Summary of the Biodiesel Forum and Technical Roundtable

Convened by the South Coast Air Quality Management District

November 7, 2006

Prepared for

South Coast Air Quality Management District
21865 E Copley Dr
Diamond Bar, California 91765

Contract Number: 07012
Task Order No. 1

May 25, 2007

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TIAX Case D0408.00.01

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Executive Summary

The South Coast Air Quality Management District (SCAQMD) convened a technical forum and roundtable discussion on key public policy issues associated with using biodiesel in heavy-duty vehicles (HDVs). Representatives and experts from Federal, state and local agencies, interested stakeholders, the biodiesel industry, the petroleum industry, diesel engine manufacturers, and end users of biodiesel-fueled HDVs were invited to a one-day meeting on November 7, 2006 at the SCAQMD in Diamond Bar, California. The forum consisted of presentations by various government and industry experts, followed by representatives of three fleets describing their use of biodiesel in HDVs. Following this, there was a roundtable discussion that included all of these participants. The forum ended with a comment / question & answer period open to the general public.

A wide range of topics were discussed at this forum. All involved the market potential of biodiesel as a sustainable transportation fuel in California, and the associated societal costs and benefits. A specific focus of the forum was to examine the possible role of biodiesel in the context of the AQMD's Draft Air Quality Management Plan.

This report provides a series of summaries about the topics covered, presentations made, and the discussions that occurred during the roundtable. The tables that follow provide broad summaries of findings and conclusions from the forum, organized by key issues.

Table 1. Summary: California Market Drivers, Regulatory Landscape, and Potential

Market Drivers

- √ Compared to conventional diesel, renewable biodiesel has potential to significantly advance three major goals for California 1) reduce emissions of PM and air toxics, 2) displace petroleum usage / enhance energy security, and 3) reduce emissions of greenhouse gases.
- √ The potential for biodiesel blends to result in increased emissions of NOx (an ozone precursor) has been a barrier to wider use in the South Coast Air Basin, which has the nation's worst air quality. Recent testing indicates the relationship between biodiesel use and NOx emissions is complex and remains poorly defined. New test programs and better data are needed to fully resolve questions regarding the impact of biodiesel on NOx emissions. In addition, it will be necessary to validate differences in NOx emissions between the existing fleet and new, post-2007 engines.

Regulatory Policies and Landscape

- √ California has enacted a series of important policy initiatives that relate to biodiesel, including the state's Bioenergy Action Plan and the Governor's Executive Order S-06.
- √ The ARB and the CEC are in the process of translating these policies into more rigorous regulatory initiatives.
- √ The AQMD wishes to work with all stakeholders to help ensure that expanded use of biodiesel in the SCAB advances, or at least does not harm, efforts to attain health-based ambient air quality standards.
- √ The European Commission is targeting usage of 10% biofuels in the transportation sector by 2020.

Potential to Displace Conventional Diesel

- √ Wide-scale use of B5 could make a very significant contribution towards meeting California's goals for petroleum displacement. While feasible, this represents an order of magnitude

increase from current biodiesel usage in California, which will be very challenging to meet over the near term (see "feedstock and supply" table).

Table 2. Summary: Specific Effects on Emissions and Air Quality

Criteria Pollutants and Air Toxics / Effect on Ambient Air Quality

√ There is a consistent PM / NOx emission tradeoff associated with conventional diesel engines; most workshop participants concurred that this tradeoff appears to occur with biodiesel fuels as well.

NOTE: not all participants believe that the available data support this. For example, Robert McCormick (NREL) et al provide significant insight into this issue in a paper published in 2001. Figure 4 in the paper shows that biodiesel fuels with a range of density caused NOx emissions to vary by well over 1 g/bhp-hr, while PM emissions were nearly constant. This indicates that "the NOx/PM tradeoff is NOT at work here." Also, "there is one true outlier in this PM plot, a biodiesel made from linseed oil that had a cetane number below 40 – the engine did not run well on this." (Post-workshop comments provided by R. McCormick, NREL.)

√ The impact on NOx emissions of biodiesel blends up to B20 is uncertain and seems to vary as a function of several factors (e.g., engine types, test conditions, saturated fat levels in fuel feedstock, duty cycles). The NOx impact estimated by EPA's 2003 analysis reflects the disproportionate effect of a single engine type and model year; 45% of the data from over 900 test points are based on a 1991 DDC Series 60 engine, which may have unique sensitivity to NOx emissions. Recent data available from NREL indicate B20 may result in little or no significant NOx increase. Additional emissions tests across a representative matrix of engines (especially those with the newest technology), fuel blends, applications, and test cycles are needed to make definitive conclusions.

√ For PM control, there may be significant synergistic emissions reduction effects of using biodiesel fuel in conjunction with aftertreatment devices such as diesel oxidation catalysts and diesel particulate filters. This is related to biodiesel's tendency to increase the soluble organic fraction and reduce carbon parts of PM.

√ Some test data indicate that biodiesel may help to reduce the ignition temperature of PM within passive DPF systems, assisting regeneration in low-temperature HDV applications. However, petroleum industry representatives have pointed out that there may be interactions between biodiesel and lubricating oil that may increase the deposition of carbon in DPFs. Further work is needed to fully explore the synergistic and antagonistic effects of using biodiesel fuel on after-treatment devices.

√ A formulation is needed for biodiesel emissions certification test fuel.

Greenhouse Gas Emissions / Effect on Climate Change

√ The use of biodiesel can provide very substantial GHG reduction benefits compared to conventional diesel. However, the actual amount of GHG reductions (especially for species other than $C0_2$) can be quite variable. The full fuel-cycle GHG emissions impact of conventional and alternative fuels like biodiesel are complex; a highly accurate analysis requires substantial data as well as carefully crafted assumptions about average production, distribution, and use conditions. More rigorous accounting principles and reporting requirements are also needed.

Table 3. Summary: Feedstock, Supply and Distribution Issues

Feedstock / Fuel Chemistry

√ NREL estimates that sufficient feedstock exist to potentially result in up to 10 billion gallons of biodiesel production in the U.S. by 2030, assuming additional improvements in production yield and related technology. However, it was noted that most of these feedstock are not located within California.

√ Currently, the predominant source of biodiesel is from soybean feedstock. For purposes of

federal programs such as EPACT (1993 and 2005), "biodiesel" refers to mono-alkyl esters on long chain fatty acids derived from vegetable oils or animal fats.

√ Alternative processing technology converts vegetable and animal fats and oils through a refinery hydro-treating process, resulting in a very high cetane diesel-like fuel with very low sulfur and aromatic content. This highly paraffinic fuel is sometimes also referred to as "biodiesel," but technically the better term is "renewable diesel". Renewable diesel may offer a high value blend stock while not producing the potential NOx emissions impact associated with conventional biodiesel, and also allowing for mass distribution through current pipeline infrastructure..

√ There may be synergies between non-ester and mono-alkyl ester biodiesel formulations, as the latter may provide needed lubricity enhancement, while the former provides higher cetane blending opportunities along with mitigated NOx impacts. However, the petroleum industry notes that chemical-based lubricity additives are more cost effective than biodiesel, so this should be considered a "side benefit" rather than a market driver.

<u>Supply and Distribution</u>

√ Many new biodiesel plants are under construction, and some existing plants are undergoing expansion. Capacity additions underway within the biodiesel industry are expected to increase supply from approximately 500 million gpy today, to approximately 2 billion gpy by about 2030, if all currently planned and under-construction plants become operational.

√ There is need for more systematic assessment of the integrated water and resource requirements for sustained biodiesel production above 2 billion gallons nationally.

√ There is a potential for additional corn-based ethanol demand to stimulate the conversion of soybean production into corn production, thereby changing the potential supply picture for biodiesel in the medium term.

√ Some workshop participants believe that biodiesel valuation can exceed diesel cost per gallon based on its premium blending value from its low sulfur and aromatic content. Not all participants agree. An oil industry representative notes that compared to ULSD, biodiesel has poorer oxidation stability, reduced energy content, and it cannot be pipelined with petroleum diesel -- all of which contribute to higher transportation costs and poor overall economics.

√ There are significant production cost credits – including a federal excise tax credit for producers of $1.00 per gallon – which enhance the near-term market potential of biodiesel.

√ Jet fuel contamination concerns will likely prohibit the transport of any biodiesel product via pipelines. This is due to the propensity of biodiesel to deposit trace materials due to surface interactions during its movement within the pipeline.

√ Unlike diesel refining, biodiesel production is more amenable to a distributed production business model in which relatively smaller volume plants are situated near production areas and or distribution facilities. This agility will be increasingly important if the growth in biodiesel continues along its most recent trajectory.

√ The oil industry has been historically centered on very high volume production and distribution practices; applying this business model to biodiesel will present near-term logistic challenges.

√ The potential high-volume demand for biodiesel by refiners could reinforce the value of strict product quality standards, especially as various feedstock besides soybeans are used within California to produce biodiesel.

√ Localized biodiesel production offers opportunities for community partnerships typically not available to oil refiners seeking to increase regional production capacity.

√ Distributed energy production offers significant opportunity to more efficiently match incremental growing diesel demand with incremental biodiesel production and distribution networks.

√ A gradual deployment for biodiesel, rather than an expedited high-volume biodiesel commercialization, is most optimal for California. This approach provides the necessary time for all production to attain the highest standards feasible for quality and downstream consistency (see Table 4). NOTE: an oil industry representative pointed out that the GHG impacts of FAME- based biodiesel are uncertain. If FAME-based biodiesel is shown to have poor GHG performance, California's LCFS may curtail its production.

