Biodiesel and Renewable Diesel Emissions Study (Regulated Emissions)

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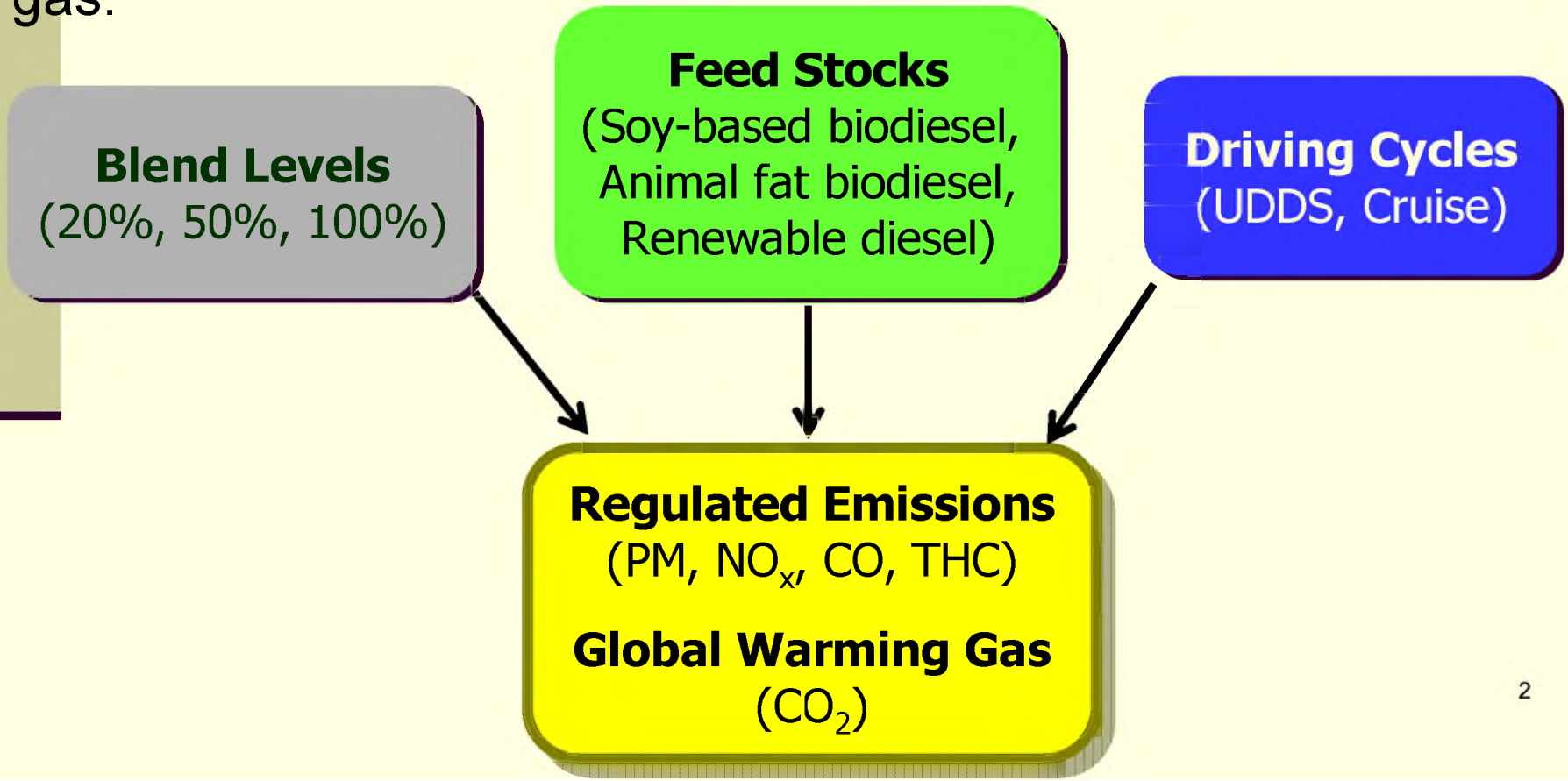
Kwangsam Na

