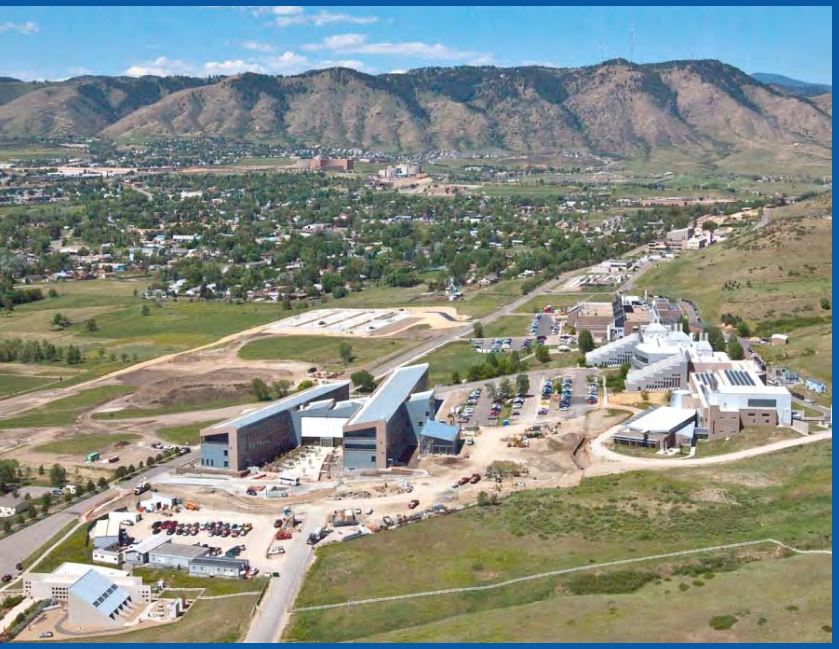
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Impact of Biodiesel on Modern Diesel Engine Emissions



Vehicle Technologies Program Merit Review – Fuels and Lubricants Technologies

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Washington, DC

Project ID: FT011

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Overview

Timeline

Start date: Oct 2010

End date: Sept 2011

Percent complete: 66%

Program funded one year at a time

Barriers

VTP MYPP Fuels & Lubricants Technologies Goals

- By 2013 identify light-duty (LD) non-petroleum–based fuels that can achieve 10% petroleum displacement by 2025
- By 2015 identify heavy-duty (HD) non-petroleum–based fuels that can achieve 15% petroleum displacement by 2030

Budget

Total project funding

FY10: $1.8 M

FY11: $1.6 M – estimated

NBB cooperative research and development agreement (CRADA) provides around $750K per year to cost-share biodiesel research

Partners

- National Biodiesel Board (NBB) and member companies
- Manufacturers of Emission Controls Association and member companies
- Engine Manufacturers Association and member companies
- Coordinating Research Council and member companies
- Colorado School of Mines
- Oak Ridge National Laboratory
- State of Colorado

Relevance / Objectives

Objective: Solve technical problems that are preventing expanded markets for current and future biofuels and biofuel blends

Necessary to achieve MYPP petroleum displacement goals and RFS requirements

Goal of solving problems for current biofuels and early identification of problems for future/proposed biofuels – valuable information for planning future R&D

Relevance

- To date there is a large amount of data showing biodiesel's impact on emissions from older model engines manufactured prior to 2007 EPA standards
- There is a lack of data showing biodiesel's impact on modern diesel engines equipped with aftertreatment technology manufactured after 2007

