Biodiesel and Renewable Diesel Research Study

December 5, 2007

California Environmental Protection Agency

Air Resources Board
Introductions
Agenda

• Introduction
• Summary of previous workgroup discussions
  • Fuels
    • storage, blending, biodiesel and renewable diesel
  • Engine selection
• Engine test matrix-CECERT
  • On-road vehicle test matrix-MTA
    • Detailed description of unregulated emissions tests
• Test schedule
  • Others
• NOx mitigation
  • Selection of NOx mitigation strategies
• Presentation by others
• Open discussion
• Executive Order S-1-07 Low Carbon Fuel Standard (LCFS)
  – Reduce at least 10 percent of the carbon intensity of California's transportation fuels by 2020.
  – Early action item with a regulation to be adopted and implemented by 2010.
• Executive Order S-06-06, establishing targets for the use and production of biofuels and biopower
  – Includes biodiesel and ethanol.
  – California shall produce a minimum of 20 percent of its biofuels within California by 2010, 40 percent by 2020, and 75 percent by 2050.
• Low Carbon Fuels Standard
  – Biofuels Specifications adopted by the first quarter of 2009
  – Biodiesel and renewable diesel research study is needed
Biodiesel and Renewable Diesel Research Study

- Biodiesel and renewable diesel emissions evaluation
- NOx formation and mitigation evaluation
- Multi-Media evaluation
Funded Research Update

• Biodiesel and Renewable Diesel Research Study
  – Biodiesel and renewable diesel characterization and NOx mitigation study-$1,689,000
  – Biodiesel and renewable diesel multimedia study-$400,000
  – Total cost $2,189,000

• Other contributors
  – South Coast Air Quality Management District-$50,000
  – National Biodiesel Board-$50,000
  – WSPA will provide CARB diesel
  – Innerstate Oil will provide transportation and short term storage of fuels
  – Tentative agreement on renewable diesel
  – Discussions on-going with other contributors
Duration of Contracts and Grants

• Initial biodiesel characterization study: 6/06-6/08
• Biodiesel and renewable diesel characterization and NOx mitigation study: 6/07-6/09
• Biodiesel and renewable diesel multimedia: 6/07-6/09
Biodiesel and Renewable Diesel Emissions Characterization and NOx Mitigation Research

“Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California- Biodiesel Characterization and NOx Formation and Mitigation Study”

Principal Investigators: Thomas D. Durbin (UCR) and J. Wayne Miller (UCR)
University California Riverside-CE-CERT
University California Davis
Scope of Work

Task 1: Biodiesel and Renewable Diesel Emissions Evaluation Study
- Evaluate emissions and health effects
- Evaluate NOx impact

Task 2: NOx Formation and Mitigation Study
- Investigate the mechanism of NOx formation and evaluate possible NOx mitigation options
  - Changes in fuel specifications-match blending
  - Refinery process
  - Additives
  - Engine recalibration
Summary of previous workgroup discussions
Fuel Storage Update

• Long term storage
  – Difficulty in finding temperature controlled storage facility
  – Options:
    • Possibility of a non-temperature controlled cinder block storage facility
    • Also looking at non-temperature controlled storage facility on the coast where there is smaller temperature swings
Fuel Blending

• No updates—still need to resolve how, when, and where to do fuel blending
Biodiesel Feedstocks and Fuels Update

• Original proposal was to avoid additives
  – May need to consider anti-oxidants and anti-microbial
  – Which anti-oxidants and anti-microbial?
Fuel Specification Analysis

- CARB diesel fuel-D975
- Renewable diesel fuel and blends-D975
- Biodiesel feedstocks-D6751
- Biodiesel blends
  - D975
  - D6751
- All analyses conducted in triplicate
Storage Stability Criteria Update

• Conduct quarterly stability tests for biodiesel fuels and biannual stability tests for CARB and renewable diesel
  – EN14112 Rancimat 6 hrs
  – D664 Acid number 0.5
  – D2274 Gums ?
  – D3703 Peroxide ?
CARB Diesel Update