Heavy Duty Diesel Emission Testing Laboratory
Mobile Source Control Division

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

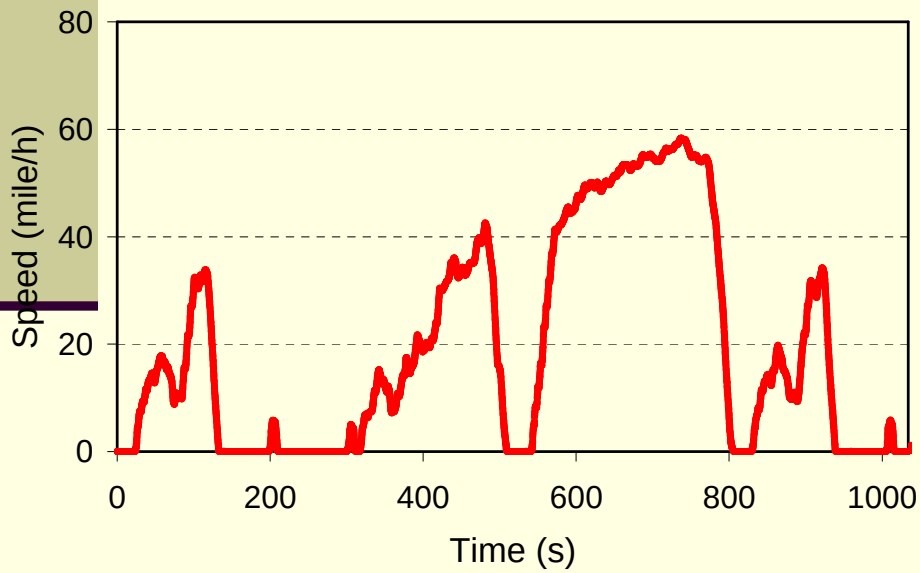
Veh. #3: 2008 Freightliner Mercedes Benz MBE 4000

Description on vehicles and fuels tested

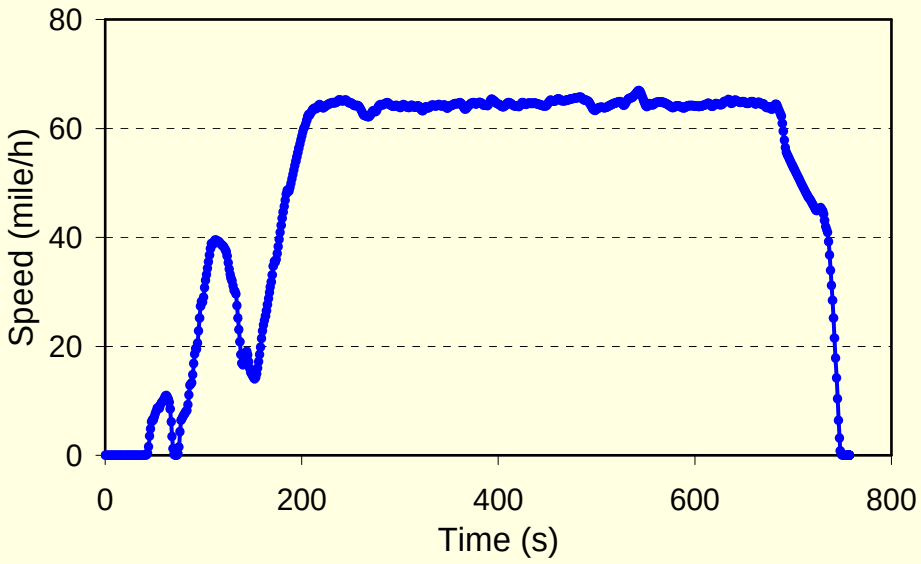
Make/model/year	Emission Control Devices	Odometer (miles)	Inertia weight (lbm)	Engine Displacement (liter)	Horse power/ Torque	Test fuels
2000 Freightliner C15 Caterpillar		34,000	Cruise: 58,744 UDDS: 43,861	14.6	550 at 1800 rpm	CARB diesel, Soy-based biodiesel (S20, S50, S100), Animal-based (A20, A50, 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),

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)

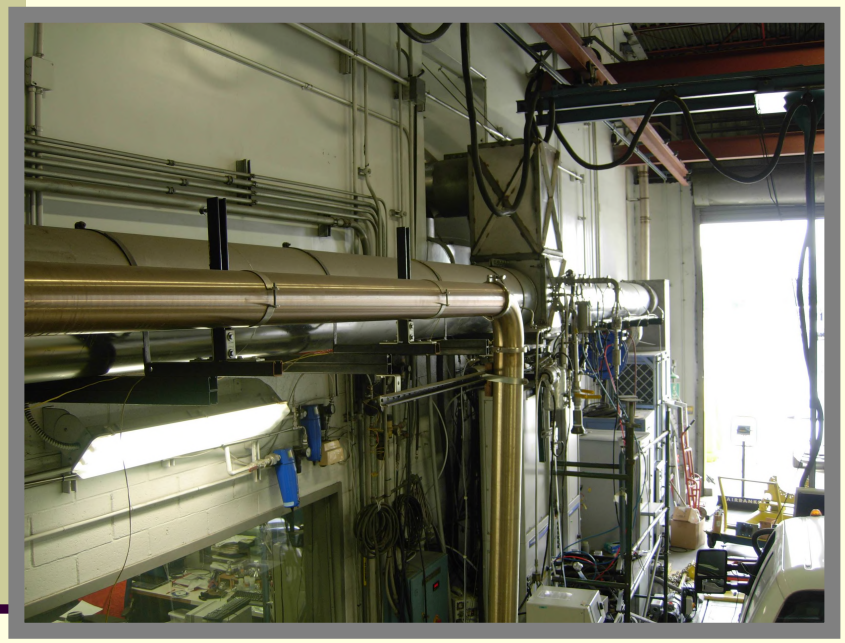
- NO_2 fractions in NO_x

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 ^{o}C
- Heated filter temp.: 47±5 ^{o}C
- Filter face velocity: 100±10 cm/s

