Biodiesel and Renewable Diesel Study

January 20, 2010

California Environmental Protection Agency

Air Resources Board

Summary of Study

Emissions Tests

- NOx impact and mitigation (CECERT)
  - Engine tests
- In-depth characterization
  - Vehicle tests
  - Regulated and unregulated emissions
  - Health effects tests
- Non-road
  - Engine tests
    - TRU at El Monte, John Deere engine Stockton
- Light Duty
  - Vehicle tests

Summary of Study Cont

- Durability Survey
- Fuel species characterization

Multi-Media Evaluation

- Biodiesel
  - –Tier one completed
  - –Tier two test biodiesel protocol completed
- Renewable diesel
  - –Draft Tier one completed

Schedule

- Complete emissions testing and multimedia evaluations
- Post remaining results on website
- Final report
- Conference call for interested parties to discuss results

Biodiesel Impact

- NOx increase
- Other regulated emissions generally decrease including PM
- Generally reduce toxics

Engine Tests: NOx Emissions Comparison Between Biodiesel and CARB Diesel

	Cummins ISM	Cummins ISM	MBE4000	MBE4000
	Soy 100	Animal 100	Soy 100	Animal 100
UDDS	17.4% P=0.000	1.9% P=0.243	36.6% P=0.000	16.0% P=0.000
FTP	26.6% P=0.000	14.1% P=0.000	38.1% P=0.000	29% P=0.000
40 mph Cruise	20.9% P=0.000			
50 mph Cruise	18.3% P=0.000	5.3% P=0.000	47.1% P=0.000	39.4% P=0.000

Engine Test: NOx Results for 20% Biodiesel

	Cummins ISM	Cummins ISM	MBE4000	MBE4000
	Soy 20	Animal 20	Soy 20	Animal 20
UDDS	4.1% P=0.002	-1.5% P=0.376	4.4% P=0.005	1.6 P=0.000
FTP	6.6% P=0.000	1.5% P=0.000	5.9% P=0.000	4% P=0.000
40 mph Cruise	3.9% P=0.000			
50 mph Cruise	0.5% P=0.800	-2.3% P=0.151	6.9% P=0.000	5.9% P=0.000

Engine Tests: NOx Results for 5% Biodiesel

	Cummins ISM	Cummins ISM	MBE4000	MBE4000
	Soy 5	Animal 5	Soy 5	Animal 5
FTP		0.3% P=0.298	0.9% P=0.007	1.3% P=0.000
40 mph Cruise	1.7% P=0.135			
50 mph Cruise	-1.1% P=0.588			

Chassis Tests: NOx Results for Biodiesel

	2000 Caterpillar			
	Soy 20	Animal 20	Soy 100	Animal 100
UDDS Light Load	-4.2% P=.895	3.3% P=.891	20.2% P=0.003	13.7% P=0.011
50 mph Cruise	-1.9% P=0.583	0.4% P=0.866	17.5% P=0.000	17.1% P=0.000

Renewable and GTL Emissions Impact

- Regulated emissions generally decrease including NOx and PM
- Generally reduce toxics