Table 4. Summary: Product Quality, Specifications and End-User Impacts

Specifications and Product Quality

- √ Consistent product quality through the entire value chain – from production, distribution, storage and use – is critical to ensure customer acceptance and growing, sustainable commercialization.
- √ ASTM 6751 has defined biodiesel as a fatty acid ester with limited levels of alcohols, glycerin, free fatty acids, and catalysts. A recent modification now includes a specification for oxidation stability. More detailed specification of blended fuel properties need to be measured.
- √ The test methods underlying current B100 and D975 specifications were derived from either diesel test methods or from FDA practices; there is a need to develop more robust, sensitive and repeatable test methods designed specifically around biological properties of biodiesel.
- √ Currently, there is no biodiesel blend specification beyond B5.
- √ A final blend specification is needed that reflects the review and best judgments of the ASTM process. This may take several years to achieve.
- √ Production Q/A voluntary standards for producers and distributors have been issued by the National Biodiesel Accreditation Commission, formed by various industry leaders through their efforts with the National Biodiesel Board. These BQ 9000 accreditation standards define high industry benchmarks for storage, sampling, testing, blending, shipping, distribution and fuel management practices.
- √ There may be a need to further codify these standards into enforceable product quality requirements to ensure high product integrity and consistency, as biodiesel use approaches 3-4 billion gallons, compared to the current 580 million gallons of annual national production volume.
- √ NREL has published detailed best practices manuals for production, distribution, storage and use of biodiesel (September 2006, http://www.nrel.gov/docs/fy06osti/40555.pdf).
- √ A 2006 NREL B100 survey showed that 59% of B100 sampled did not meet ASTM D6751.
- √ Only 13 of 89 production plants, representing 30% of biodiesel production, are currently certified under the National Biodiesel Board's quality assurance standards.
- √ B100 specifications can be designed to accommodate 2nd generation biodiesel formulations that result in zero oxygenates through the conversion of feedstock into paraffinic HC's. NOTE: one workshop participant points out that such "2nd generation formulations" are not mono-alkyl esters and don't qualify as "biodiesel" – thus, they will need to have separate fuel specifications.
- √ EMA has issued a "test specification" to facilitate use of B20 or below, but has not issued a final commercial specification.
- √ More data are needed, especially on new engines (e.g., new fuel injection systems and aftertreatment devices), to better understand the issues of operability, compatibility and emissions.
- √ Variability in the quality of B100 can be especially problematic, even when the fuel meets specifications. One goal of improving specifications is to make sure that compliant B100 will not be problematic.
- √ ARB should consider establishing a de-facto biodiesel blend ratio as deemed best suited for wide-scale commercialization.

Demand / End User Impacts / Engine Warranties

- √ Use of up to B5 is unlikely to produce problems for end users if proper fuel specifications are met. Recent problems with trucks using B2 in Minnesota were in part caused by poor product quality (high glycerin content and /or sterol glucosides) for fuel sourced from a supplier registered as BQ 9000 compliant, suggesting that there may be issues with in-use compliance, etc. Some fuel met specifications but was impacted by solid precipitation which was found to occur well above the cloud point.
- √ B5 could become a standard target value for biodiesel blends in a wide range of end uses and

locations.

- √ Generally, engine manufactures won't void warranty for use of B20 or below, but won't cover engine damage if related to biodiesel (or any other fuel).
- √ Users should exercise due diligence to ensure product quality. Many producers do not meet voluntary BQ 9000 specifications.
- √ When quality can be assured in fleet operations, engine manufacturers seem to have much less anxiety about the use of biodiesel.
- √ There are positive lubricity benefits from biodiesel, which may help mitigate concerns about the lubricity levels of ULSD. However, the petroleum industry considers chemical-based additives to be better options than biodiesel as lubricity improvers.
- √ Some users would like to increase the use of higher biodiesel blends, including B100, although such users are in the minority at present.

Table 5. Summary: Confidence Building Measures and Next Steps

Confidence Building Measures

- √ Adopt and implement better ASTM test methods
- √ Rigorous feedstock monitoring
- √ Tighter product quality and uniformity standards
- √ Codified fuel handling best practices
- √ Periodic end-use fuel sampling and testing
- √ Expanded in-use emissions testing across various fuel blends and engine technologies
- √ Emission certification on biodiesel-based fuels beyond 2010.
- √ More extensive in-use monitoring and enforcement (e.g., Dept. of Weights and Measure standards) for biodiesel).

Next Steps

- √ Stakeholders should continue to work together to resolve remaining issues, including to finalize blend specifications and improve industry standards for B100
- √ "Industry finished" fuel biodiesel blend standards need to be completed, e.g.:
  - o Define oxidation stability criteria
  - o Define water separator criteria
  - o Identify cold flow improvers
  - o Address solid precipitation above the cloud point
- √ Air quality impacts of biodiesel should be further assessed through emissions research
- √ CARB will conduct a multimedia evaluation on biodiesel
- √ The State needs to develop regulations and guidelines for use of biodiesel blends as a greenhouse emission reduction strategy
- √ Improved industry practices should be worked on, e.g.:
  - o Develop a biodiesel fuel education program
  - o Promote and expand the use of BQ-9000 or similar quality programs intended to provide consistent product
- √ Up to B5 can be promoted as preferred blends for California while quality, distribution, supply, and performance issues are resolved
- √ Testing should be ongoing to ascertain the severity of potential performance and durability problems and evaluate / develop solutions

1. Background and Forum Agenda

The South Coast Air Quality Management District hosted the Biodiesel Forum and Technology Roundtable at the AQMD headquarters on November 7, 2006. The purpose of the Forum was to examine the possible role of biodiesel in the context of the Draft Air Quality Management Plan currently under consideration.

There are numerous issues related to the use and possible expanded commercialization of biodiesel. There is growing recognition of the fuel diversification benefits offered by biodiesel as a means of addressing important energy security and global climate change imperatives. Biodiesel can also significantly reduce the impacts on air toxics and particulate emissions. However, air quality regulatory agencies such as AQMD and CARB are concerned about the potential for NOx emission increases with varying levels of biodiesel blends. Concerns about fuel quality specifications and biodiesel's impact on engine warranties have also been raised by certain stakeholders.

The Forum was held to provide perspectives of key stakeholders involved in the regulation, production, distribution and use of biodiesel. Specifically, the Forum explored the following issues related to biodiesel:

- Supply perspective of the California Energy Commission in the context of the Governor's recently announced Bioenergy Action Plan and AB 32 related to greenhouse gas emissions;

- California Air Resources Board perspective on appropriate biodiesel specifications;

- Engine Manufacturer perspective on engine operation and warranty and issues;

- Latest emissions research data and planned studies by the National Renewable Energy Lab and the Coordinating Research Council;

- Production, fuel logistics and handling issues from the perspective of major refiners as well as the biodiesel industry;

- User experience and lessons learned from the Cities of Glendale and Santa Monica and the National Park Service, Channel Islands National Park.

Table 2 shows the agenda for the November 7th meeting and the invited roundtable members.

Table 6. Agenda for Biodiesel Forum and Technical Roundtable (SCAQMD, 11/7/06)

9:00 AM	Welcome and Introductions	Dr. Barry Wallerstein, Executive Officer, AQMD
9:10 AM	Background and AQMD Perspective	Paul Wuebben, Clean Fuels Officer, AQMD
9:30 AM	Supply Perspective	Susan Brown, Special Advisor to Commissioner James Boyd, California Energy Commission
9:50 AM	Summary of Emissions Issues	Chris Weaver, President, Engine Fuels and Emissions Engineering, Inc.
10:10 AM	Regulatory Perspective	Dean Simeroth, Chief, Criteria Pollutant Branch, California Air Resources Board
10:30 AM	***Break***	
10:50 AM	Market Status and Potential for California	Steve Howell, Chair, ASTM Biodiesel Committee and Director, Technical Committee, National Biodiesel Board
11:05 AM	Proposed Biodiesel Specifications	Roger Gault, Technical Engineer, Engine Manufacturers Association
11:20 AM	Engine Manufacturers' Perspective	Barbara Goodrich, Manager Engine Fluids, John Deere Product Engineering Center
11:35 AM	Production, End Use and Emissions Issues	Robert McCormick, Ph.D., Principal Engineer, National Renewable Energy Laboratory
11:50 AM	Recent and Planned Biodiesel Studies	Ken Kimura, Global Fuels Technology BP, Coordinating Research Council (Advanced Vehicle/Fuel/Lubricants Committee)
12:05 PM	Refiner Perspective (including downstream marketing)	Roger Organ, Emerging Fuels Technical Consultant, Chevron USA Inc.
12:20 PM	***Lunch (60 minutes)***	
1:20 PM	User Experience and Perspectives	**Moderator:** Michael D. Jackson Senior Director, TIAX LLC
		Rick Sykes, Fleet Superintendent, City of Santa Monica
		Robert LaRoche, Fleet Manager, City of Glendale
		Kent Bullard, Maintenance Supervisor, National Park Service, Channel Islands National Park
1:50 PM	Expert Roundtable Discussion	**Moderator:** Michael D. Jackson Senior Director, TIAX LLC
3:30 PM	**Public Comments**	
4:00 PM	**Adjourn**	

The roundtable facilitated face-to-face discussions about important biodiesel issues among experts and end users on the agenda above. It also provided the general public with opportunity to ask questions of these experts and end users.

