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sasol reaching new frontiers

Performance Characteristics of Coal-to-Liquids (CTL) Diesel in a 50-State Emissions Compliant Passenger Car

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U.S. DEPARTMENT OF ENERGY
DEER 2010
DETROIT
DIRECTIONS IN ENGINE-EFFICIENCY AND EMISSIONS RESEARCH CONFERENCE

Objective and Presentation Overview

Objective

Address a gap in tank-to-wheels criteria emissions and CO_2 data for coal-to-liquids fuels for use in life-cycle analyses

Overview

- Test Programme
- Test Vehicle
- Test Fuels
- Results
- Conclusions and Recommendations

Test Programme

Vehicle
- 2009 VW Jetta Tdi (diesel)
- 50 State Compliant
- 4 000 miles preconditioning

Test Cycles (Triplicate Tests)
- Cold Start FTP
- HWY
- US06
- NEDC

Fuels
- US ULSD
- LTFT diesel
- HTFT diesel
- European EN590 diesel

Vehicle / Engine Specifications

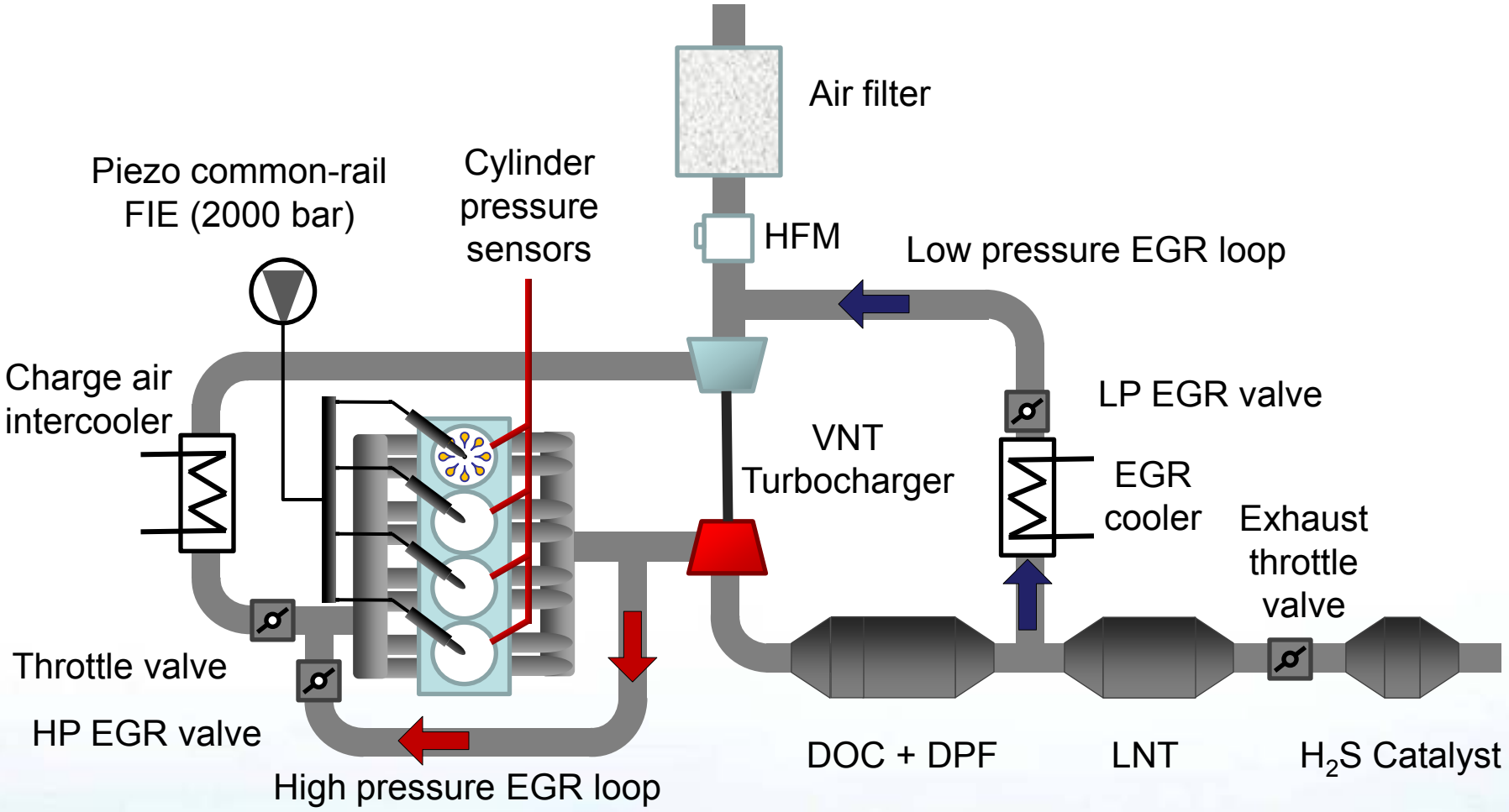
<u>Vehicle</u>

Description :	Four door compact sedan
Curb Mass :	1 480 kg

<u>Engine</u>

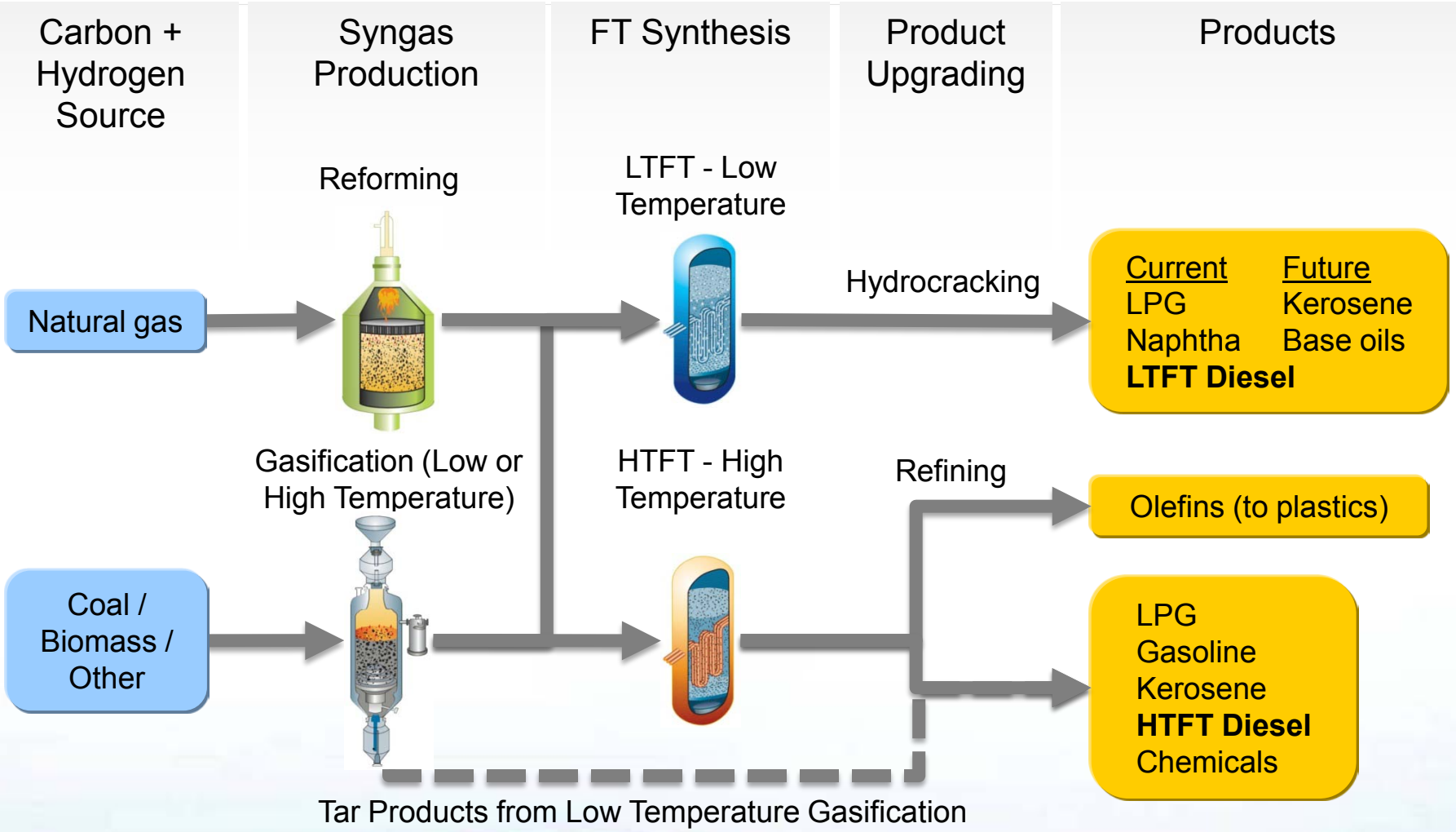
Cylinders :	4 in-line
Displacement :	1 968 cm^3
Bore :	81.0 mm
Stroke :	95.5 mm
Compression Ratio :	16.5:1
Maximum Power :	103 kW @ 3750-4150 min^{-1}
Maximum Torque :	320 Nm @ 1750-2800 min^{-1}