PM and Gas Analysis

- **PM: Mettler Toledo UMX2 Micro Balance**

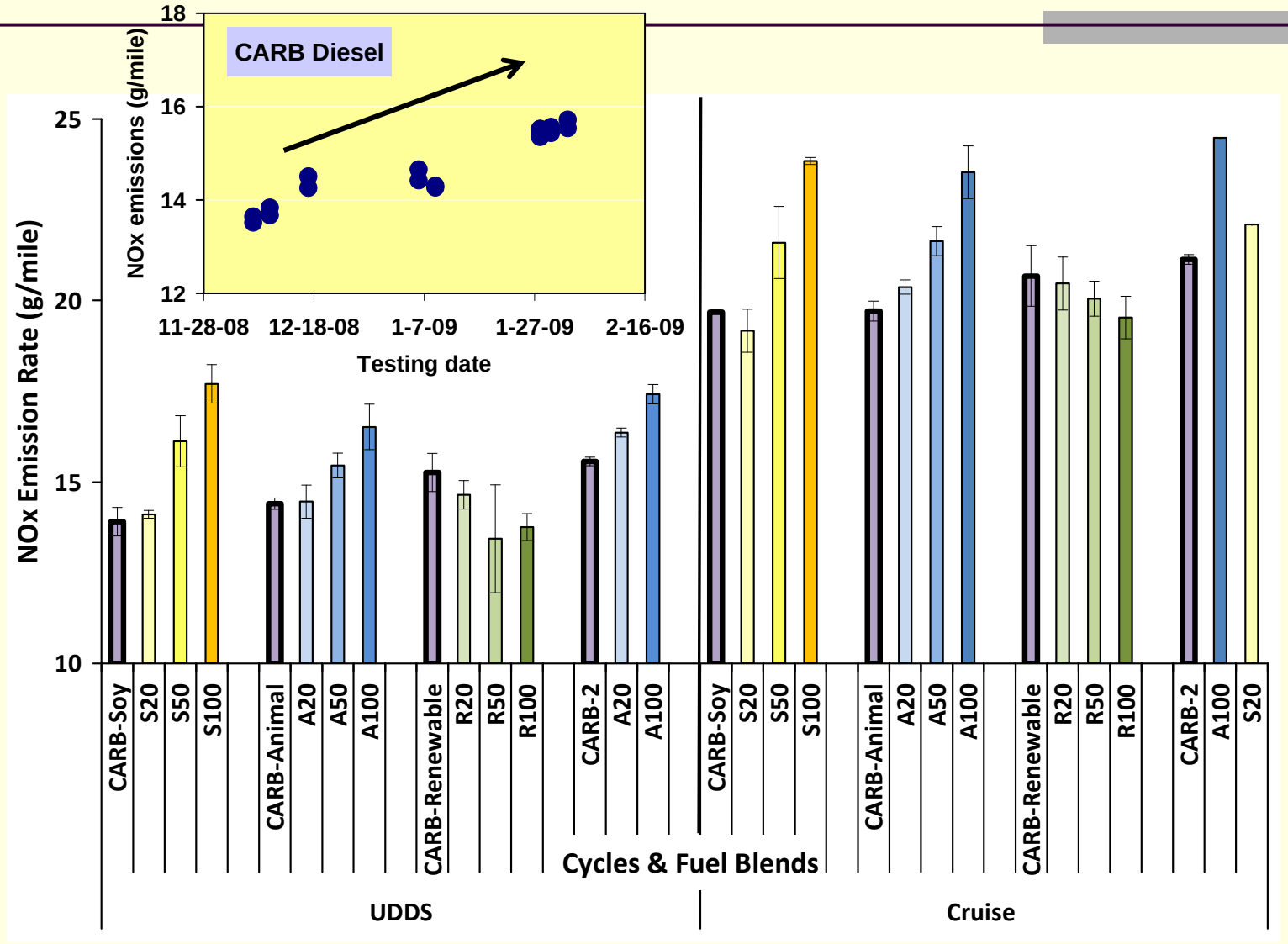
Readability: 0.1 µg

- **Gases: Horiba MEXA 7200D Exhaust Gas Analyzer**

