

BioE - Emissions from the engine combustion of biofuels and fuel mixtures

The project “BioE – Emissions in the engine combustion of biofuels and fuel mixtures” received financial assistance from the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Agency for Renewable Resources (FNR) as part of the development program for renewable raw materials.

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BioE – tasks

The project examined the limited (CO, HC, NO_x, CO₂, particle mass) and not limited exhaust emissions (PAK, particle number, mutagenicity) of a EURO V HDV with SCR system and of a STEP III A tractor engine operating on different kinds of fuels.

Test fuels

- Diesel fuel max. 10 ppm Sulfur (ECE - Fuel)
- Biodiesel (FAME) according to EN 14214
- B10 (10% FAME, 90% diesel fuel)
- B7 (7% FAME, 93% diesel fuel)
- B7+3 (3% plant oil hydrotreated, 7% biodiesel, 90% diesel fuel)
- Plant oil according to V 51605

BioE – test vehicle

HDV EURO V

6-cylinder turbodiesel, common rail system, 324 kW/1900 rpm

Exhaust gas aftertreatment

SCR- System (Oxikat und SCR Kat)

Plant oil system with 2 tanks

Variation → diesel- or plant oil operation

established criteria

Engine speed >900 rpm, coolant temperature >60 °C,
fuel temperature >60 °C

BioE – test engine

STEP III A tractor engine

6-cylinder turbodiesel, common rail system, EGR, 124 kW

Plant oil system (mono-tank-system)

Fuel heating system, plant oil application

BioE - measuring program

EURO V HDV: ESC - European Stationary Cycle FIGE Cycle

The FIGE cycle was developed by the FIGE Institute, Aachen, Germany based on real road cycle measurements of heavy duty vehicles (FIGE Report 104 05 316, January 1994). For the purpose of engine certification/type approval, the ETC cycle was developed out of the FIGE dataset.

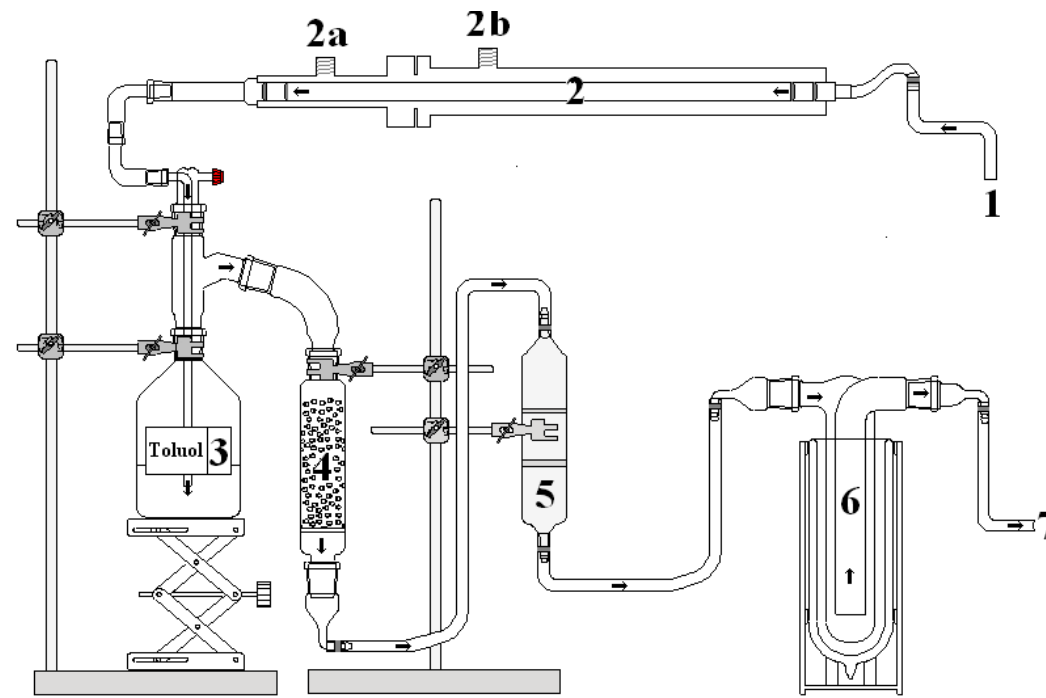
STEP III A tractor engine : NRSC - Non Road Steady Cycle NRTC - Non Road Transient Cycle

BioE - sampling PAH und carbonyl



- sampling of PAH and carbonyl at the end of the dilution tunnel
- at particle boundet PAH und Nitro-PAH → quartzfilament filter (Ø 70 mm)
- gaseous carbonyl → gas washing bottle

