
Biodiesel and Renewable Diesel Emissions Study (Regulated Emissions)

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Heavy Duty Diesel Emission Testing Laboratory
Mobile Source Control Division

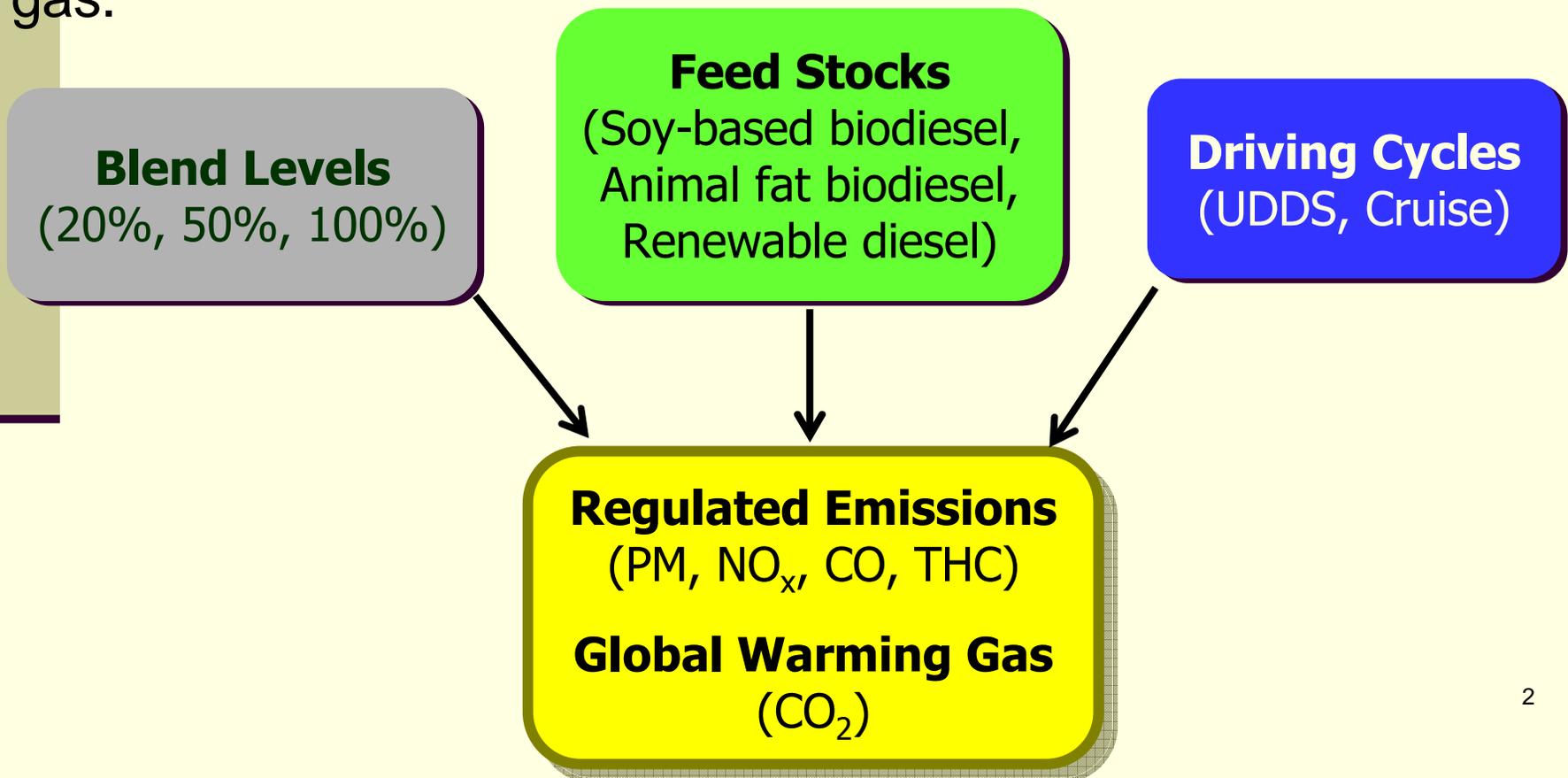
California Environmental Protection Agency



Air Resources Board

Objectives

To look at the impact of blend levels, feed stocks, and driving cycles on regulated emissions and a global warming gas.





