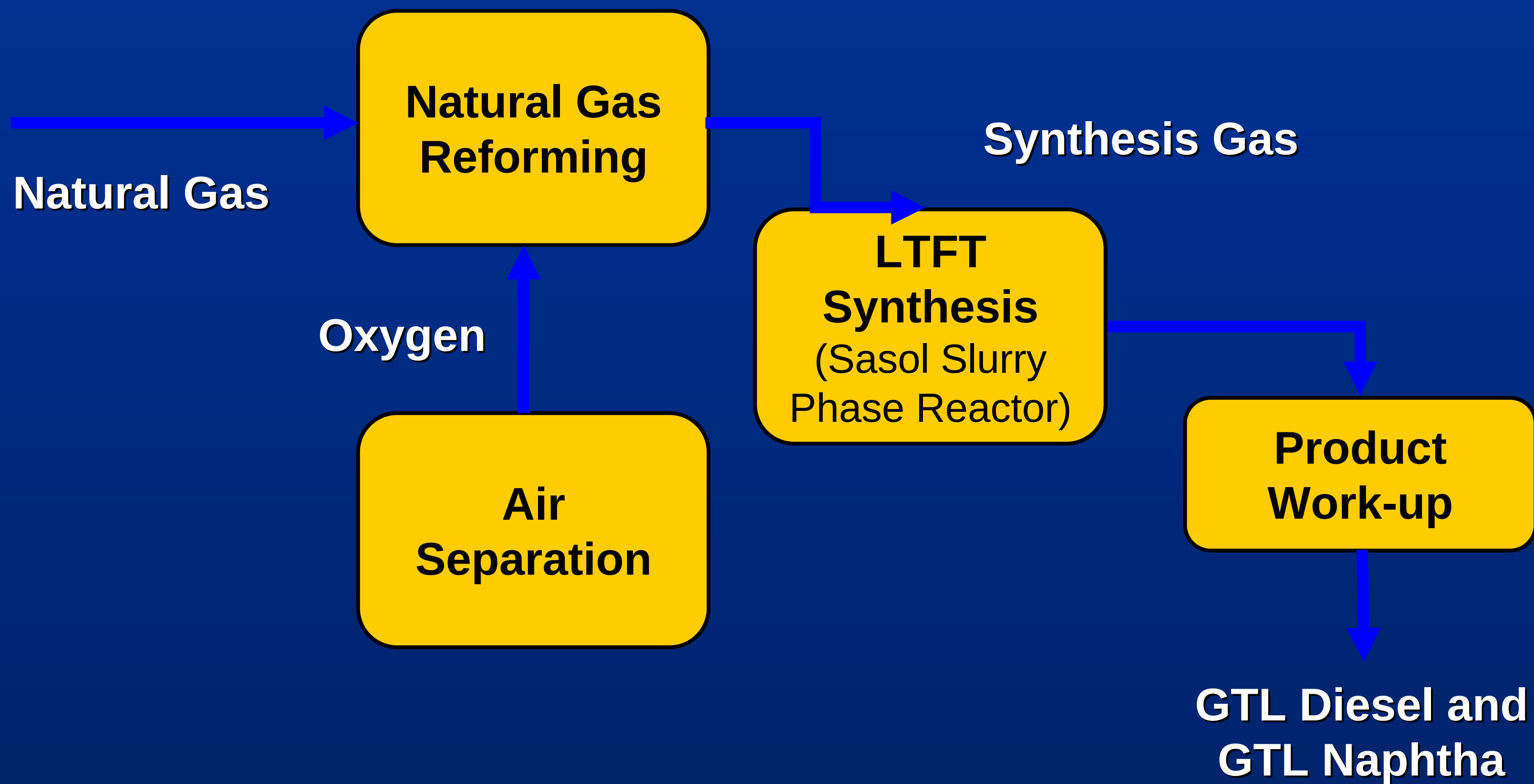
- Progress in GTL (Gas To Liquid) technology over the last decades has lead to business decisions to built large scale production plants. The first one – Sasol’s 35.000 bpd plant in Qatar - will come on stream end of 2005
- GTL Diesel fuel will be produced in increasing amounts by several oil companies. In Qatar alone, contracts have been signed for a total of 610.000 bpd of GTL products, coming on stream until 2011
- It is estimated that by 2020, significant quantities of GTL Diesel will become available corresponding to 29 % of the EU 2000 Diesel demand. For 2010 the share is estimated to reach 5 - 10 %

Motivation (2)

- GTL Diesel is an ultra-clean fuel containing virtually no sulfur and no aromatics. It is odor-free with a Cetane number > 70
- In order to assess the potential benefits of GTL Diesel a dedicated study was jointly carried out by DC and Sasol on a Mercedes E 220 CDI with EU3 hardware status.
- The GTL fuel was supplied by SasolChevron Consulting Limited, London
- The study focused on the effect of GTL Diesel on existing engine technology without any hardware adaptation.
- The effect of different calibrations and fuel blends on emissions and performance were investigated. EU S-free Diesel fuel was used for reference