BioE - sampling for mutagenicity test



1 Entnahmestelle

2 kühlbare Sonde

2a & 2b Wasseranschlüsse

3 Waschflasche mit Toluol und Wasser

4 XAD-Kartusche

5 Filterhalter

6 Kühlfalle

7 Anschlussstelle für die Pumpe

→ Richtung des Gasstroms

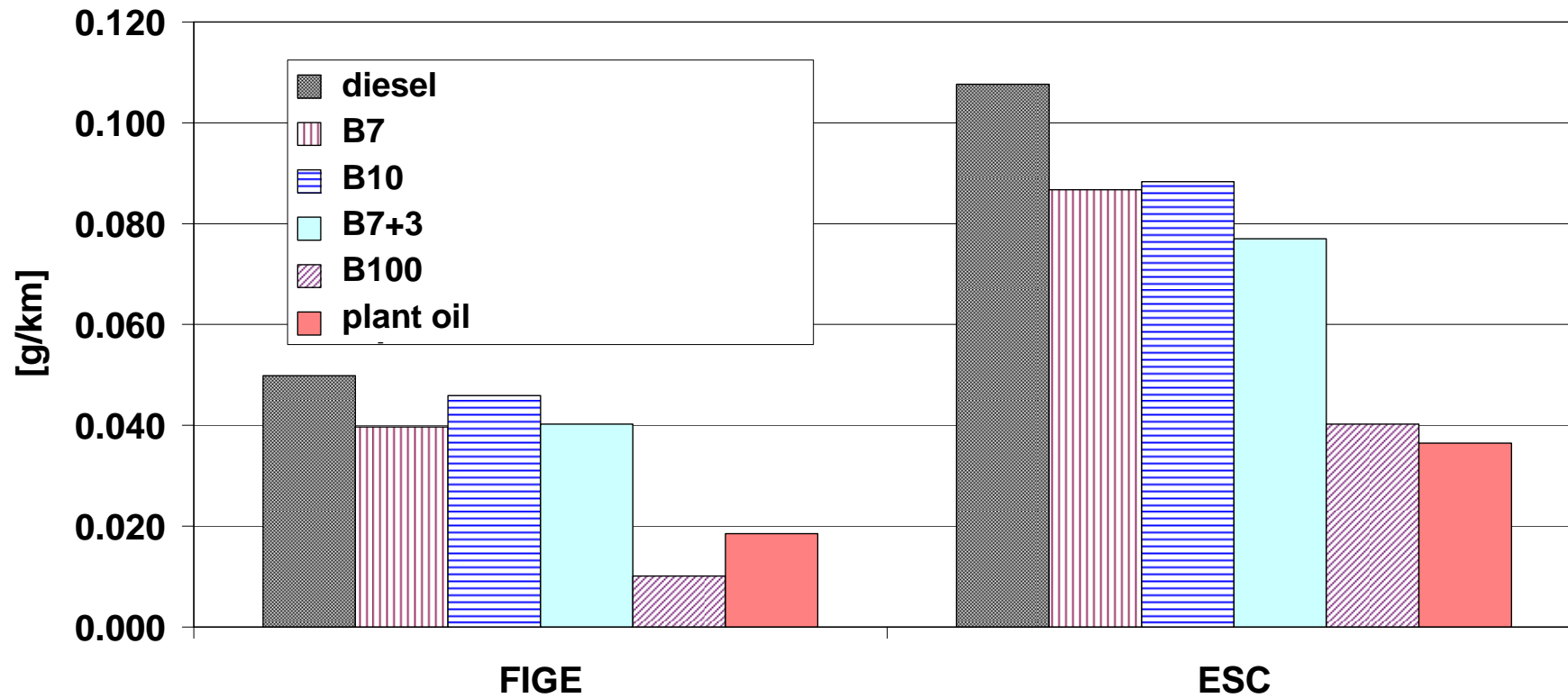
- composite sample sediment / condensate
- according to VDI-Norm 3499, extra condensation trap
- sampling out of raw exhaust gas

Mutagenicity test: AMES-test (Maron und Ames, 1983)