Engine Tests: NOx Emissions

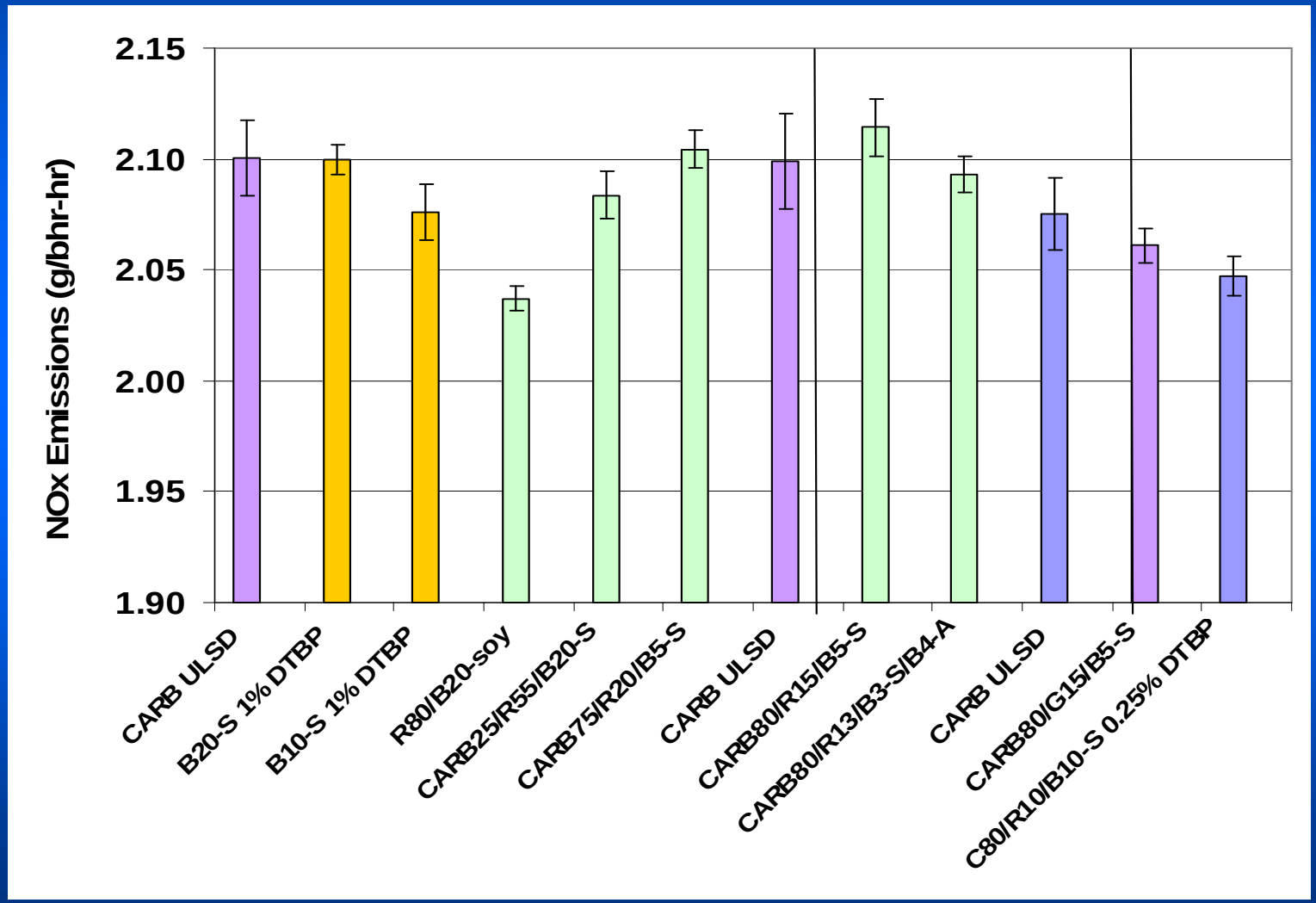
- Comparison of emission differences between CARB, renewable diesel, and GTL

	Cummins ISM	Cummins ISM	Cummins ISM	Cummins ISM
	R20	R100	GTL20	GTL100
UDDS	-4.9% P=0.000	-18.1% P=0.000		
FTP	-2.9% P=0.000	-9.9% P=0.000	-0.9% P=0.053	-8.7% P=0.000
50 mph Cruise	-3.8% P=0.000	-14.2% P=0.000		

NOx Mitigation Approaches

- Strategies effective for low level blends of biodiesel
  - Additive: di-tertiary butyl peroxide
  - Low NOx feedstocks: Blend biodiesel with renewable diesel or GTL
- Other approaches still to be evaluated

NOx Mitigation for 2006 Cummins ISM



NOx Mitigation for 2007 Detroit MBE4000