AVFL-17 Biodiesel Emissions Analysis Results

Biodiesel Technical Workshop

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CRC AVFL-17 Literature Review Project

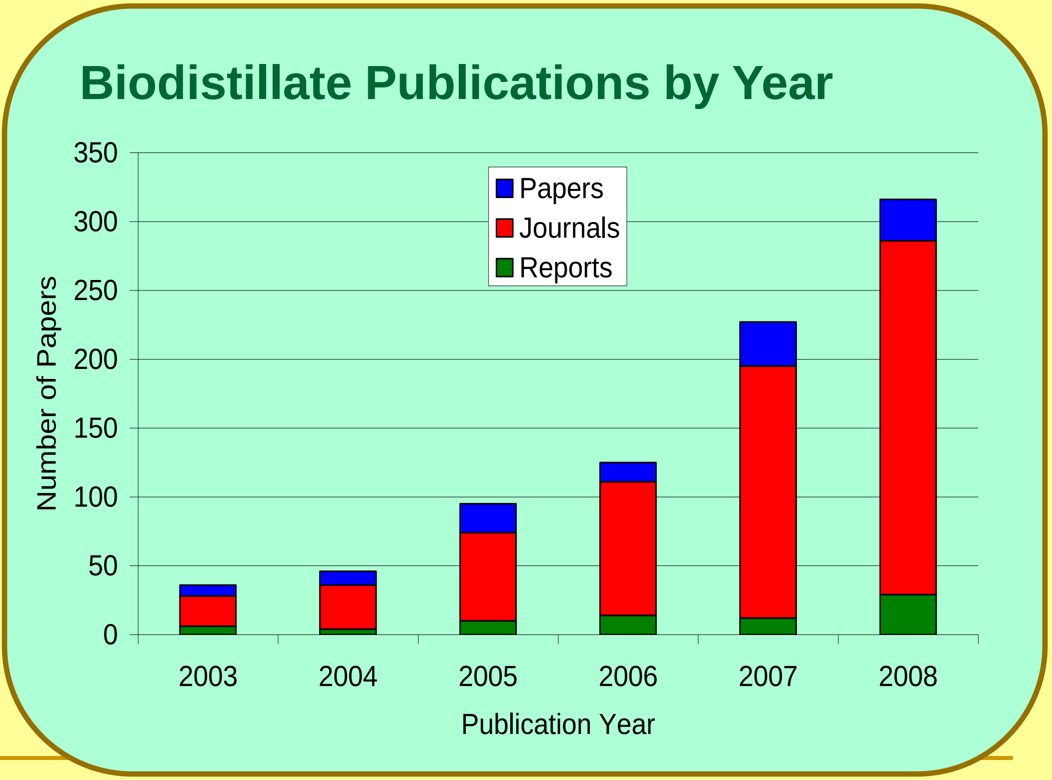
- Objective: Assess state-of-knowledge regarding bio-derived mid-distillate fuels
- Aspects covered:
  - Policy drivers
  - Biofuel feedstocks
  - Fuel production technologies
  - Fuel properties and specifications
  - In-use handling and performance
  - **Exhaust emissions**
  - Life-cycle impacts

- Final report is available from CRC website: www.crcao.org

Topic of Biodistillates is very active in the literature

Literature review focused on years 2000 to present

- Over 1000 items of interest identified
- Included 94 emissions studies, with 346 individual test results



Methodologies for data selection

- Engine Categories:
  - Heavy-duty (HD), light-duty (LD) and single cyl. Test-Engine (TE)
  - Medium-Duty was categorized with heavy-duty
- All blend levels were considered: B5-B100
- All No. 2 Diesel base fuels were considered (ULSD and others)
- Both biodiesel and renewable diesel fuels
- All biodistillate sources: soy oil, rapeseed oil, tallow, etc.
- All engine test conditions:
  - Steady state and transient driving cycles
  - Engine and chassis dynamometers