Test Fuels

GTL Production Process



GTL Diesel has ideal properties for CI ICE's:

Sulfur = 0 | Aromatics = 0 | Olefins ≈ 0 | Cetan No > 70 | Arbitrary boiling range

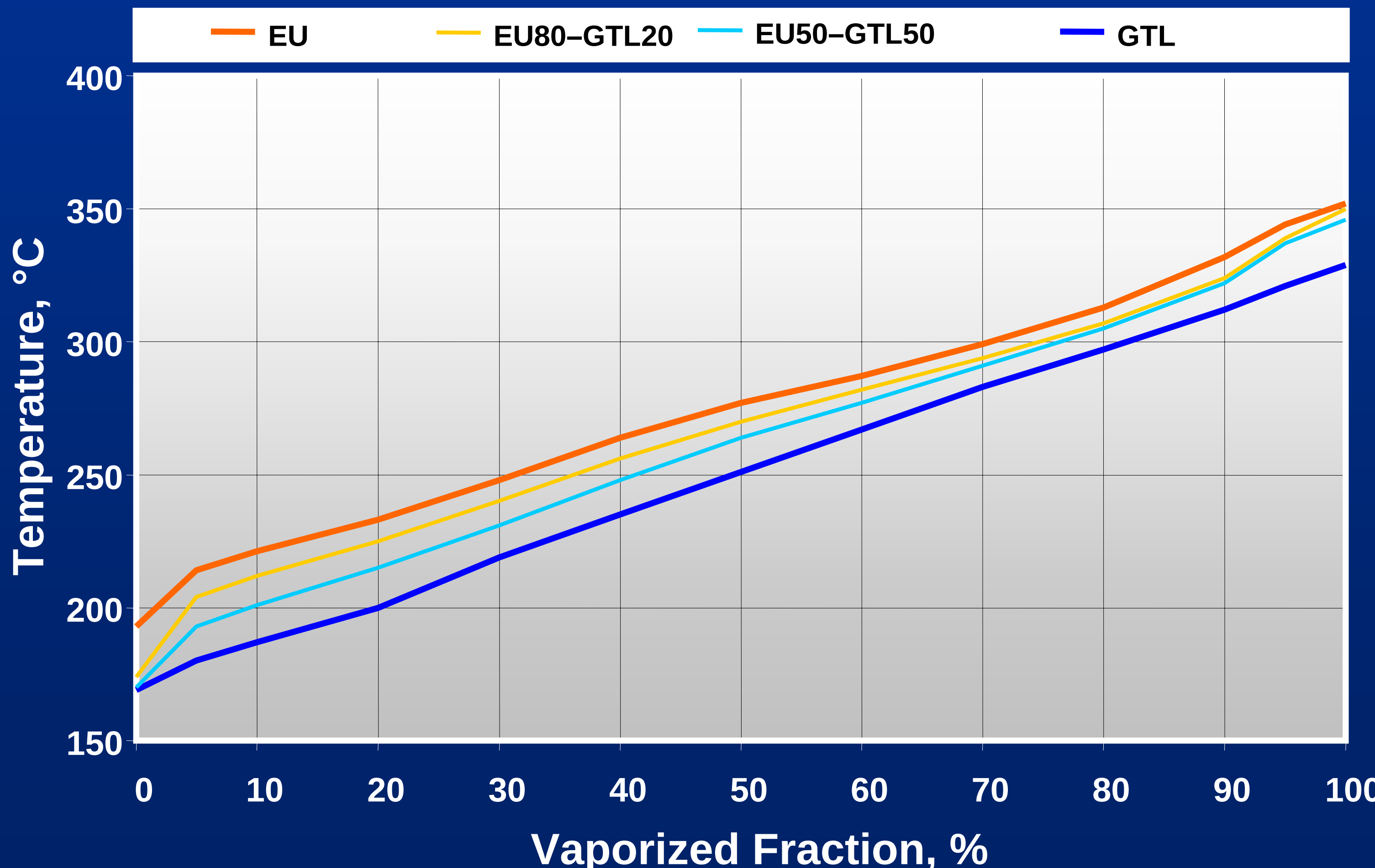
Characteristics of the Four Test Fuels

Test fuels were: EU S-free Diesel, GTL Diesel and 2 blends, 20% and 50% GTL

Property	Units	EU2005 Diesel (Reference Fuel)	blend EU/GTL 80/20	blend EU/GTL 50/50	GTL Diesel SasolChevron
Density @ 20°C	kg/L	0.832	0.821	0.802	0.765
Lower Heating Value	kJ/kg	43 073	43 200	43 500	43 836
Kinematic Viscosity @ 40°C	cSt	2.87	2.79	2.54	1.97
Cetane Number	-	53	58	62	75
Cold Filter Plugging Point	°C	-17	-17	-18	-19
Total Sulphur	ppm wt	8 (< 10)	6	4	< 1
Total Aromatics	% wt	28.0	21.5	13.5	0.14
H/C Ratio (molar)	-	1.83	1.91	1.98	2.10
Flash Point	°C	82	76	66	59
Lubricity Index (HFRR)	µm	394 (<460)	(< 400)	(<400)	370 (<460)
ASTM D86 Distillation 10%	°C	221	212	201	187
ASTM D86 Distillation 95%	°C	354	339	337	321