- No update
Renewable Diesel Update

- Original proposal was to test R20 and R50
- Add additional blend level: R100
Test Engine Update

• Engine secured for testing
  – 2006 11 L Cummins ISM purchased

• Other engines under consideration
  – 2007 14 L Detroit Diesel series 60
  – 2007 International
Additional Parameters Update

- Lube oil-APICJ4-OL
- Engine parameters-J1939
Toxics Testing Update

- Elements: Filter/XRF or ICP/MS
- No Chromium (VI) sampling and analysis will be conducted
Discussion
Test Design

• Task 1: Biodiesel and Renewable Diesel Characterization Study
  – Unregulated emissions and health effects
  – NOx Impact

• Task 2: NOx Mitigation Study
  – Phase one
  – Phase two
Test Design: Biodiesel and Renewable Diesel Characterization Study

Biodiesel and Renewable Diesel Characterization Study

On-Road Engines Tests
NOx Impact Study

CE-CERT

NOx Pre-test
Engine Dynamometer

NOx Main Test
Engine Dynamometer

Chassis Test
Emissions and
Health Effects Study

MTA Lab
On-Road Vehicles

Pre-Test
Transfere Chassis Cycles into Engine Cycles
Toxics Pre-test

Main Test
Emissions and
Health Effects

Stockton Lab
Off-Road Vehicles/Engines

Off-Road Engines/Vehicles
Criteria Emissions Characterization

Main Test
Chassis
Biodiesel and Renewable Diesel NOx Impact Study

Biodiesel and Renewable Diesel Characterization Study

- On-Road Engines Tests
  - NOx Impact Study
  - CE-CERT
  - NOx Pretest Engine Dynamometer
  - NOx Main Test Engine Dynamometer

- Chassis Test
  - Emissions and Health Effects Study
  - MTA Lab
    - On-Road Vehicles
    - Pre-Test
      - Transfere Chassis Cycles into Engine Cycles
      - Toxics Pre-test
  - Stockton Lab
    - Off-Road Vehicles/Engines
    - Off-Road Engines/Vehicles
      - Criteria Emissions Characterization

- Main Test
  - Emissions and Health Effects
  - Main Test Chassis
Test Design Considerations
Possible Biodiesel NOx Impacts

• Evaluate test cycle load effects on NOx
• Evaluate biodiesel level effects on NOx
Biodiesel NOx Effect-Average Cycle Power

Figure 1: B20 and B50 Effects on NOx Emissions
MY 2004 Cummins ISB Engine

\[
y = -5.576 + 0.445 \times x \\
y = -2.094 + 0.17 \times x
\]

$R^2 = 0.99$

Ratio of slopes: 2.6

EPA data only

- B20 FTP
- B20 HWY55
- B20 UDDS 28k
- B20 UDDS 6k
- B20 WHTC
- B50 FTP
- B50 HWY55
- B50 UDDS 28k
- B50 UDDS 6k

- EPA CBET Program
CE-CERT NOx Pre-test

• Test cycle and replicates:
  – Minimum of 9 FTP replicates of CARB diesel on day one and 9 replicates of biodiesel on day two
  – Additional test days may be required

• Test Pattern:
  – Minimum of 9 FTP replicates of CARB diesel on day one and 9 replicates of biodiesel on day two
  – Additional tests maybe run on UDDS and HHDT cycles
CE-CERT NOx Impact Study: Main Test

- Build upon USEPA and NREL studies
- Test conducted on an engine dynamometer
  - Engine dynamometer is suited to conduct the NOx impact study study
  - Provides precision necessary to distinguish small differences in NOx i.e. 2% change at B20
- Engines
  - 2006 Cummins ISM and 2007 engine
- Test cycles
  - FTP, UDDS light, HHDDT cruise
CE-CERT Main Test

• Fuels:
  – Biodiesel: two feedstocks at four blend levels: B5, B20, B50, and B100
  – Renewable diesel at three levels: R20, R50, and R100

• Optional unregulated emissions testing:
  • VOCs, 1,3-butadiene, and carbonyls
  • Limited ultra-fines
Revised CE-CERT Main Test

