

# 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

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The project examined the limited (CO, HC, NO<sub>x</sub>, CO<sub>2</sub>, 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

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## 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

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## 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

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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

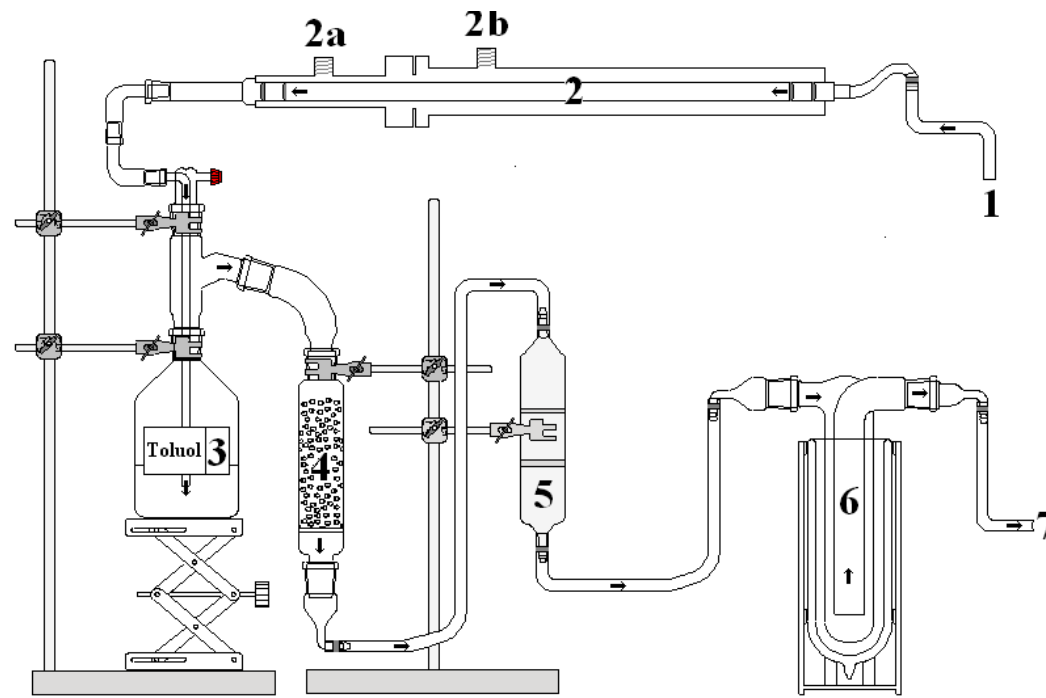
# BioE - sampling PAH und carbonyl

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

# BioE - sampling for mutagenicity test



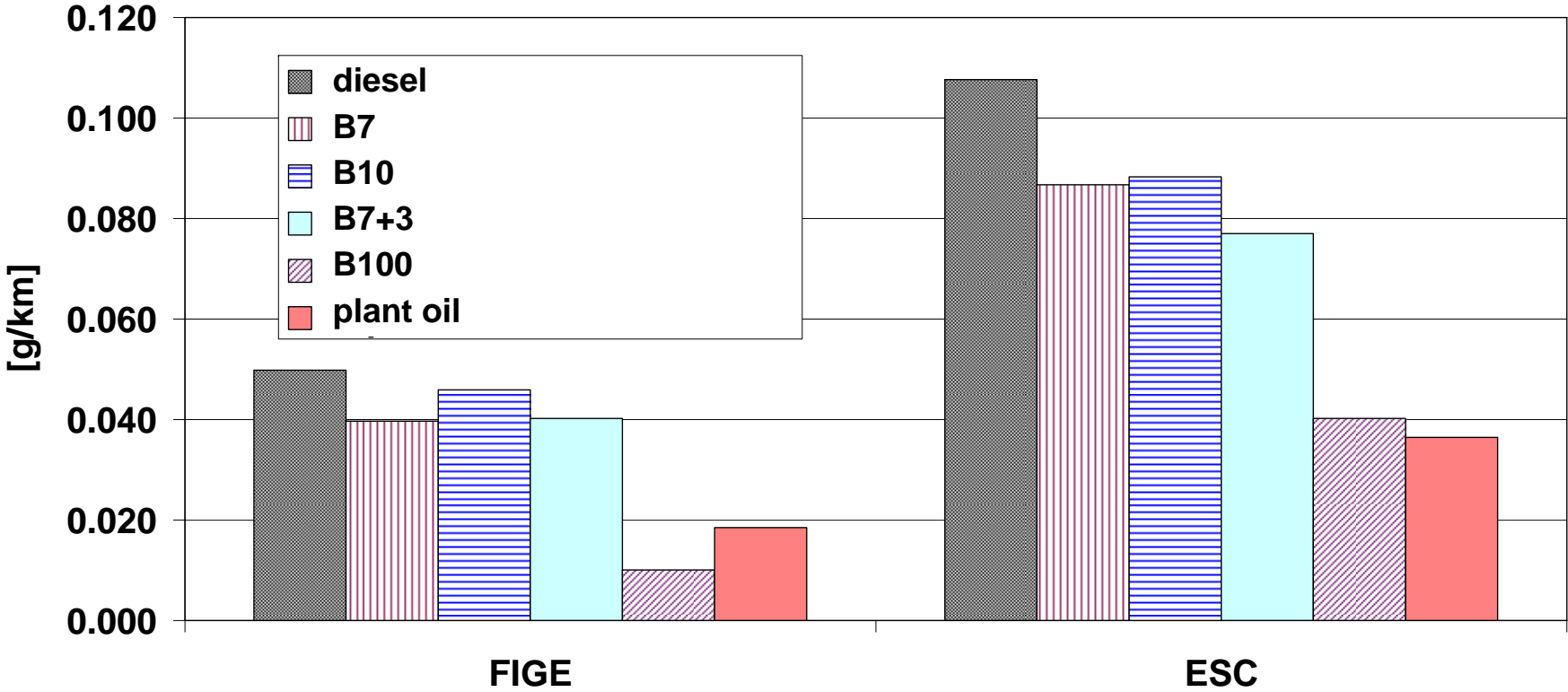
- 1 Entnahmestelle
- 2 kühlbare Sonde
- 2a & 2b Wasseranschlüsse
- 3 Waschflasche mit Toluol und Wasser
- 4 XAD-Kartusche
- 5 Filterhalter
- 6 Kühlfalle
- 7 Anschlussstelle für die Pumpe
- Richtung des Gasstroms