Emission Control Technology



Adapted from MTZ 69, 2008

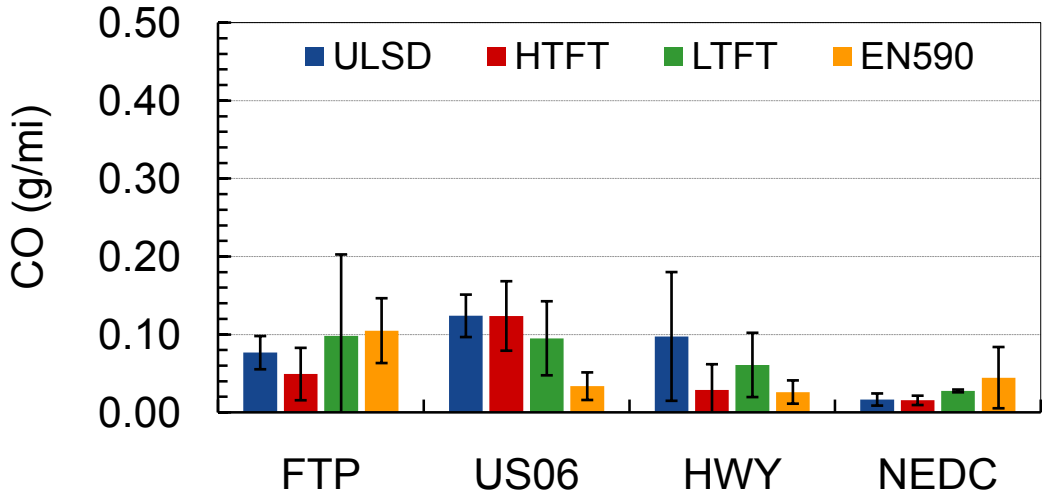
Fischer-Tropsch (FT) Technology

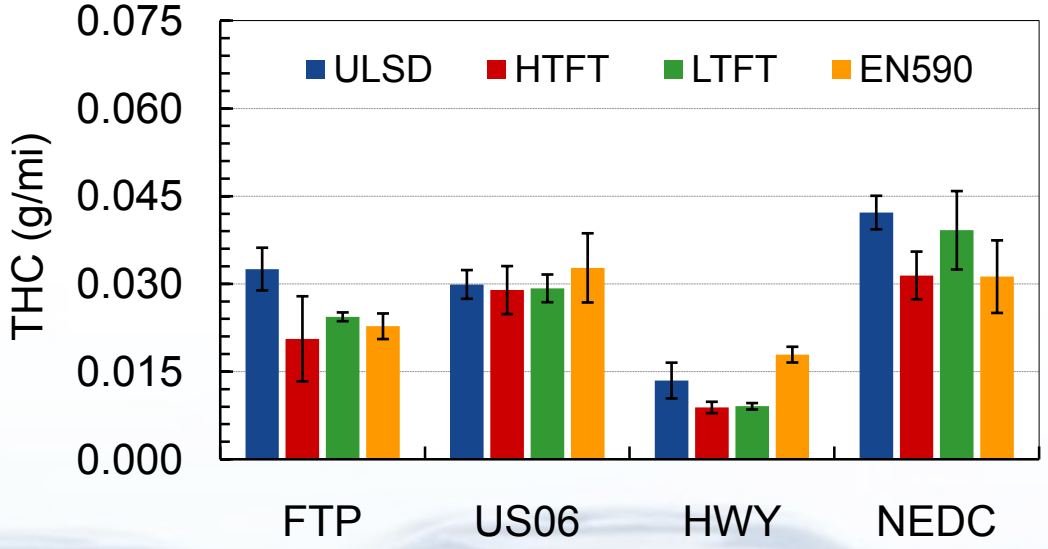


Test Fuels

Fuel Property		ULSD	EN590	HTFT	LTFT
Density @ 15 ºC (kg/l)		0.854	0.832	0.810	0.773
Distillation (ºC)	10% 50% 90%	208 262 320	185 255 325	210 235 340	213 271 347
Flash point (C)		67	62	60	63
Kin. Viscosity @ 40ºC (mm^2/s)		2.73	2.30	2.16	2.64
CFPP (ºC)		-28	-25	-2	-5
Sulphur (mg/kg)		9	4	2	1
Cetane Number		48.8	53.6	58.4	>73
Carbon content (%m/m)		86.8	86.2	85.9	85.0
Hydrogen content (%m/m)		13.2	13.8	14.1	15.0
H/C ratio (mol/mol)		1.81	1.91	1.96	2.10
Aromatics (%m/m)	Monocyclic Polycyclic Total	28.1 3.1 31.2	18.6 4.3 22.9	22.8 1.8 24.6	<0.1 <0.1 <0.1
Heating value (nett) (MJ/kg)		42.7	42.9	43.1	43.7
Heating value (nett) (MJ/ℓ)		36.5	35.7	34.9	33.8