Limitations and caveats

- Factors not accounted for:
  - Engine model year/technology
  - Operating conditions such as temperature, elevation, and engine tuning
  - Biodistillate source
  - Fuel quality
- Only studies that included a comparison between biofuel and reference fuel were included
- Individual results varied widely from study-to-study

Results from previous literature reviews

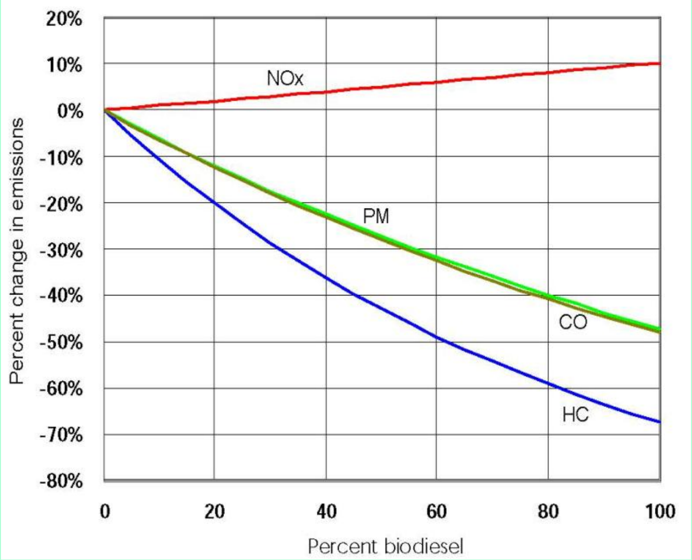
- Conventional wisdom:
  - Biodiesel reduces emissions of CO, HC, and PM
  - Biodiesel increases emissions of NOx

Emissions Effects of B20

Pollutant	EPA (2002)	McCormick et al. (2006)
NO_x	+2.0	+0.6*
CO	-11.0	-17.1
HC	-21.1	-11.6
PM	-10.1	-16.4**

*Reported as statistically insignificant.
**Excludes engines equipped with DPF.

Average emissions impacts of biodiesel in HD highway engines (from U.S. EPA)