Emission Testing

Vehicles Tested

Veh. #1: 2000 Freightliner C15 Caterpillar



Veh. #2: 2006 International ISM 370



Veh. #3: 2008 Freightliner Mercedes Benz MBE 4000

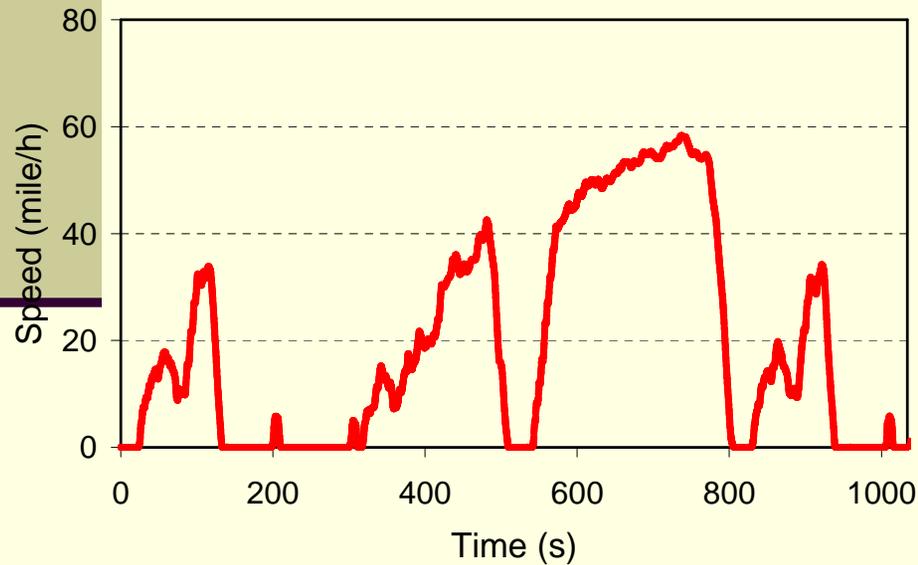


Description on vehicles and fuels tested

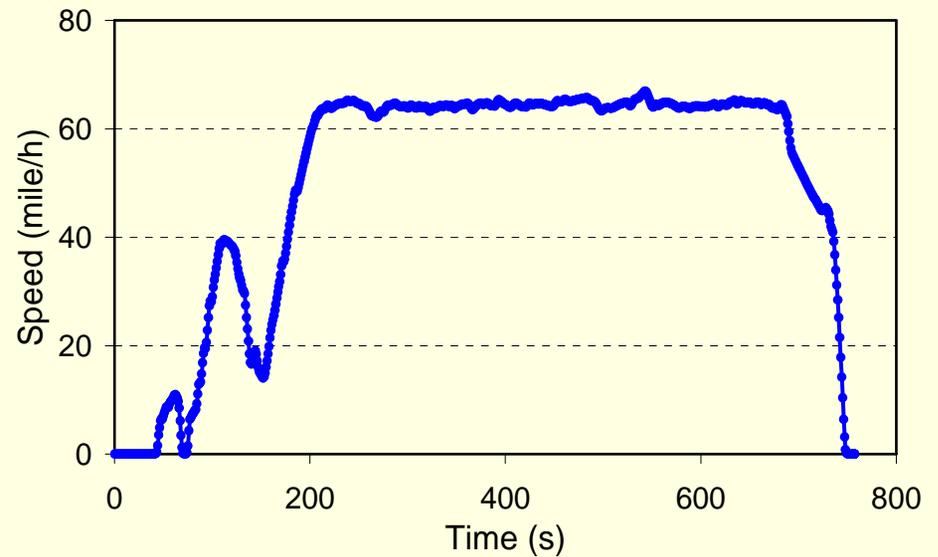
| Make/model/year | Emission Control Devices | Odometer (miles) | Inertia weight (lbm) | Engine Displacement (liter) | Horse power/ Torque | Test fuels |
|--|--------------------------|------------------|--|-----------------------------|---------------------|---|
| 2000 Freightliner C15 Caterpillar | | 34,000 | Cruise: 58,744 UDDS: 43,861 | 14.6 | 550 at 1800 rpm | CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), Renewable diesel (R20, R50, R100) |
| 2006 International ISM 370 | EGR | 93,000 | Cruise: 61,189 UDDS: 43,480 | 10.8 | 370 at 2100 rpm | CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), |
| 2008 Freightliner Mercedes Benz MBE 4000 | EGR, DOC, DPF | 8,000 | Cruise: 57,490 UDDS: 43,480 | 12.8 | 450 at 1900 rpm | CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, A100), ⁵ |

Driving Cycles Tested

**I. Urban Dynamometer
Driving Schedule (UDDS):
low load cycle**



**II. 50 mph Highway Cruise:
High load cycle**



Emission Data Measured

Regulated components

- Oxides of Nitrogen (NO_x)
- Particulate Matter (PM)
- Total Hydrocarbons (THC)
- Carbon Monoxide (CO)