- 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

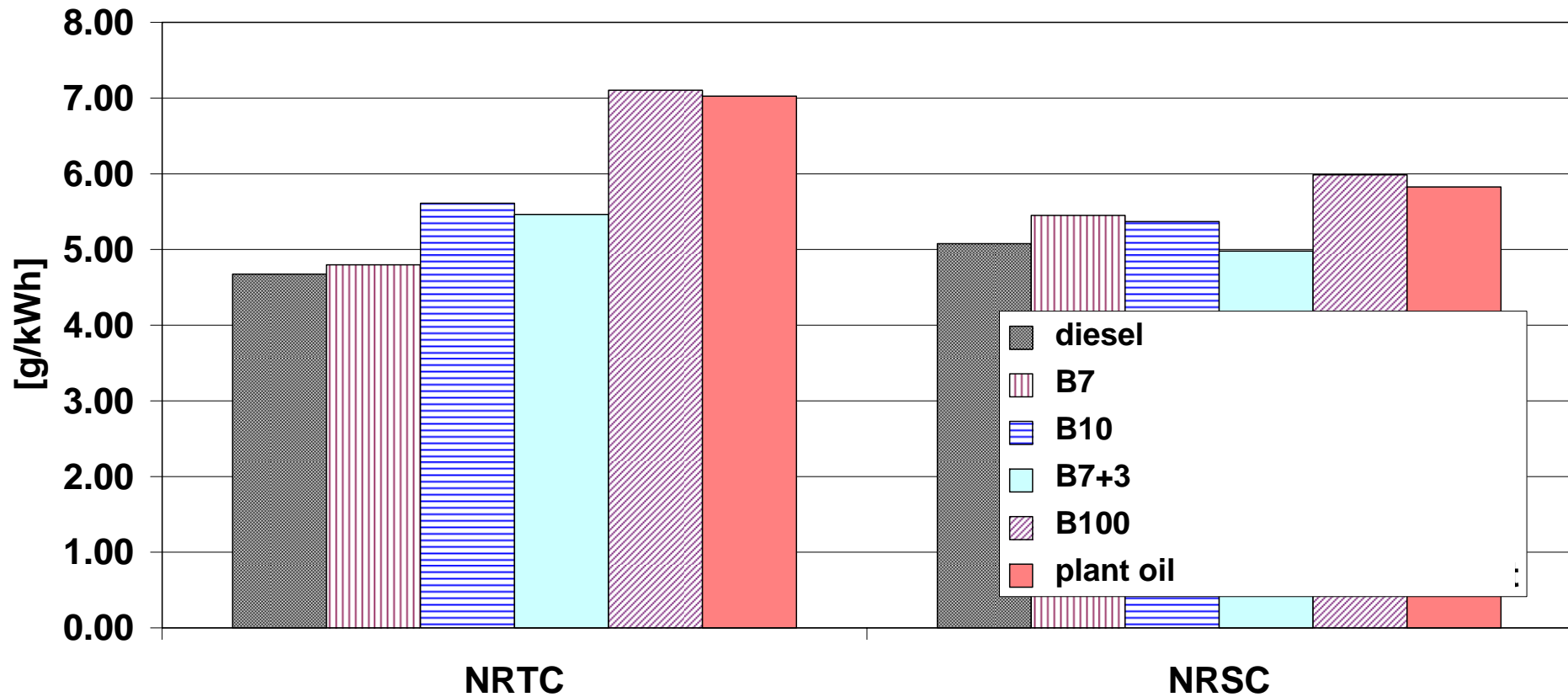
## HDV EURO V particle mass emissions





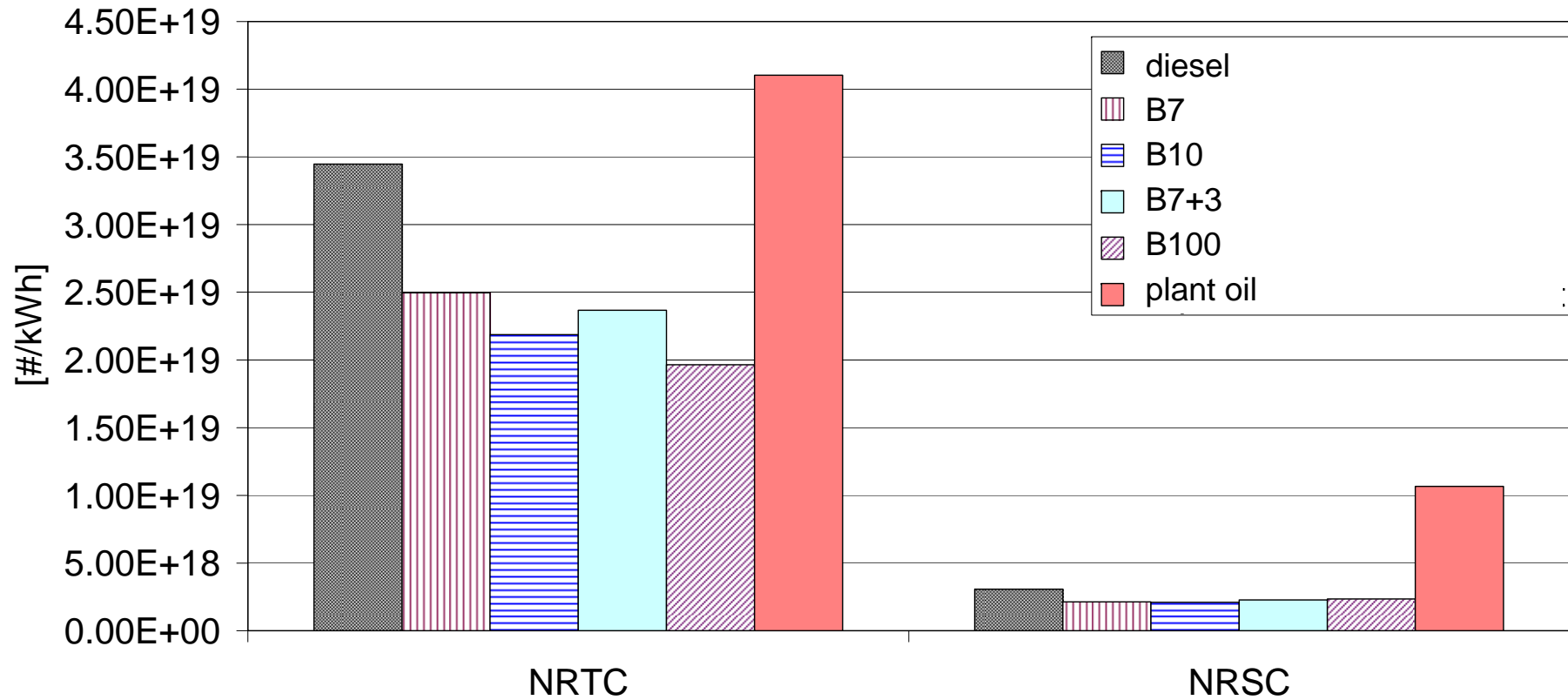
