

Biodiesel and Renewable Diesel Research Study

February 26, 2008

California Environmental Protection Agency



Air Resources Board

Introductions

Agenda

- Introduction
- Summary of previous workgroup discussions
 - Fuels
 - Engine selection
 - Vehicle Selection
 - Test Matrix
- Test Protocol
- Test schedule
- NOx mitigation

- New Discussion Topic
 - Comparison of Emission Benefits of CARB Diesel vs. Federal Diesel

- 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

Fuels Update-Status

- Purchased CARB fuel and the fuel is currently being stored in steel drums at the Innerstate's Woodland Facility
- Soy based biodiesel fuel has been delivered and is also being stored in Woodland
- Animal based feedstock needs to be delivered
- Renewable diesel has arrived in California and final arrangements are being made to have the fuel delivered to CE-CERT

Fuels Update-Specifications

Initial base fuel specifications analysis

- CARB diesel fuel-ASTM D975
- Renewable diesel fuel ASTM D975
- Biodiesel feedstocks-D6751
- Samples from multiple drums will be pooled
- All analyses conducted in triplicate
 - One replicate will be the certificate of analysis

Fuels Update-Biodiesel Additive

- An anti-oxidant will be added to the biodiesel feedstocks
 - Tenox 21
- No anti-microbial will be added

Fuels Update-Blending

- Gravimetric blending
- Fuels will be blended in polycarbonate totes- multiple totes will be needed
- Uniform mixing will be achieved by a pump recirculating the fuel
- Blend level will be checked by ASTM D7371-07
 - Samples will be collected at various depth levels

Fuel Storage Update

- On-going search for suitable long term storage facility
 - Option one: Temperature controlled facility
 - Difficulty in finding temperature controlled storage facility
 - Options two:
 - 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

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

Test Vehicle Update

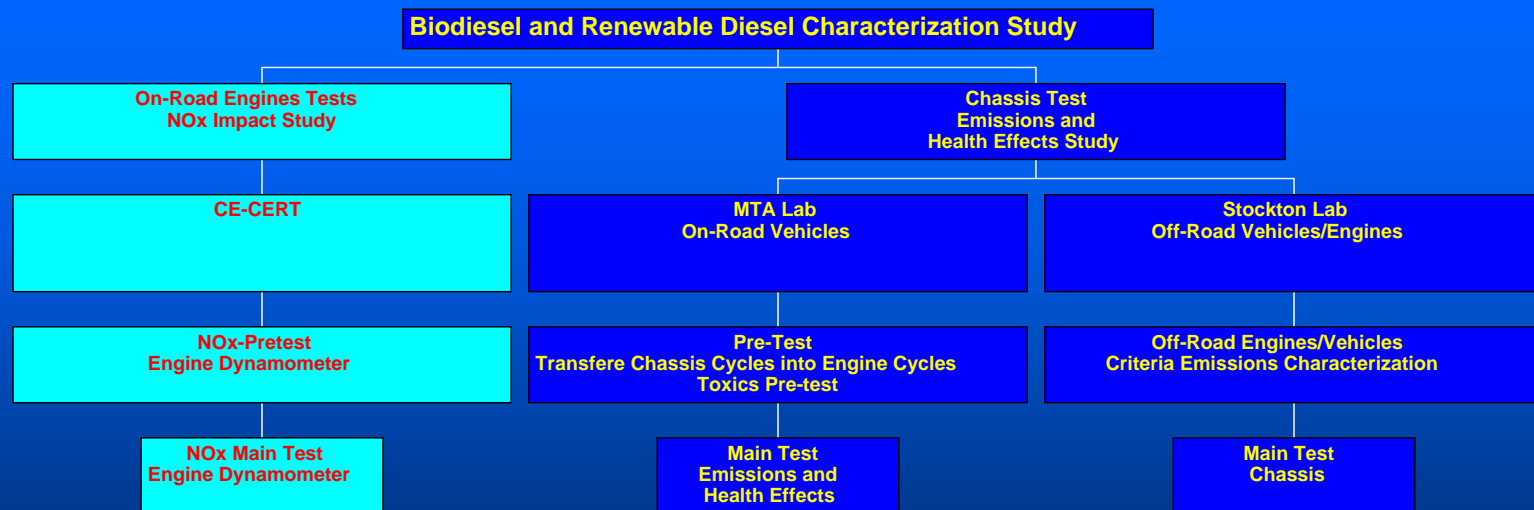
- Engine secured for testing
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Discussion