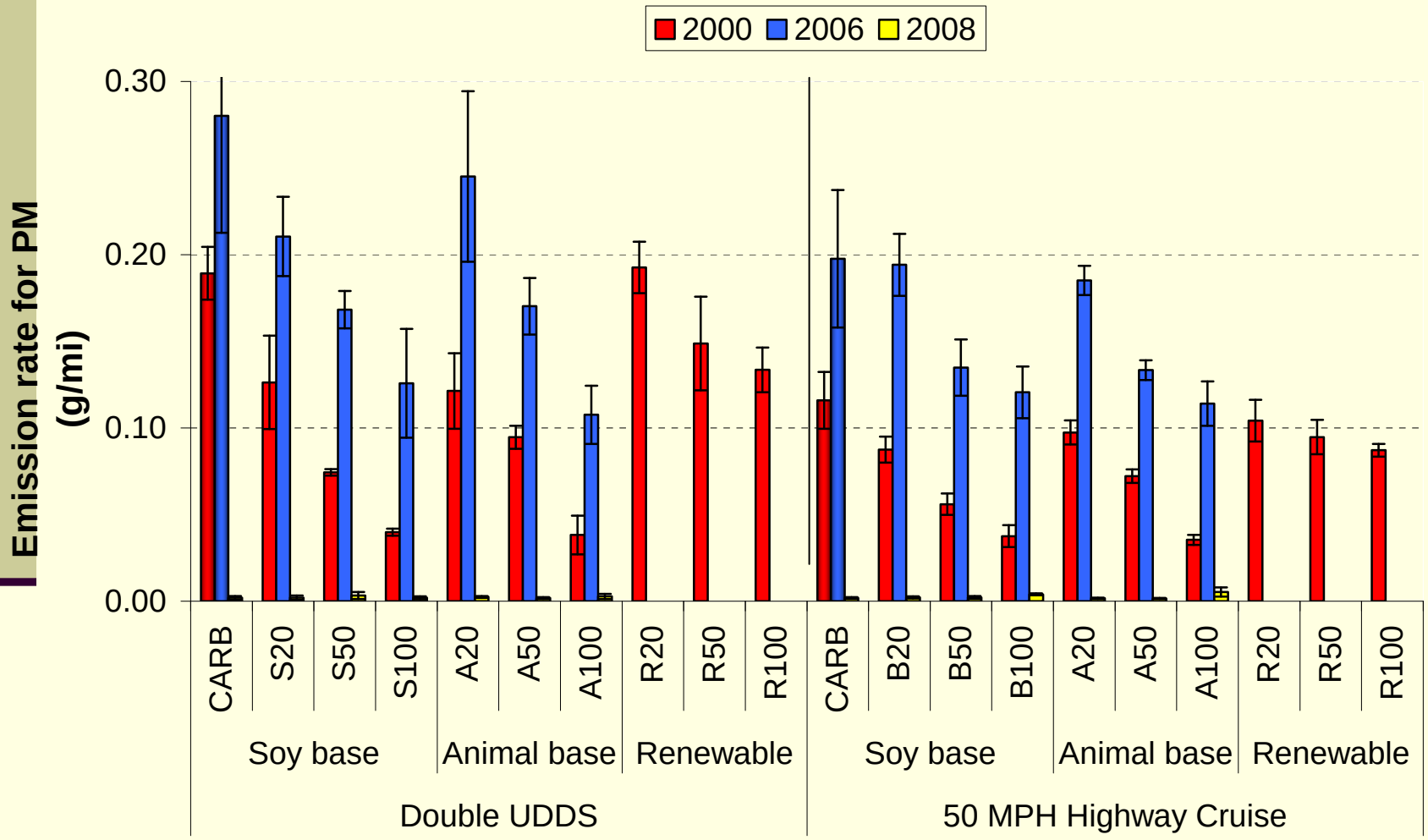
- **Detector for Gas Analysis**
  - CO, CO_2: NDIR (Non-dispersive infrared)
  - THC: FID (flame ionization detector)
  - NOx: CLD (Chemi-luminescence detector)