TIAX LLC was responsible for documenting written and oral content from the roundtable, moderating the roundtable discussion, and writing this report summarizing the findings of the meeting. In writing this report, we have attempted to accurately summarize the meeting through notes that outline each presentation, questions and answers, and by synthesizing the major points and conclusions that were reached during the meeting. This report is NOT a literal transcript of the forum or statements made by participants, nor does it attempt to claim consensus on any given summarized point. Readers who seek exact wording of a participant's comments including specific context should review transcripts. A recording of the entire forum webcast (approximately six hours of discussion) can be viewed by selecting the desired link directly from the menu below:

Direct link to Webcast recording of Biodiesel Forum and Technology Roundtable:

11-07-2006	Biodiesel Forum and Technology Roundtable (more info)	Broadband - Dial-Up -Audio Only

In addition, individual presentations made by forum participants can be viewed on AQMD's webpage by selecting the link below.

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/biodiesel_forum_agenda.htm

2. Forum Topics and Presentations

2.1 Background and AQMD Perspective (Dr. Barry Wallerstein, Paul Wuebben)

Dr. Barry Wallerstein, AQMD Executive Officer, opened the forum by providing some important context for the day's activities. He described how the biodiesel forum was part of AQMD's ongoing series of technical roundtables about new fuels, advanced low-emissions technologies and air quality issues – all with the goal to assist AQMD in its mission to restore healthful air quality in the South Coast Air Basin. He described the general need to commercialize and deploy progressively larger volumes of clean fuels in the SCAB, and AQMD's longstanding efforts to assist this process. He noted that AQMD has been cautious to embrace biodiesel as an air quality strategy, due to concerns about the potential to trade off reductions in some pollutants (e.g., PM) with increases in others (NOx). He acknowledged AQMD's general goal to encourage petroleum displacement while pursuing its primary mission to improve air quality.

Paul Wuebben, AQMD Clean Fuels Officer, initiated the forum's detailed technical agenda by providing extensive background on biodiesel issues, and AQMD's perspective on them. The following is a summary. Mr. Wuebben's complete presentation can be accessed at:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Wuebben_Slides.pdf

Mr. Wuebben provided a comprehensive overview of the South Coast Air Basin's (SCAB's) status as a non-attainment area for ozone and $PM_{2.5}$. He described progress, trends, and challenges with meeting the one hour and eight hour ozone standards in the SCAB. Although there has been considerable progress in reducing ozone levels in the basin, trend showing ozone improvements began to level off in the 1998 time frame, as shown in Figure 1.

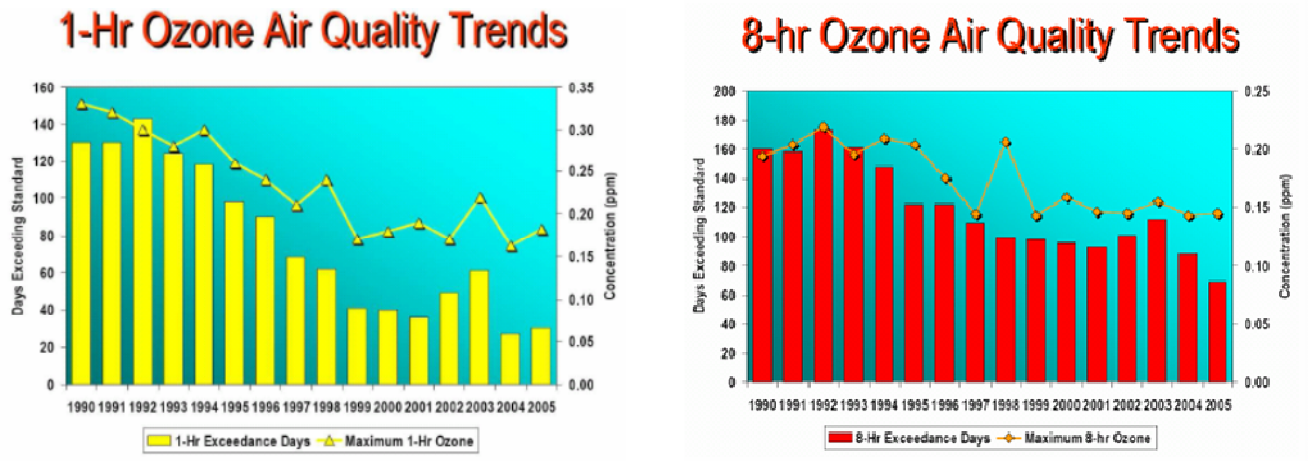


Figure 1. Ozone Air Quality Trends in the South Coast Air Basin

In addition, four counties in the basin have some of the highest annual average $PM_{2.5}$ concentrations in the U.S. High exposures to ozone and $PM_{2.5}$ levels are linked to public health issues of asthma and increased cancer risk.

Mr. Wuebben provided an overview of strategic drivers for the use of alternative fuels such as biodiesel; these include improving ambient air quality, reducing petroleum dependence, and addressing global climate change. He discussed trends in the usage of biodiesel, noting that the U.S. military has been among the largest users of biodiesel.

Next, Mr. Wuebben provided an outline of emissions trends from HDVs that use biodiesel blends, and an overview of market development and end-user issues, such as feedstock reliability, blend level, effect on engine warranties, and impact on vehicle fuel economy. He also discussed the three major sources of feedstock for biodiesel.

Mr. Wuebben provided the following list of "SCAQMD Biodiesel Policies."

- Need to specify composition / source
- Initial focus: agricultural issues
- Focus on blends less than or equal to 20%, starting with lowest blends of 2% to 3%
- Need for no net increase in NOx (achieve PM and NOx reductions concurrently)
- Need to obtain better test data (diversity of engines, test cycles, durability, etc.)
- Potential role in Air Quality Management
- Plan with sufficient NOx mitigation

Mr. Wuebben listed the following R&D needs for biodiesel:

- In use emissions testing of diverse engines, applications and blend rates
- Assessment of supply potential to offset growing conventional diesel fuel demand
- Fuel quality assurance reporting / monitoring
- Assessment of alternative formulations to optimize emissions, performance and durability

In closing, Mr. Wuebben posed nine "key questions" for further discussion in the forum roundtable. These questions and the discussions that ensued are provided in Section 4.

2.2 Supply Perspective (Susan Brown, CEC)

Ms. Susan Brown of the California Energy Commission presented on this topic. Ms. Brown was speaking on behalf of CEC Commissioner James Boyd, who is Vice Chair & Presiding Member of the Transportation & Fuels Committee. The following summarizes Ms. Brown's presentation; her complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Brown_Slides.pdf

- California is 95% dependent on petroleum for the transportation sector (people and goods movement)

- Californians drive a lot; state usage in 2005: gasoline 15.7 billion, diesel 2.9 billion, ethanol 900 million, alternative fuels 535 million (all gallons)
- The demand for fuels like gasoline and diesel in California is expected to grow at a significantly faster rate than state's available supply, assuming no change in the volume of fuels imported (see Figure 2)

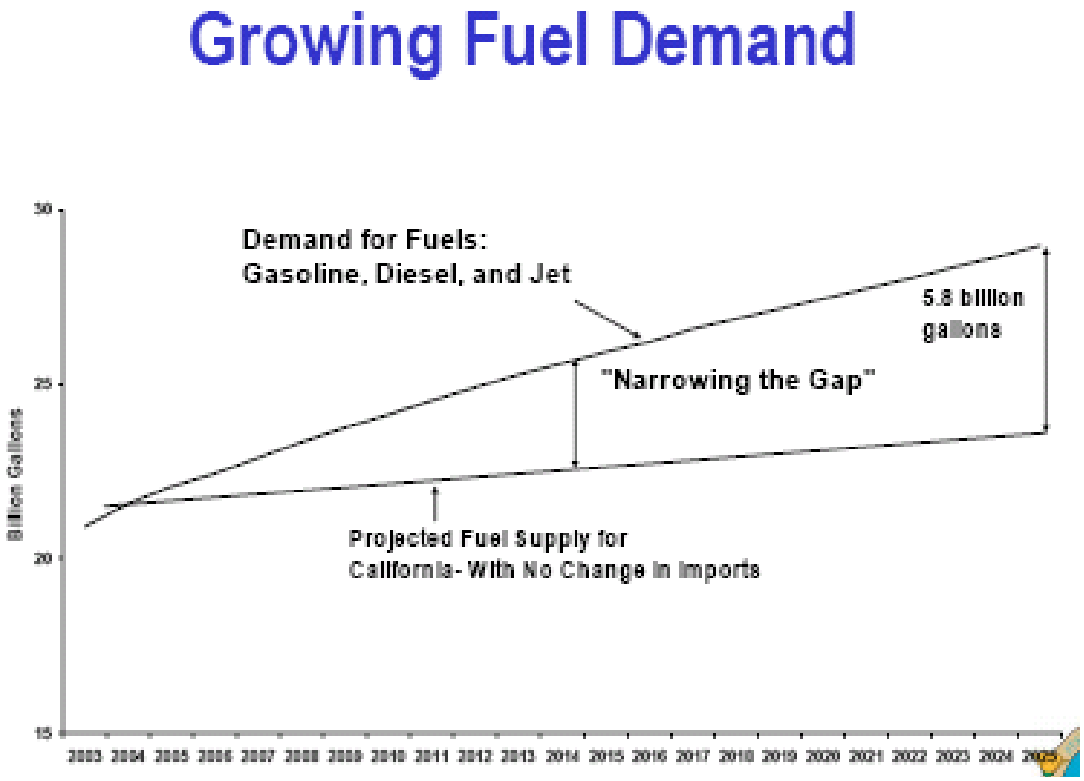


Figure 2. California's growing demand for fuels vs. the projected fuel supply

- California has vast sources of biomass in state—and various pathways to produce biofuels; estimated production of 2 billion gallons by 2010, and 3 billion by 2020
- The state needs to narrow the gap between demand and supply by importing products, improving fuel efficiency, and moving to alternative fuels
- Petroleum displaced by alternative fuels: natural gas 22 million gallons, biodiesel 15 million gallons, propane 4 million gallons
- EPACT compliance[1] is currently a major driver for use of biodiesel in California
- A Bioenergy Interagency Working Group (chaired by CEC) has been convened to identify issues and barriers of bio power, biogas, and bio fuels (this report can be accessed at: http://www.energy.ca.gov/2006publications/CEC-600-2006-004/CEC-600-2006-004-F.PDF)
- B20 is the maximum blend allowed under CARB rules
- Most vehicles can use B5 directly