Results : CO and THC Emissions

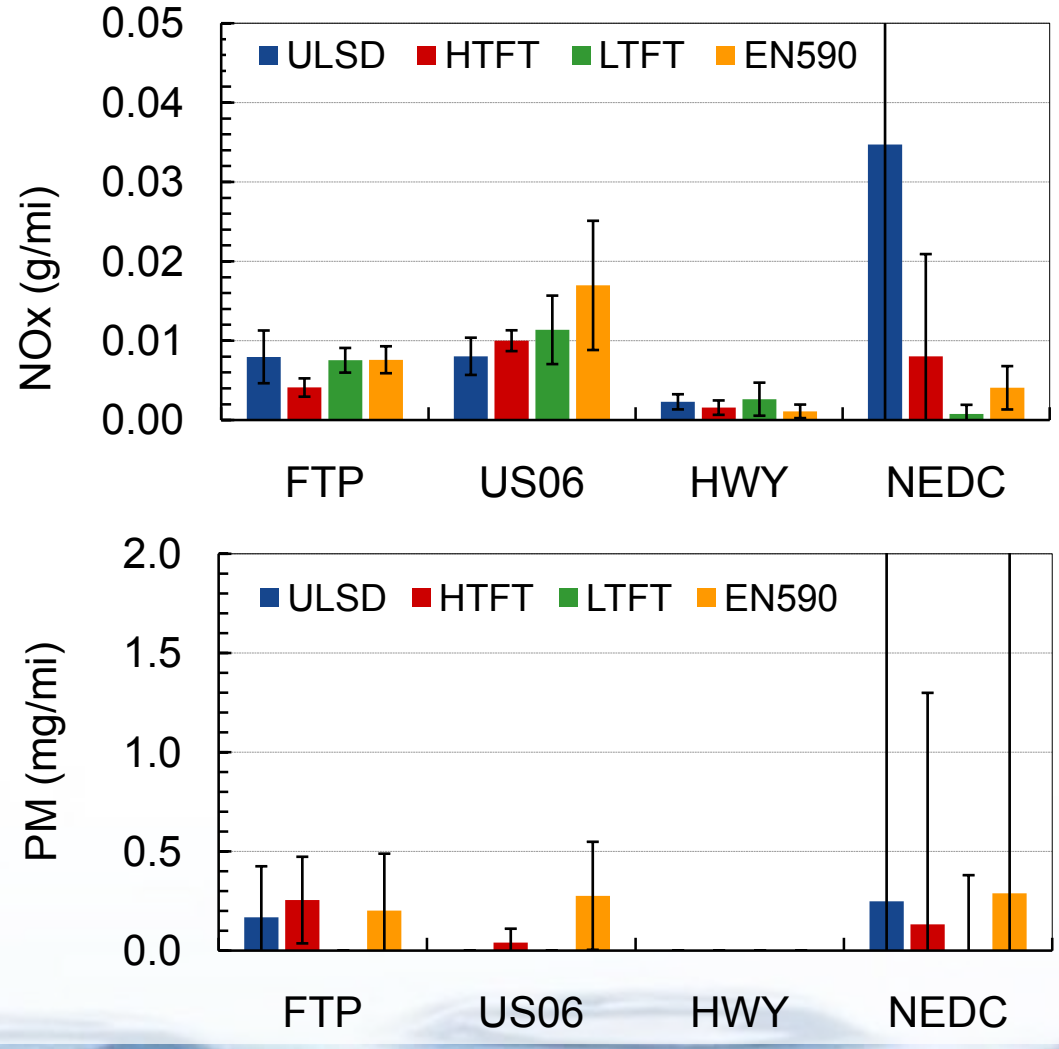




- CO and THC well below Tier 2 Bin 5 limits (3.4 and 0.075 g/mi resp.)
- Differences between fuels mostly not statistically significant

Averages of triplicate tests, error bars indicate +/- 1 standard deviation