Salmonella typhimurium TA98 und TA100

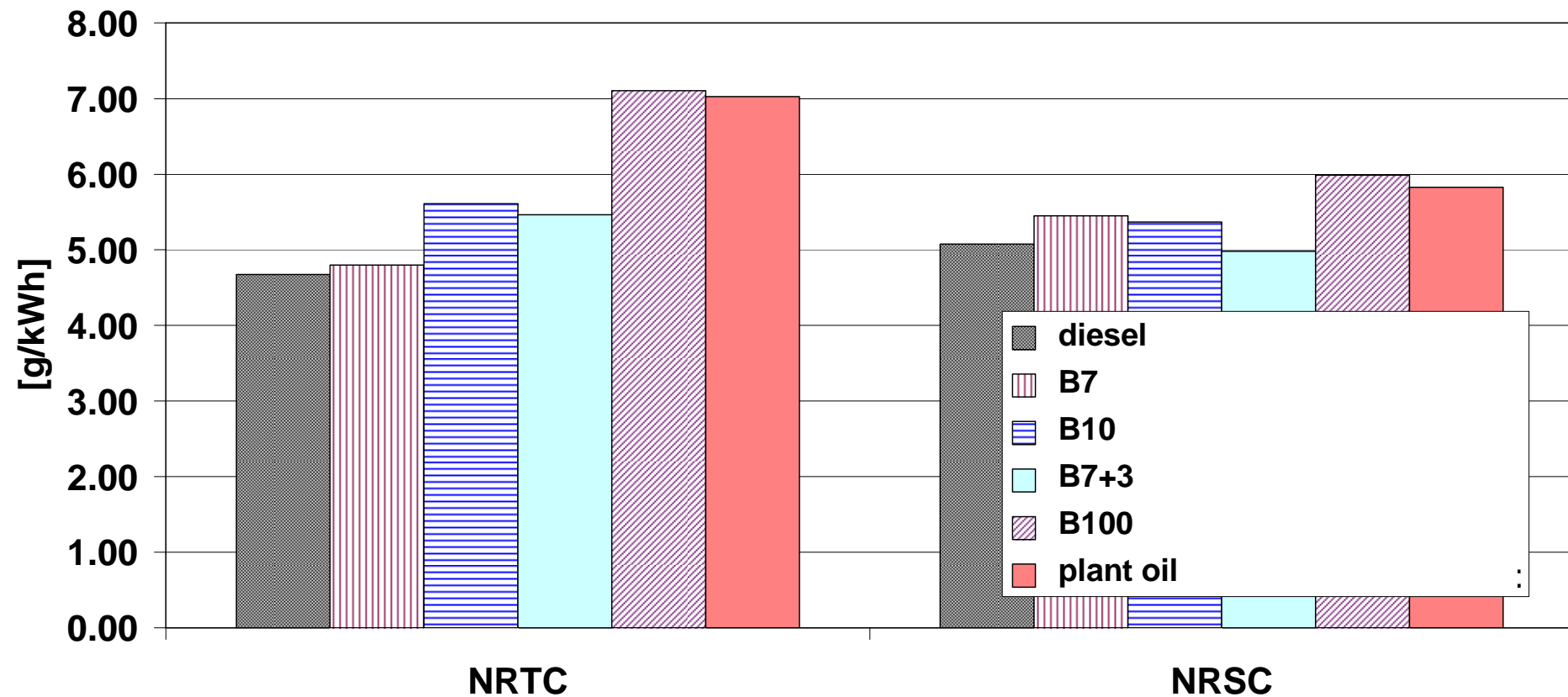
BioE – results, limited emissions

HDV EURO V particle mass emissions