NOx impacts are very uncertain and controversial

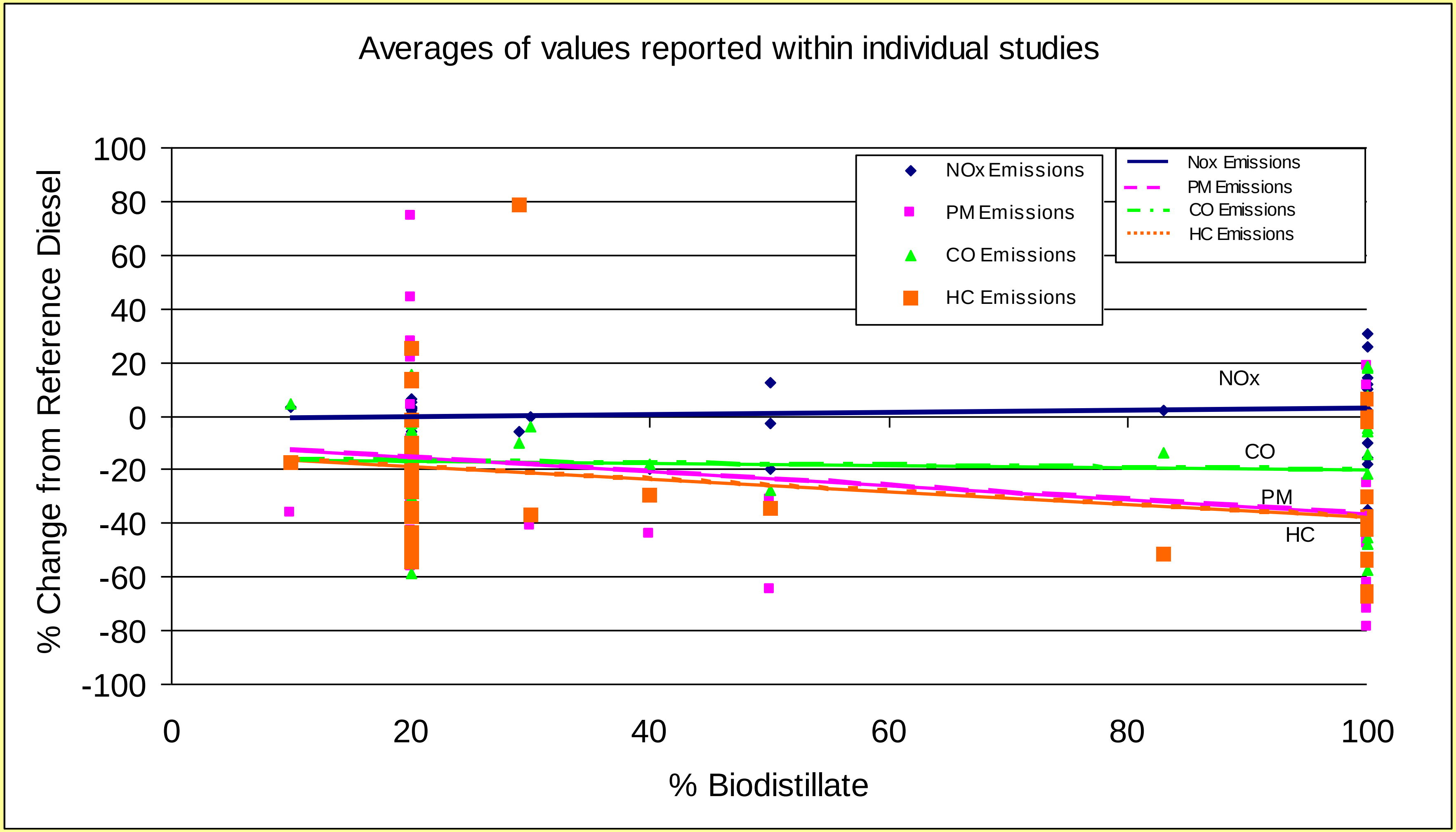
Data analysis from AVFL-17

- Biodistillate emissions results were computed as a percentage change from the reference fuel for:
  - Criteria pollutants: CO, HC, PM and NOx
  - All engine types: HD, LD and TE
  - All biodistillate sources: soy, rapeseed, etc.

- Data were analyzed to show
  - Variability among results from different studies
  - Influence of blend level upon criteria emissions