- Revised test matrix designed to better measure small differences between CARB and test fuels
  - Closer pairing of CARB fuel and test fuels
  - Account for differences in morning and afternoon testing
  - Testing all three test cycles in one day
Revised CE-CERT Main Test

- Emission differences are expected to be lower for the 2007 engine and lower blend levels especially at the 5% blend level
- Low blends and the 2007 engine may require more test replicates
- Test matrix designed to take this into consideration
  - Split out B5 testing
  - Split tests of other fuels into main and supplemental testing
  - Evaluation of main test results will determine if the supplemental tests need to be conducted
## Emissions Characterization

<table>
<thead>
<tr>
<th>Chemical species</th>
<th>Sampling method</th>
<th>Sampling schedule</th>
<th>Vehicle test cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen Oxides</td>
<td>Direct Chemiluminescence (CLM)</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>NO:NO₂</td>
<td>Direct Duel CLM</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>Total hydrocarbons</td>
<td>Direct/Tedlar Bag FID</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Direct/Tedlar Bags NDIR</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Direct NDIR</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>Filters</td>
<td>All tests</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
<tr>
<td>Ultra-fines</td>
<td>Direct</td>
<td>TBD</td>
<td>UDDS, FTP, ARB Hwy</td>
</tr>
</tbody>
</table>
**CE-CERT Main Test (Revised)**

- **Test pattern for both biodiesel feedstocks and engines**

**Main program**

<table>
<thead>
<tr>
<th></th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
<th>Day 6</th>
<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
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<tbody>
<tr>
<td>Fuel</td>
<td>CARB</td>
<td>B20</td>
<td>B50</td>
<td>CARB</td>
<td>B100</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
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<tr>
<td>Cycle</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>A</td>
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**Supplemental**

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<th>Day 4</th>
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<td>B20</td>
<td>B50</td>
<td>B100</td>
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<tr>
<td>Cycle</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>A</td>
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[...]

[...]
### CE-CERT Main Test (Revised)

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<th>Day 7</th>
<th>Day 8</th>
<th>Day 9</th>
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<tbody>
<tr>
<td>CARB</td>
<td>A</td>
<td>R20</td>
<td>A</td>
<td>R50</td>
<td>A</td>
<td>CARB</td>
<td>A</td>
<td>R100</td>
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<tr>
<td>R20</td>
<td>A</td>
<td>R50</td>
<td>A</td>
<td>CARB</td>
<td>A</td>
<td>R100</td>
<td>A</td>
<td>R20</td>
</tr>
</tbody>
</table>

- No testing on R5
- Renewable diesel tested only on 2006 Cummins ISM engine
Discussion
On-Road Biodiesel and Renewable Diesel Characterization Study Conducted at ARB’s Heavy Duty Dynamometer Facility’s (MTA) Chassis Dynamometer Test Laboratory in Los Angeles
On-Road Biodiesel and Renewable Diesel Characterization Study

• Objective:
  – Test on-road vehicles
  – Emissions and health effects characterization
    • In-depth toxics characterization
    • Greenhouse gas emissions
    • Ultrafines and other species

• Conducted at MTA
Linking Engine and Chassis Dynamometer Emission Tests Results

- Test an engine on a chassis dynamometer and then test the same engine on an engine dynamometer using the same test cycle
- Two of the test cycles will be used on both engine and chassis tests
Update: Un-regulated On-Road Characterization Study - Emissions Characterization

• Eliminate 5% blend level fuels from test matrix
  – Variability much greater in chassis testing making it difficult to discern differences at the 5% blend level
## Emissions Characterization

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<td>UDDS, ARB Hwy</td>
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</table>
### Emissions Characterization