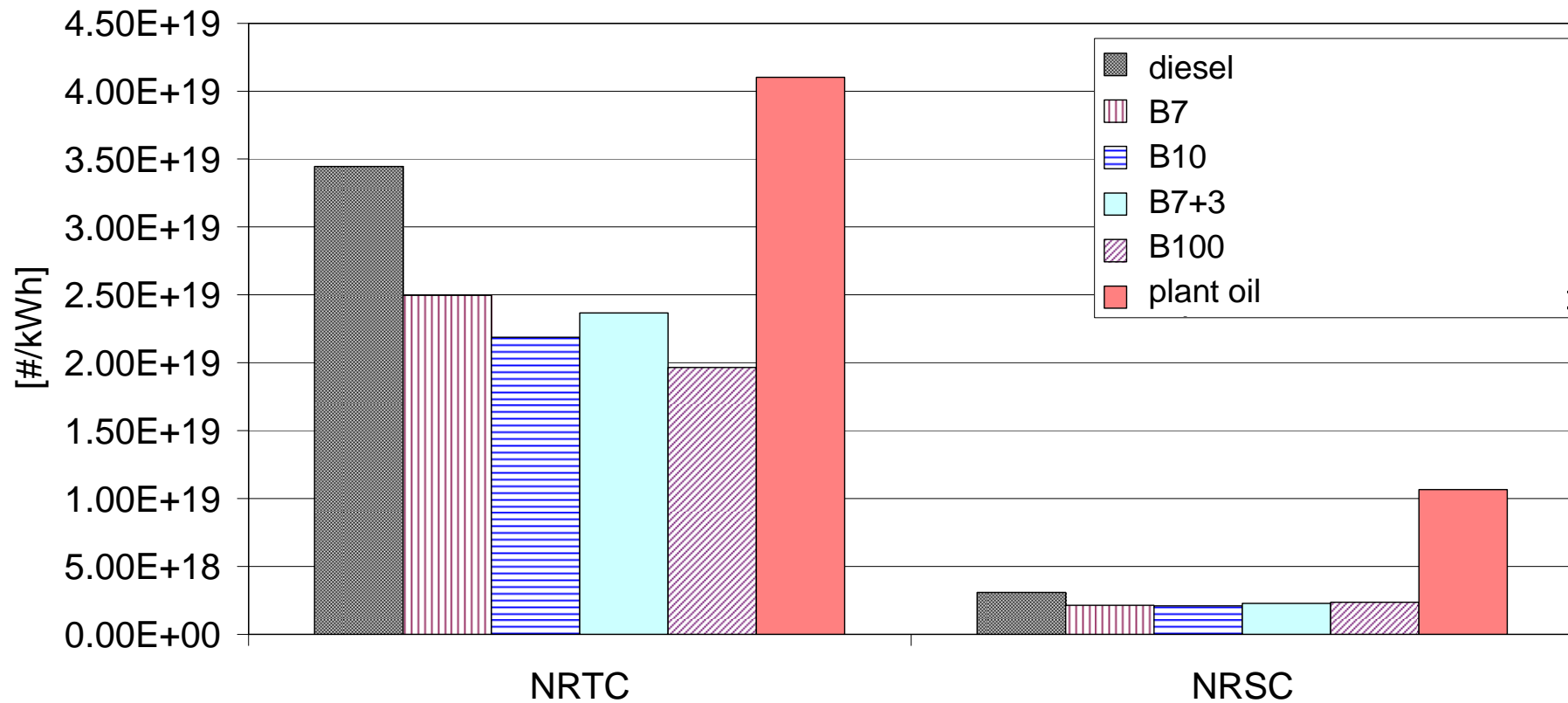
BioE – results, limited emissions

STEP III A tractor engine NO_x emissions

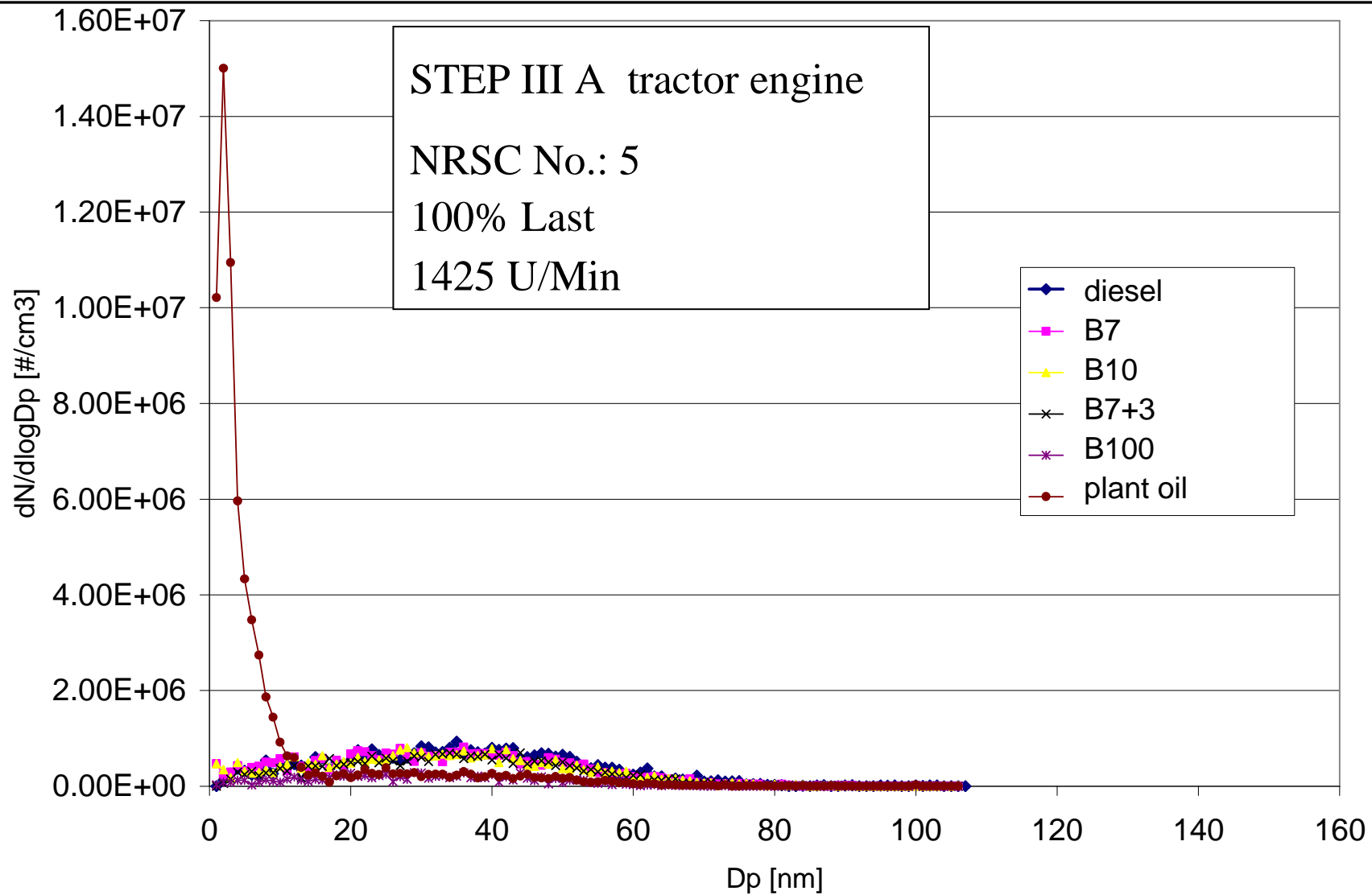