# BioE – results, limited emissions

## STEP III A tractor engine NO<sub>x</sub> emissions

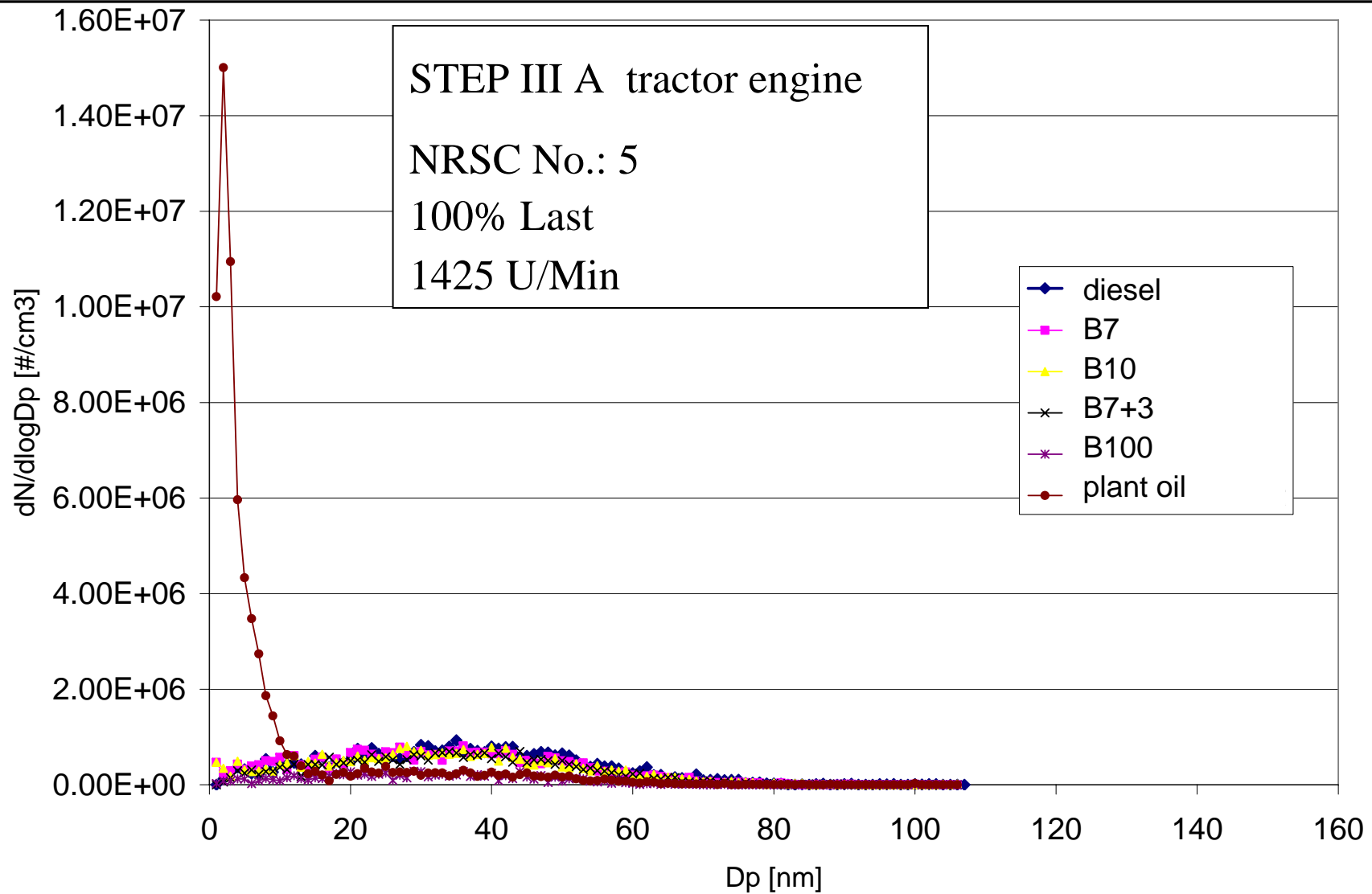