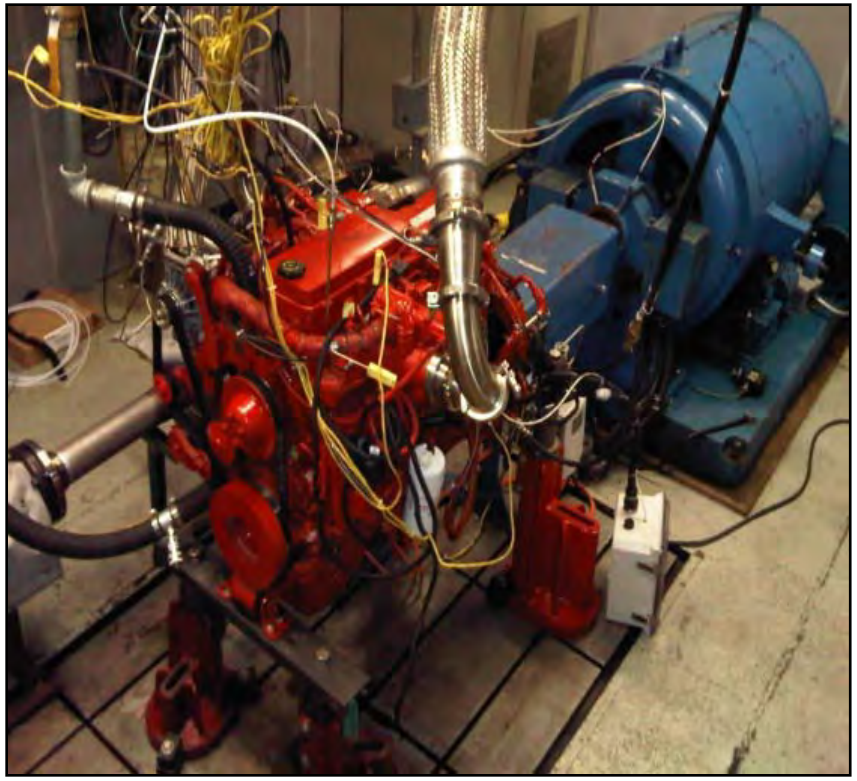
Objectives

- Investigate the impact of biodiesel on emissions in modern engines equipped with aftertreatment systems
- Investigate how changes in emissions seen with biodiesel compare to changes in emissions seen with various petroleum diesel fuels available in the market
- Investigate how biodiesel will impact the operation and maintenance of diesel aftertreatment systems

Biodiesel Tested in Model Year 2008 Engines

- 2008 International MaxxForce 10
- DOC + DPF equipped engine
- Used in fire truck applications