BioE – results, particle number

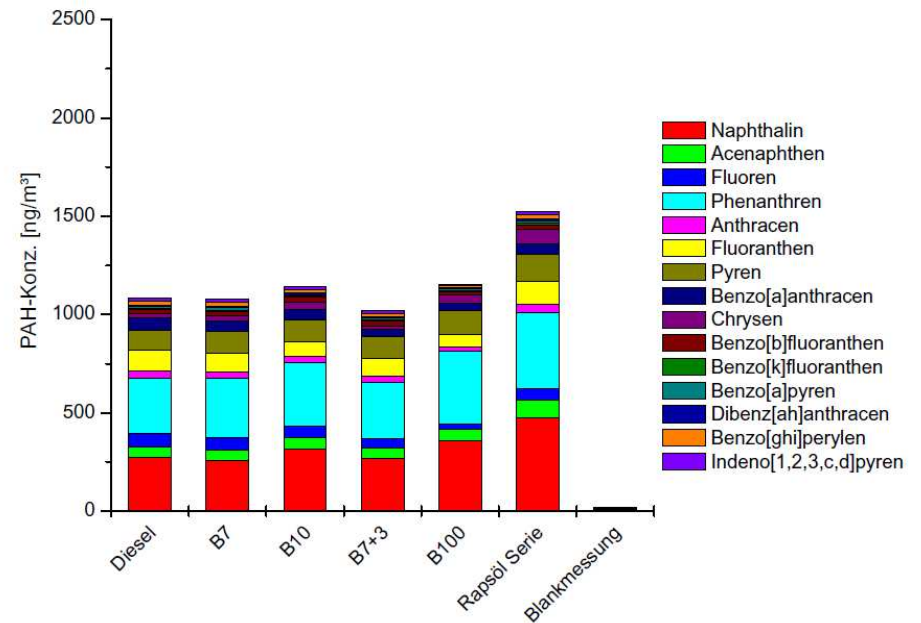
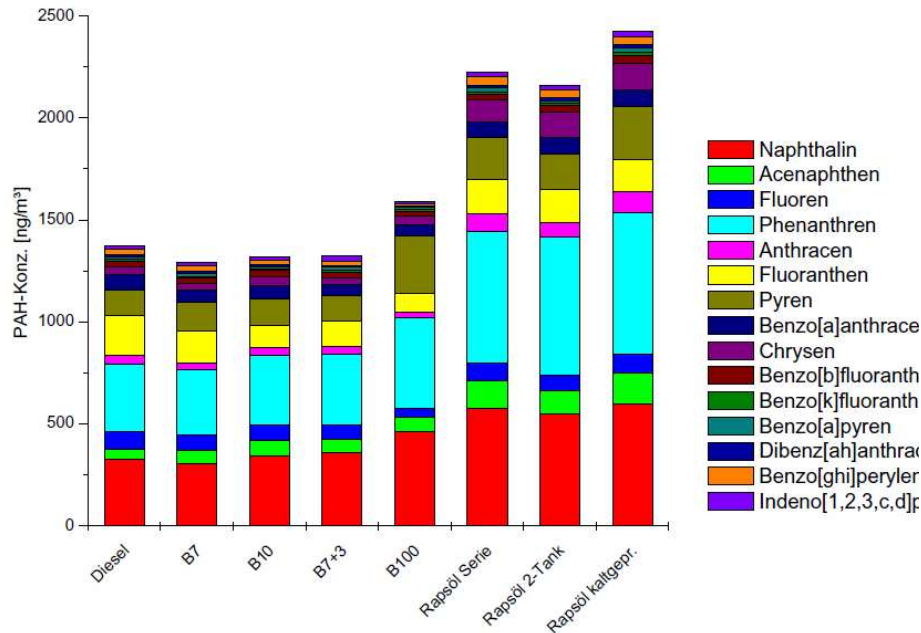
STEP III A tractor engine, particle number