[1] EPACT allows state and utility fleets an alternative compliance path (to using alternative fuel LDVs) by using biodiesel (and other alternative fuels) in their HDVs

- California Executive Order S-06-06 mandates significant levels of biofuel production (min 20% by 2010; 40% by 2020, 75% by 2050)
- AB 1007 requires CEC to develop a State alternative fuels program; this process is underway including full fuel cycle analysis
- Under AB32 (Global Warming Solutions Act of 2006), alternative fuels are one of the 46 mechanisms recommended to meet goals to reduce emissions from the state's major emissions sectors

2.3 Summary of Biodiesel Emissions Issues (Chris Weaver, EF&EE)

Mr. Christopher Weaver of Engine Fuels and Emissions Engineering presented on this topic. The following is a summary; Mr. Weaver's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Weaver_Slides.pdf

- EF&EE performed a biodiesel study for SCAQMD in 2002; the complete report is available at: http://www.efee.com/download/Final%20Biodiesel%20Report.pdf
- Biodiesel is a liquid fuel with physical and chemical properties compatible with diesel
- It consists of alkyl esters of long-chain fatty acids derived from biological sources; most biodiesel in the U.S. is produced from soy oil.
- Drivers: high petroleum prices, reduce demand for petroleum (reduce prices), reduce petroleum imports, emit less greenhouse gases, comply with EPACT requirements, comply with new AB32 legislation, other environmental benefits (water, and soil spills).
- Most engines will run on up to B100 without modifications
- "Varying degrees of manufacturer acceptance, "consensus" is that up to B5 is okay for general use (okay by EMA). Test programs using B20 show "minimal problems."
- B100 "attacks" rubber engine and fuel line components, but little is known about long term durability (fuel system materials, filter plugging etc.)
- Emissions: impacts of biodiesel on NOx and PM emissions depends on blend amount, feedstock, and engine loads

- Under high loads (e.g., heavy-duty federal test procedure, or HDFTP) NOx emissions tend to increase and PM emissions decrease (see Figure 3).

- Light loads (FTP 75) tend to show decreases in NOx and increases in PM; PM increases come from increases in SOF, outweighs solid carbon decrease at light loads
- Most toxics, CO, and HC reduced; nanoparticticles probably increase, but health effects of biodiesel nano-PM "may be different" than diesel nano-PM
- Biodiesel's effect on NOx emissions during vehicle (chassis dynamometer) testing indicates "no consistent" correlation; NOx emission changes are caused by test cycle and engine technology differences.
- Fatty acid composition does affect emissions; ethyl esters tend to impact NOx and PM more than methyl esters
- Some stocks like tallow and yellow grease have minimal NOx impacts and significant PM reductions

- There is a synergistic emissions reduction effect of using biodiesel fuel in conjunction with catalytic diesel aftertreatment devices (e.g., DOCs), due to biodiesel tendency to increase solid organic fraction and reduce carbon parts of PM
- Other environmental benefits of biodiesel: biodegradable, lower GHG emissions, harmless if spilled, not hazardous.

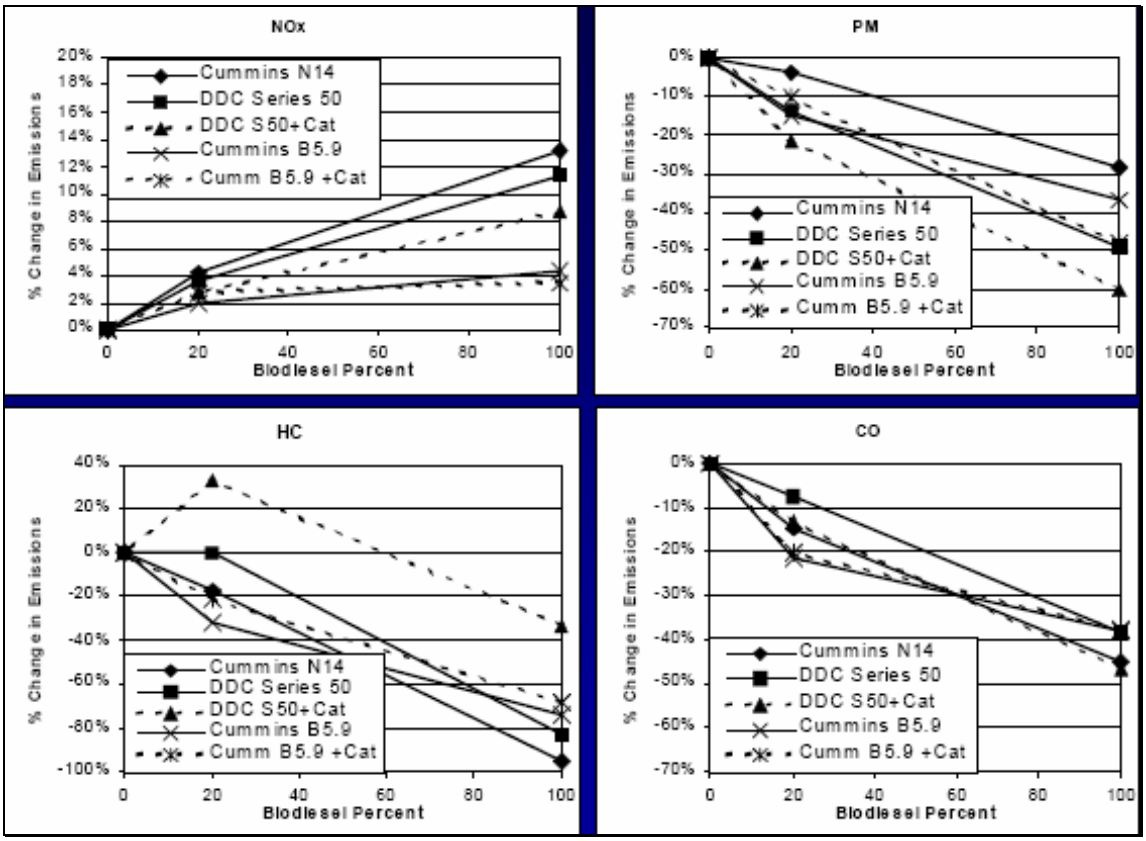


Figure 3. Biodiesel effect on heavy-duty engine emissions during FTP (Engine, Fuels & Emissions Engineering)

- Environmental disbenefits: increased farming leads to greater use of pesticides and fertilizers
- Conclusions: environmental impact mixed, air quality impacts will be minor, synergy with exhaust gas aftertreatment, real world testing needed.

2.4 Regulatory Perspective (Dean Simeroth, CARB)

Mr. Dean Simeroth of the California Air Resources Board presented in this topic area. The following is a summary; Mr. Simeroth's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Simeroth_Slides.pdf

- California needs emissions reductions from mobile sources
- ARB will consider fuel specs for biodiesel fuels

- EO S-06-06 Climate Action Team published report in '06 calling for 2 to 4 percent biodiesel fuel to reduce GHG emissions by 0.8 MMT/year
- Biodiesel-fueled engines can reduce GHG emissions by 70-80% compared to conventional diesel engines
- The potential for GHG reductions is pushing alternative fuel development; ARB's task is partly to mitigate emissions impacts from implementation of these fuels
- California currently meeting 0.5% of total diesel demand with biodiesel. 10x increase needed to blend at 5%
- Competition for feedstock to make fuel versus agricultural uses
- Need to evaluate NOx and other emissions impacts compared to ULSD
- Need fuel specification and to understand how biodiesel affects engine
- To be used in California, biodiesel must meet ARB diesel regs for sulfur and aromatics, and meet regulations for Division of Measurement Standards, which has adopted biodiesel regulations
- Status: ARB has drafted a biodiesel advisory, which clarifies allowable use including with verified PM reduction technologies
- Needed: suitable fuel specs that control emissions and protect engines; "basic" research to better understand how biodiesel affects emissions (esp. NOx); and a multimedia evaluation (per H&S Code Section 43830.8)
- Biodiesel working group set up in 2004, will next meet in December '07
- Next steps: continue to work with affected stakeholders, complete multimedia assessment, complete regulations

2.5 Market Status and Potential for California (Steve Howell, NBB)

Mr. Steve Howell, Technical Director of the National Biodiesel Board (and chairman of the ASTM Biodiesel Task Force) presented in this topic area. The following is a summary; Mr. Howell's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Howell_Slides.pdf

- Energy security was identified during a consumer survey as the most important benefit of Biodiesel
- Federal tax credits exist
- Renewable fuel standards are in place – 7.5 Billion gallons by 2012; not a large driver for biodiesel because ethanol is largely used to meet this requirement
- Seeing increase in OEM support for biodiesel
- EMA has issued a B20 test specification; John Deere supporting biodiesel products
- The biodiesel blendstock specification under ASTM 6751[2] was balloted and has passed

[2] ASTM D6751 provides a complete set of specifications for the purity of biodiesel, independent of the starting material. This standard identifies the parameters that pure biodiesel (B100) must meet before being used as a pure fuel or being blended with diesel fuel. The National Biodiesel Board has adopted ASTM biodiesel specifications. Changes and additions to this specification may still be needed.