# BioE – results, particle number

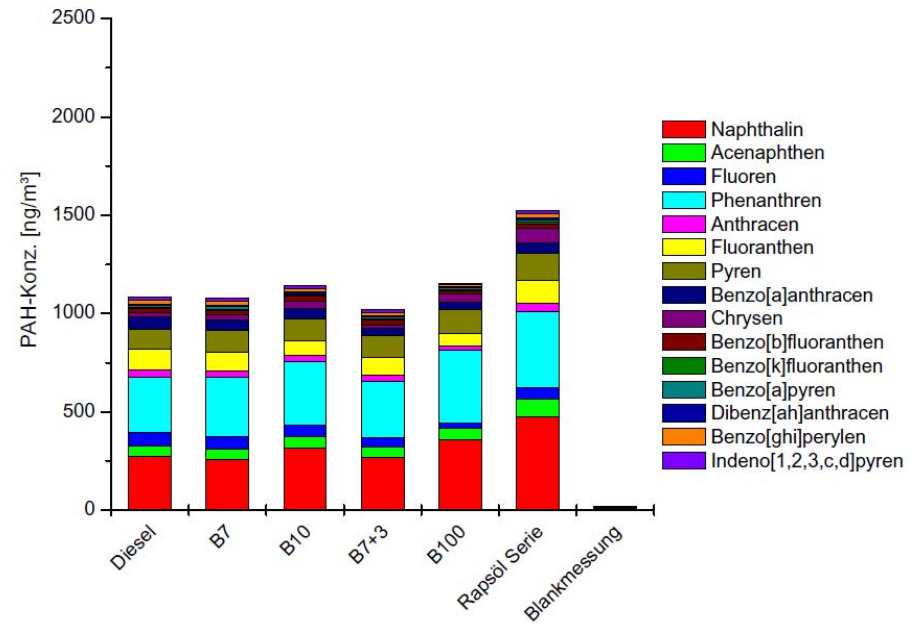
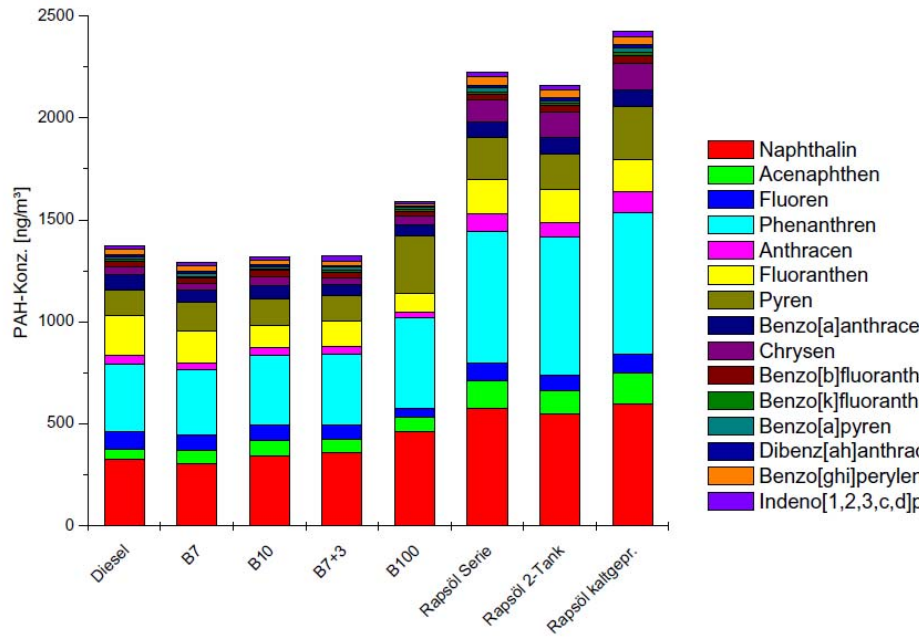
## STEP III A tractor engine, particle number



