Alternative Fuels Studies

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Background

- Increased interest to promote the use of alternative fuels to reduce dependence on foreign oil, greenhouse gases, and air pollution
- CA initiatives - AB32, AB1007 and Low Carbon Fuel Standards
- Comprehensive studies to understand impact on tailpipe emissions and investigate mitigation measures on NOx

AQMD Funded Alternative Fuel Testing Projects

AQMD Board approved grants to CE-CERT in December 2007 to study

- Biodiesel and renewable diesel blends
- Ethanol blends
- Natural gas blends (Hot Gas)

CE-CERT Three Project Costs

	Biodiesel Blends	Ethanol Blends	Nat. Gas Blends
CARB	$1,380k	-	-
CEC	-	-	350k
Nat Biodiesel Brd	50k	-	-
AQMD LOE	50k	39k	-
AQMD	150k	250k	50k
Total	$1,630k	$289k	$400k

Project 1 – Biodiesel/Renewable Testing Matrix

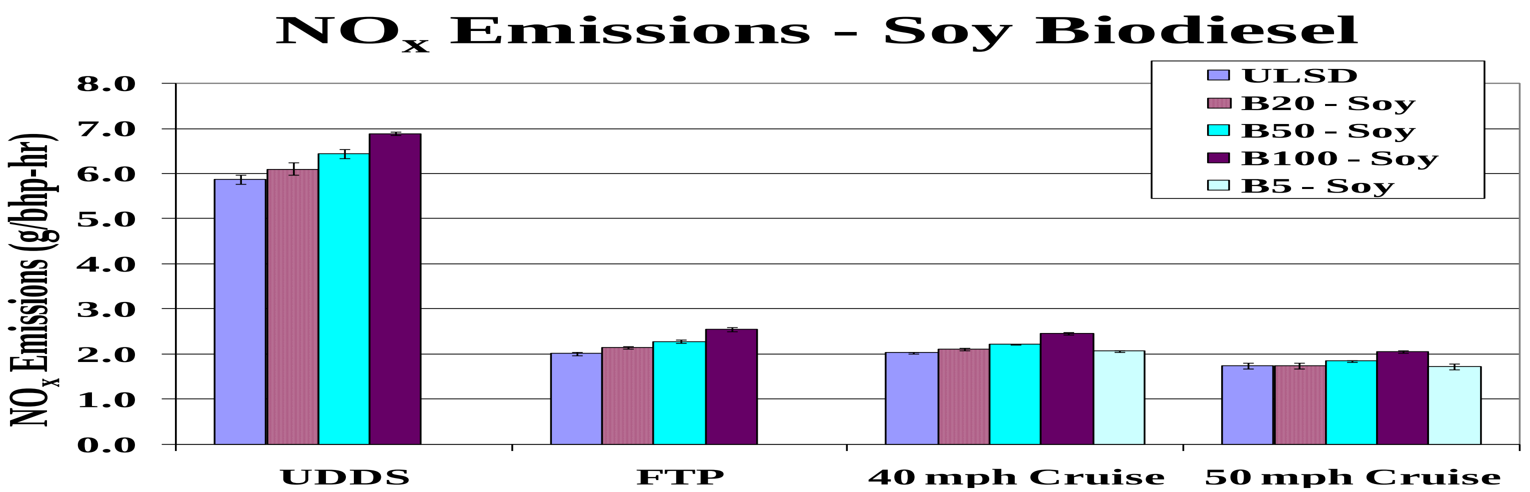
	Units Tested	Test Cycles[1]	Biodiesel Blends[2] (Soy/Animal)	Renewable Diesel Blends[3]
Engine Dyno	2	4	4	3
Chassis Dyno	3	2	4	3
Off-Road Dyno	2		4	3

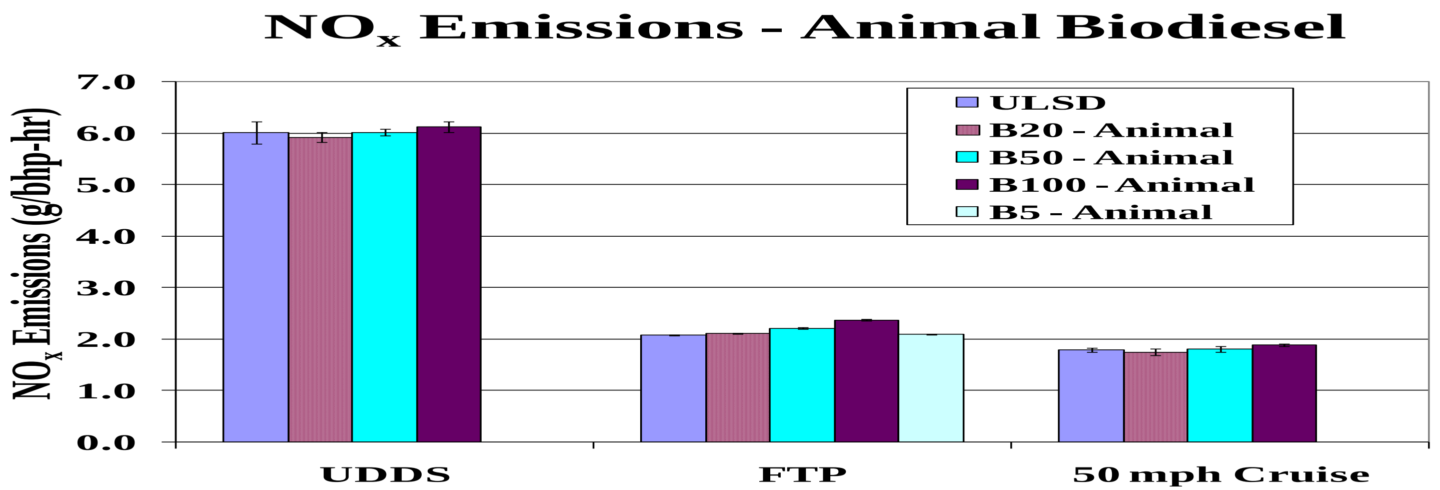
1. FTP, Light UDDS, HHDDT Cruise 40 & 50 mph
2. Biodiesel Blends (B5, 20, 50, 100)
3. Renewable Blends (R20, 50, 100)

Project 1 – Biodiesel/Renewable
- cont.