<table>
<thead>
<tr>
<th>Chemical species</th>
<th>Sampling method/Analytical method</th>
<th>Sampling schedule</th>
<th>Vehicle test cycle</th>
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</thead>
<tbody>
<tr>
<td>Carbonyls</td>
<td>DNPH coated cartridges HPLC/LCMS</td>
<td>General</td>
<td>UDDS, ARB Hwy</td>
</tr>
<tr>
<td>VOCs</td>
<td>Tedlar Bags GC/FID</td>
<td>General</td>
<td>UDDS, ARB Hwy</td>
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<tr>
<td>1,3-butadiene</td>
<td>Tedlar Bags GC/FID</td>
<td>in-depth</td>
<td>UDDS</td>
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<tr>
<td>Nitrous Oxide</td>
<td>Tedlar Bags/FTIR</td>
<td>in-depth</td>
<td>UDDS</td>
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<tr>
<td>EC/OC</td>
<td>Quartz filters Thermo-optical analyzer</td>
<td>in-depth</td>
<td>UDDS</td>
</tr>
<tr>
<td>Ions</td>
<td>Teflon filters Ion chromatography</td>
<td>in-depth</td>
<td>UDDS</td>
</tr>
<tr>
<td>Elements</td>
<td>Filters TBD</td>
<td>in-depth</td>
<td>UDDS</td>
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<tr>
<td>PAHs</td>
<td>Filters/PUF/XAD GC/MS</td>
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<td>UDDS</td>
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<td>nitro-PAHs</td>
<td>Filters/PUF/XAD GC/NCIMS</td>
<td>in-depth</td>
<td>UDDS</td>
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<tr>
<td>Unsaturated Carbonyls</td>
<td>Bisulfite mist chamber GC/NCIMS</td>
<td>in-depth</td>
<td>UDDS</td>
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</tbody>
</table>
## Emissions Characterization

<table>
<thead>
<tr>
<th>Biological Test</th>
<th>Sampling method</th>
<th>Bioassay/biological endpoints</th>
<th>Sampling schedule</th>
<th>Vehicle test cycle</th>
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<tbody>
<tr>
<td>Mutagenicity</td>
<td>Filters/PUF</td>
<td>TA98 +/-S9</td>
<td>in-depth</td>
<td>UDDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TA100 +/-S9</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>TA102 (selected samples)</td>
<td></td>
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<tr>
<td></td>
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<td>TA104 (selected samples)</td>
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<td>DNA damage</td>
<td>Filters</td>
<td>Comet assay</td>
<td>in-depth</td>
<td>UDDS</td>
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<tr>
<td>Oxidative stress and inflammation</td>
<td>Filters</td>
<td>Human lung and macrophage assays:</td>
<td>in-depth</td>
<td>UDDS</td>
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<td></td>
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<td>Inflammatory cytokines: IL-8 &amp; TNF</td>
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<tr>
<td></td>
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<td>Prostaglandin synthase COX-2</td>
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<td></td>
<td></td>
<td>Heme oxygenase-1 HO-1</td>
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<tr>
<td></td>
<td></td>
<td>C reactive protein</td>
<td></td>
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</table>
In-Depth Emissions Characterization

- Test only UDDS (A)
- Applies to all chemical species and biological assays except carbonyls, VOCs, and ultrafines
- Vehicle one equipped with 2006 ISM
  - Test all blend levels-CARB, 20, 50, and 100 percent
  - Test all feedstocks
- Vehicle two equipped with 2007
  - Test all blend levels
  - Test only soy feedstock
### Emissions Characterization of Carbonyls and VOCs

#### General

<table>
<thead>
<tr>
<th></th>
<th>Vehicle 1</th>
<th>Vehicle 2</th>
<th>Vehicle 3</th>
<th>Vehicle 3r</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
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<td>TB</td>
<td>1</td>
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<tr>
<td>CARB</td>
<td>3</td>
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<tr>
<td>SoyB20</td>
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<td>SoyB50</td>
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<td>SoyB100</td>
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<td>R20</td>
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<td>R50</td>
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<tr>
<td>R100</td>
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<tr>
<td>TB</td>
<td>39</td>
<td>39</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

#### Test Details

- **Vehicle one (2006 ISM):** Test UDDS (A) and ARB Hwy (B) cycles
  - Test all blend levels and feedstocks
- **Vehicle two (2007):**
  - Test all blend levels
  - Test only biodiesel feedstocks
- **Vehicle three with and without aftertreatment:**
  - Test A and B cycles
  - Test only biodiesel feedstocks
  - Test only CARB, B20, and B100
Un-regulated On-Road Characterization Study - Emissions Characterization