Boiling Curves of the 4 Test Fuels

GTL blends exhibit a linear blending characteristic



Dynamometer Tests

Vehicle Data and Testing Conditions

Mercedes-Benz E 220 CDI Limousine

MY 2003

MB OM 646 engine

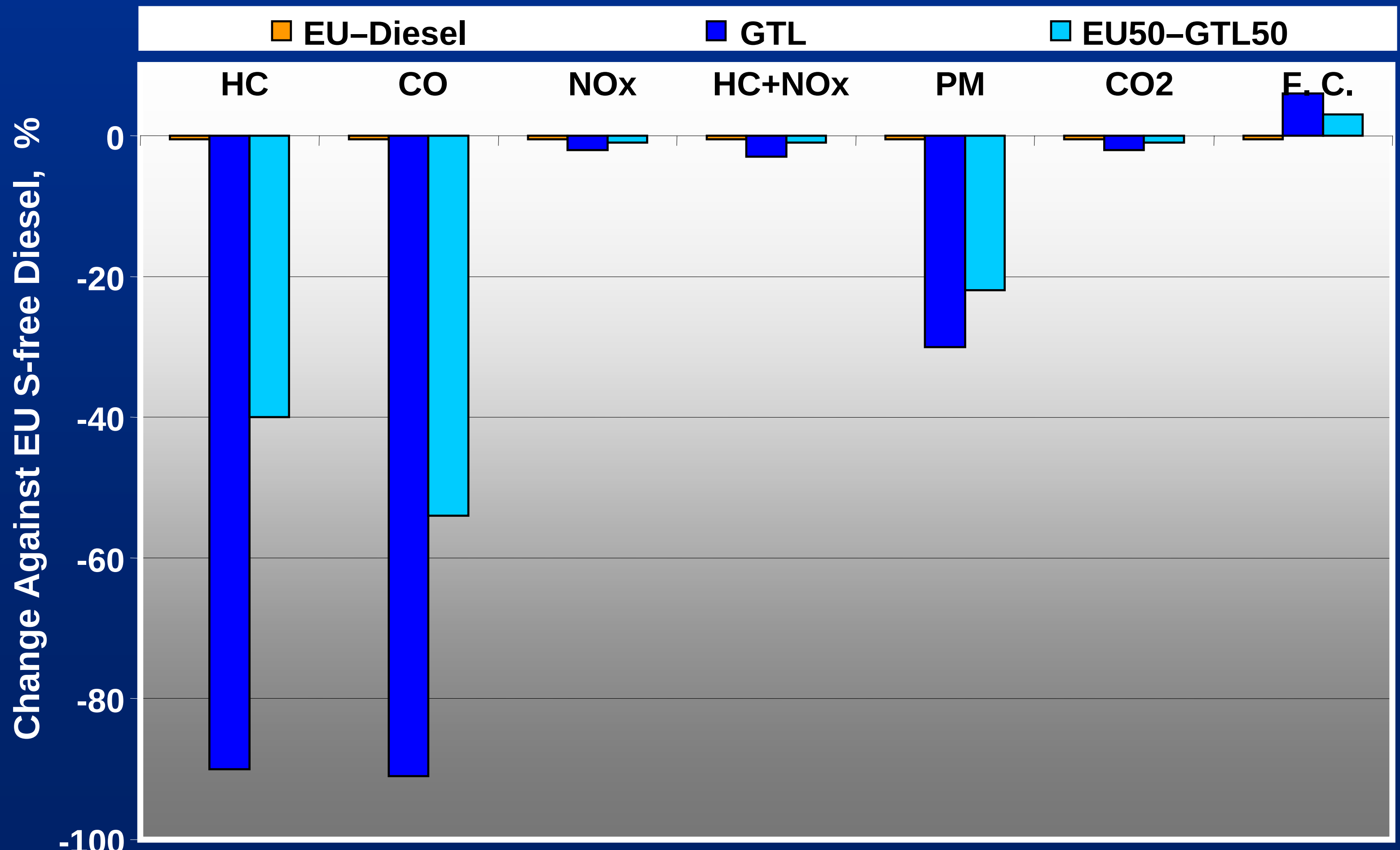
6-speed manual gearbox

New European Driving Cycle NEDC 2000

Cold and hot tests on a chassis dynamometer

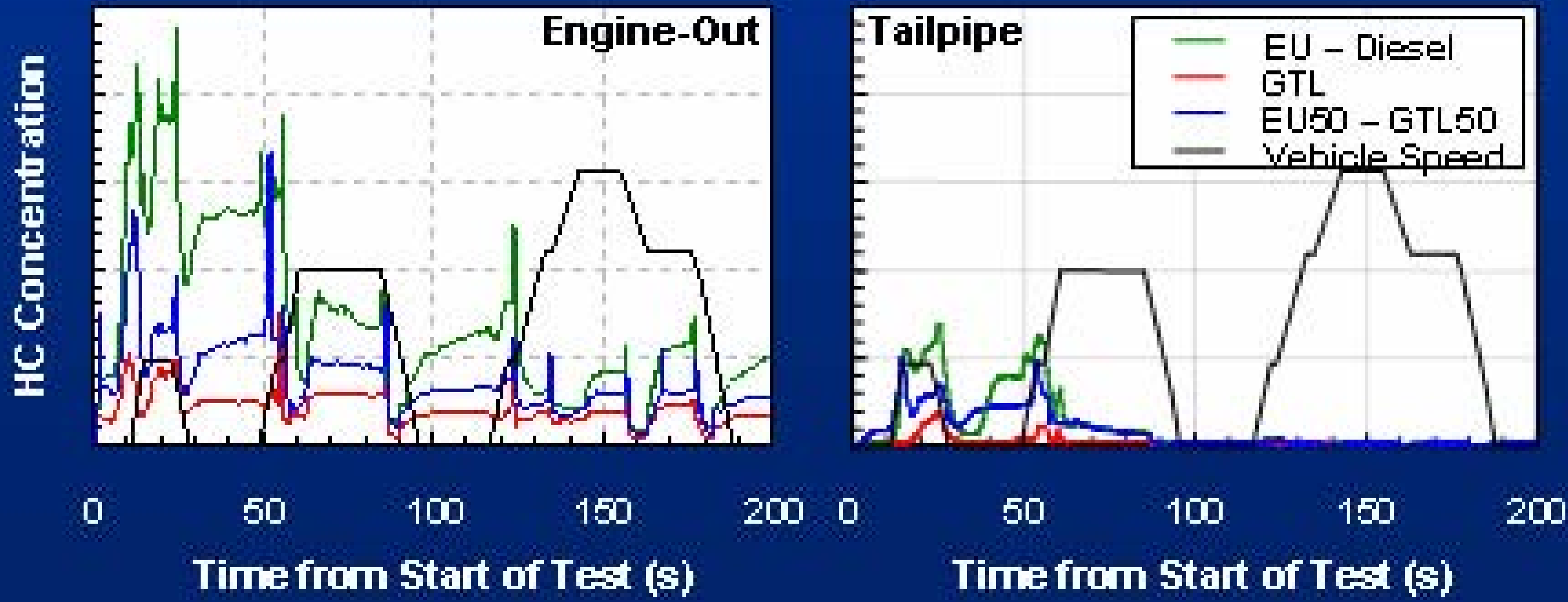
Emission Test Results (NEDC 2000)

Volumetric fuel consumption was about 5% higher
In energy terms, however, the <u>fuel efficiency was improved by 2-3%</u>