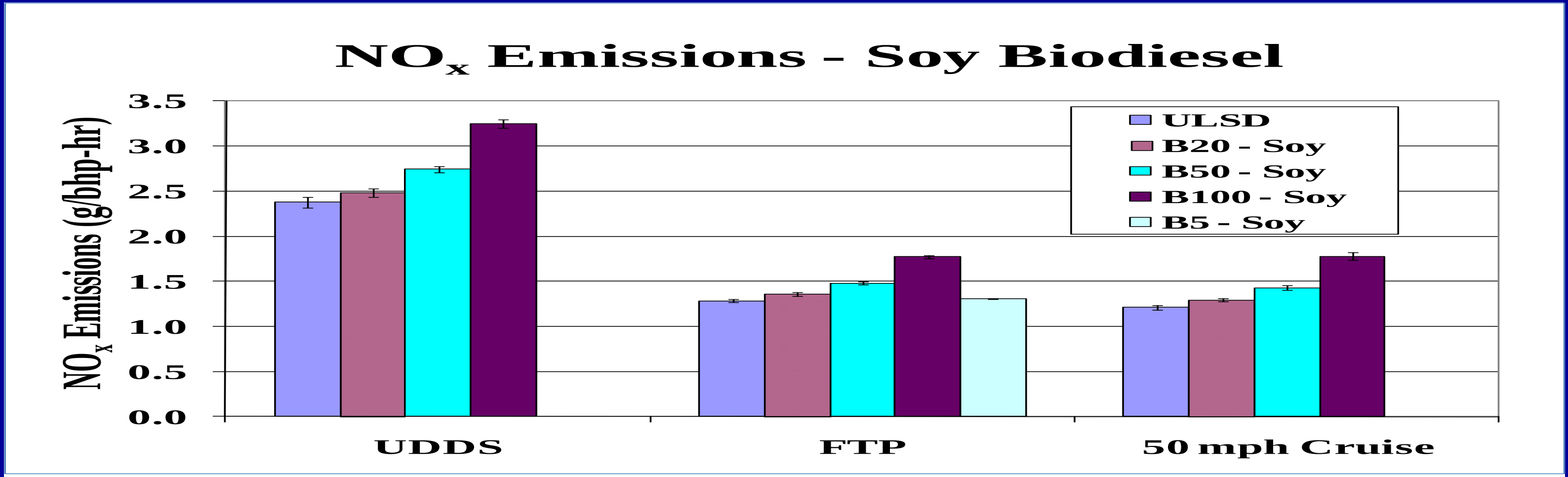
- CE-CERT investigated NOx mitigation measures for biodiesels (e.g., blends, additives, composition, etc.)
- UC Davis to analyze samples for toxics & potential biological impacts (under separate CARB contract)