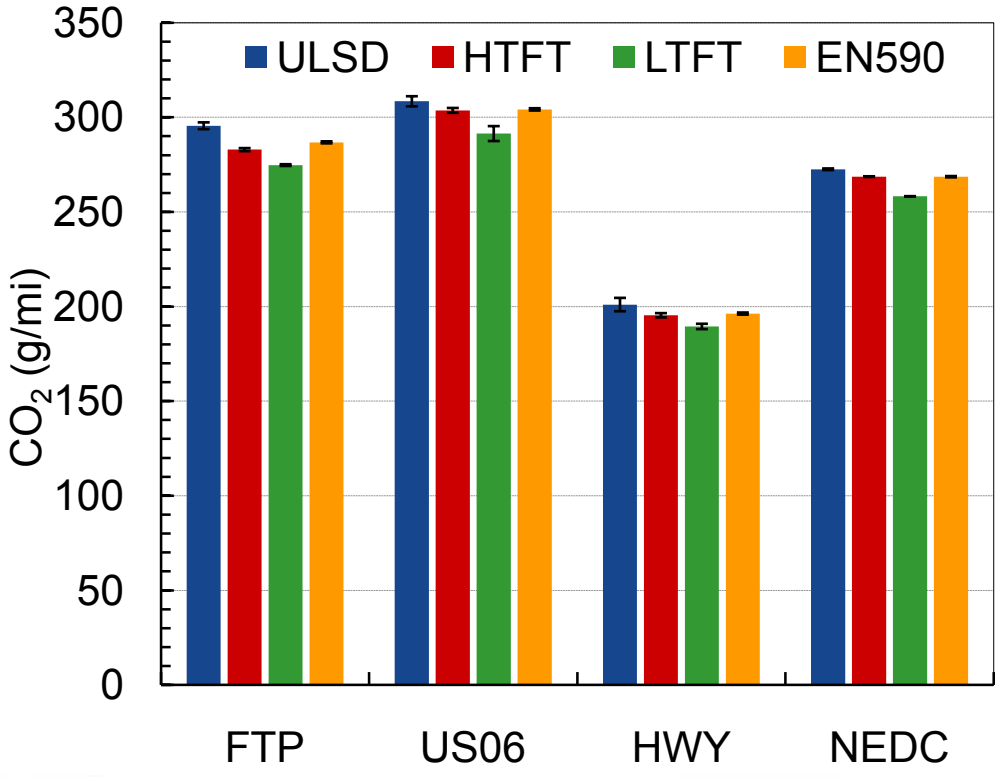
Results : NOx and PM Emissions



- NOx well below Tier 2 Bin 5 limit (0.05 g/mi)
- PM extremely low, below detection limit in some cases (e.g. HWY test).
- NOx and PM differences between fuels not statistically significant