# BioE – results, particle size distribution



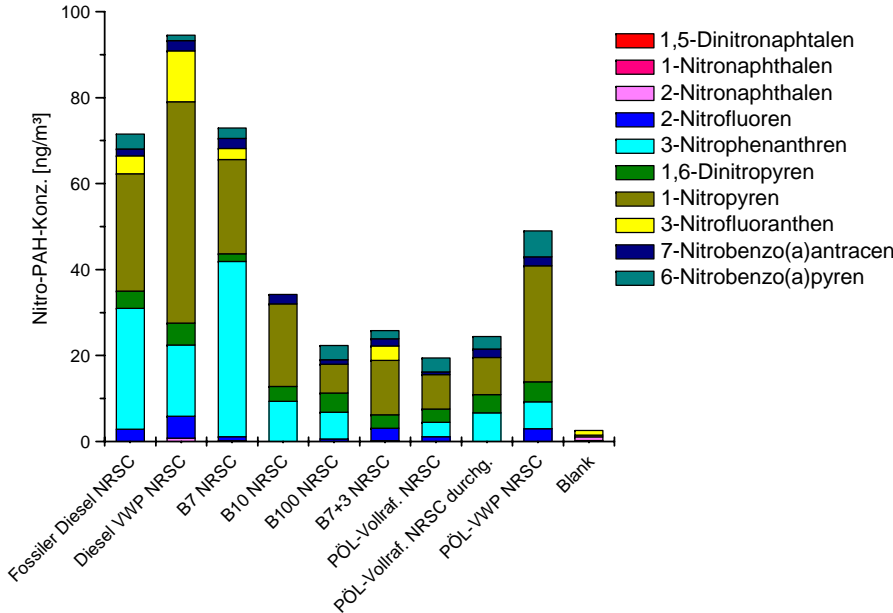
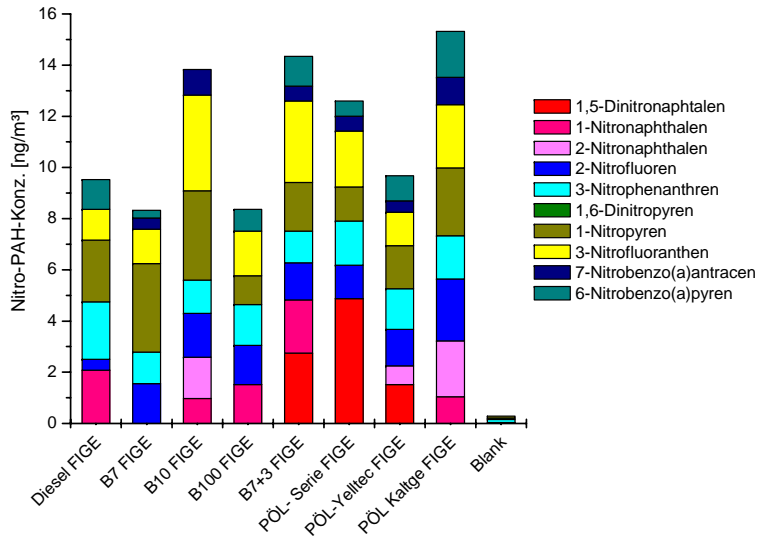
# BioE – results, PAH



EURO V HDV  