Test Results

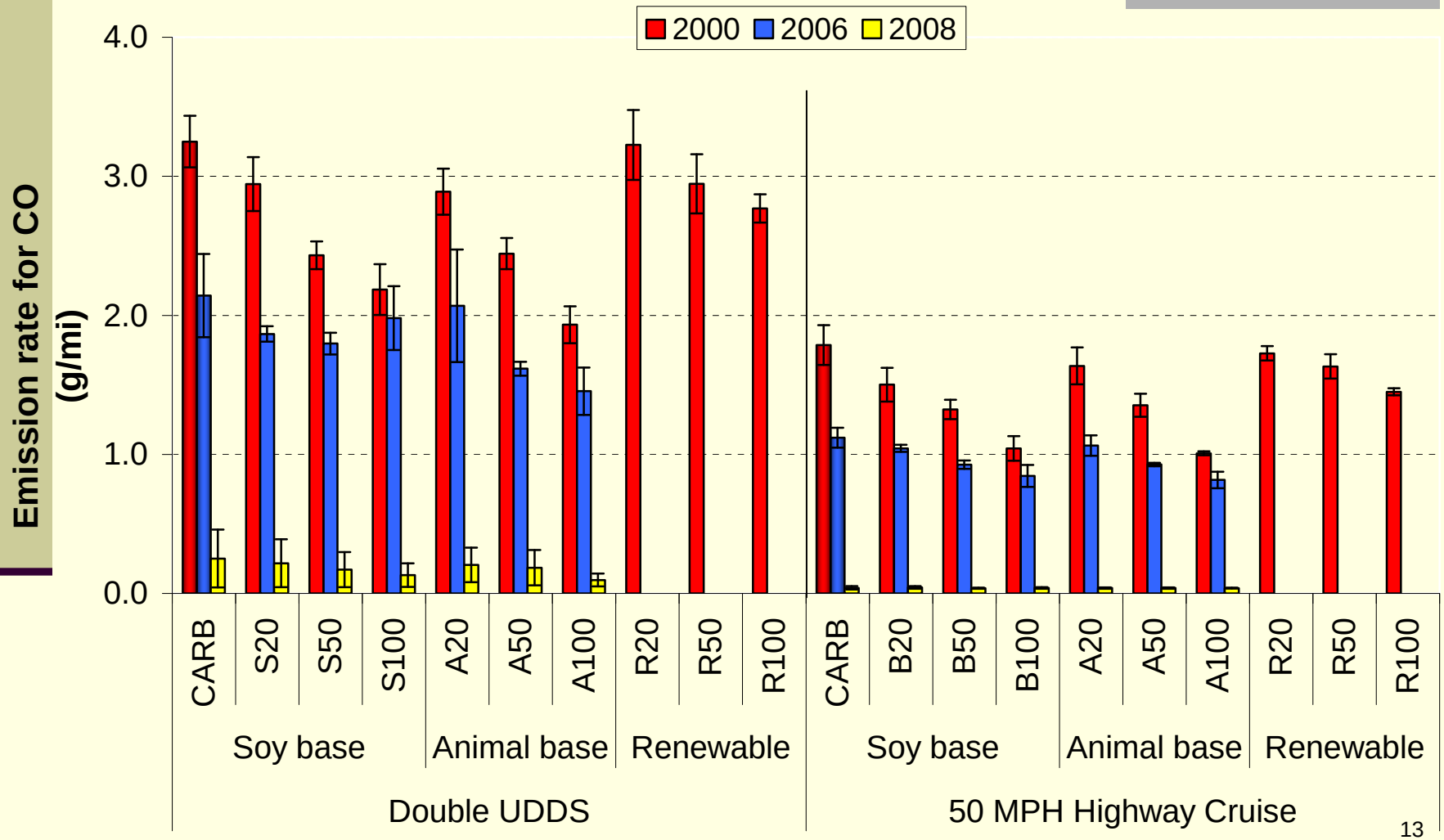
Drift of NO_x Emission for 2000 Vehicle



PM Emissions