- Willie Nelson and other celebrities are interacting with other stakeholders (truckers) to improve overall dialogue
- Significant increase in demand and number of distributor locations (most in Midwest)
- BQ-9000 is a certification for biodiesel fuel producers[3]
- 580 million gallons per year capacity nationwide
- Indiana, Minnesota and Texas have the highest biodiesel production capacities (Figure 4)
- 6.8 million gallons/year average plant size
- Many plants undergoing expansion or construction- 1.4 billion gallons/year to be added, average size will go to 17.9 million gallons per year

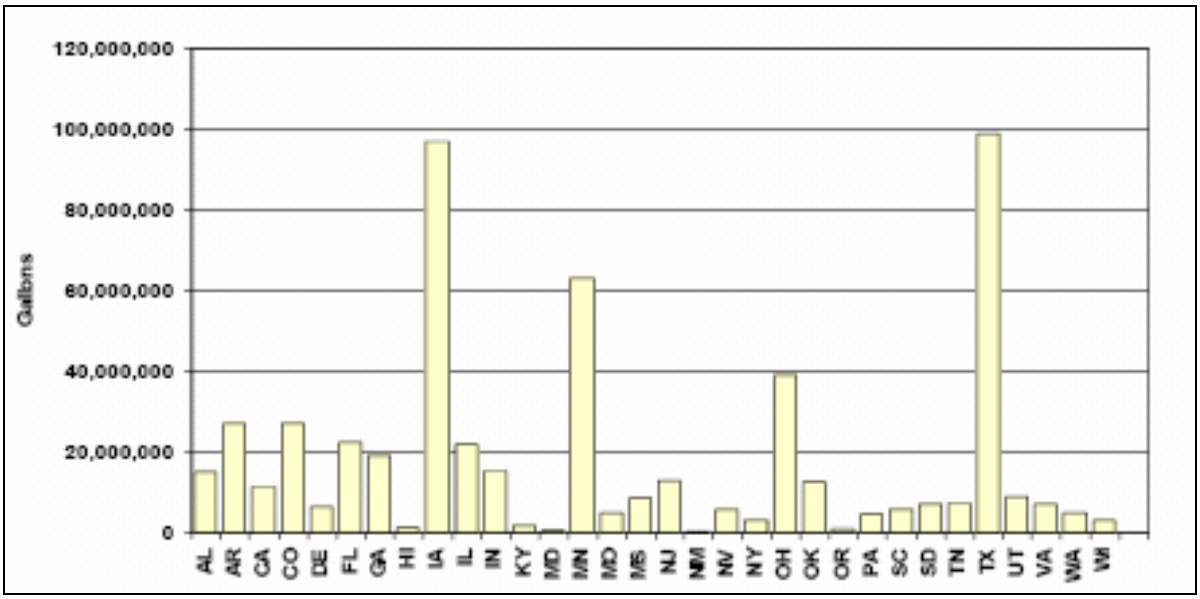


Figure 4. Biodiesel production capacity by state (preliminary as of 8/28/06)

- Biodiesel in 2% blend solves lubricity problems of ULSD
- Energy balance and life cycle reductions of GHGs are key opportunities
- Reductions in HCs may be more important for ground level ozone production rather than NOx
- Maintaining OEM support and ensuring fuel quality are key challenges
- Must confirm B20 effects on new engines and after-treatment
- Other markets are possible and need testing and certifications (railroads, turbines, home heat, etc)
- We will soon be limited by feedstock available for the increased capacity demand. What can we do to grow crops that maximize oil/fat content of feedstock?
- Vision: increase demand, volume use in US equal to 5% of diesel demand by 2018 (1.85 billion gallons/year)

[3] The National Biodiesel Accreditation Program is a cooperative and voluntary program for the accreditation of producers and marketers of biodiesel fuel called BQ-9000. The program is a unique combination of the ASTM standard for biodiesel, ASTM D 6751, and a quality systems program that includes storage, sampling, testing, blending, shipping, distribution, and fuel management practices.

- Conclusions: biodiesel is fast growing alt fuel ("simple and transparent"); has tremendous potential in the U.S.; and "aggressive public policy" will help maximize its potential in CA.

2.6 Proposed Biodiesel Specifications (Roger Gault, EMA)

Mr. Roger Gault of the Engine Manufacturers Association provided the presentation in this topic area. The following is a summary; Mr. Gault's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Gault_Slides.pdf

- Engine manufacturers have limited data regarding biodiesel in real-world usage with current engine technologies
- EMA website http://www.enginemanufacturers.org includes information about biodiesel position
- EMA's "technical position": biodiesel only acceptable as a blend component with petroleum diesel fuel up to B5 maximum, if established standards are met (ASTM D6751, EN 14214, D975) are followed; compliance with California Division of Weights and Measures is also critical since they regulate use of B20
- EPACT is a driver for B20 use, which has prompted EMA to address blends up to 20%
- http://www.enginemanufacturers.org/admin/library/upload/924.pdf provides B20 test fuel spec, which can be a means to evaluate B20 fuel quality
- This "test fuel specification" establishes a baseline B20 biodiesel blend that can be used for further testing and evaluation; it does not imply or constitute EMA's endorsement / approval of B20 blends in any engines
- Engine manufacturers consider the specifications a critical and necessary first step in further testing and evaluating fuel blends with biodiesel content greater than 5%
- Successful implementation of any biofuel requires parallel path development of engines capable of properly using the fuel and quality feedstock, blending and delivery of the fuel itself (see Figure 5)

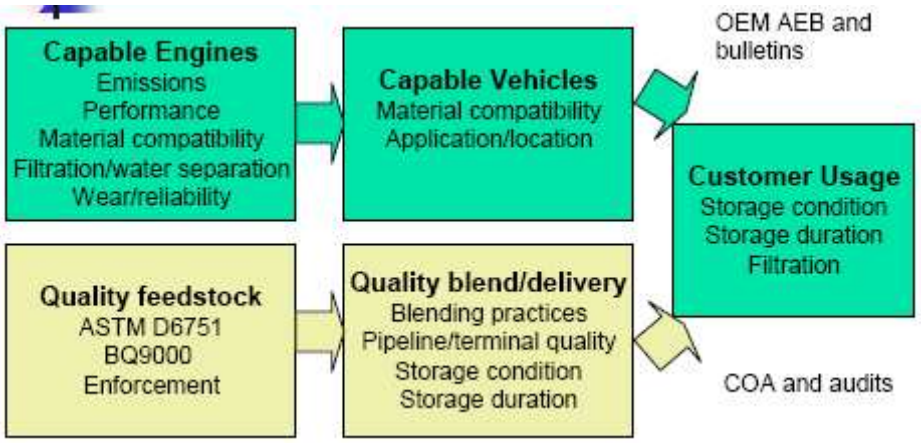


Figure 5. EMA's concept of successful implementation for biofuels (e.g., biodiesel)

- Quality concerns with biodiesel include 1) stability of biodiesel (not stable by nature), 2) microbial growth, 3) water separator performance, material compatability, and cold flow
- Oxidation specification is critical to ensure long term quality of delivered fuel; not all producers meet BQ-9000 requirements
- As capacity increases, there will be more biodiesel being stored; fuel stability will become a bigger issue.
- Not all test criteria exist to evaluate a finished biodiesel fuel blend (e.g. glycerin content)
- Next steps: create "industry finished" fuel biodiesel blend standards to address above concerns, and promote improved industry practices (e.g., education and quality programs)

2.7 Engine Manufacturers' Perspective (Barbara Goodrich, John Deere Engineering)

Ms. Barbara Goodrich of the John Deere Product Engineering Center provided the presentation in this topic area. The following is a summary; Ms. Goodrich's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Goodrich_Slides.pdf

- John Deere has approved B5 for general use in all its products (December 2001)
- Since 2005, John Deere has used B2 for factory fill of tractors, combines, self-propelled sprayers, and other diesel powered machines