BioE – results, particle size distribution



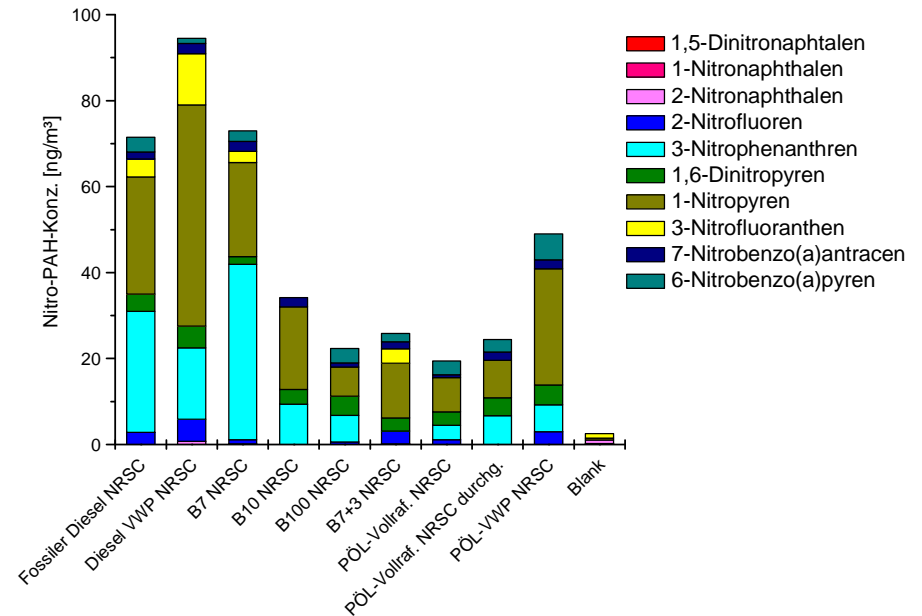
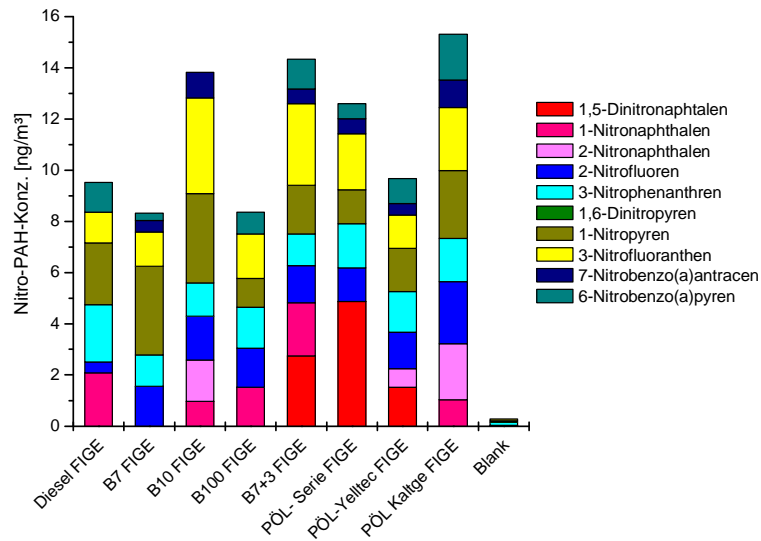
BioE – results, PAH



EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

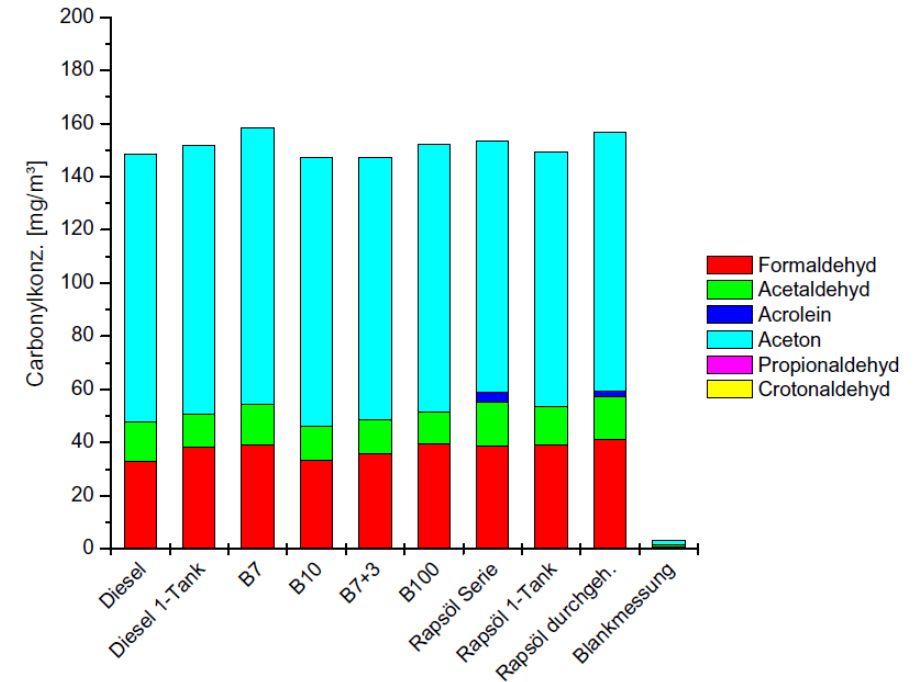
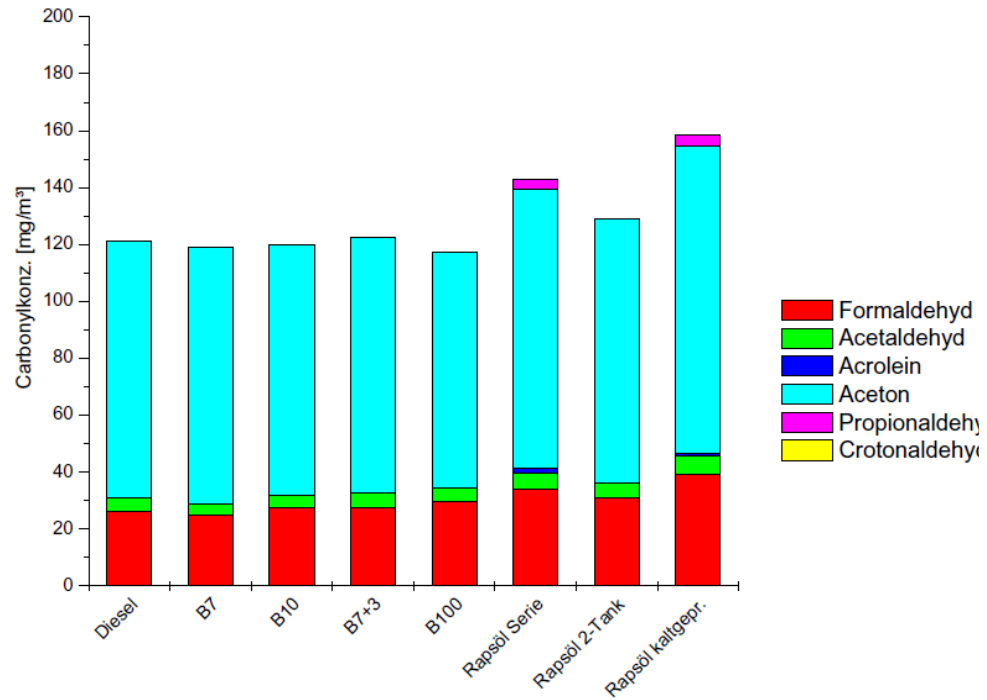
Ergebnisse – results, NITRO PAH



EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

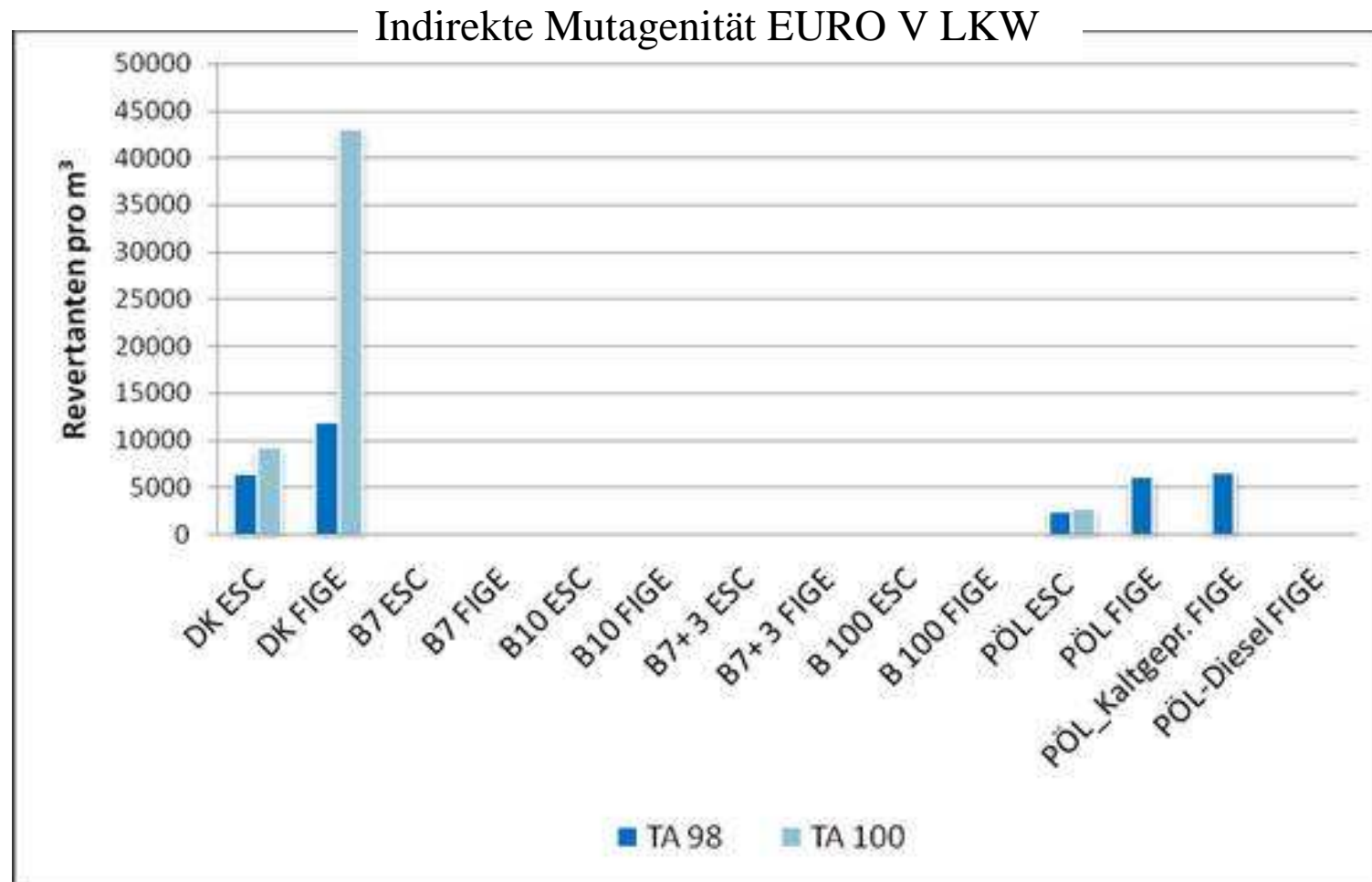
BioE – results, carbonyl



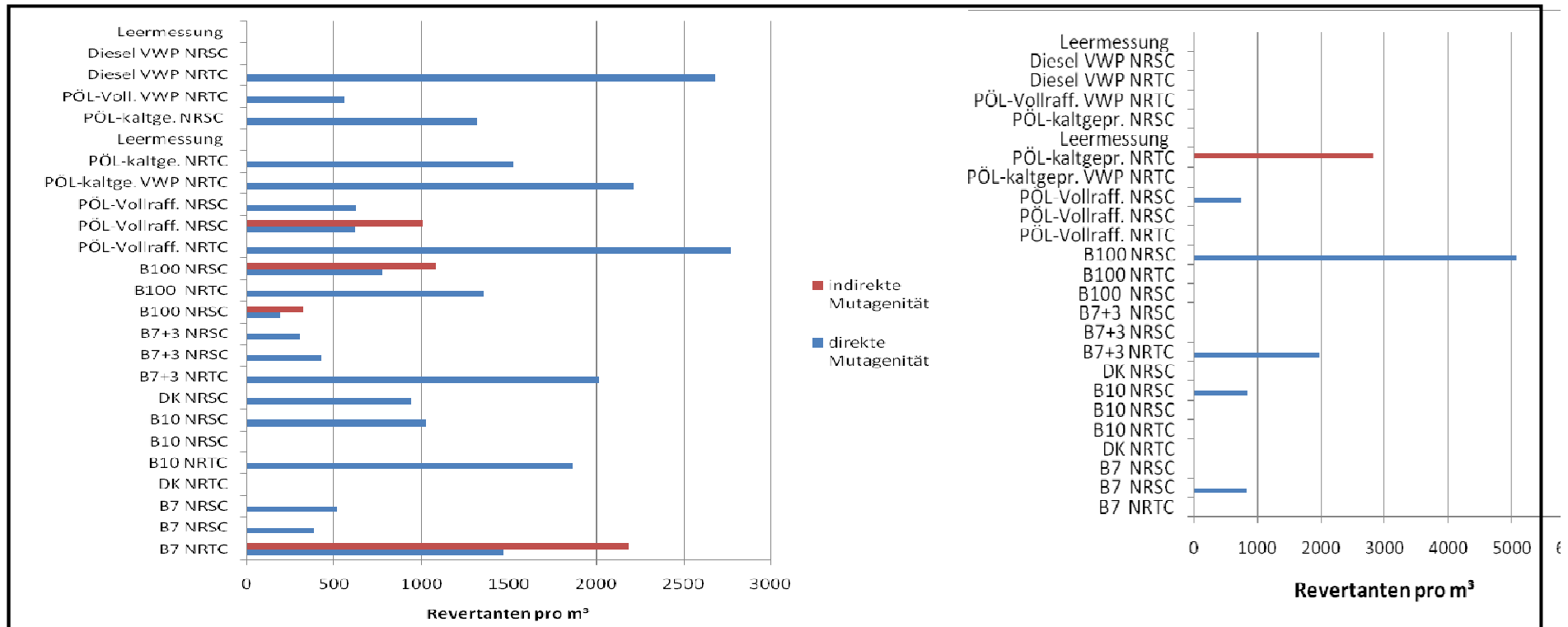
EURO V HDV
FIGE Cycle

STEP III A
tractor engine
NRSC

BioE – results mutagenicity EURO V HDV



BioE – results mutagenicity STEP III A tractor engine



Mutagenitäten von TA98

Mutagenitäten von TA100

BioE - summary

The results for limited gaseous emission components derived from the measurement series correspond to a large extent with the results from previous measurements.

Concerning the emission components NO_x and particulate mass, which are critical for diesel engines, increases (NO_x) and decreases (particle mass) occur when biofuels are used.

An increase in PAH in emissions for both test vehicles was found for operation with vegetable oil.

No significant change in emissions could be detected for nitro PAHs in the tested EURO V HDV with SCR system. For the STEP III A tractor engine, the use of biofuels and fuel mixtures thereof resulted in a significant reduction of nitro PAH emissions.

BioE - summary

In the mutagenicity analyses (AMES tests), there was no evidence of direct mutagens for the EURO V HDV engine used. However, an increase in premutagens was found for vegetable oil used in the test strains TA98 and TA100. The difference to the reference fuel diesel was not clear though. Similar effects were found for the tested STEP III A tractor engine, although the revertant level proved to be much lower in this case.

BioE - cross references

The same results, at least in terms of the trend, as well as deviating results in mutagenicity tests with vegetable oil from other projects are being discussed at the moment. A proposal for standardizing the collection of samples is currently being worked out in a follow-up project in order to be able to run standardized evaluations and comparisons of future results of test series from different research projects and institutions.

BioE

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Thank you for your attention!