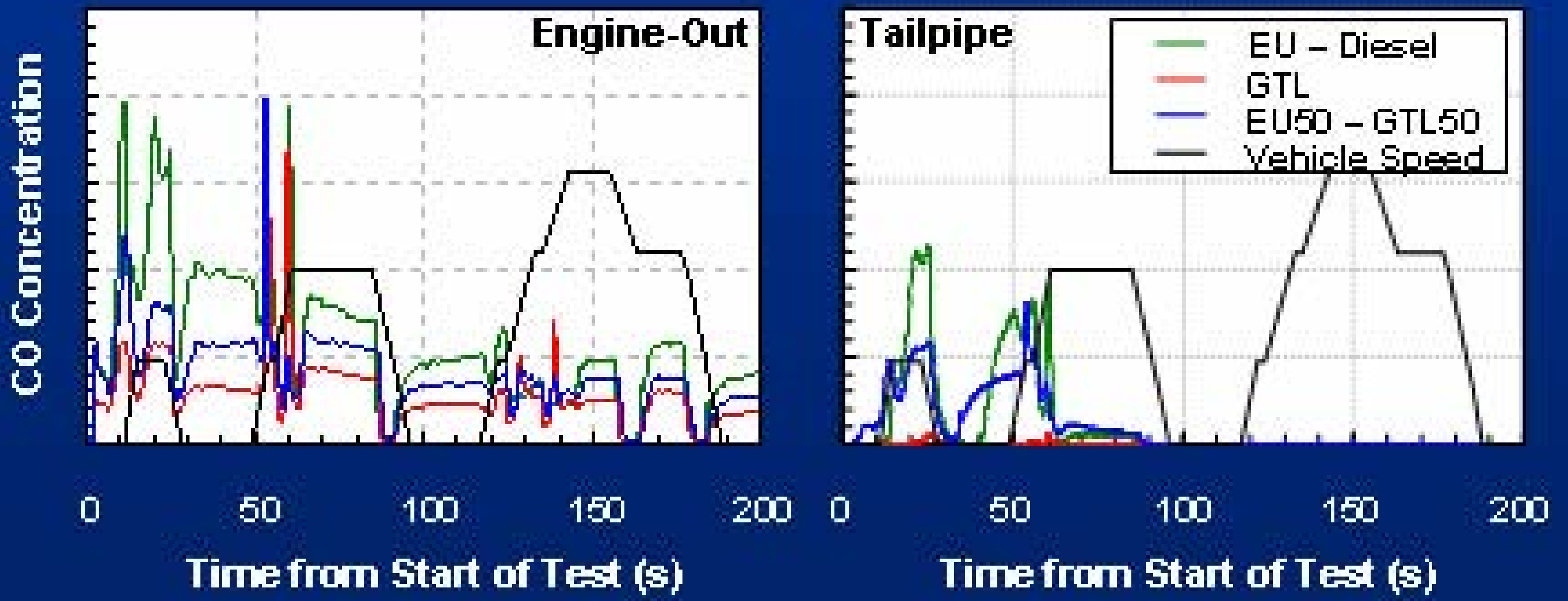
HC Emissions NEDC 2000, Cold Start

HC emissions with GTL are very small even during the warm-up phase of the catalyst
This is due to low raw emissions which can be adsorbed on the cold catalyst



CO Emissions NEDC 2000, Cold Start

CO emissions with GTL are almost zero even during the warm-up phase of the catalyst
This is due to low raw emissions which can be adsorbed on the cold catalyst



Engine Bench Tests

Characteristics of the MB Test Engine

Engine bench tests were carried out to clarify the reasons for the observed reductions in emissions