- 2008 Cummins ISB
- DOC+DPF equipped engine
- Used in transit bus application

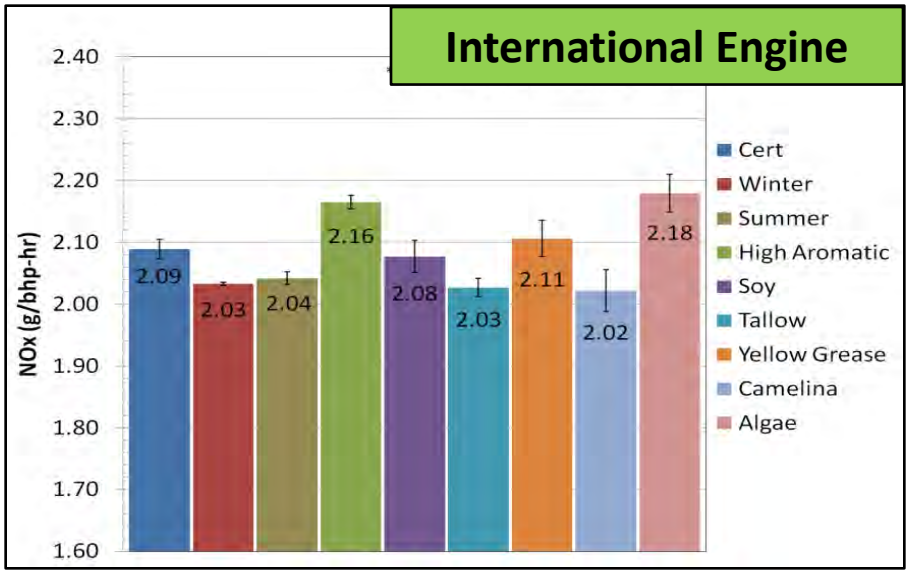


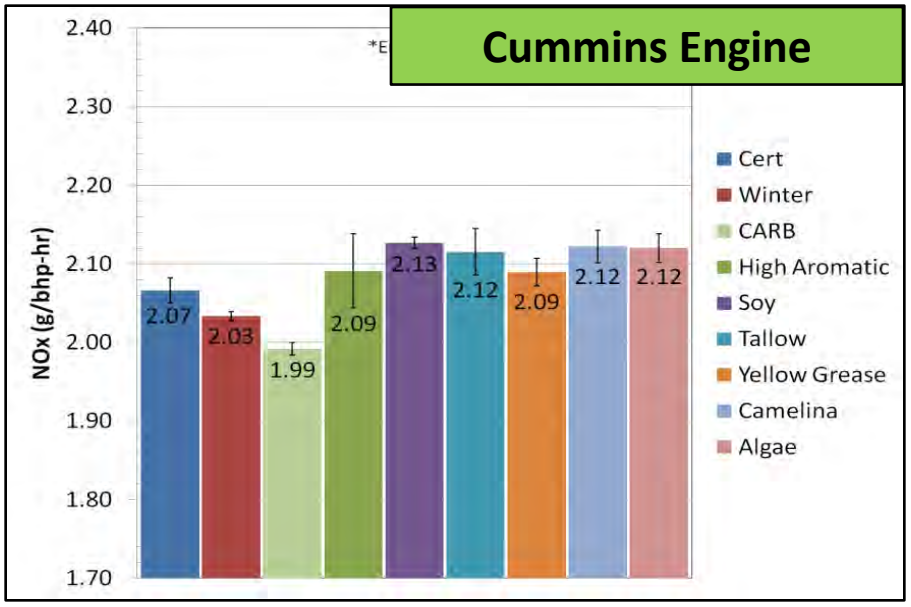
Experimental Approach

- Emission testing conducted with nine different fuels
- Testing conducted over the Heavy Duty Diesel Transient test cycle
- Measurement of NOx, CO, THC, PM and fuel consumption

Test Fuels	Cetane #	Aromatics (%)
ULSD (certification)	43.6	32.8
ULSD (local pump)	51.3	24.4
ULSD (low aromatic)	51.2	9.4
ULSD (high aromatic)	43.9	36.7
B20 (soy + cert)	49.7	26.2
B20 (tallow + cert)	50.1	26.2
B20 (yellow grease + cert)	47.5	26.2
B20 (camelina + cert)	47.9	26.2
B20 (algae + cert)	48.4	26.2

Emission and Fuel Consumption Results

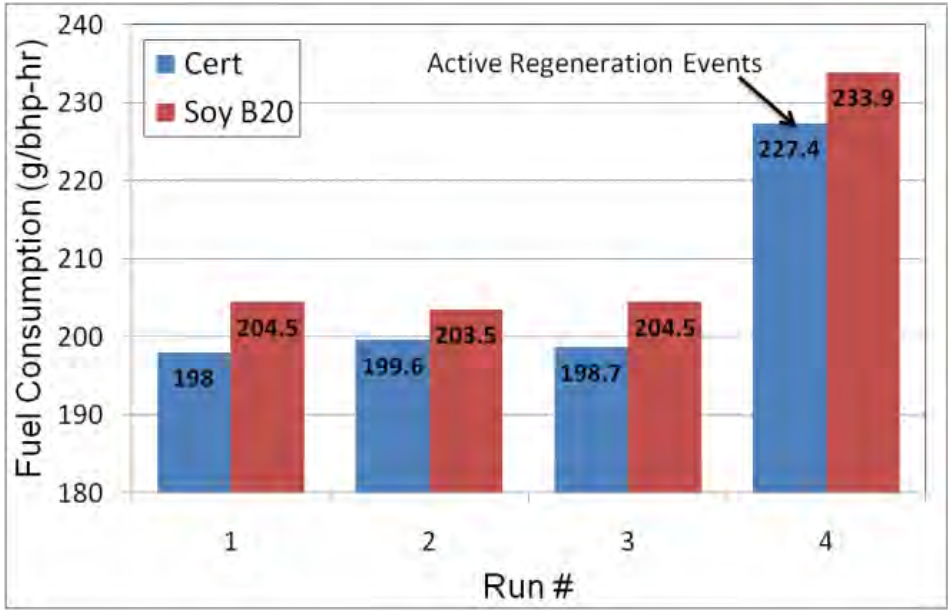




- International B20 NOx emissions fall within variability seen for petroleum diesels
- Cummins B20 NOx emissions ~2% higher
- Fuel consumption ~2% higher for B20 on both engines
- DOC+DPF reduces tailpipe emissions of CO, THC and PM to extremely low levels
- Impact of B20 on tailpipe CO, THC and PM cannot be measured