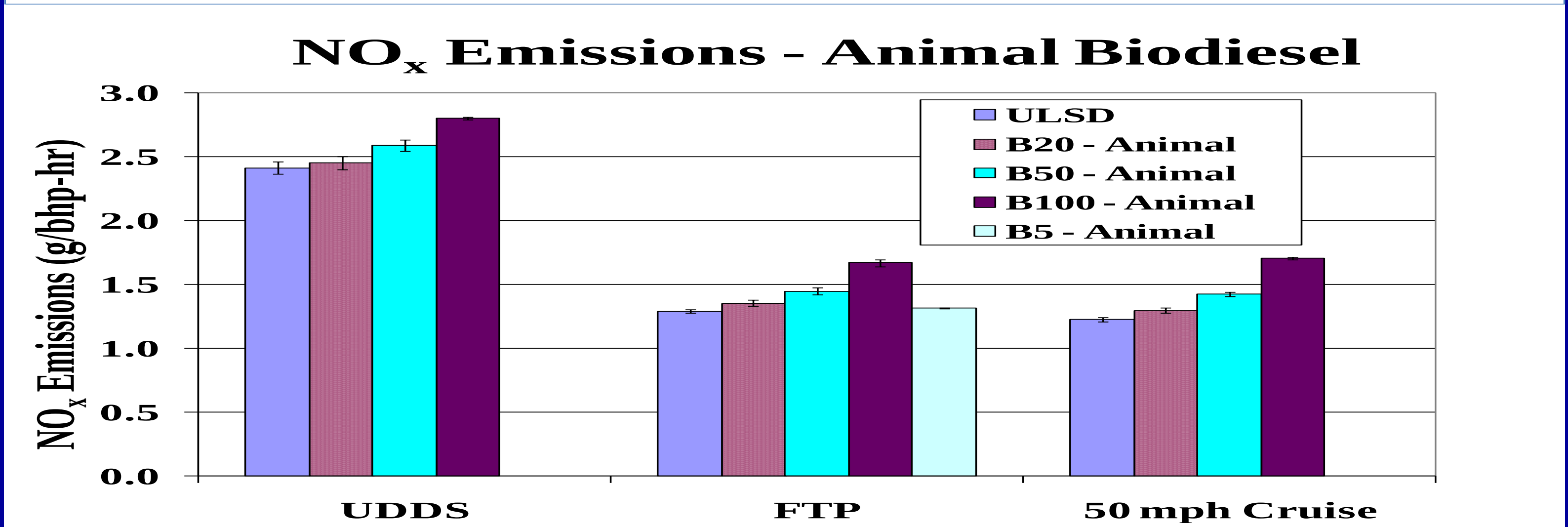
2006 Cummins Dyno Test
NOx - Biodiesel



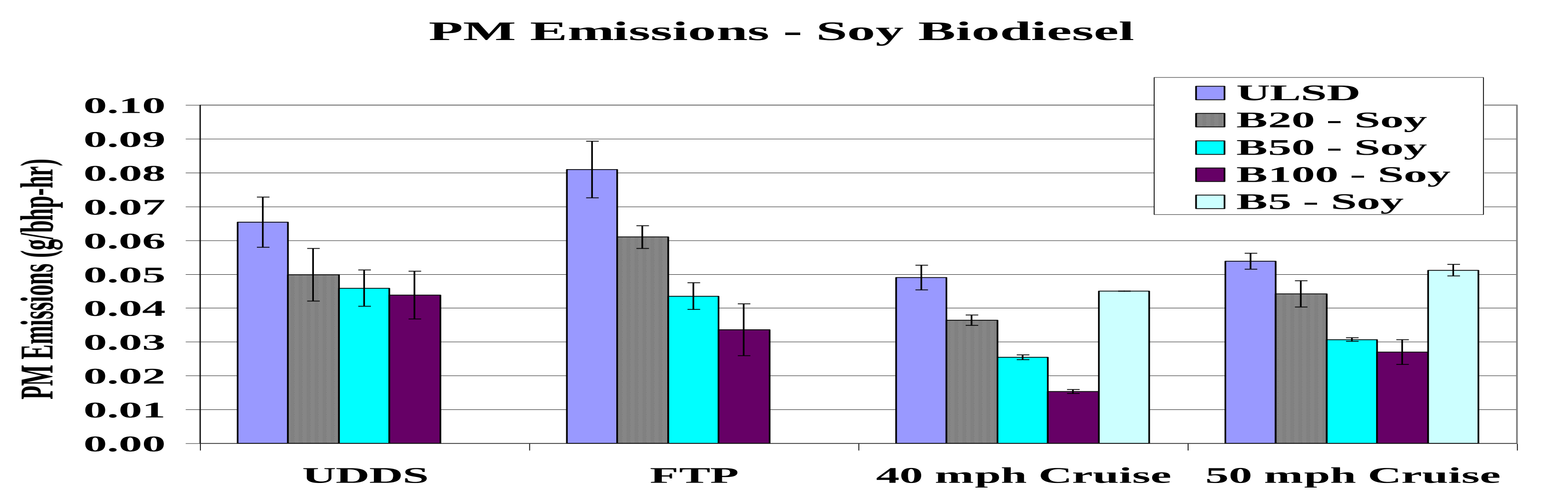


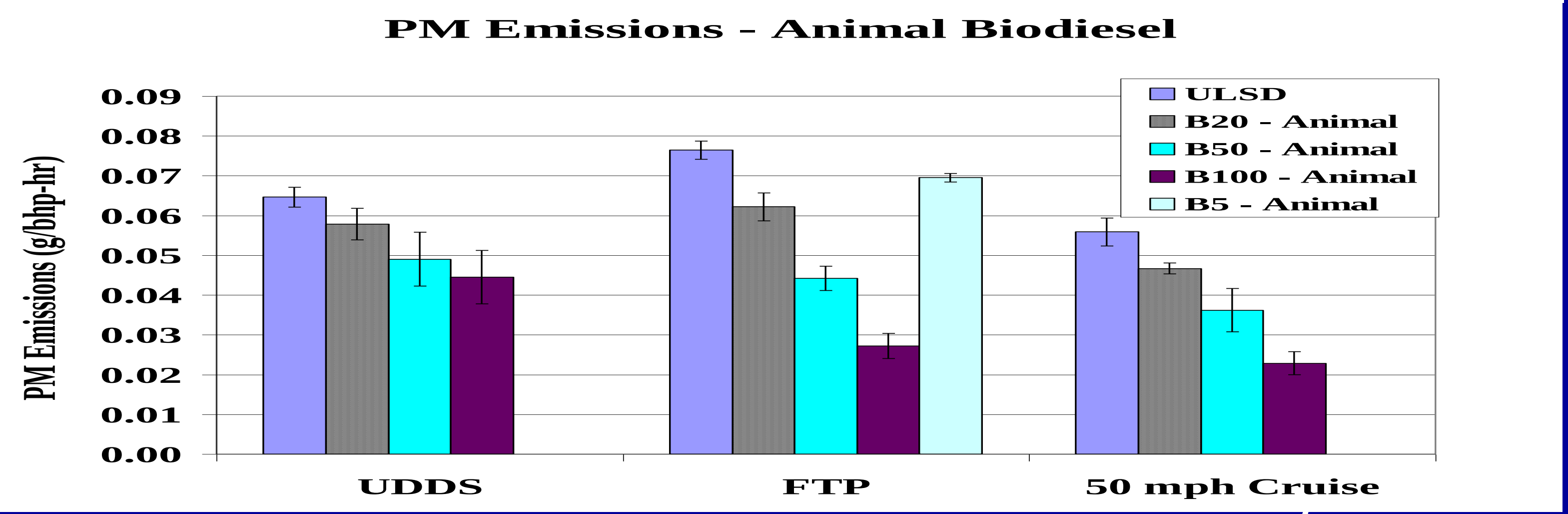
2007 MBE 4000 Dyno Test
NOx - Biodiesel





2006 Cummins Dyno Test
PM - Biodiesel