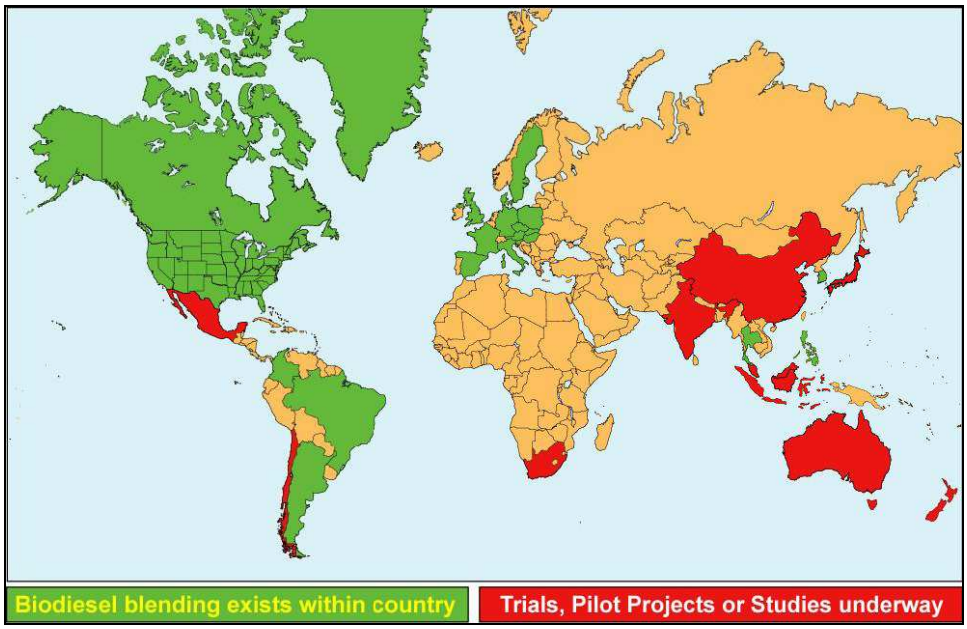


Figure 6. Global view of biodiesel usage, 2006 (Source: B. Goodrich of John Deere, citing IFQC Global Biofuels Center, August 2006).

- John Deere has not gone to higher blends because they do not feel the biodiesel industry has sorted out its quality control issues
- Approximately 1/3 of the total US Biodiesel production is from accredited producers (BQ-9000)
- Global biodiesel fuel usage is increasing from North and South American into Mexico, Australia, and Asia (see Figure 6), but standards vary by area and are all incomplete
- Quality control for B100 and other blends is lacking
    - Minnesota filter plugging was due to out of spec B100 (high glycerine content)
    - 50% of B100 samples checked by NREL did not meet ASTM D6751
- Deere intends to promote B2 until quality issues resolved, then consider higher blends
- Key trade associations (EMA, Fuel Injection Equipment Manufacturers) don't officially recommend blends above B5, primarily due to "standards, quality, and handling issues"
- Customer tests on B20 are ongoing
- In Europe they sell an extended warranty for biodiesel

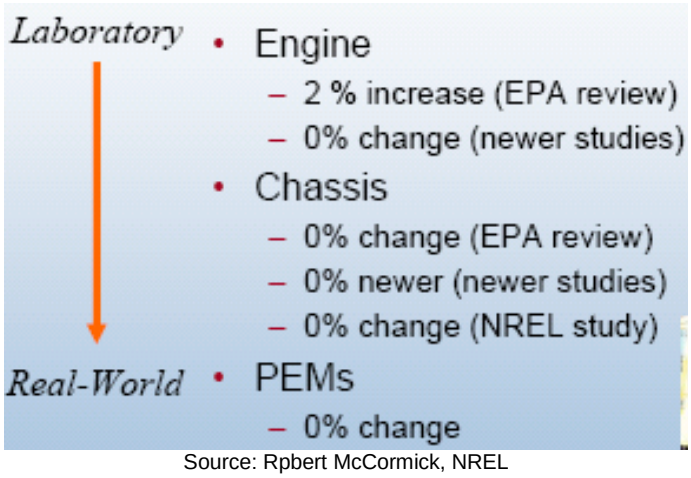
2.8 Production, End Use and Emissions Issues (Robert McCormick, NREL)

Dr. Robert McCormick of the National Renewable Laboratory presented in this topic area. The following is a summary; Dr. McCormick's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/McCormick_Slides.pdf

- NREL has a broad-based program to look at biodiesel
- Emissions: broad agreement that it reduces PM, CO, HC, and toxics;10-20% for B20
- However, NOx impact is uncertain
- The often-cited EPA report that shows a NOx increase was heavily weighted to 1991 DDC engines, which show a consistent slight increase in NOx
- NREL recently published a report (10-06) evaluating emissions impacts from different blends and fuel stocks (see http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/40554.pdf)
- Report shows range of NOx effects; average change from soy based biodiesel is near zero
- Several new studies have shown minimal to no impact of B20 on NOx emissions, including a variety of test methods and types (see Table 7)
- Different engine calibrations and algorithms could explain impacts on NOx levels
- Summary: NOx can go up or down depending on engine
- Potential for NOx increase is not well understood quantitatively; hypothesis is there's a "varying ECU response to small change in density/energy density for B20 versus diesel"
- Reduction in PM and other pollutants from biodiesel is "robust"
- Details provided in slides and report at www.nrel.gov/docs/fy07osti/40554.pdf

Table 7. Summary of B20 effect on NOx emissions, using three different test methods



Source: Rpbert McCormick, NREL
PEMS = Portable Emissions Monitoring System

2.9 Recent and Planned Biodiesel Studies (Ken Kimura, British Petroleum / CRC)

Mr. Ken Kimura of BP (representing the Coordinating Research Council) provided the presentation in this topic area. The following is a summary; Mr. Kimura's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Kimura_Slides.pdf

- CRC project AVFL-2a: "Impact of Biodiesel on Fuel System Component Durability"; (http://www.crcao.com/Annual%20Report/2006%20Annual%20Report/AVFL/AVFL-2a.htm)
- Objective: provide technical data on the impact of B5 and B20 blends on elastomer integrity, wear of fuel injectors, wear of rotary and common rail fuel pumps
- Finding: fluorocarbon elastomers of medium to high fluorine content are most compatible with biodiesel blends; other elastomers may be acceptable in specific applications.
- The lubricity of fuels typically showed no problems with the exception of highly oxidized B20 (beyond what is normally found), which can separate from diesel fuel
- AFVL-2b: scope is to test the effects of realistic storage and handling conditions on biodiesel oxidation in a controlled laboratory environment
- Currently completed literature review, work is ongoing

2.10 Refiner Perspective (Roger Organ, Chevron USA Inc.)

Mr. Roger Organ of Chevron Products provided the presentation in this topic area. The following is a summary; Mr. Organ's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Organ_Slides.pdf

- Recommends the API website (http://api-ec.api.org/aboutoilgas/sectors/segments/index.cfm) for an overview of biodiesel
- Reliability and quality are major issues for fuels, including biofuels
- Costs to produce and handle the fuels are also critical
- There are some fuel characteristics of biodiesel that may need to be specified that are not currently specified for diesel fuel
- Biodiesel has good miscibility with diesel, emission reductions of CO and HC and particulates, but can be compromised at high levels of biodiesel blendstock due to injector fouling ; lower energy content is seen as a problem for consumers; and further research is needed to nail down impacts on NOx emissions.
- Challenges: blends stocks with different properties; Chevron wants consistency in quality (e.g., oxidation stability)
- High feedstock costs; not sure biodiesel is sustainable without government credits; long term issues need time in the market place to work out best practices and cost effective solutions
- Biodiesel production challenges; poor shelf life (see Figure 7), soap formation, filter plugging

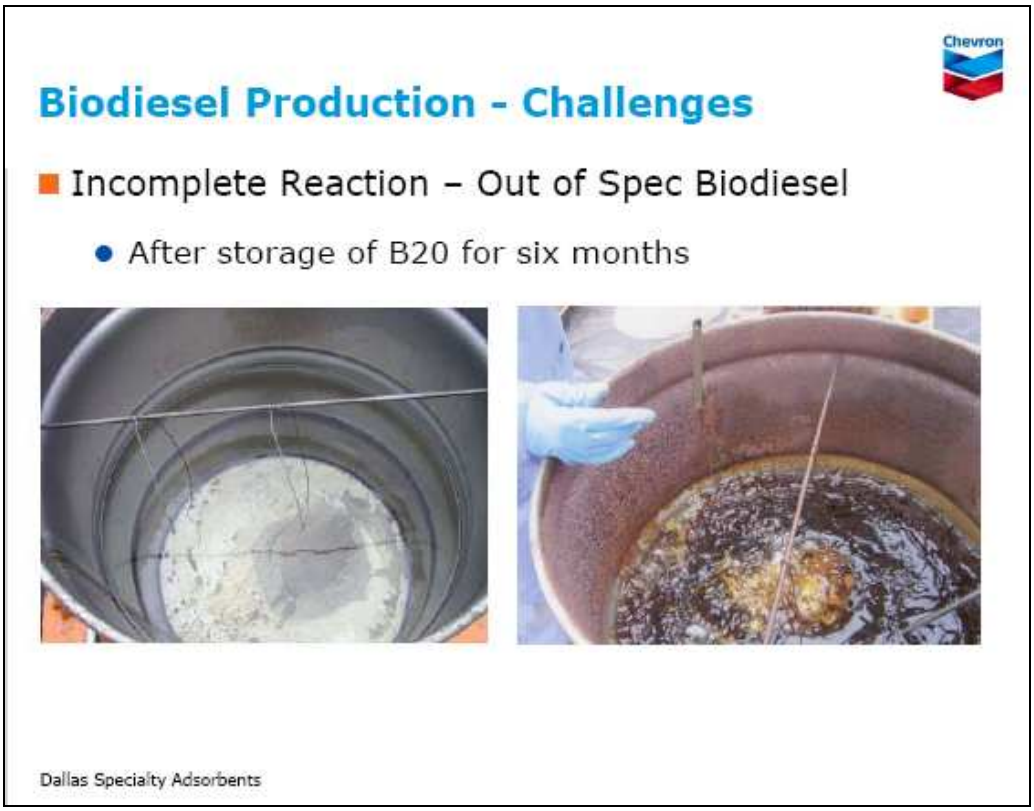


Figure 7. "Poor shelf life" of B20 resulting from production problems that result in excessive amounts of mono-, di-, and tri-glycerides

- The industry's BQ-9000 specification is a good start. Biodiesel blendstock and biodiesel that is sold to market must meet specifications 100% of the time.
- Getting consistent feedstock is a major concern

- Problems with blends usually come from un-reacted or partially reacted oils and fats
- 2% to 5% biodiesel by volume must be handled by pipelines for widespread economical supply; trucks and rail will not be able to handle significantly increased volumes. Trail back into jet fuel in pipelines is seen as a problem and needs more work so that it can be managed. Work is on-going for acceptance of pipelining of B5 blends.
- Chevron considering manufacturing own biodiesel to ensure quality.