Exhaust emissions from HD engines

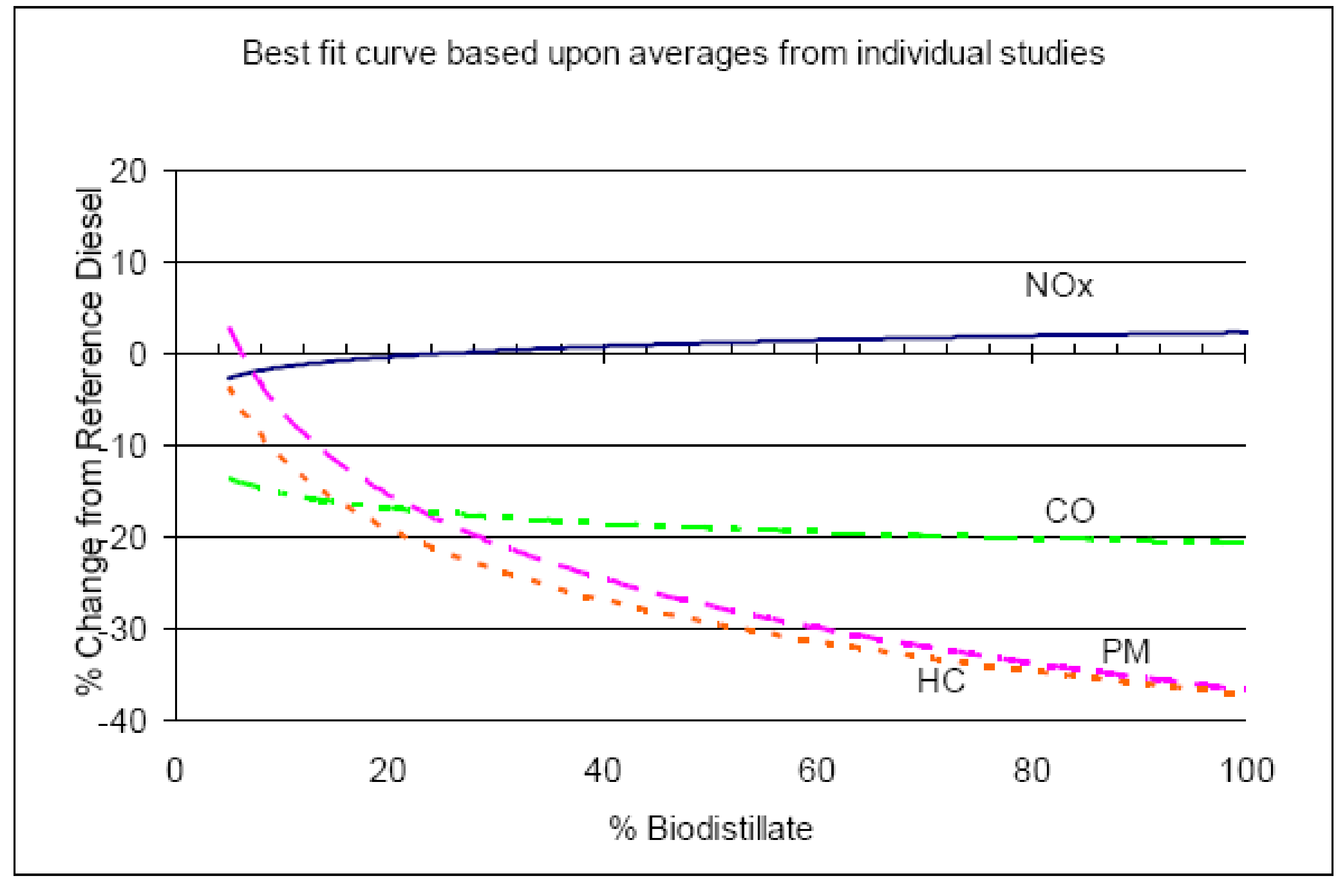
Linear regression used to show average blend level effects