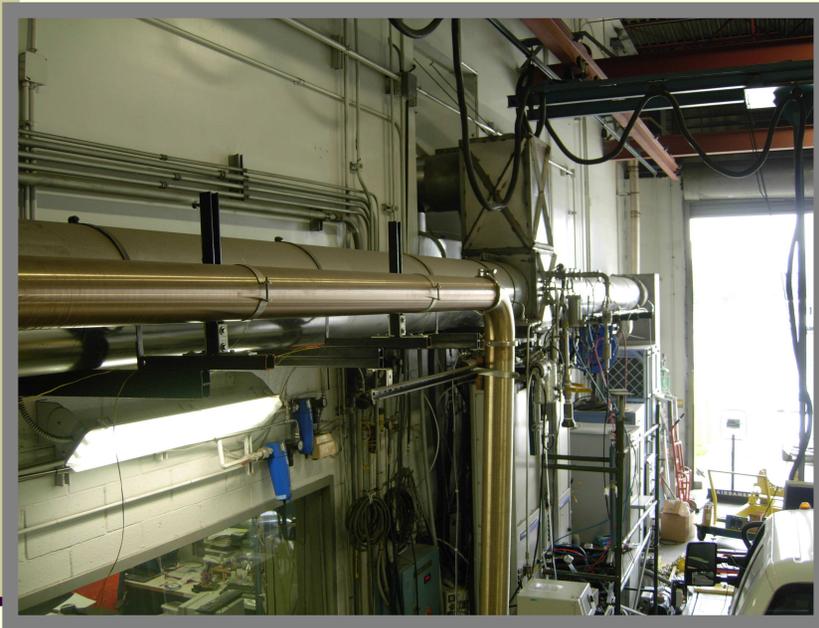
- NO_2 fractions in NO_x

Non-regulated components

- Carbon Dioxide (CO_2)
- Nitrous Oxide (N_2O)

Constant Volume Sampling (CVS) Dilution Tunnel and PM sampling Conditions

Horiba full flow dilution tunnel



Horiba PM filter unit



- Dilution air temp.: 25 ± 5 °C
- Heated filter temp.: 47 ± 5 °C
- Filter face velocity: 100 ± 10 cm/s₈

PM and Gas Analysis

● PM: Mettler Toledo UMX2 Micro Balance



Readability: 0.1 μg

● Gases: Horiba MEXA 7200D Exhaust Gas Analyzer



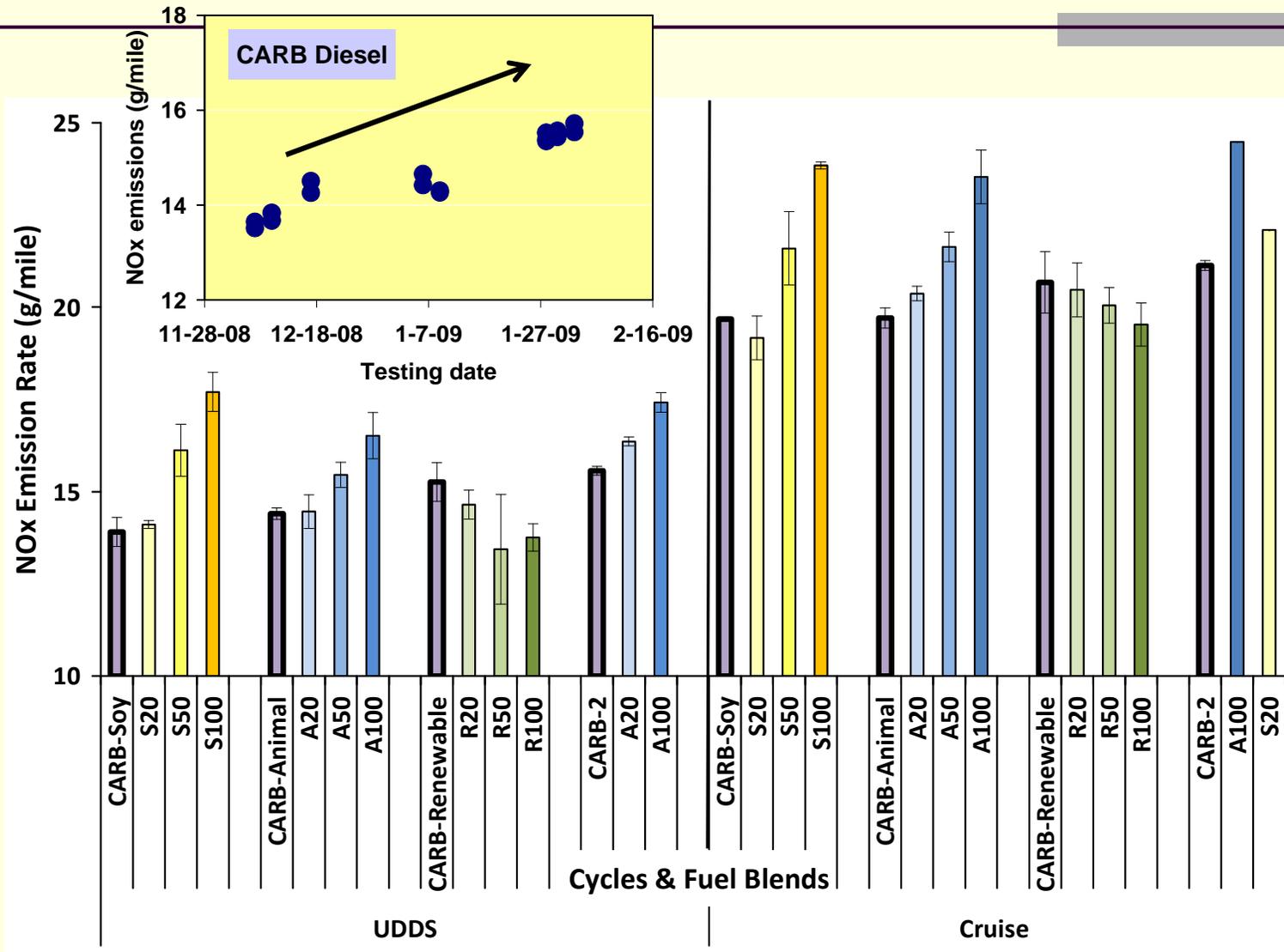
● Detector for Gas Analysis

- CO, CO₂: NDIR (Non-dispersive infrared)
- THC: FID (flame ionization detector)
- NO_x: CLD (Chemi-luminescence detector)