Designation	MB OM 646, EU 3 emission level
Displacement, configuration	2.2 L, 4 cylinder in-line 4 valves per cylinder
Compression ratio	18 to 1
Fuel management	Common rail fuel injection (peak 1 600 bar)
Air management	Turbocharged (VNT), intercooled
Emission control	Cooled EGR; inlet swirl control; close coupled and underfloor oxidation catalysts
Rated Torque	340 Nm from 1 800 to 2 600 rpm
Rated Power	110 kW at 4 200 rpm

Engine Operating Points

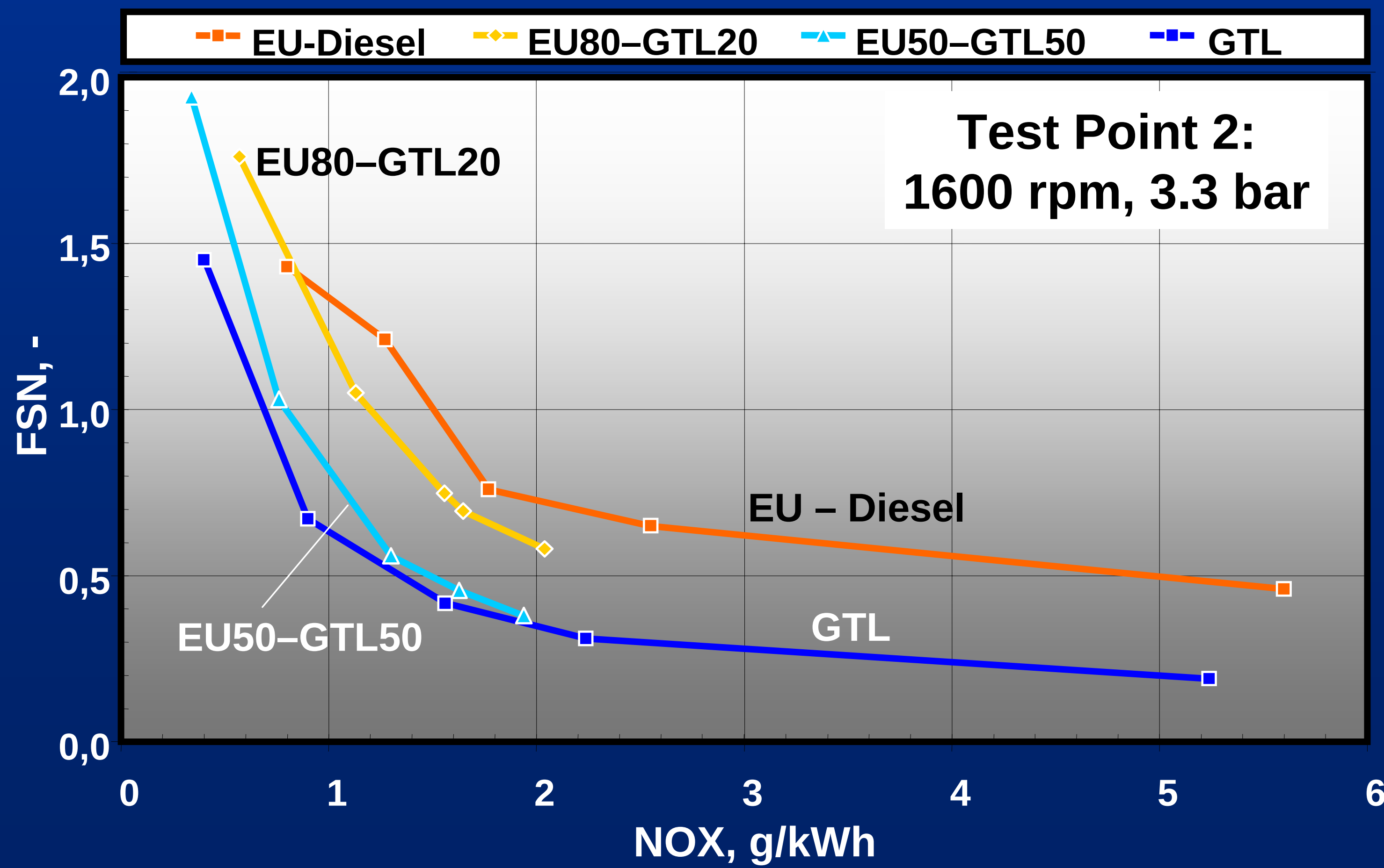
5 typical test points were chosen to analyze the fuel effects in the NEDC