- Vehicle one: 2006 Cummins ISM engine
- Test matrix soy feedstock
- Applies to second biodiesel feedstock and renewable diesel
Un-regulated On-Road Characterization Study - Emissions Characterization

- Vehicle 2 equipped with 2007 engine
- Soybased biodiesel
Other Issues

• Discussed in detail at a later meeting
• QA/QC
  – QA samples
  – Dilution tunnel considerations
  – Sampling and analytical
  – Data review and tracking
• Data Reduction
Ultrafine Particles Measurements

- Will be mainly conducted during vehicle testing
  - Particle Number
  - Particle Size Distribution
  - Real-time Mass
  - Surface Area
- European PMP protocol will be considered
- Sampling from CVS dilution tunnel for all three vehicles
- Pre-trap and post-trap partial flow sampling will also be conducted for vehicle 3 w/ aftertreatment configuration
Ultrafine Particles Sampling Locations

- 1: Pre-trap partial flow sampling: vehicle 3 w/ aftertreatment only
- 2: Post trap partial flow sampling: vehicle 3 w/ aftertreatment only
- 3: Full flow sampling (post trap): all vehicles

Image from Herner et al., 2007

Truck image from Cleaire ICAT seminar. Presented at ARB 8/31 2006
Recommended PMP Sampling System

Carbon and HEPA filters provide particle free and low HC background air

Dilution air in

Humidity and T controlled

C. HEPA

PSP and PTT comprise the sample probe

CVS Tunnel

PSP

PTT

VPR

PND2 cools and dilutes

ET: Heated evaporation tube

PND1 heats and dilutes

To mass flow controller and pump

PCF: provides sharp cut-point at 2.5μm

To CFV

Particle number Concentration

Size selective inlet: D50 - 20nm

PNC

Image from OICA, 2007
Discussion
Off-Road Characterization Study - Emissions Characterization

Biodiesel and Renewable Diesel Characterization Study

- On-Road Engines Tests NOx Impact Study
  - CE-CERT
  - NOx-Pretest Engine Dynamometer
  - NOx Main Test Engine Dynamometer

- Chassis Test Emissions and Health Effects Study
  - MTA Lab On-Road Vehicles
  - Pre-Test Transfere Chassis Cycles into Engine Cycles Toxics Pre-test
  - Main Test Emissions and Health Effects

- Off-Road Vehicles/Engines
  - Stockton Lab Off-Road Vehicles/Engines
  - Off-Road Engines/Vehicles Criteria Emissions Characterization
  - Main Test Chassis
Off-Road Characterization Study - Emissions Characterization

- ARB’s emissions test facility in Stockton
- Propose test design
  - Two Vehicles/Engines-TBD
  - Criteria emissions only
  - Two biodiesel feedstocks and four blend levels B5, B20, B50, B100 compared to CARB diesel
  - Three renewable diesel blends R20, R50, and R100 compared to CARB diesel
  - Eight mode steady state
- Detailed test matrix presented at next meeting
Off-Road Equipment

• Top Emission Contributors
  – Construction & mining equipment (~55%)
  – Agriculture equipment (~20%)

• Issues:
  – Speed limitation of Stockton Chassis Dyno: 25 mph
  – Most construction and agriculture equipment cannot run higher than 25 mph
Off-Road Diesel NOx Emission Inventory (2007)

- Construction and Mining Equipment: 55.5%
- Agricultural Equipment: 19.0%
- Industrial Equipment: 6.5%
- Oil Drilling: 5.9%
- Transport Refrigeration Units: 4.3%
- Light Commercial Equipment: 4.2%
- Industrial Equipment: 6.5%
- Logging Equipment: 1.5%
- Lawn and Garden Equipment: 1.1%
- Airport Ground Support Equipment: 1.0%
- Other Portable Equipment: 0.0%
- Railyard Operations: 0.0%
- Military Tactical Support: 0%
- Dredging: 0.3%
- Entertainment Equipment: 0.1%
- Pleasure Craft: 0.4%
Off-Road Diesel PM Emission Inventory (2007)