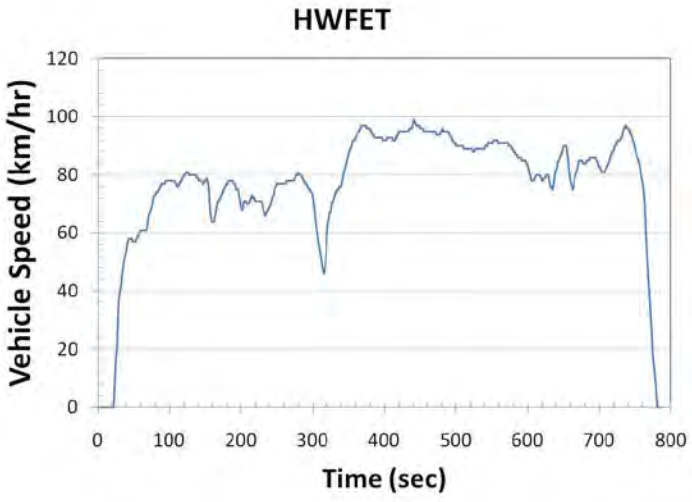
DPF Regeneration Event – International Engine

- Soot stored on DPF must be burned off about every 500 miles
- Regeneration created ~300% increase in NOx and ~15% increase in fuel consumption
- Biodiesel results in slower soot loading for a DPF
- Thus, DPF may regenerate less often with biodiesel
- Potential for NOx reduction and increased fuel economy with biodiesel