2006 Cummins Dyno Test
NOx – Renewable Diesel

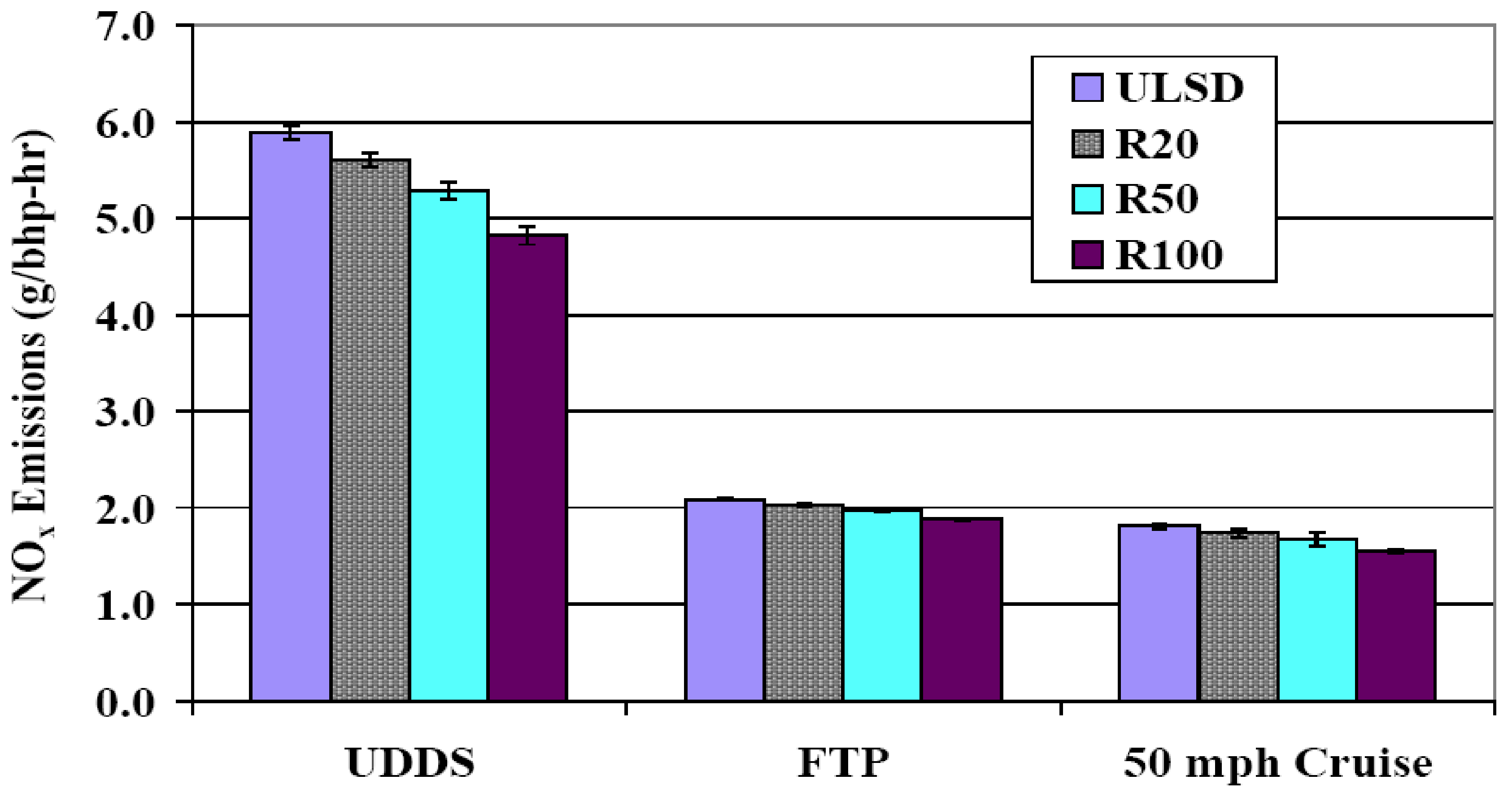


Figure ES-5. Average NO_x Emission Results for the Renewable Blends

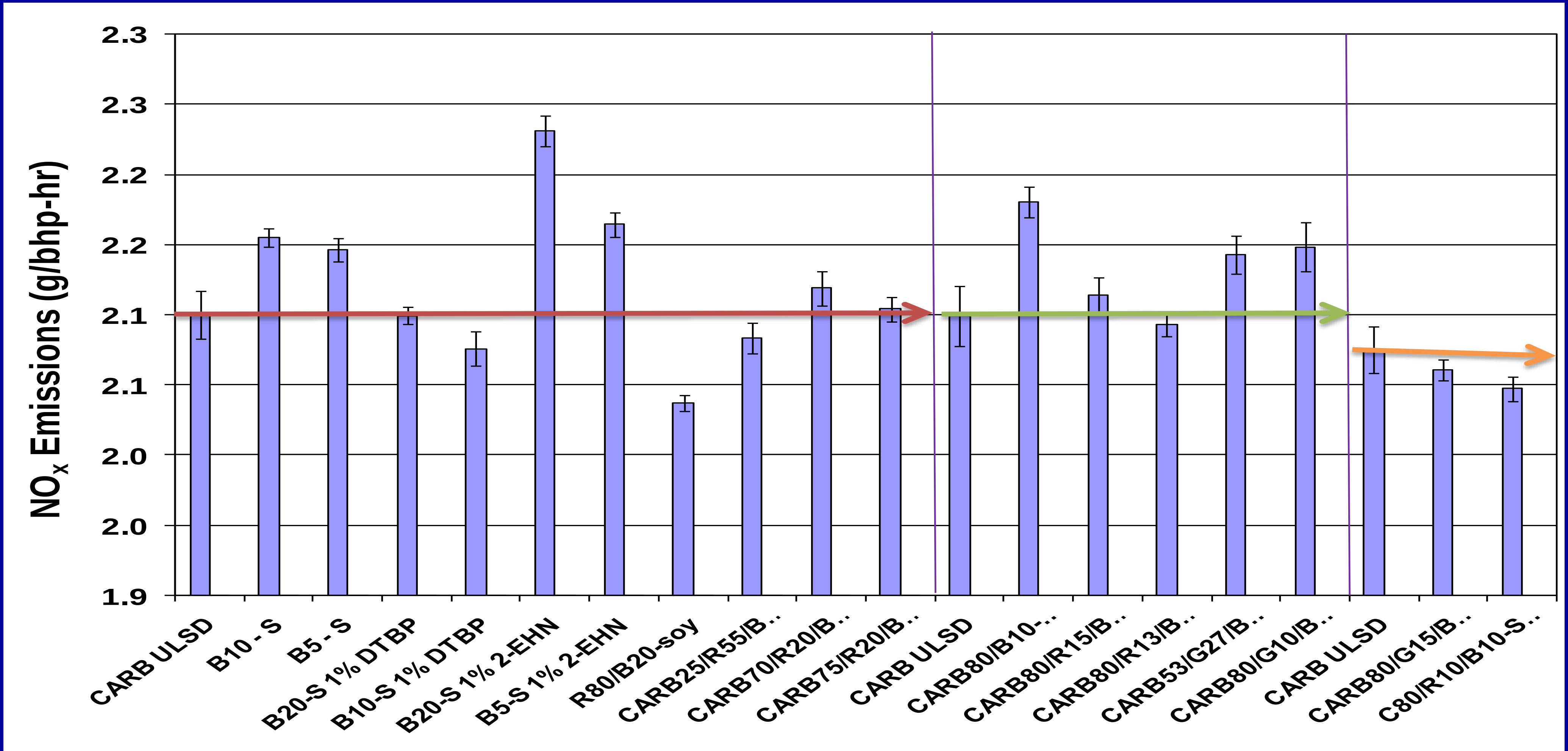
Project 1 - Biodiesel/Renewable Engine Dyno Tests Summary