Engine Test Points	Engine Speed rpm	BMEP bar	Power kW	Description
1	1 000	0	0	Pseudo Idle
2	1 600	3,3	9	Characteristic operating points for emission tests
3	2 000	2	7	
4	2 000	5	18	
5	2 800	4	20	

At each test point EGR rates, time of pilot injection and time of main injection were varied over wide ranges in a design of experiments approach.

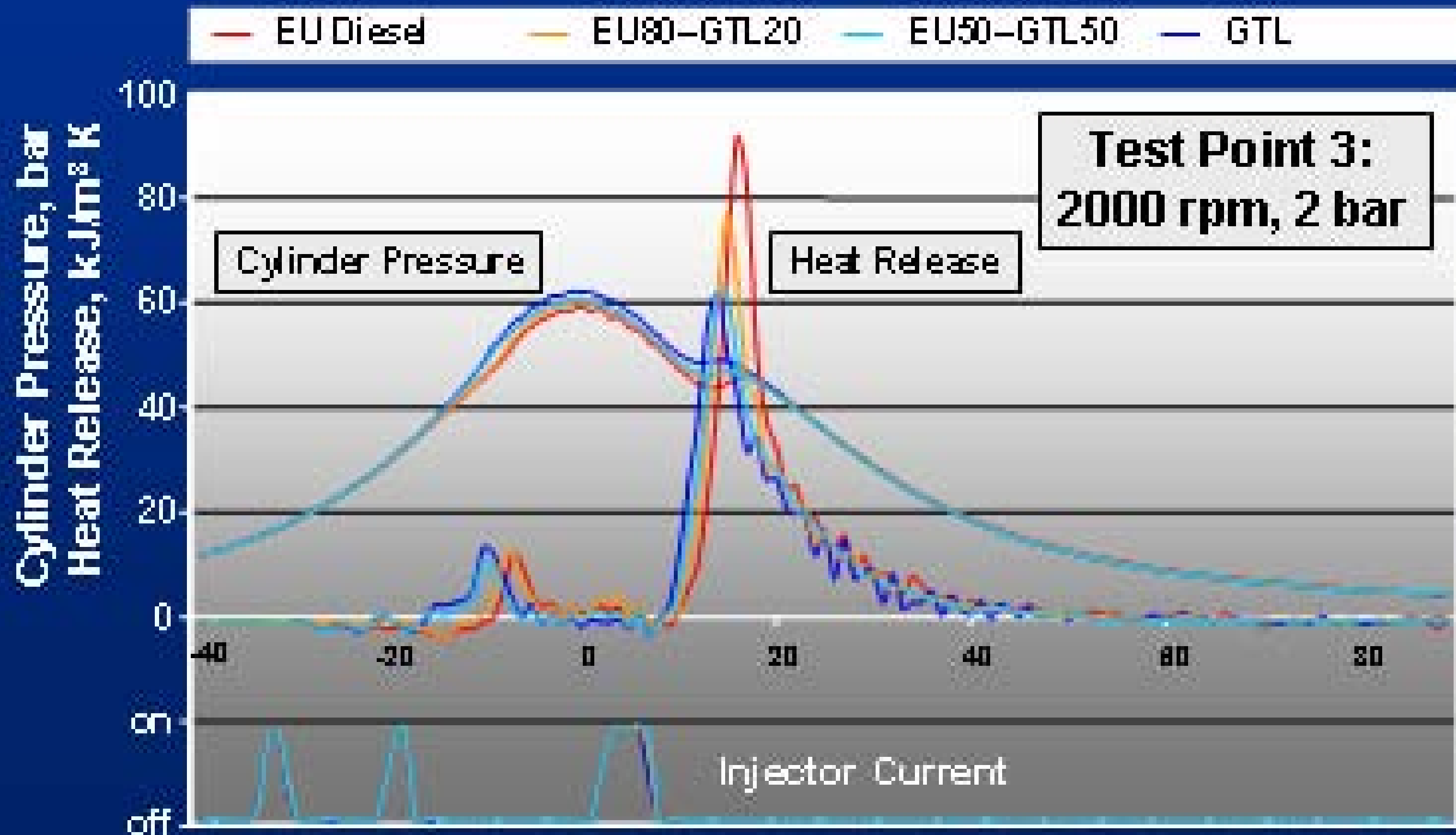
FSN-NOx Trade-Off for GTL Blends

50 % GTL in EU–Diesel shows almost the same properties as neat GTL: a large reduction in soot emission and a higher EGR tolerance



In-Cylinder Pressure and Heat Release

GTL and EU50–GTL50 ignite 4 degrees earlier and burn earlier than EU80–GTL20 and EU–Diesel