FIGE Cycle

STEP III A  
tractor engine  
NRSC

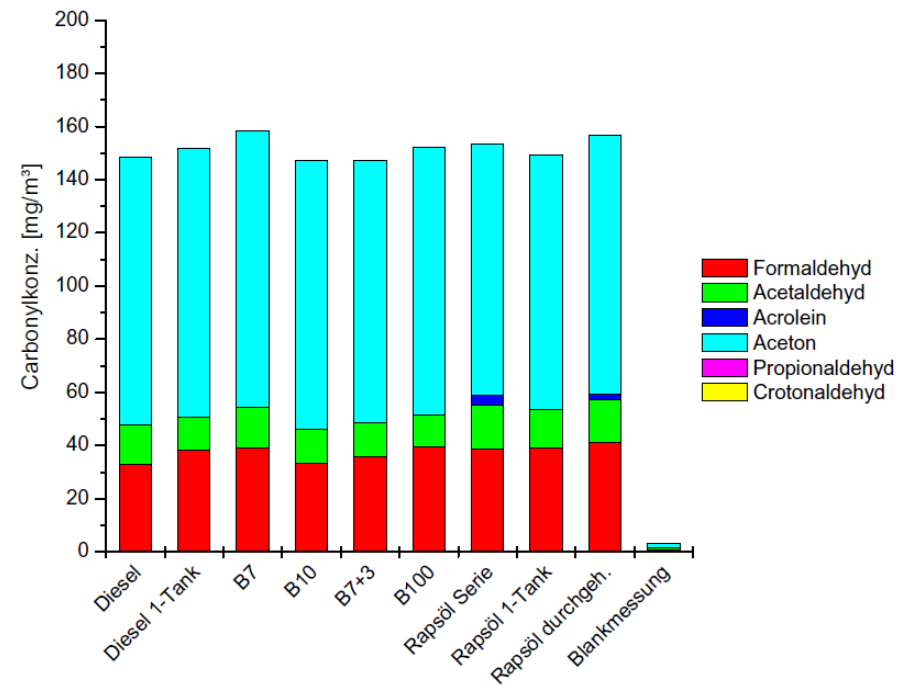
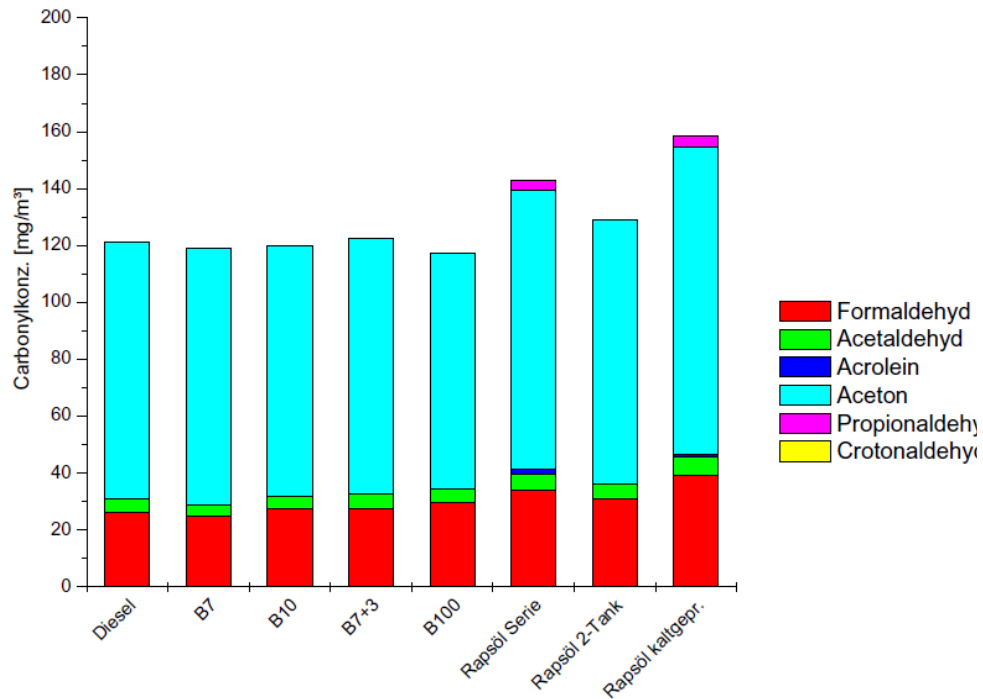
# Ergebnisse – results, NITRO PAH