- Increasing NOx for the higher biodiesel blends
- Decreasing THC, PM and CO with increasing biodiesel blends
  - Limited trends for MBE 4000 due to DPF
- CO_2 increase insignificant (1-5%)
- Increasing fuel consumption (1-10%)
- NOx and PM reductions with higher blends of renewable diesel

Biodiesel
NOx Mitigation Strategies

- Additives
  - 2-ethyl-hexyl-nitrate (EHN)
    - 1% level in B5, B10, and B20
  - Di-tert-butyl-peroxide (DTBP)
    - 1% level in B10 and B20
  - Both studied by NREL and SwRI
- Renewable/biodiesel blends
- GTL/biodiesel blends
- All testing on FTP

NO_x Mitigation Dyno Test
2006 Cummins



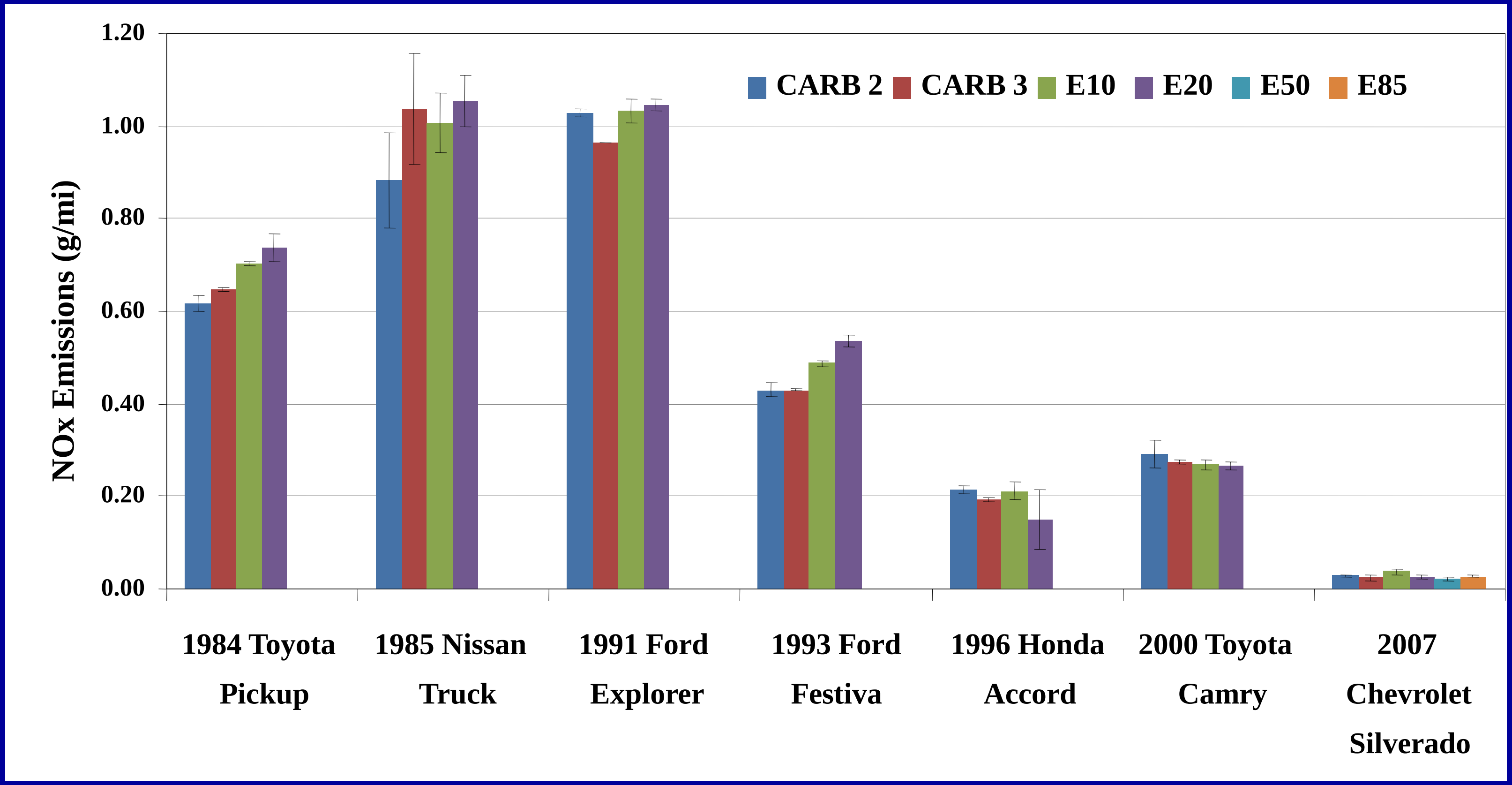
NO_x Mitigation Dyno Test Summary

- DTBP is more effective than EHN
  - B20-S 1% DTBP (0.0%)
  - B10-S 1% DTBP (-1.1%)
- Renewable/GTL diesels are also effective to mitigate NOx impact
  - CARB80/R13/B3-S/B4-A (-0.3%)
  - CARB80/GTL15/B5-S (-0.7%)
  - CARB80/R10/B10-S 0.25% DTBP (-1.3%)