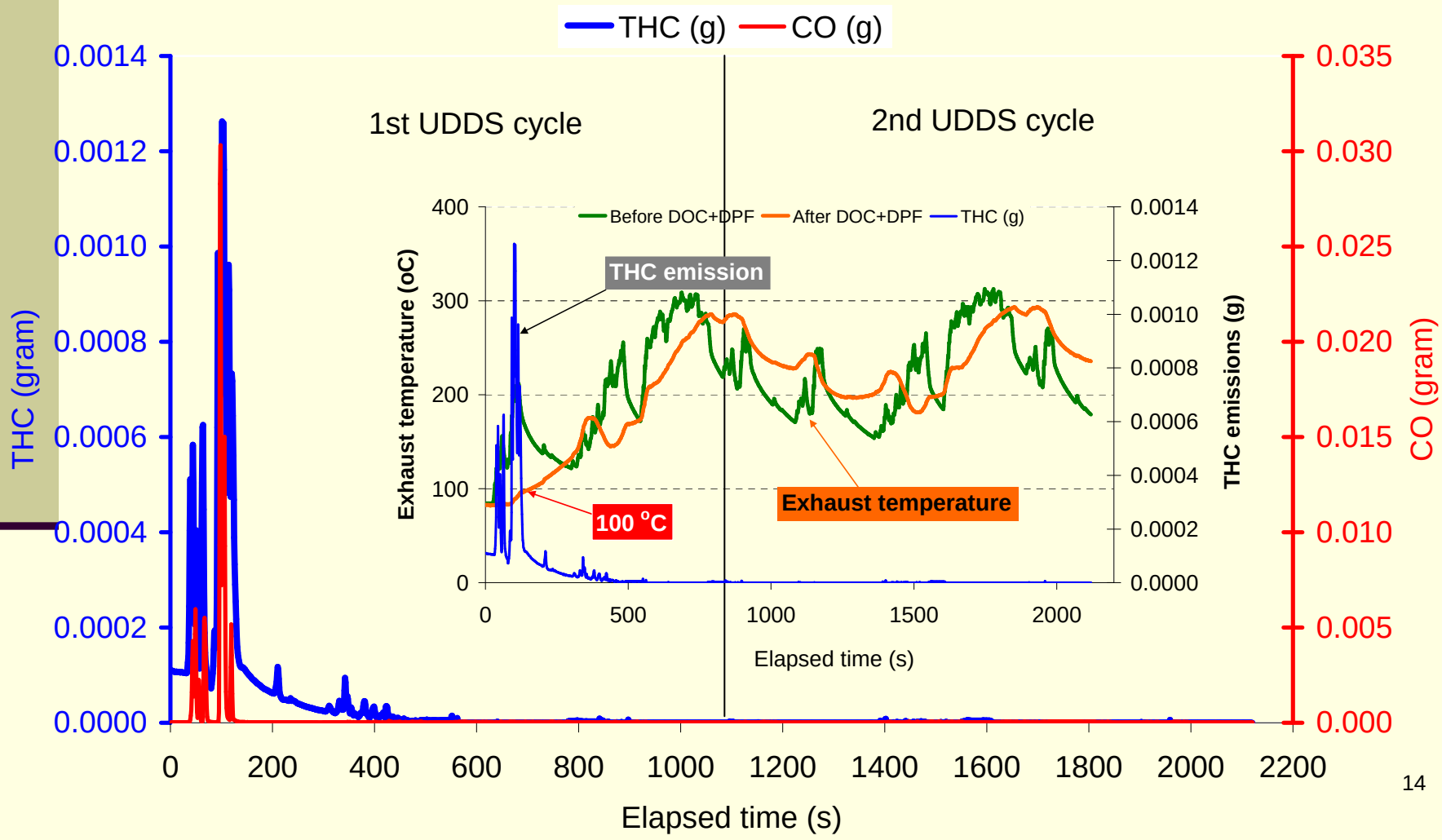


CO Emissions

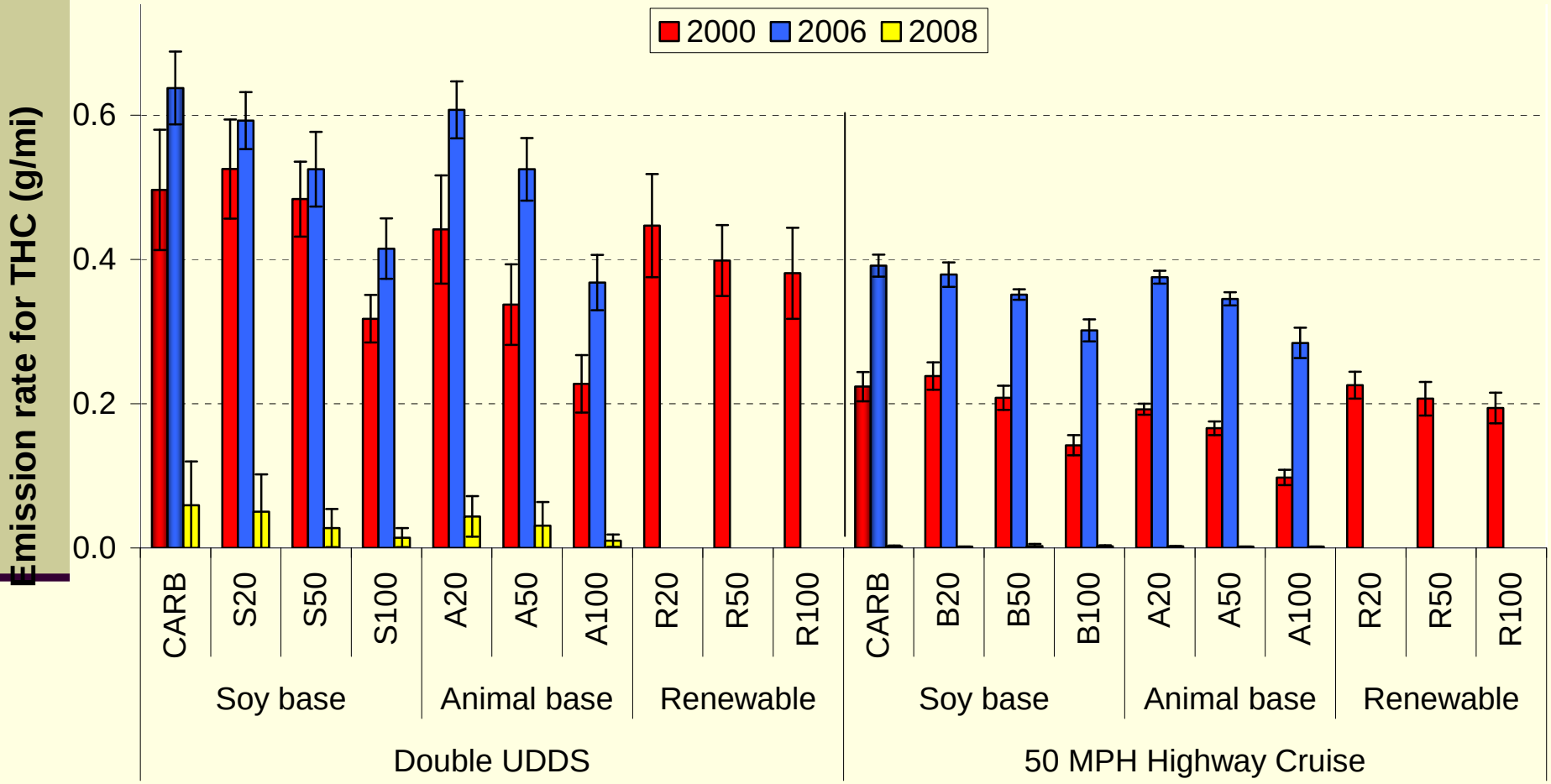


THC and CO Emissions Before and After