Averages of triplicate tests, error bars indicate +/- 1 standard deviation

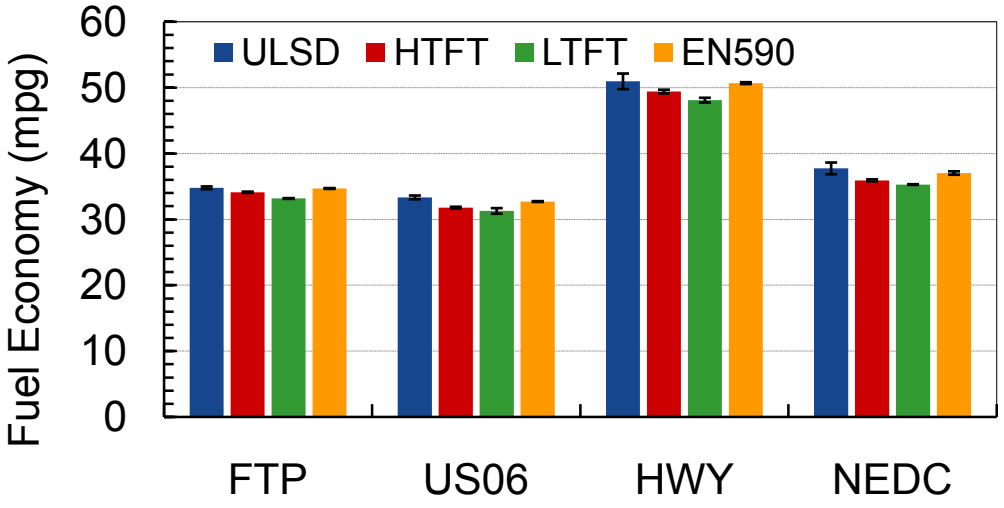
Results : CO_2 Emissions

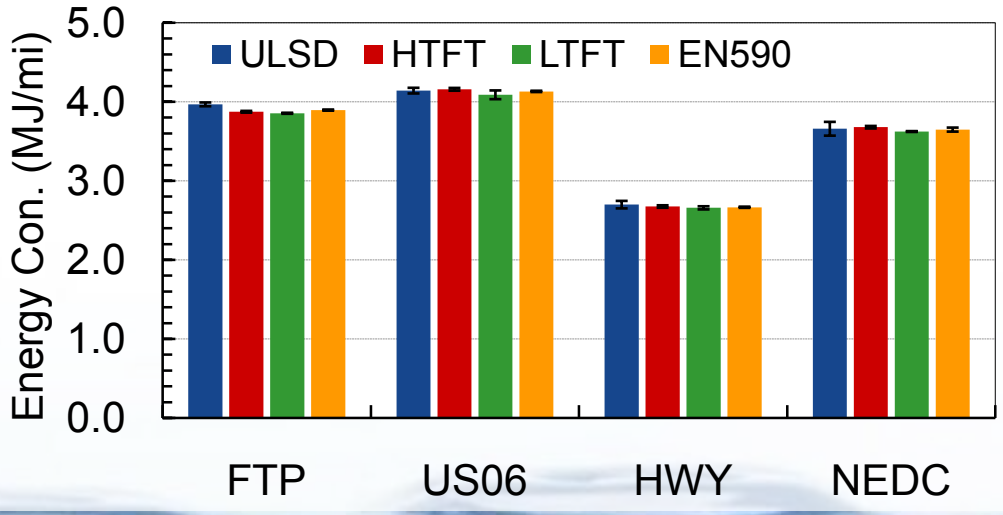


- Statistically significant differences with HTFT, LTFT, and EN590 fuels in FTP test.
- Statistically significant differences with LTFT fuel in US06 and HWY tests.
- Differences primarily due to difference in carbon content of fuels.