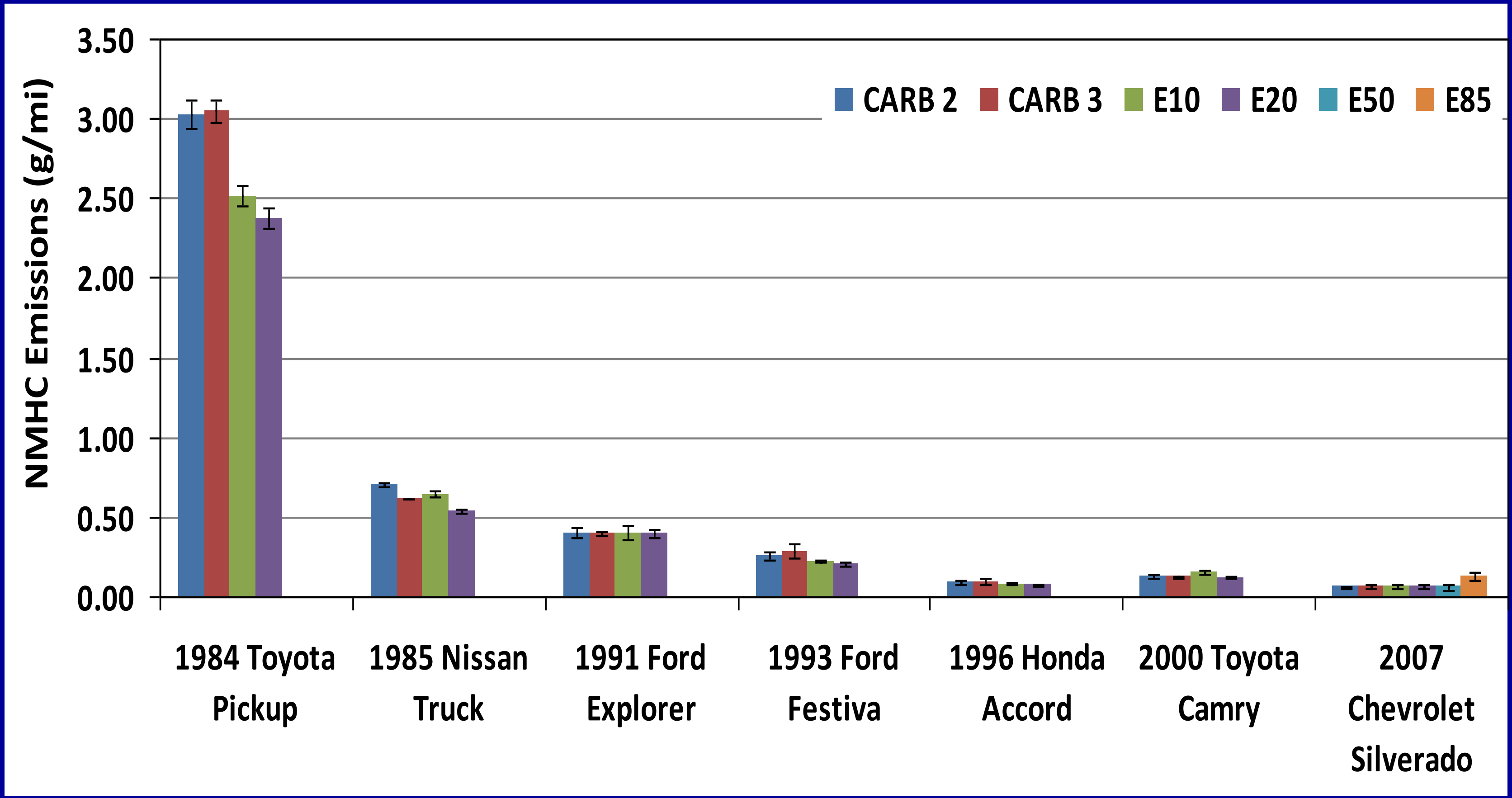
Project 2 - Ethanol Blends Testing

- 7 light-duty test vehicles (1 FFV)
  - 2 Tech 3 (1981-1985)
  - 2 Tech 4 (1986-1995)
  - 3 Tech 5 (1996-2010)
- 5 different ethanol-gasoline blends and/or mixtures (E5.7, E10, E20, E50, E85)
- Chassis dynamometer at CE-CERT (FTP)
- Criteria pollutants & certain toxic species measured – BTEX and carbonyl groups