the DOC is Warmed up

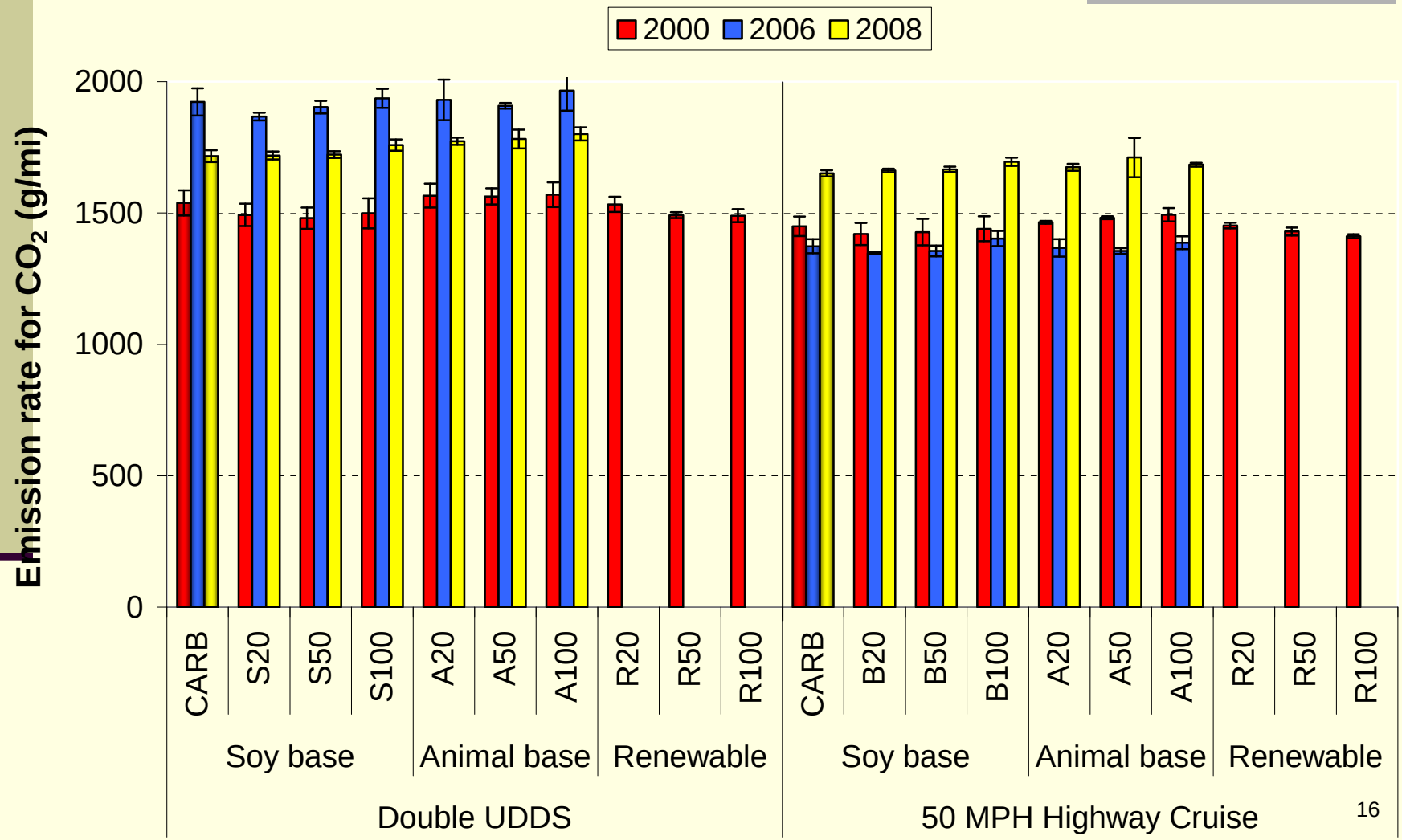
(2008 model year vehicle, CARB diesel, double UDDS cycle)