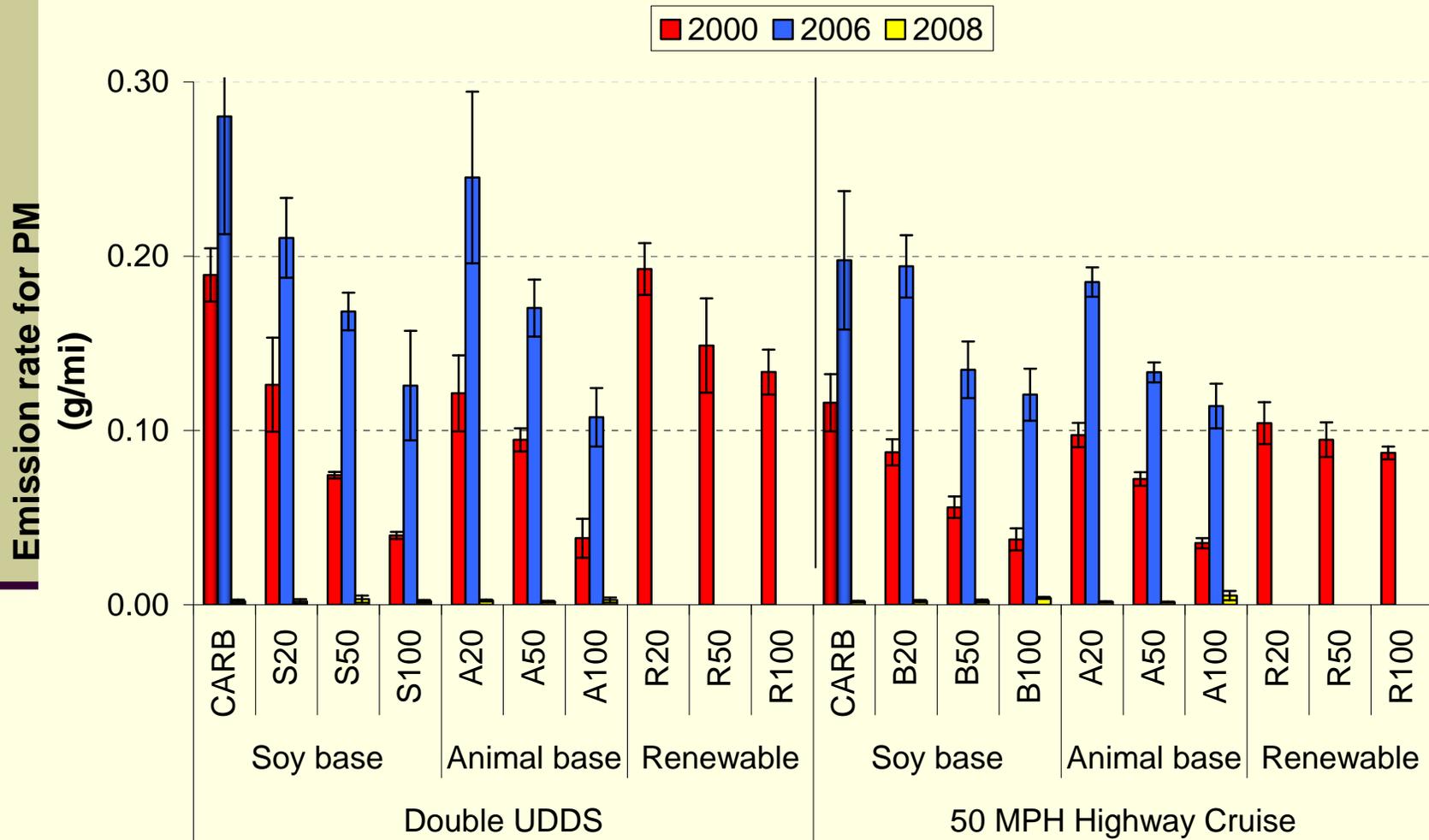


Test Results

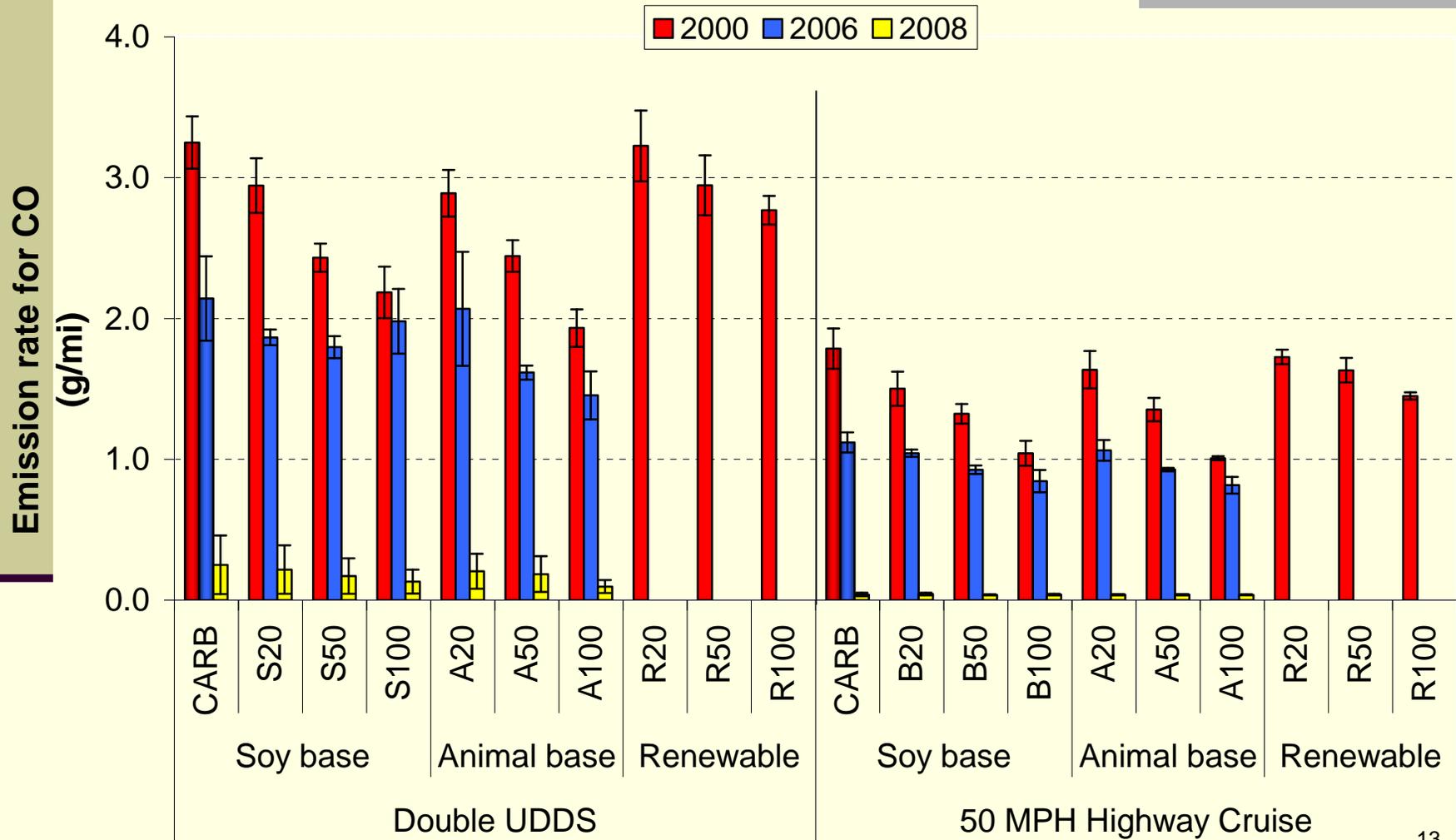