3. User Experience and Perspectives

This section provides summaries of the presentations provided by three end users of biodiesel in their heavy-duty vehicle fleets. Mr. Michael Jackson of TIAX LLC served as the moderator for this discussion.

3.1 City of Santa Monica (Rick Sikes, Fleet Superintendent)

Mr. Sikes provided a presentation about the City of Santa Monica's use of B20 in its HDV fleet. The following is a summary; Mr. Sikes's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/Sikes_Slides.pdf

- Santa Monica is working towards "sustainable" city policy (adopted in 1994)
- They seek energy and pollution solutions across all aspects of City activities.
- Place alt fuel vehicles in as many applications as possible
- They give themselves an "A" for effort, but more needs to be done in the transportation sector.
- The City is using a wide variety of alterative fuels in its fleet, including biodiesel, CNG (the greatest number), battery electric, battery hybrids, propane, and hydrogen.
- The City maximizes use of "green" electricity
- They have trained mechanics on biodiesel (e.g., potential for filter plugging)
- They intend to increase biodiesel levels up to B50 and B99.
- The City has had issues reported with their biodiesel fleet vehicles, including plugged filters, injector problems, storage tank issues, and odor issues.
- However, these have largely been proven to be issues of "perception" rather than substantive problems attributable to biodiesel
- It's just like diesel; you can get bad biodiesel, but it's unlikely
- B99 did have a significant increase in NOx over ULSD, in line with other reports
- SCR with urea injection is also being tested
- Santa Monica will stay with CNG for the future, but will also try other fuels.
- Personal preference to see B5 in all diesel fuel, with eventual move to greater use of higher blends

3.2 City of Glendale (Robert LaRoche, Fleet Manager)

Mr. LaRoche provided a presentation about the City of Glendale's use of B20 in its HDV fleet. The following is a summary; Mr. LaRoche's complete presentation can be accessed at the following address:

http://www.aqmd.gov/tao/ConferencesWorkshops/Biodiesel_Forum-11-07-06/LaRoche_Slides.pdf

- The City of Glendale looked at many alt fuels, biodiesel allows least infrastructure changes
- They conducted opacity tests on diesel fleet; B20 with CARB diesel fuel improved smoke tests significantly for their HDVs
- uses alternative fuels including B20 in some of its HD vehicles
- In 2003 they began using B20 with ULSD; they get good, consistent results
- Specifically, Glendale Water & Power (GWP) has been using B20 since 2002 as the only diesel fuel they inventory.
- All diesel equipment they own run on B20 including construction, generators, tools, etc.
- They are very happy with B20, and have not experienced a single biodiesel-related failure
- Never been denied warranty coverage due to using B20
- Their opacity tests showed significant improvements with B20

3.3 U.S. Nat'l Park Service (Kent Bullard, Maintenance Supervisor)

Mr. Bullard, who is the maintenance supervisor for the Channel Islands National Park, discussed his agency's use of biodiesel in heavy-duty park vehicles. The following is a summary (Mr. Bullard did not provide a presentation).

- The Park Service seeks to make positive changes about how it operates, biodiesel is one tool in the toolbox
- Anacapa Island is diesel free, it uses B100 for power generation
- They have used both B5, B20 and 100 in boats
- Some boats have been re-engined, certain heavy-duty engines not optimal for B20
- 63 pieces of equipment use biodiesel in their system (various blends)
- Equipment by equipment decisions are appropriate for blend type
- They seek to maximize biodiesel use in this way
- They must be careful about minimizing fuel spills and impact in the National Park
- He seeks fuel that meets quality specifications
- Airborne Toxic Control Measures can be hard to obtain permits under; there needs to be leeway to allow air districts some flexibility where alternative fuels are concerned
- Supply and cost: very little production on the West Coast is a problem
- Biodiesel from a local resource that meets quality measures is something to strive for
- Supply from the consumer's end is drastically short; need competition and diversity
- Need stable fuel to use in stationary generations; don't run things all the time.

4. Expert Roundtable Discussion

A roundtable discussion followed the formal presentations. This discussion was moderated by Michael Jackson of TIAX LLC. The discussion in the roundtable focused on the questions posed by Paul Wuebben of AQMD in his introduction. These nine questions and a summary of the responses are provided below.

NOTE: prior to the structured roundtable moderated by Mr. Jackson, various panel members engaged in detailed discussions as follow-up to the presentations made. Those comments can generally be categorized within the nine questions below. For convenience to the reader, they have been integrated into the responses below, even though specific comments on these subjects may have been made throughout the forum. Where exchanges and interaction among the expert panel members occurred, context has been kept intact.

4.1 Air Quality Benefits and Issues

Q: What are the air quality benefits and issues associated with biodiesel?

M. Jackson: It seems clear that there is an agreement on reductions of PM, CO, HC, toxics. NOx is a more complex issue. What are the opinions of the panel on whether NOx emissions increase or decrease with biodiesel fuel? If there is an increase in NOx emissions, what are the fundamental reasons?

R. Organ: This gets back to properties we don't measure, in this case, the bulk modulus[4] of the fuel. For B100, the change in bulk modulus advances the timing of the high-pressure injection engines by as much as 2 degrees. This is generally thought to be the reason for NOx increase.

R. Gault: I think there is a NOx/PM tradeoff on diesel and biodiesel that is always present. Changes in the density of the fuel change the local flame temperatures at droplet sites within a diesel cylinder, thereby altering NOx formation. The best we can say is that the NOx emissions associated with biodiesel use are highly variable, but it appears the average NOx increase is close to "a wash".

C. Weaver: To the extent to which we understand the phenomenon, it does appear that the changes are due to bulk modulus changes. However, this doesn't seem to be important in real world applications compared to emissions lab testing on the federal FTP. When you do real world drive cycles it appears that the difference in NOx seems to not be statistically different from zero. The variability is within the current variability for diesel engines, at least for B20. For B100, there isn't much chassis driving data available, but it is worth investigation. There

[4] This refers to the change in volume of a solid substance as the pressure on it is changed.

does seem to be a robust PM reduction that can be enhanced with catalytic aftertreatment devices. My recommendation to ARB on policy is to push forward with B5 universally and B20 where you can use it. At the same time, continue implementing diesel control measures to get particulate control devices out there.

K. Kimura: If you look at recent studies on the NOx impacts of biodiesel, a lot of people try to adjust the parameters that affect NOx formation. However, they don't typically do a good job isolating the factors that impact NOx formation. A current Sandia National Laboratory project does give me hope that we can solve this. Sandia tried to account for bulk modulus by accounting for heat release and timing changes, and they still found NOx increases in that test. Lots of variability exists in the testing. These are very difficult tests to do to isolate all the factors that impact NOx formation.

C. Liu: The tests that show a 2% change in NOx seem to fall within (normal statistical variation). However, most emissions studies in recent years have shown major NOx effects from having "off-specification" biodiesel fuels. The real concern is when the biodiesel industry cannot guarantee fuel quality, which can lead to significant NOx variability and emissions increases. Also, the biodiesel board's goal of 5% biodiesel by 2015 is very ambitious. In the short term there isn't a quantity that really justifies high percentages of biodiesel on a system-wide basis. The panel consensus seems to agree to be go slow, build confidence, ensure quality, see where we are.

D. Simeroth: From my perspective I would agree with that. We need well-crafted test programs to further test the emissions implications of biodiesel.

M. Jackson: To implement a B5 system, it would require an order of magnitude increase in biodiesel production levels.[5]

D. Simeroth: Yes, in fact, an even larger increase would be needed. Moreover, many quality issues must be addressed, especially in lieu of the new emissions standards for HDVs. High pressure single rail injection systems that are emerging to meet stringent standards are different. If we have fuel quality problems, we will have engine failures. The 2010 standards are "make or break" and we can't jeopardize the ability of the HD engine industry to meet them. It's a question of priorities.

R. Gault: When you talk about a 2% variability of NOx on a 2010 engine, we are talking about 2% of a 0.2 gram engine which isn't measurable, at least not repeatably.

Regarding reduction of GHG emissions and California's goals:

Unknown male: how will California meet its goals for GHG emission reductions?

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[5] According to the CEC, about 15 million gallons of diesel were displaced by biodiesel in 2005 in California. This represents about 0.5% of the 2.904 billion gallons of diesel consumed in 2005.