Exhaust emissions from HD engines

Logarithmic regression used to define "best fit" blend level effects

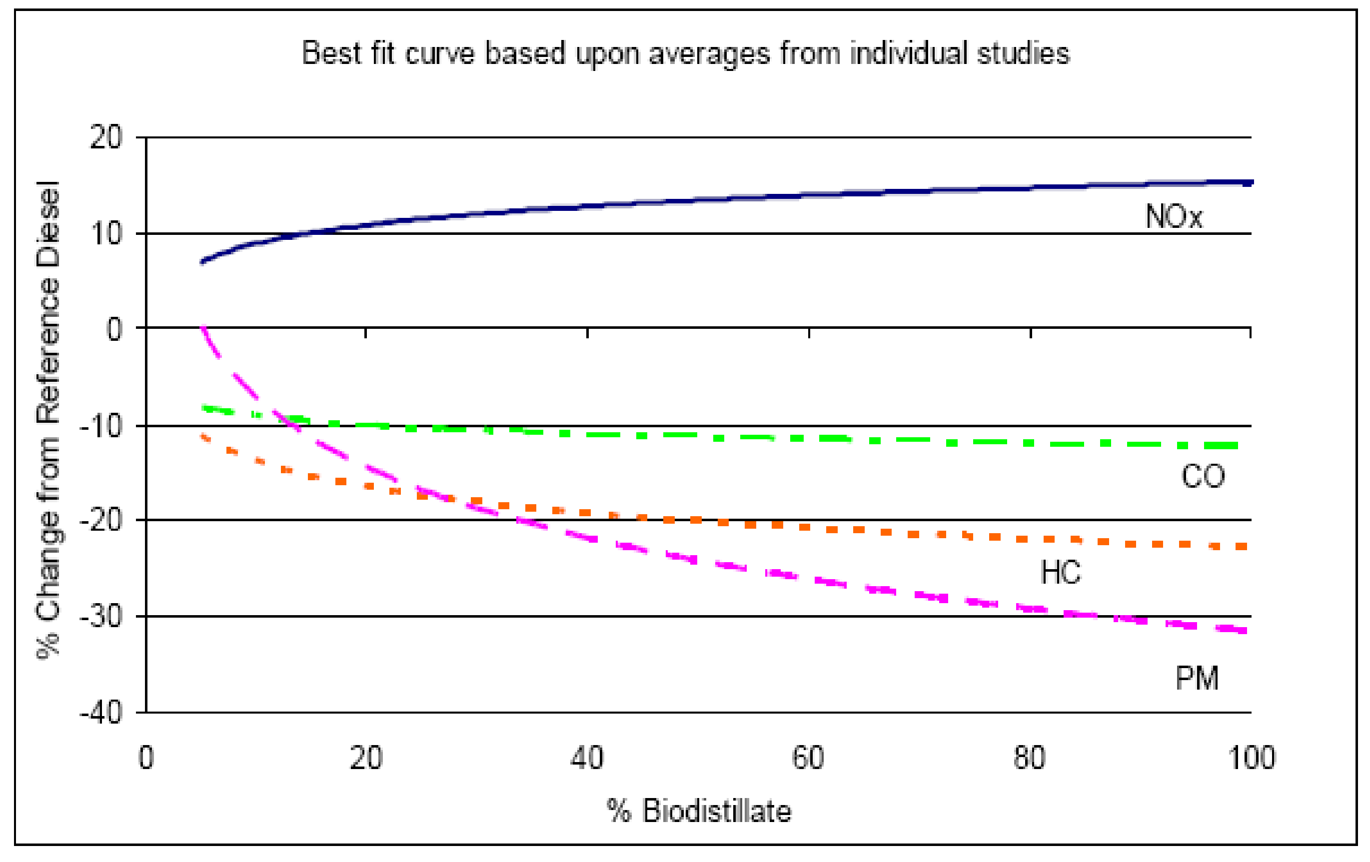
- Overall shape of curves resembles EPA results
- CO, HC and PM all reduce with increasing %B
- Larger effects for HC and PM than for CO
- Very little effect of %B upon NOx