Drift of NO_x Emission for 2000 Vehicle



PM Emissions

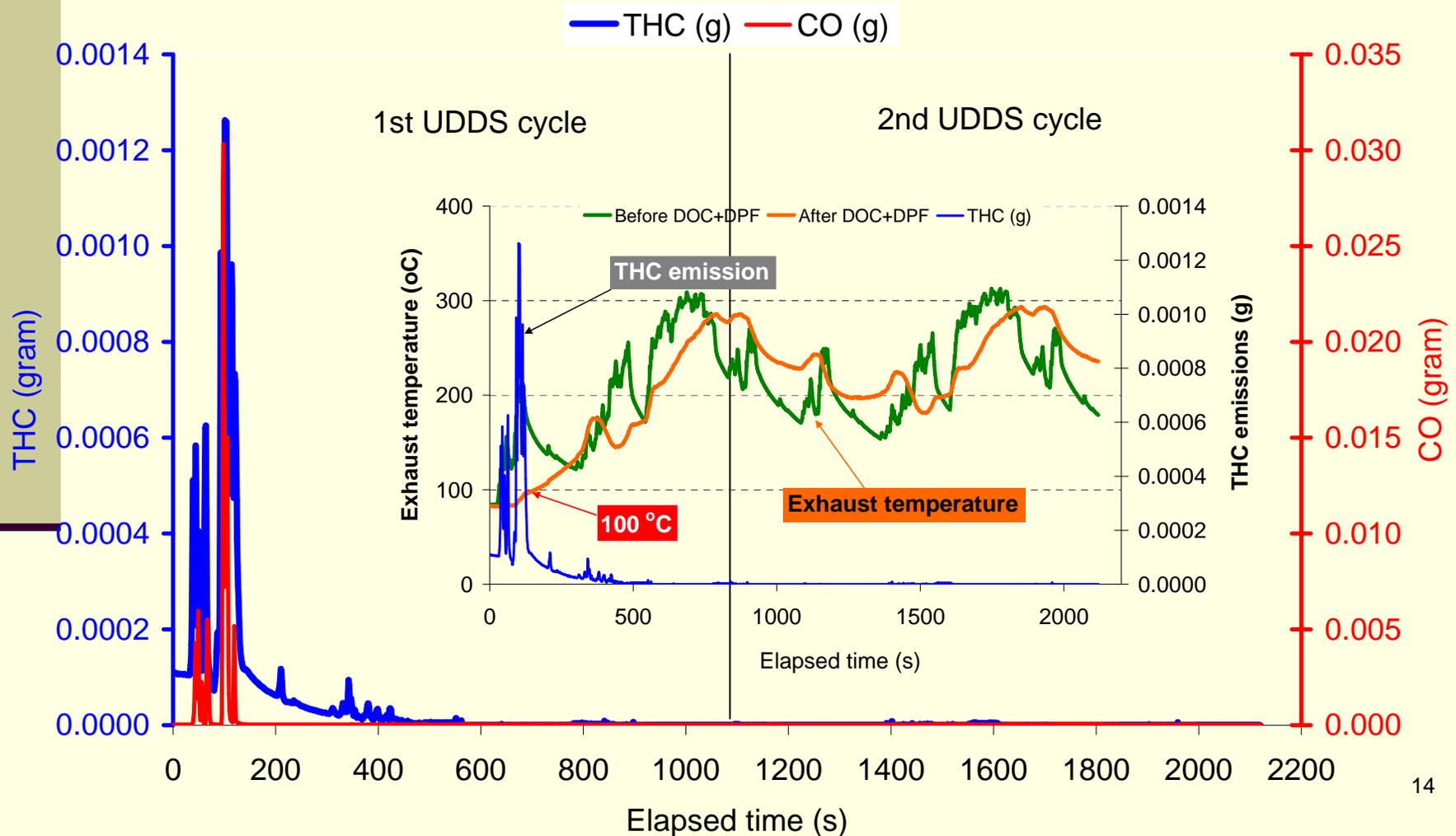


CO Emissions