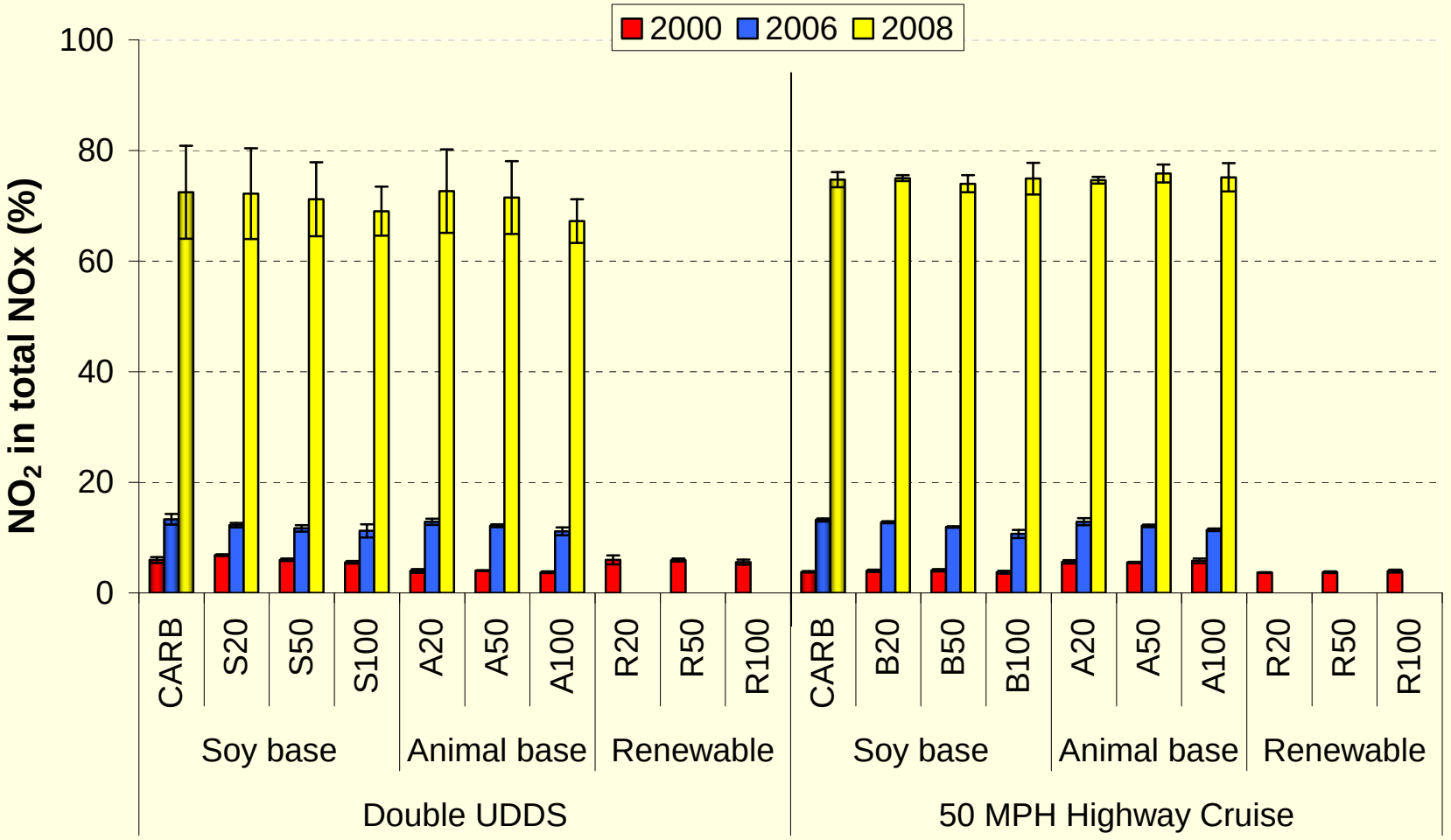
THC Emissions



CO_2 Emissions



NO_2 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 CO_2 emissions.

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Summary (Contd)

- NO_x significantly increased for 50% and higher biodiesel blends regardless of the driving cycles and the vehicle model year. Increase in NOx 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.

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Summary (contd)

- CO_2 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 CO_2 emissions for both driving cycles.

- No significant impact of biodiesel was found on NO_2 fractions for all vehicles tested. The NO_2 fractions were the highest for the 2008 vehicle equipped with a DOC. The 2006 vehicle equipped with EGR showed a higher NO_2 fraction than the 2000 vehicle with no EGR.

Thank you for your attention !!!