EURO V HDV  
FIGE Cycle

STEP III A  
tractor engine  
NRSC

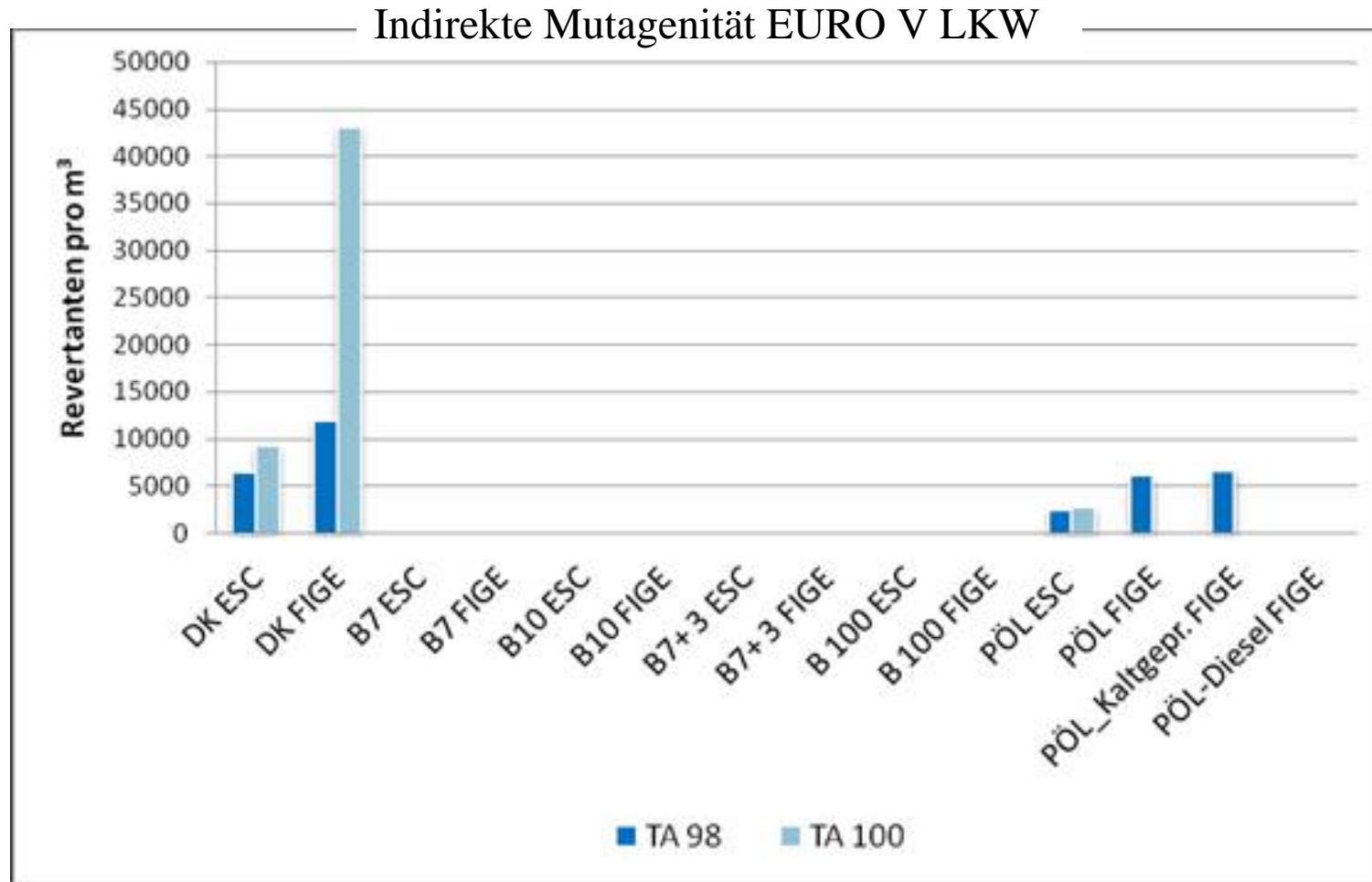
# BioE – results, carbonyl



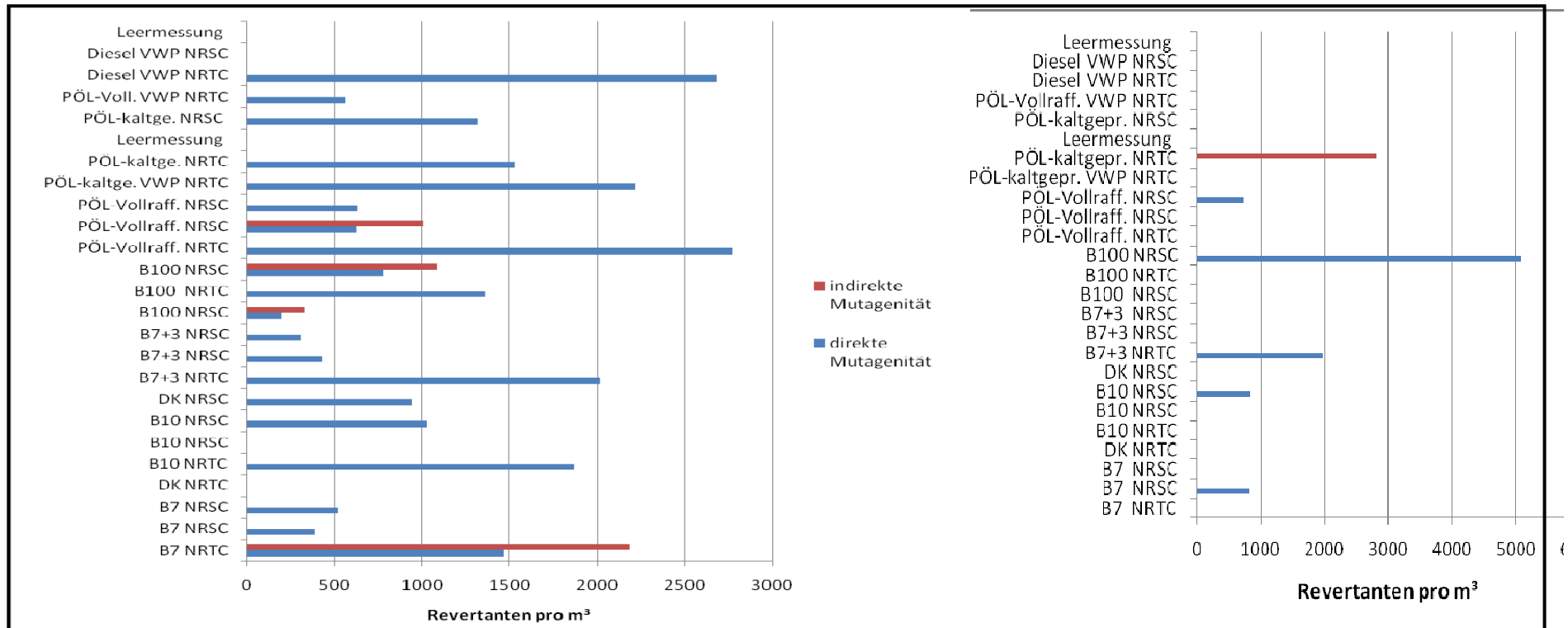
EURO V HDV  
FIGE Cycle

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

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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  $\text{NO}_x$  and particulate mass, which are critical for diesel engines, increases ( $\text{NO}_x$ ) 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

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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

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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

Emissions from the engine combustion of bio fuels and fuel mixtures

Thank you for your attention!