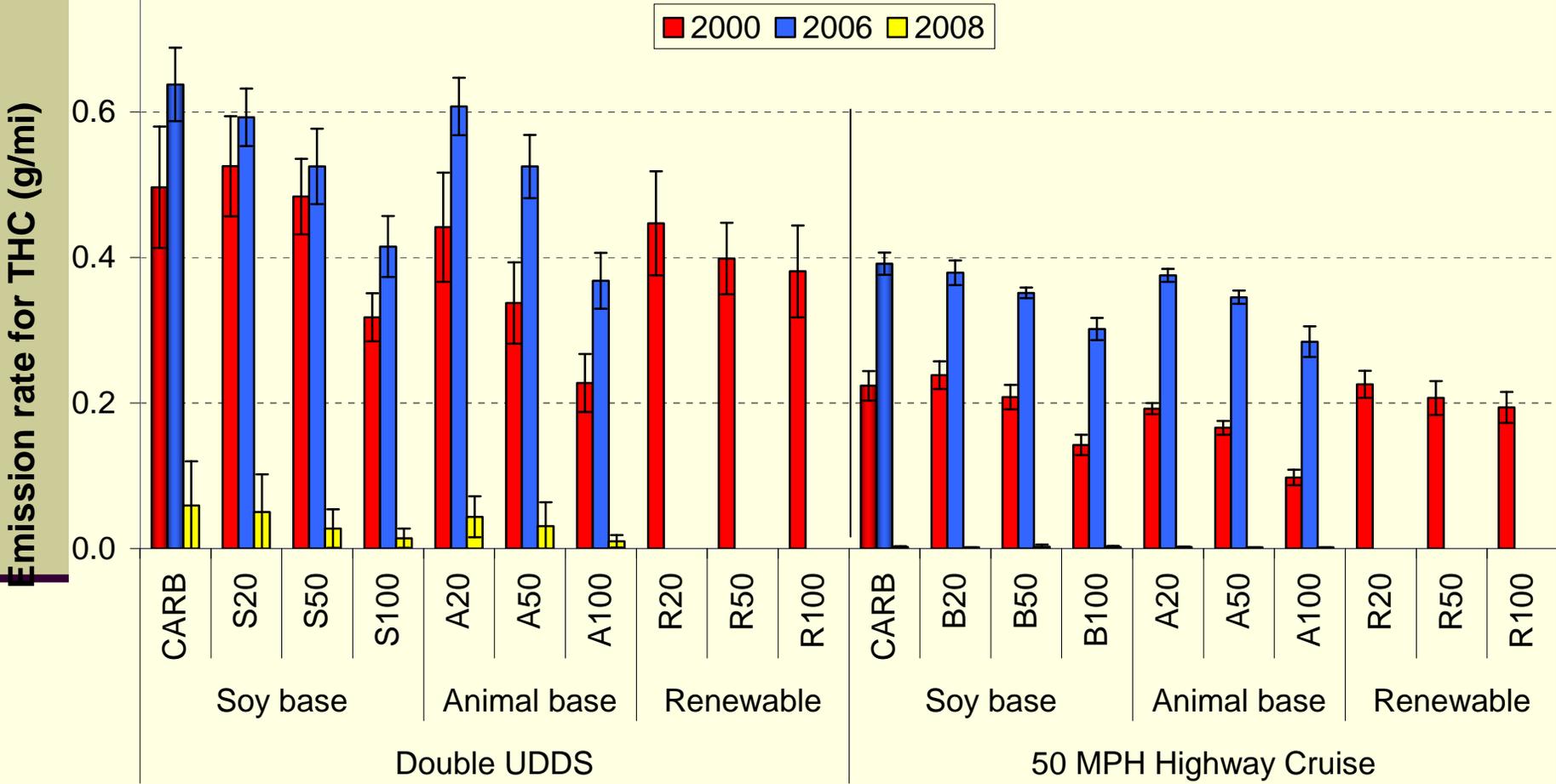


THC and CO Emissions

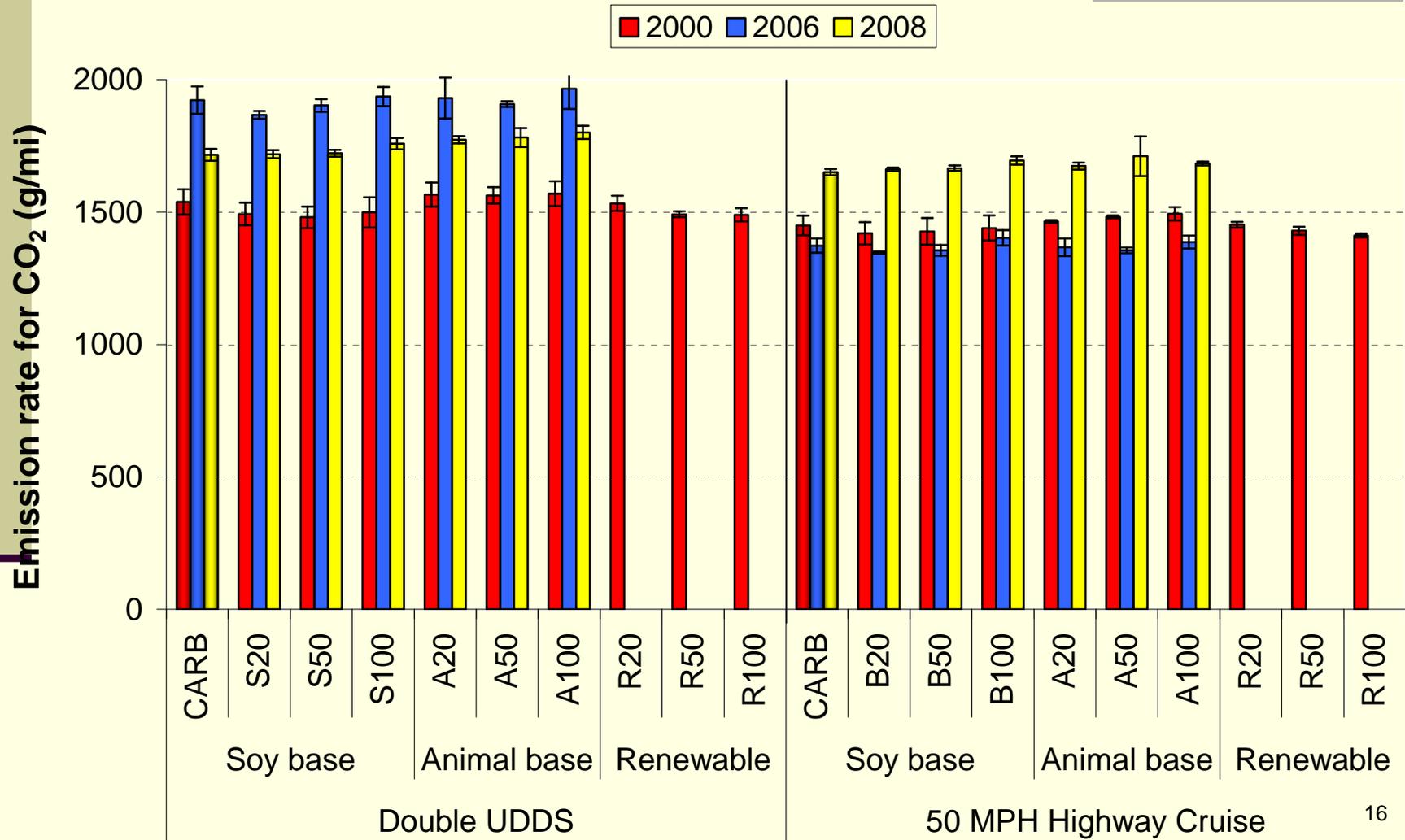
Before and After the DOC is Warmed up (2008 model year vehicle, CARB diesel, double UDDS cycle)