Test Design

- Task 1: Biodiesel and Renewable Diesel Characterization Study
 - NO_x Impact
 - Unregulated emissions and health effects
- Task 2: NO_x Mitigation Study
 - Phase one
 - Phase two

Biodiesel and Renewable Diesel NOx Impact Study

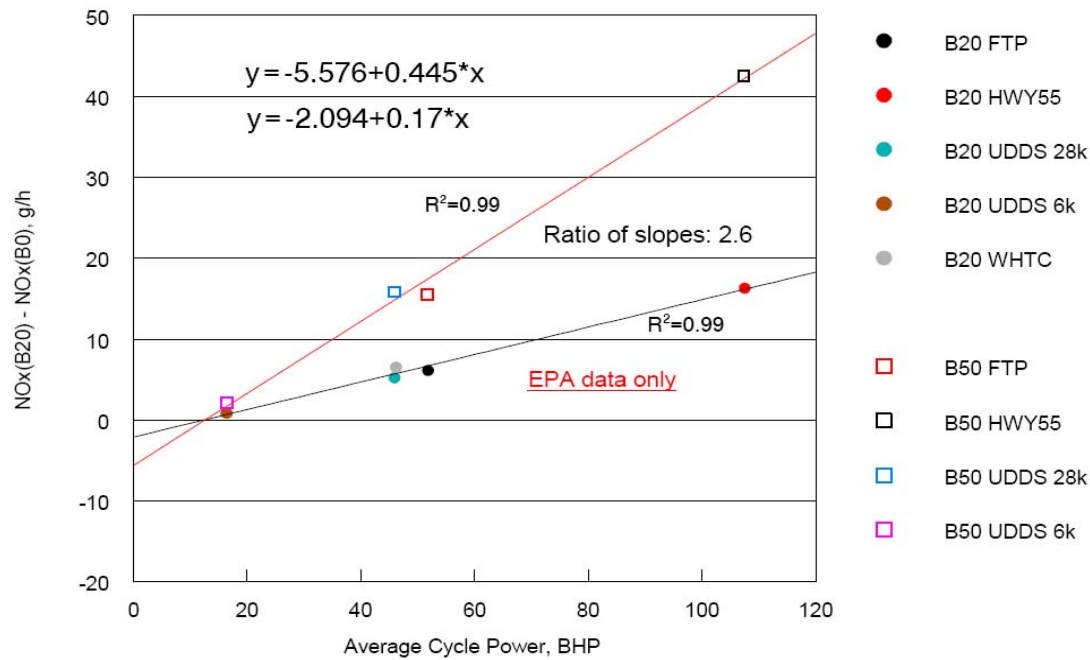


Possible Biodiesel NOx Impacts

- 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



CE-CERT NOx Impact Study: Main Test

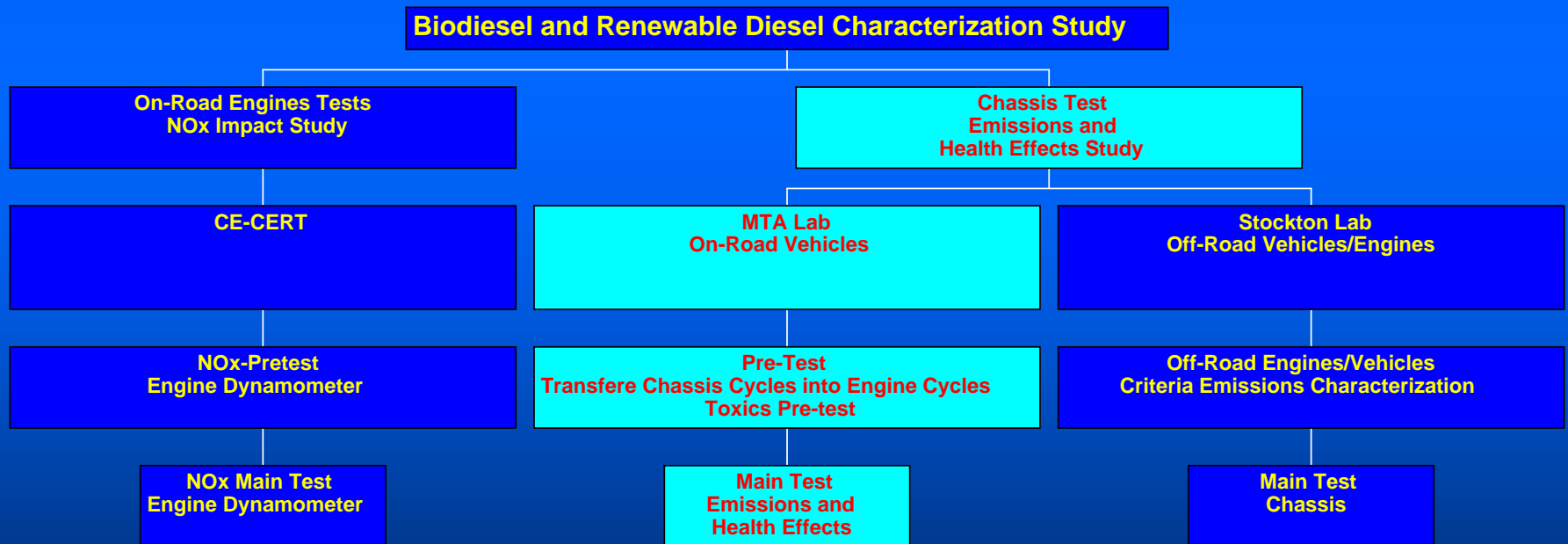
- Build upon USEPA and NREL studies
- Test conducted on an engine dynamometer
 - Engine dynamometer is suited to conduct the NOx impact study
 - Provides precision necessary to distinguish small differences in NOx i.e. 2% change at B20
- Engines
 - 2006 Cummins ISM and 2007 engine
- Test cycles
 - FTP,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

CE-CERT Main Test Protocol

- Handout

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 a 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
- Proposed Increase of number of UDDS replicates from 3 to 4 for the 2007 engine

Test Protocol

- Handout

Discussion

Off-Road Vehicle Test Conducted At Stockton's Emission Test Facility

- No updates at this time

NOx Mitigation Study

- No updates at this time

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

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

Test Schedule-Pretests

- Stockton test of Truck equipped with 2006 engine completed
- MTA emissions characterization pretest
- CE-CERT pre-test

Test Schedule-Main Tests

- Biodiesel and renewable diesel characterization study
 - NOx impact study (CE-CERT)
 - Engine one-Spring
 - Engine two-Spring-early Summer
 - Phase one NOx mitigation study Summer 2008
 - On-road vehicle characterization study (MTA)
 - Spring-early Summer 2008
 - Stockton-off-road vehicle study
 - Start in 2008
 - NOx Mitigation Study
 - CE-CERT Phase one
 - MTA Phase two
 - Mid-Late Summer

Discussion

NOx Mitigation Study

- Collaborate with CRC
- Evaluate four strategies
- Selection Considerations
 - Data supporting the effectiveness of strategy
 - Feasibility to be commercially relevant
 - Compatibility with existing infrastructure

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

- TRUs
 - Test B100 on TRU engines
 - Proposed test will be conducted be conducted at the small engine dynamometer facility in El Monte
 - Estimated to be conducted in the Summer 2008
- Durability Study
 - Discussions with CRC
 - Request for proposal

In Kind Contributions

- Fuels
 - 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 March 2008