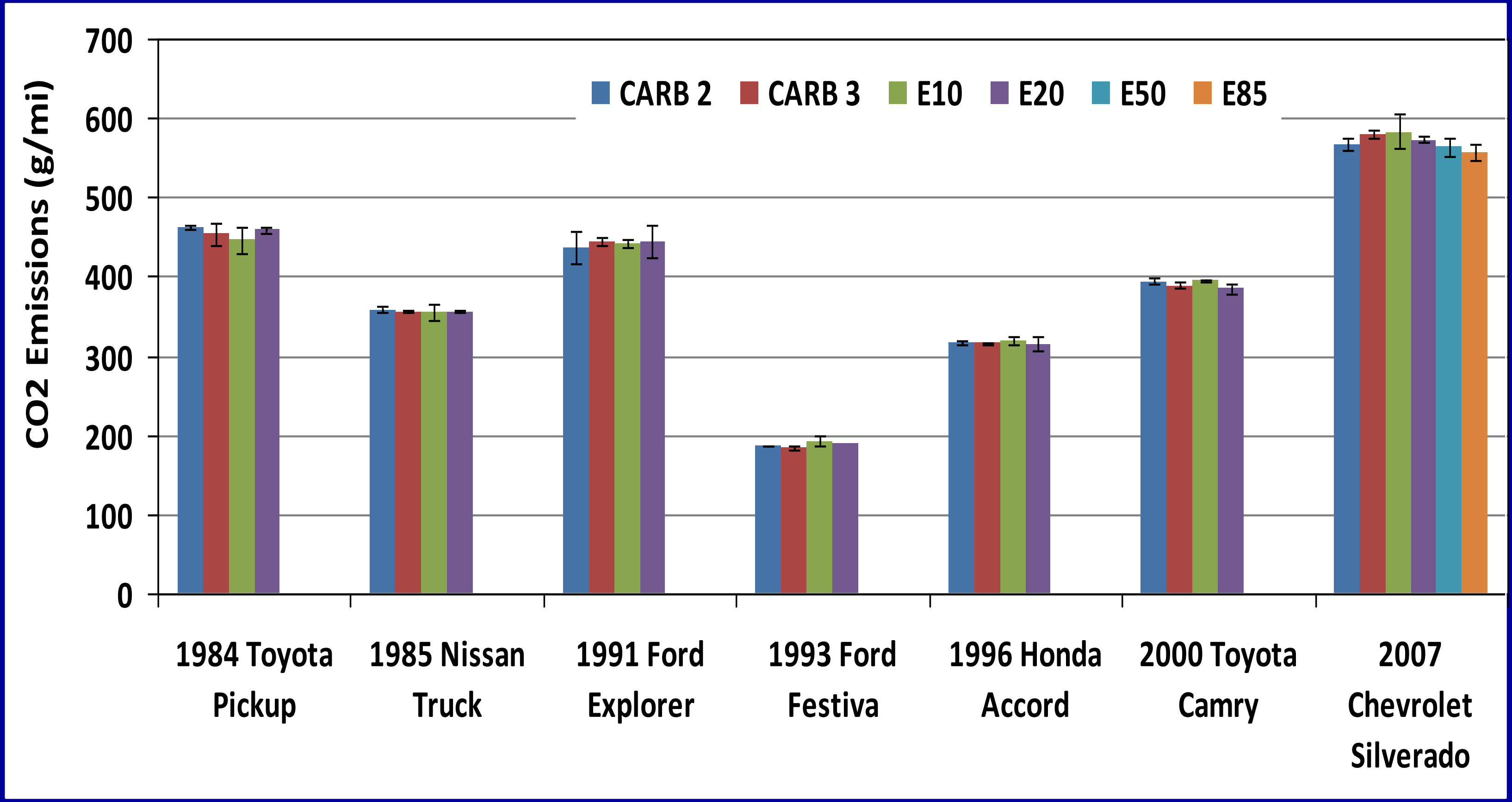
Ethanol Tests
NOx Emissions



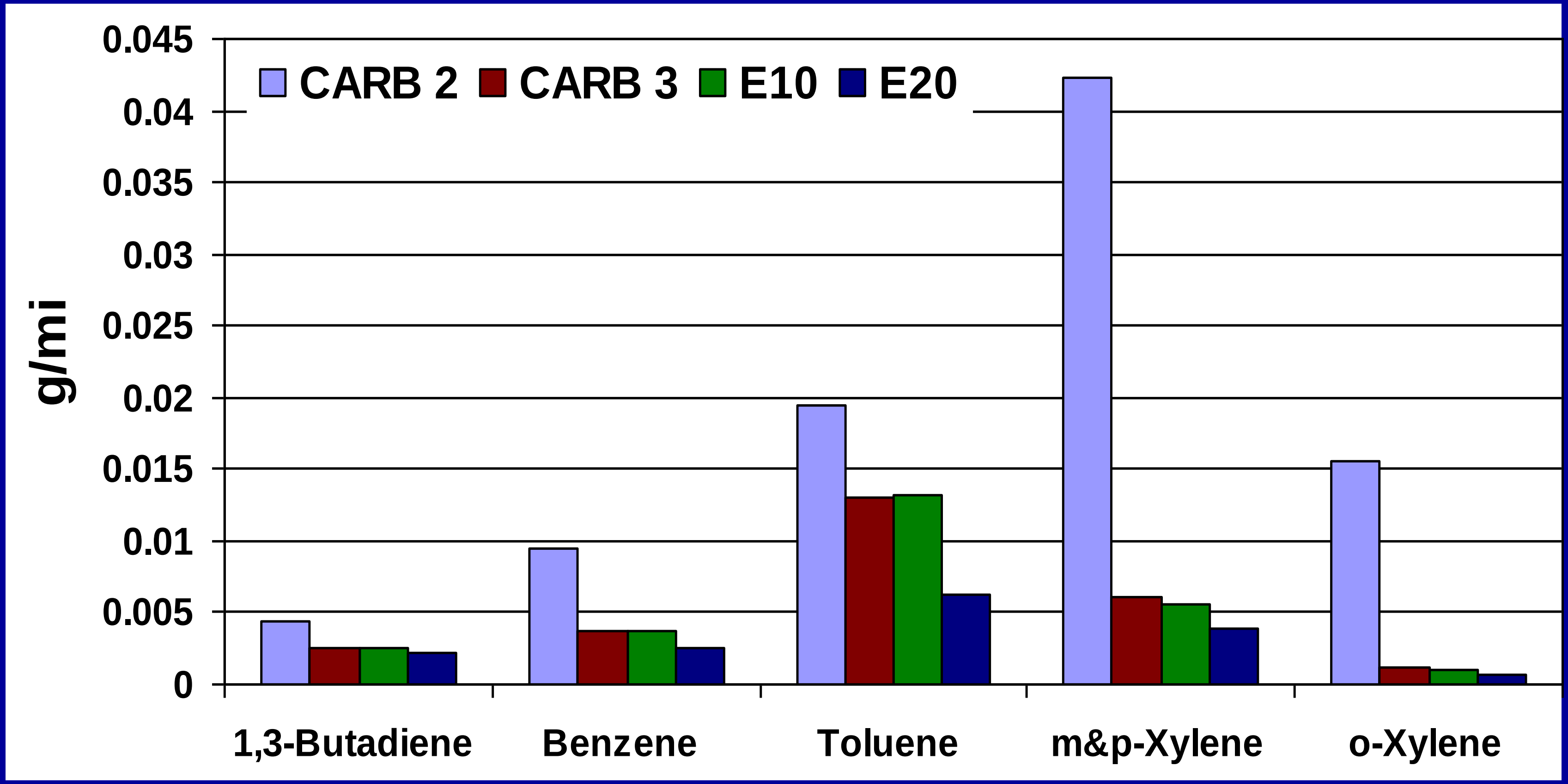
Ethanol Tests
NMHC Emissions



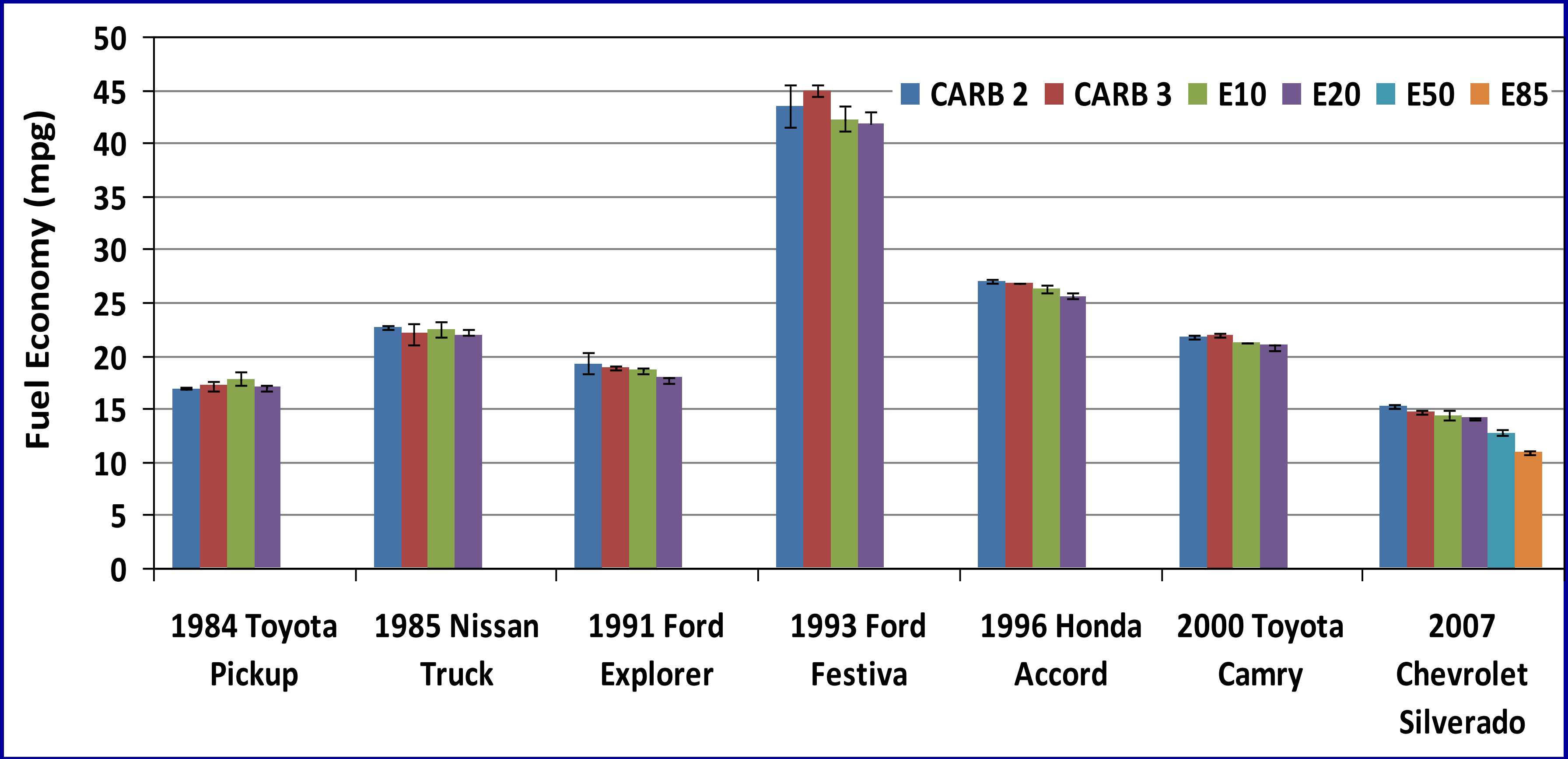
Ethanol Tests
CO_2 Emissions



Ethanol Tests
BTEX Emissions



Ethanol Tests
Fuel Economy



Project 2 - Ethanol Blends Tests Summary

- NOx increased with higher ethanol levels (older models)
- NMHC and CO decreased with increasing ethanol levels (older models)
- No significant trends for CO2
- Lower toxic aromatics with ethanol blends but no direct correlations
- Decreasing fuel economy with higher ethanol blends