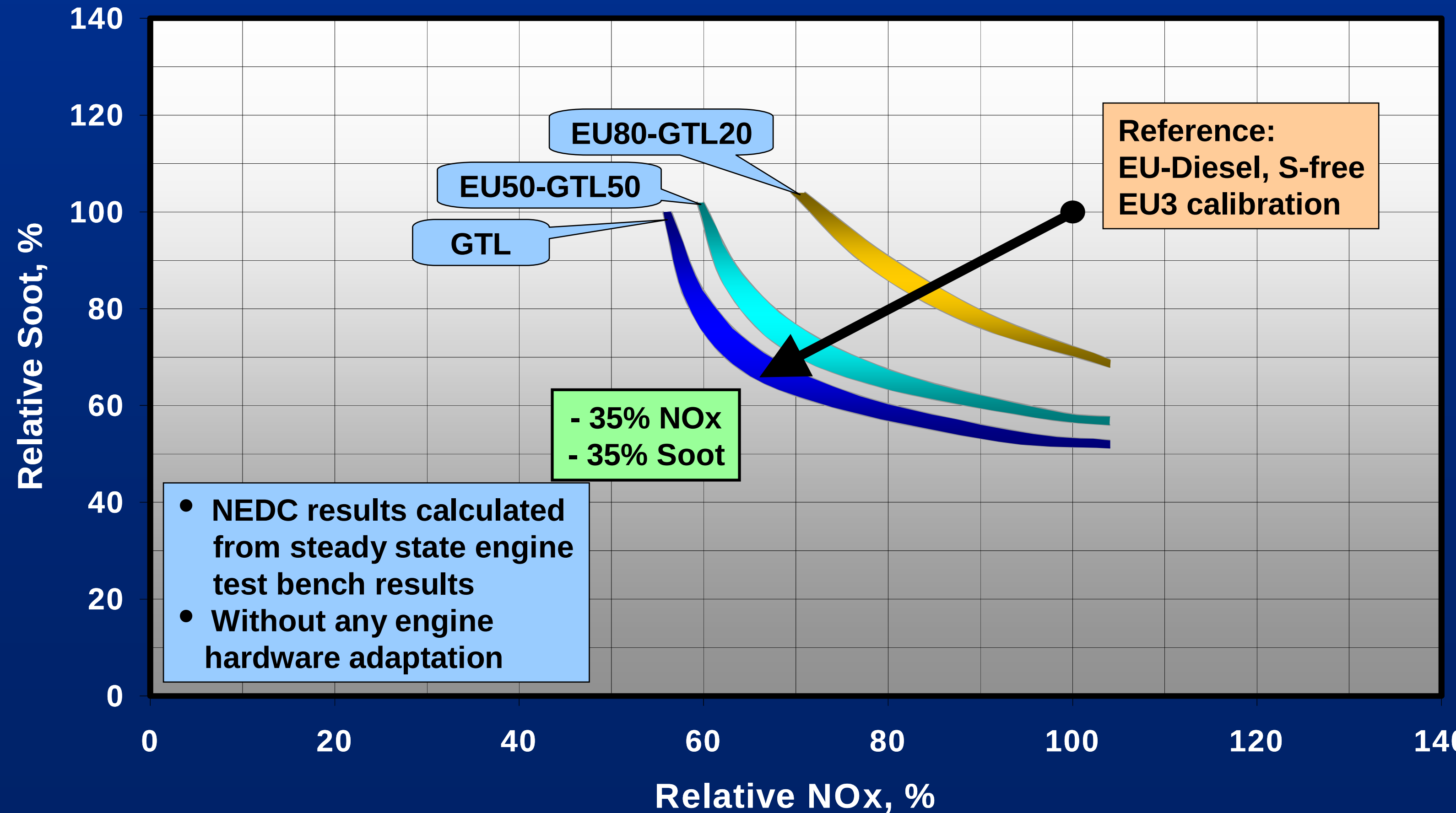
Software Optimization

The data from the 5 stationary test points were used to calculate an optimum recalibration for the ECU of the engine for minimum soot and NOx emissions in the NEDC

- The optimization was carried out under the constraints of maintaining the overall engine performance criteria e.g. engine smoothness, noise level, …
- Calculation results were verified by experimental checks

Soot-NOx Trade-Off: GTL Blending Effects

The design of experiments method predicts for the NEDC simultaneous reductions in soot and NOx by up to 35 % just by software adaptation of the CU to the GTL fuel



Conclusions (1)

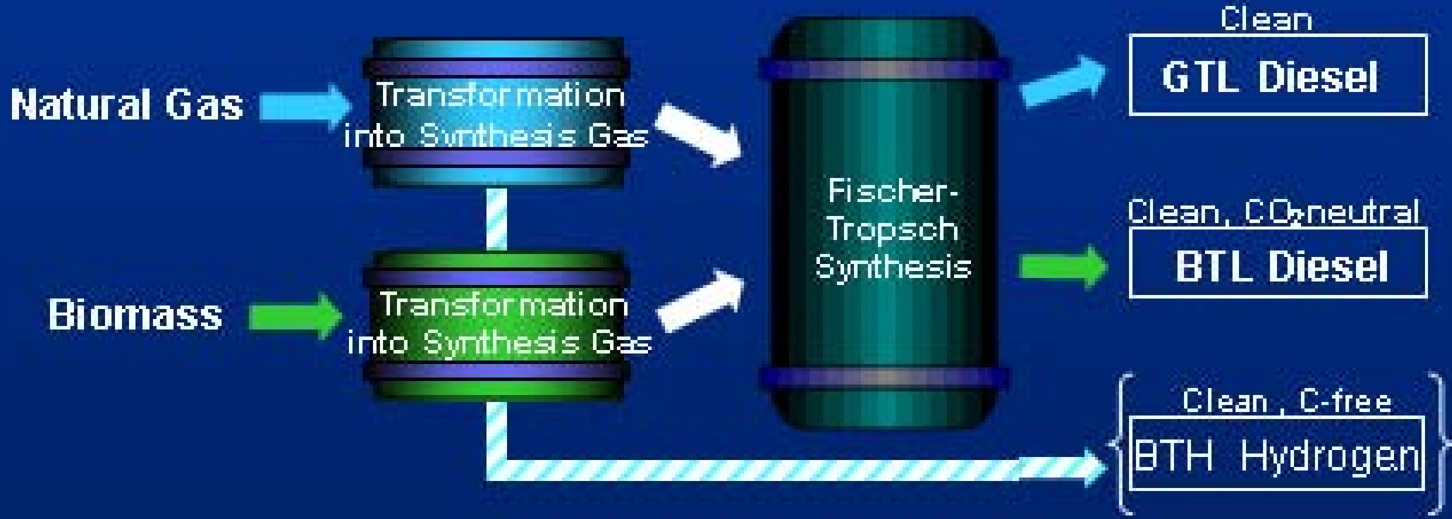
- The use of GTL diesel fuel in unmodified vehicles leads to large reductions of CO, HC and PM emissions without compromising NOx emissions even if compared to a sulphur-free European diesel fuel.
- The high cetane number of the GTL fuel is advantageous during cold-start and low temperature operation.
- The lower smoke and soot emissions with GTL Diesel facilitate NOx reductions by offering a more favourable NOx - FSN - trade-off
- NOx reduction is facilitated by the higher EGR tolerance of GTL Diesel

Conclusions (2)

- There is a large potential for further reductions in soot and NOx emissions of existing engines if the engine is recalibrated for optimum use of the GTL Diesel
- There is even more potential to be expected if in addition to a software adaptation also "hardware" adaptations of the engine are taken into account exploiting the special properties of GTL Diesel
- Very promising results were achieved also with GTL diesel as a blending component for use with conventional diesel fuel. The emission benefits scale in an over-linear fashion with the GTL fraction

Synthetic Fuels: GTL, BTL

GTL and BTL are produced by the same basic technologies
Synthetic fuels can be tailored to the needs of IC engines (designer fuels)
The technology could be used to produce renewable H_2 as well



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