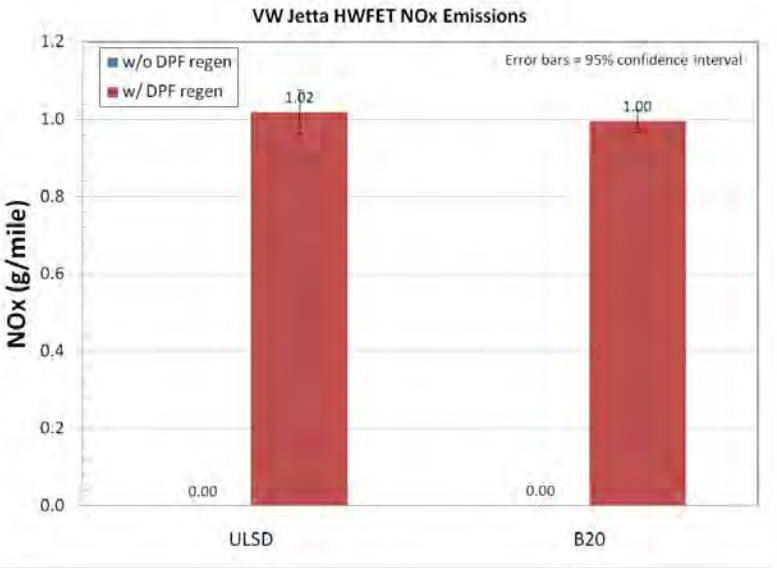


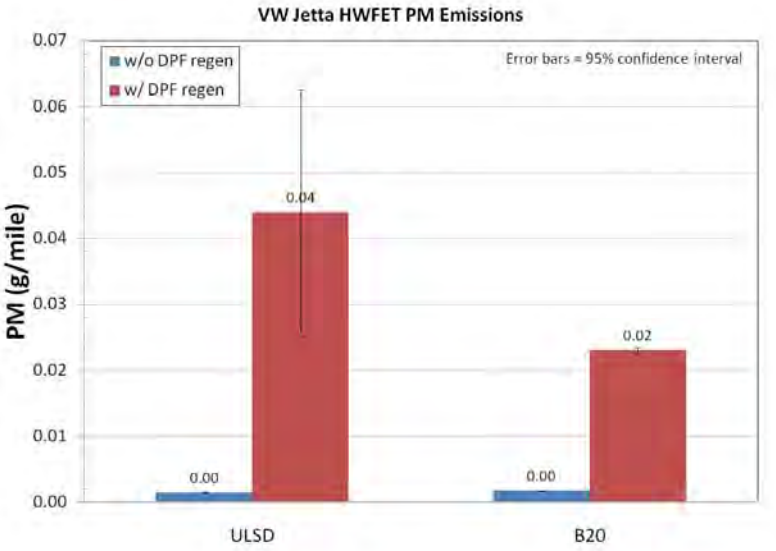
Biodiesel Tested in a 2010 VW Jetta

- 2010 VW Jetta – 2.0L TDI, DOC+DPF+LNT, Tier II Bin 5
- Emission testing conducted with ULSD and soy B20
- Measurement of NOx, CO, THC, PM and fuel consumption
- Testing conducted over the Highway Fuel Economy Test (HWFET) cycle
- Three hot-start repeats of HWFET with each fuel
- Investigation of DPF regeneration event
- Three hot-start repeats of HWFET during a forced DPF regen event
- DPF was pre-loaded with 7.8 grams of soot prior to each regen event