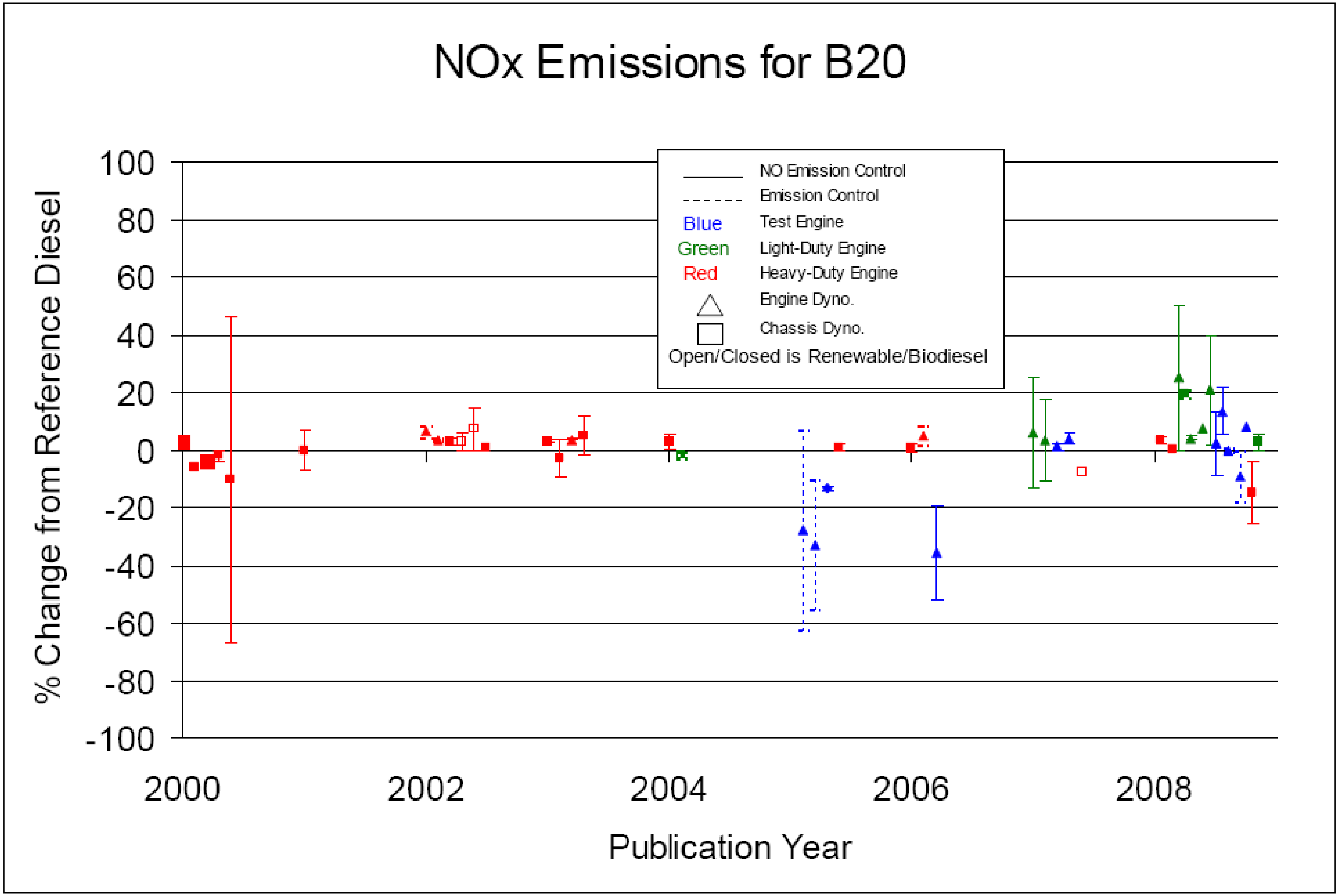
Exhaust emissions from LD engines

Logarithmic regression used to define "best fit" blend level effects

- CO, HC and PM all reduce with increasing %B
- Larger effects for HC and PM than for CO
- Noticeable increase in NOx with increasing %B



Variability of NOx effects (B20)



Comparison of results with previous assessments

- Generally good agreement for B20 effects
- Lesser emissions reductions for B100 than previously observed
- NOx impacts are very small and difficult to discern

Emissions effects of B20 in HD Engines

Pollutant	EPA, 2002	McCormick et al., 2006	This Study	
			Full Data	Biodiesel Only
NO_x	+2.0	+0.6*	-0.3	-0.6
CO	-11.0	-17.1	-16.6	-18.7
HC	-21.1	-11.6	-19.2	-21.2
PM	-10.1	-16.4**	-15.5	-24.1

*Reported as statistically insignificant.
**Excludes engines equipped with DPF.

Summary and Conclusions

- Most literature reports indicate 10-20% reductions in CO, HC and PM emissions when using B20 blends
  - Larger benefits are achieved at higher blend levels
  - Similar results occurred with both HD and LD engines
- NOx impacts are much smaller and difficult to discern
  - Probably small NOx increase (2-3%) for B100 in HD engines
  - No noticeable effect with B20 in HD engines
  - Larger NOx increase (10-15%) with B20 or B100 in LD engines
- Based upon very little data, renewable diesel and biodiesel appear to give similar results

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AVFL-17 Final Report available on the CRC website at: www.crcao.org.

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THANK YOU