- Construction and Mining Equipment: 53.9%
- Agricultural Equipment: 19.2%
- Logging Equipment: 1.4%
- Oils Drilling: 4.1%
- Light Commercial Equipment: 5.0%
- Industrial Equipment: 6.0%
- Transport Refrigeration Units: 7.7%
- Other Portable Equipment: 0.0%
- Dredging: 0.2%
- Pleasure Craft: 0.2%
- Entertainment Equipment: 0.1%
- Railyard Operations: 0.0%
- Military Tactical Support: 0%
- Airport Ground Support Equipment: 1.0%

Biodiesel/Renewable Diesel Research Study
Discussion
Test Schedule-Test Plan

- Fall 2007
  - Test design
    - Biodiesel/renewable diesel advisory group, stakeholders
  - Collaborators: working with stakeholders in obtaining in-kind contribution and funding for the study
  - Test protocol
Test Schedule-Logistics

Fuels

• Estimated time line
  – Delivery of CARB and biodiesel fuels in December
  – Delivery of renewable diesel fuel in January-February
  – Blend fuels biodiesels in December-January
  – Blend renewable diesel fuels in January-February
  – Fuel specifications conducted by independent laboratory
Test Schedule-Logistics

• Engines/vehicles
  – Purchased truck equipped with a 2006 Cummins ISM engine in November
  – Truck equipped with a 2007 C15 Caterpillar engine will be available in February for testing
  – Discussions on second engine is ongoing
  – Other vehicles are also being considered
Test Schedule-Pretests

- CE-CERT pre-test-January 2008
Test Schedule-Main Tests

• Biodiesel and renewable diesel characterization study
  – NOx impact study (CE-CERT)
    • Engine one-January-February
    • Engine two-March-April
    • Phase one NOx mitigation study Summer 2008
  – On-road vehicle characterization study (MTA)
    • Feb-May 2008
  – Stockton-off-road vehicle study
    • Start in 2008
• NOx Mitigation Study
  • CE-CERT Phase one
  • MTA Phase two
Discussion
Test Design: Diesel NOx Mitigation Study

Biodiesel and Renewable Diesel NOx Mitigation Study

- Engine Dynamometer
  - CE-CERT
  - Phase One

- Engine Dynamometer
  - MTA
  - Phase Two
NOx Mitigation Study – Phase One

• Conducted at CE-CERT
• Collaborate with CRC
• Evaluate four strategies
• Selection Considerations
  – Data supporting the effectiveness of strategy
  – Feasibility to be commercially relevant
  – Compatibility with existing infrastructure
NOx Mitigation Study – Phase One

– Additives
– Match blending properties
– Biodiesel/renewable diesel blends
– Renewable diesel
– Engine re-calibration
Stakeholders Suggested NOx Mitigation Strategies

– Water/biodiesel/diesel emulsified fuels
– Viscon additive
NOx Mitigation Study - Phase Two

- Conducted at MTA
- Select most successful NOx mitigation strategies
  - Confirmation engine
  - Conduct more in-depth study
    - Needs to be fleshed out
  - Limited toxics tests
- Evaluate other strategies if necessary
Discussion
Light-Duty Diesel Vehicle Testing

• To be collaborated with Research Division Light-Duty Test Program
• Two vehicles
  – One passenger car
  – One pick-up truck/SUV/minivan
• Plan to start test in August 2008
Other Research

- Durability Study
- Will be discussed in detail in upcoming meetings
In Kind Contributions

• Fuels
  – US EPA diesel fuel
  – Biodiesel and biodiesel blends
  – Storage (long term)
  – Fuel analysis
• Engines
• Vehicles
• Other
Future Discussion Topics

- UL certification of biodiesel pumps
- Guidelines for converting a diesel engine to biodiesel
Biodiesel and Renewable Diesel Advisory Group

• Next meeting in January/February