Averages of triplicate tests, error bars indicate +/- 1 standard deviation

Results : Fuel Economy

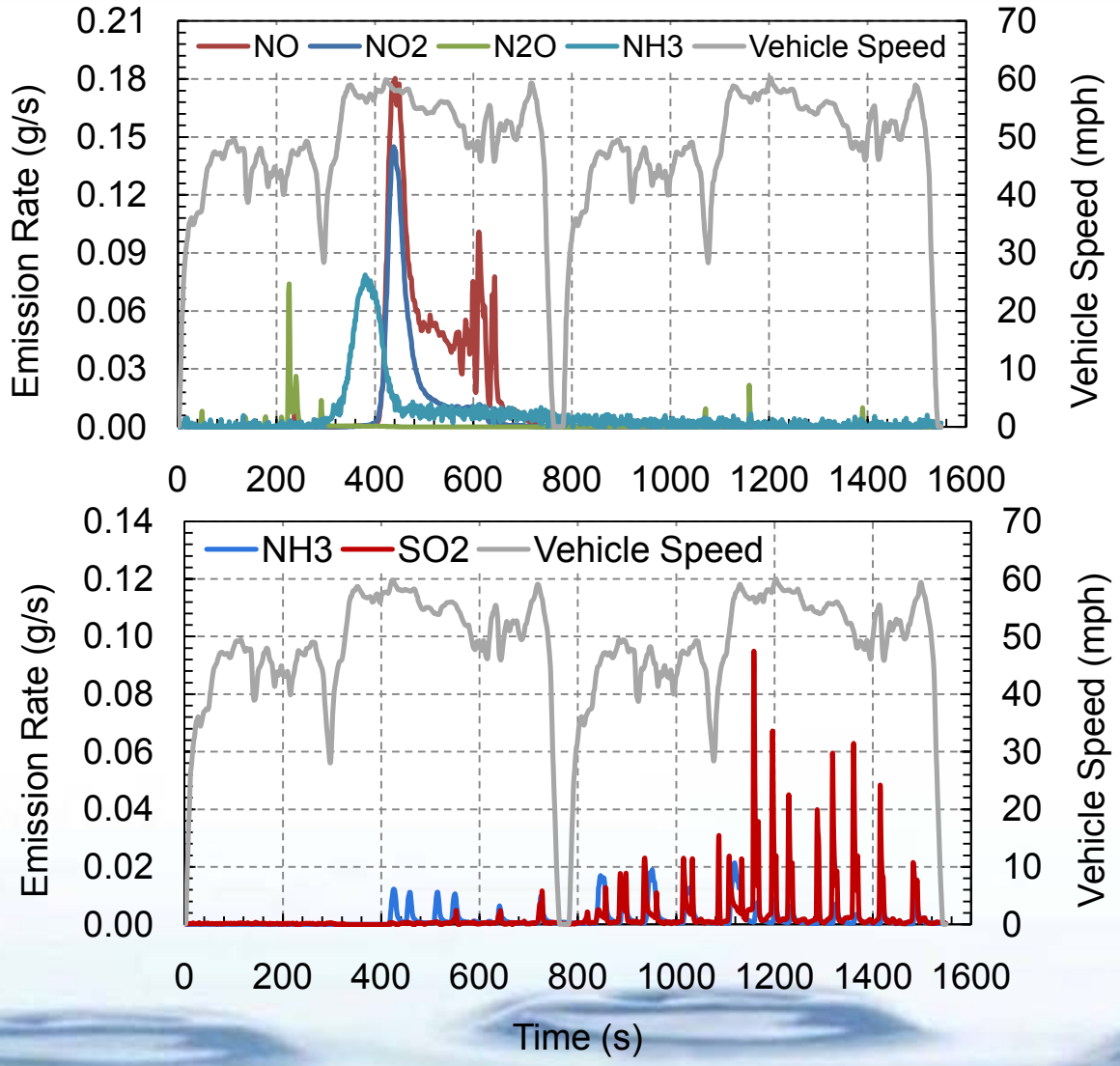




- Fuel economy with FT fuels lower due to lower density
  - ~ 2% with HTFT diesel
  - ~ 5% with LTFT diesel
- Small increase in energy efficiency with FT and EN590 fuels in FTP cycle

Averages of triplicate tests, error bars indicate +/- 1 standard deviation

Aftertreatment Regeneration



Expected regeneration modes:

- LNT NOx and SOx
- DPF

Characterized by:

- NH_3, N_2O, SO_2, NO and NO_2 emission
- Temperature increase

Test cycles during which regenerations occurred were discarded

Summary and Conclusions

- Significant differences in fuel properties did not appear to affect vehicle operation.
- Highly effective aftertreatment system (DOC + DPF + LNT) resulted in very low emissions. Low mileage on aftertreatment and non-inclusion of regeneration emission factor may result in unrealistic data.
- Differences in exhaust emissions between fuels were mostly not significant, except for CO_2 emissions which were lower with lower carbon fuels.
- FT fuels showed decreased fuel economy due to lower volumetric energy density, but tendency towards slightly higher energy efficiency.

Acknowledgements

- **U.S. Department of Energy**
  Kevin Stork

- **Sasol Technology** for providing fuels

- **Argonne National Laboratory**
  Geoffrey Amann, Michael Kern and Dave Bell

- **Phoenix Chemical Laboratory**
  Arthur Krawetz