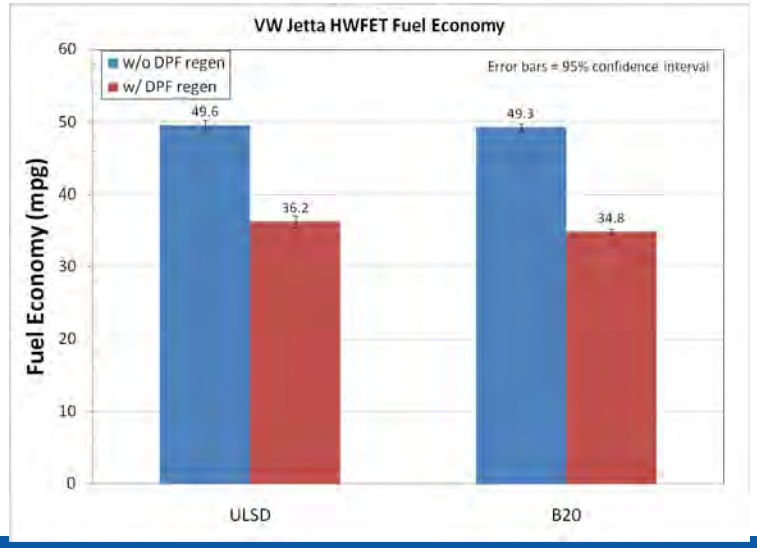


VW Jetta – Emissions and Fuel Economy Results

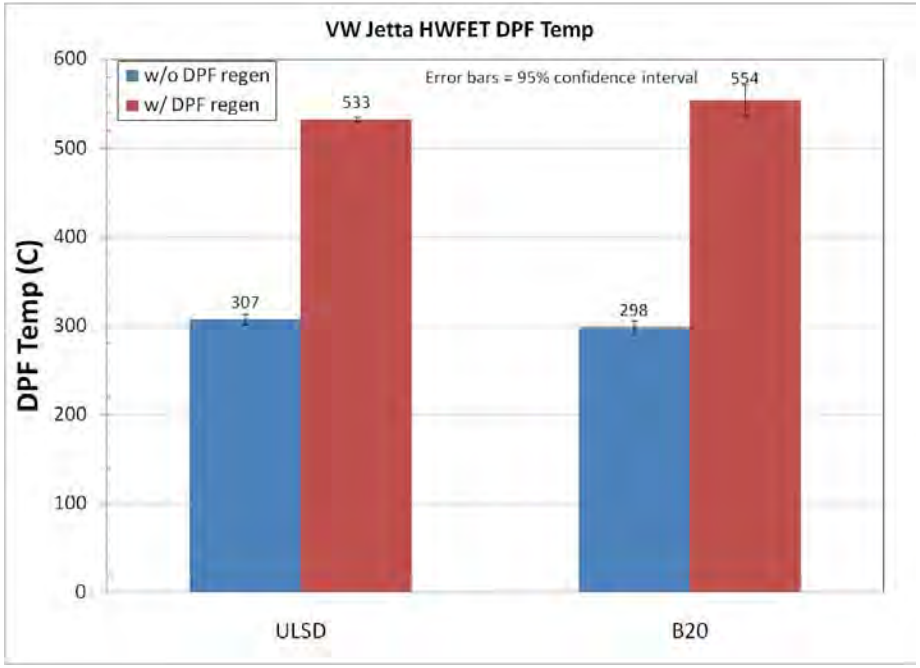




- No difference in NOx or PM for B20
- DPF regeneration event creates dramatic increase in NOx emissions
- PM slip seen during DPF regeneration event
- B20 had no impact on fuel economy compared to ULSD under normal operation
- 27% lower fuel economy during regeneration event with ULSD
- 29% lower fuel economy during regeneration event with B20

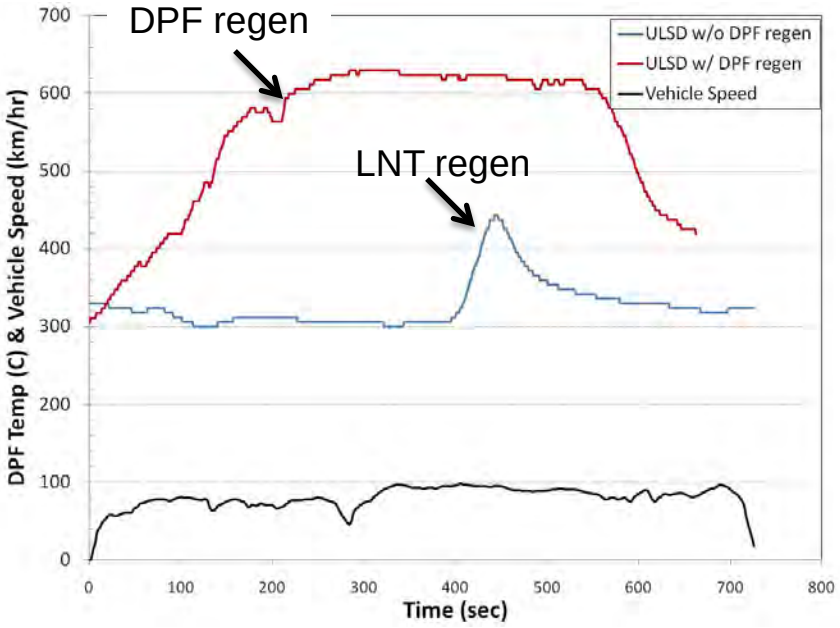


VW Jetta – Regeneration Event



- B20 resulted in slightly lower DPF temperatures during normal operation
- B20 resulted in slightly higher DPF temperatures during regen operation

- Soot load with ULSD 3.7 g/hr over HWFET
- Regeneration frequency approximately 200 miles with ULSD over HWFET
- Soot load rate and regen frequency still unknown with B20



Proposed Future Work

- Continue work to fully quantify the impact of regeneration events on emissions and fuel economy
- Additional dynamometer testing will measure the impact of biodiesel on lube-oil dilution during regeneration events
- Measure the impact of biodiesel on full useful life durability of emission control system
- Measure the impact of other advanced biofuels, including hydrocarbon biomass-based diesel fuels, on emissions and fuel consumption in modern diesel engines

Summary

- Biodiesel's impact on NOx emissions is still difficult to define in modern diesel engines
- Biodiesel's impact on THC, CO and PM can no longer be seen in DPF-equipped engines
- Biodiesel showed ~2% increase in fuel consumption in HD engines
- Biodiesel showed no change in fuel consumption in LD vehicles
- DPF regeneration events have dramatic impact on NOx and fuel consumption
- Biodiesel's impact on DPF regeneration events still needs to be fully quantified