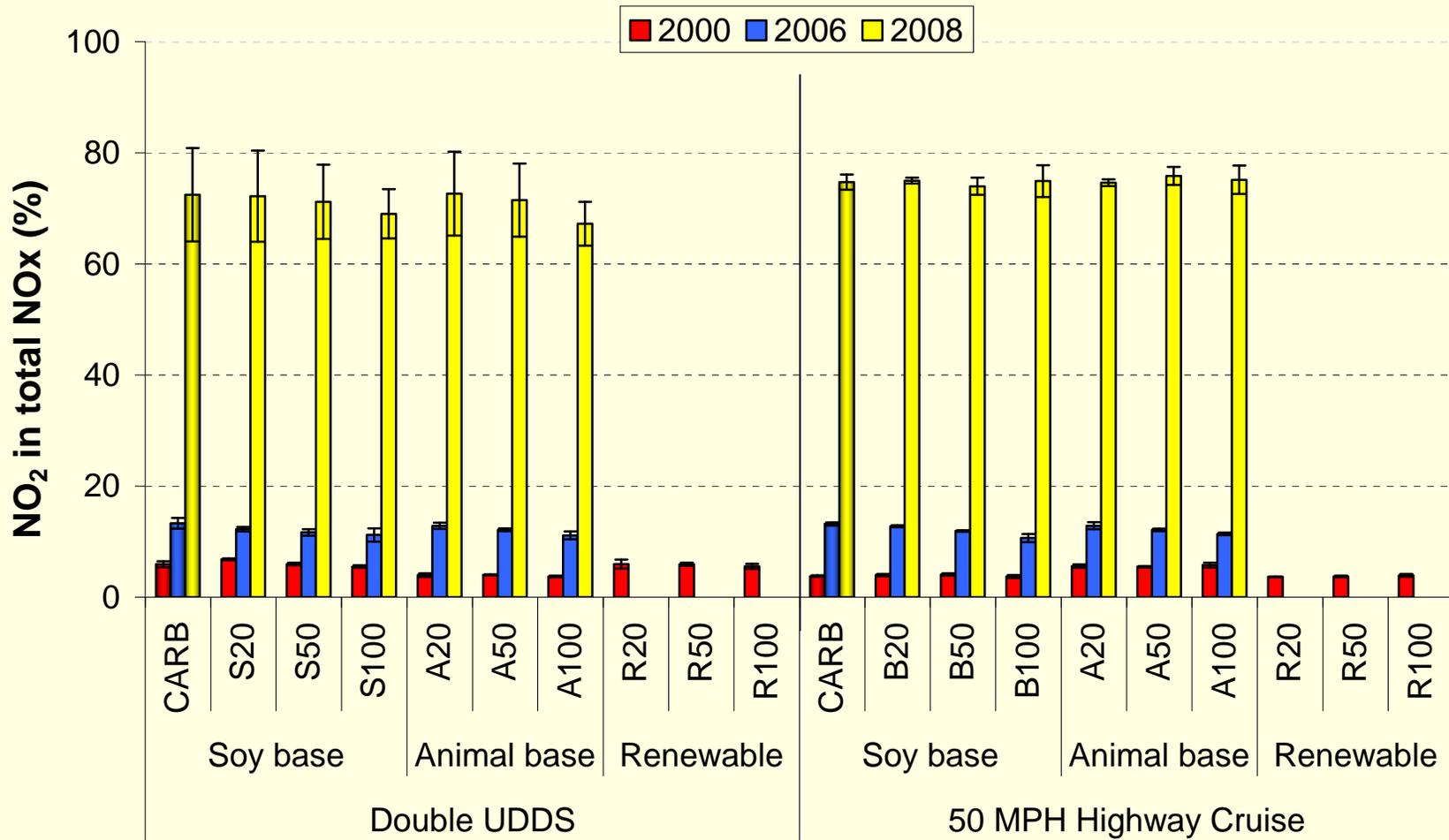
THC Emissions



CO₂ Emissions



NO₂ Fractions in total NO_x emissions



Summary

- Average PM, THC and CO emission rates decreased with increasing blend level of biodiesel regardless of the driving cycles and the vehicle model year.
- For the 2008 vehicle, THC and CO emissions sharply dropped when the DOC is warmed up and were not affected by biodiesel concentration. PM emissions were close to or below detection limit. In other words, the use of biodiesel did not show any benefits in the reduction of THC, CO and PM emissions when used with DOC/DPF.
- The 2008 vehicle equipped with DOC and DPF showed the lowest regulated pollutant emissions among the vehicles tested. However, this vehicle was not effective at reducing CO₂ emissions.

Summary (Contd)

- NO_x significantly increased for 50% and higher biodiesel blends regardless of the driving cycles and the vehicle model year. Increase in NO_x emission was most noticeable for the 2008 vehicle.
- For renewable diesel, NO_x shows a decreasing trend with increasing blend level for both driving cycles. However, its significant increase was observed for pure renewable diesel.
- For the 2000 vehicle with no NO_x control device (EGR), more NO_x was emitted for the highway cruise cycle (having high load) than the UDDS cycle (with lower load). However, this emission pattern was opposite for vehicles equipped with EGR, showing a better NO_x reduction efficiency under higher load driving cycle.

Summary (contd)

- CO₂ emissions were not significantly impacted by biodiesel blend levels for different vehicle model year except for renewable diesel blend levels higher than 50% which significantly decreased CO₂ emissions for both driving cycles.
- No significant impact of biodiesel was found on NO₂ fractions for all vehicles tested. The NO₂ fractions were the highest for the 2008 vehicle equipped with a DOC. The 2006 vehicle equipped with EGR showed a higher NO₂ fraction than the 2000 vehicle with no EGR.

Thank you for your attention !!!