S. Brown: the state hasn't worked out details on a cap and trade system. I would agree that this is a global issue. However, it is very complex and we are looking at how to properly count and credit GHG reductions for fuel created out of state. The AB 1007 process is looking at this. We just don't have all the answers yet.

C. Weaver: It is a global problem. However, California has about 20% of the national economy and uses just a little less than that in energy use. We have extremely limited water resources and rapidly growing cities. Practically, it may not be the best use of water and land resources to grow crops here rather than somewhere else that has better land and water availability.

R. Organ: I agree with Chris on that. Also, it's very difficult to get a complete life-cycle analysis accounting of GHG emissions for these processes. Even aerating the soil creates GHG emissions. We need good science and accounting on GHGs, and then we can develop cap and trade systems.

4.2 Impacts on Engine Performance and Emissions Warranties

Q: What impact does biodiesel have on engine performance and emissions warranties?

B. Goodrich: (John Deere) hasn't really seen any performance issues on biodiesel, but we were using quality biodiesel and quality diesel fuel. I think that's the key.

R. Gault: The engine industry recognizes biodiesel. Generally, our members will honor warranties up to B5 without any issue. B20 is more a case-by-case basis. Warranties aren't voided by use of B20, but coverage will not be provided if a problem is shown to be caused by biodiesel. A number of our members are working with fleets with B20, especially under EPACT, and the fuels appear to be working. For higher blends, we must move cautiously.

R. LaRoche: Glendale Water and Power has been running B20 for the last 6 years as the only diesel fuel we inventory. This means all diesel equipment we own runs on B20 including construction, generators, tools, etc. We have not had a single failure due to the use of B20, and we have never been denied warranty coverage. We're very happy with (B20).

R. Sikes: I spoke about the issues we had, and (these problems were) mostly perception (rather than actual problems attributable to biodiesel).

For D. Simeroth: if (CARB) is waiting on B20, what about B5 being considered a cleaner fuel if we had a solid feedstock?

D. Simeroth: We're going to be considering over the next couple of years if we should have a biodiesel requirement. However, there isn't enough supply to mandate B5.

R. Sikes: I don't mean as a mandate. But if you came out as leaders and recognized B5 as a cleaner fuel, it would help fleets recognize this and get past some of the perceptions. There's no noticeable difference between B5 and diesel.

C. Liu: (AQMD) fully supports fleet applications for B5. However, the benefits of B5 are small enough that we wouldn't push too hard for B5. And there are supply limitations and quality issues to requiring more than B5.

R. Sikes: What about a statement that recognizes B5 as a cleaner fuel?

C. Liu: It is something that we will want to consider.

M. Jackson: If it turns out that there is a significant benefit of biodiesel to lower ignition temperatures in DPFs, then there may be significant air quality benefits in municipal applications or other applications where you don't get up to high enough temperatures to passively regenerate a PM trap. This can help enhance compliance with ARB fleet rules.

Rick Sikes: It's more a question of perception. Because biodiesel blends are seen as alternative fuels there is a stigma associated with using them among fleet operators.

D. Simeroth: The state will be providing grants totaling $5 million for research and development in alternative fuels. Maybe that will help with perception in that it shows the state is investing in these fuels.

B. Goodrich: (Deere) is looking at the effects of biodiesel on emerging, advanced fuel injection systems. For example, high-pressure fuel rail systems may be sensitive to biodiesel blends. A lot of the existing emissions data are on older engines. We need to get a lot more data from a lot more engines and different fuel systems. We aren't sure how much of a problem there is, because there hasn't been much testing done on newer fuel systems.

R. Organ: One of the most cost effective things you can do for high pressure fuel injection systems is to upgrade your fuel handling methods. There is a need to educate end users about what happens when you get water and dirt in fuel for these high pressure systems. Understanding storage and cleanliness requirements will save end users money.

4.3 Blending Levels with Conventional Diesel

Q: What level of biodiesel should be targeted for blending with conventional diesel?

M. Jackson: B20 is okay in CA from a regulatory point of view, but we are probably limited on the supply side for larger demand scenarios as to what blend level we can support. Asking the question to refiners, is there an issue with putting biodiesel in the pool much as is done with ethanol for gasoline?

R. Organ: Our position is that B5 is diesel, except for pipeline issues. We have had problems getting quality assurances from manufacturers and making sure of limitations on the feedstock being used, and the increased costs are an issue.

C. Weaver: We have a number of issues that would be benefited if state policy set B5 as a universal blend. The universal use of B5 has some benefits. 1) There will be a market to grow capacity to B5 levels. 2) Will also ensure the availability of sources of high quality biodiesel. 3) The economies of scale will help reduce costs. 4) Larger facilities that adhere to chemical process standards would help to ensure the production of quality fuels.

P. Wuebben: We need some confidence building measures, such as: 1) Feedstock monitoring 2) Product uniformity standards 3) Fuel handling best practices 4) Periodic fuel end use sampling and reporting 5) In use emissions testing 6) Incorporate B5 into emission test fuels for NTE certification post 2010.
D. Simeroth: CARB's position has been that B49 and lower is considered diesel fuel. The complication has come regarding verified retrofit devices. ARB is putting together a draft policy that will state that verification will be upheld for B20 and lower blends except for NOx reduction verification.

M. Jackson: Has ARB done any testing to see if biodiesel blended with CA diesel meets ASTM fuel standards?

D. Simeroth: No, but we are starting a program with UCR. However, the current regs only refer to aromatics and sulfur content. If you don't alter these then you are by definition still in compliance.

M. Jackson: Most diesel fuel in California doesn't meet the 10% aromatics content.

D. Simeroth: But you still have the 5 basic properties of the fuel: sulfer, aromatic content, PCA content, cetane number, and nitrogen content. Biodiesel doesn't really affect those except by improving cetane number.

P. Wuebben (to D. Simeroth): In practice, virtually all gallons of diesel in California are certified under an alternative formulation provision. That alternative formulation provision doesn't have a database with biodiesel in it. How would ARB handle someone that wants to certify an alternative formulation of biodiesel?

D. Simeroth: Follow the standard process. For using biodiesel in existing certified applications, as long as the biodiesel doesn't negatively affect the five aspects of the fuel that are regulated, then that is a certified application.

P. Wuebben: What about the possibility that high levels of aromatics increases stability of biodiesel?

D. Simeroth: It would be a rare day ARB would endorse increasing aromatic levels in diesel fuels for any reason.

P. Wuebben: Because California has a commitment to lower aromatics, do we create a tougher regime in which to implement biodiesel blends? (Address synergistic effects.)

R. Gault: Early on, Chevron did some testing that indicated ULSD may have certain negative interactions with biodiesel. However, subsequent testing did not seem to substantiate that. But I don't know if it was carried far enough to determine if the interaction was based on aromatics.

R. Organ: This is purely conjecture, but there are some reasons you could see synergistic effects if biodiesel had higher aromatics. One would be improved flow properties. Another possibility, that is perhaps counter-intuitive, is that if you have fuels that have not been fully hydro-treated, they could have higher oxidation test results through better solvency and natural inhibitors being present and lower peroxide values. So it's possible, but I think we just don't know. Oxidation and resultant polymer levels are highly variable and depend on the fuel test matrix. But of course generally hydrotreated fuels are more stable.

4.4 Steps to Enhance Biodiesel Specifications

Q: What steps should be taken to enhance the specifications for biodiesel?

R. Gault: This is an ongoing issue being addressed through ASTM. It would be helpful to identify appropriate tests, especially for blends. We are using petroleum based tests but these are probably not the right tests, simply the closest ones we have.

R. Gault: Beyond focusing on defining specifications and enforcement of those specifications, I'm not sure what more the state of California can do. Until there is a national fuel blend for biodiesel, the manufacturers will continue to design around diesel. The biodiesel industry needs to mature quickly to allow manufacturers to evaluate the impact of a consistent biodiesel fuel on their systems. You can't write a spec tight enough to control everything you need to control, and still produce something on a consistent basis. We need to figure out how to mature this industry in a very short period of time.

K. Bullard: The state (should be) the enforcement agency to make sure BQ-9000 standards are met by biodiesel producers. These standards are a QA certification, not a product certification. So, it is an important role for the state to step forward to ensure that customers are getting quality fuel, and for the ARB to make sure we are using all the same fuel. The state needs to start enforcing the ASTM 6751 standards.

K. Bullard: We need to have a state initiative to develop economical tests that help producers quickly certify fuel quality in the field. Right now we are relying on a certificate of analysis from the manufacture, but we need to know where we can go to be assured we are getting quality fuel.

R. Organ: Agreed. It's absolutely critical that we (continue to improve) the ASTM standards. I still have doubts about traditional oxidation additives and their effectiveness and also cold flow improvers because of the narrowness of the molecular ranges and solubility issues. Biodiesel fuels in cold operations behave differently than the waxes in petroleum fuels and how we treat them needs to be tailored accordingly. It is going to take a few years to sort this out.

K. Kimura: I agree that the important factor is nailing down fuel quality. One of our views is that (ASTM standard no.) 6751 is "kind of on the edge." So it seems more important that quality issues are addressed up front.

B. Goodrich: Producers need to put an antioxidant into biodiesel right at the production stage for enhanced stability.

B. Goodrich: As oil companies get increasingly engaged in biodiesel production, they bring a lot of clout to demand that minimum quality standards be met. They will be buying large quantities of biodiesel to enhance their enforcement clout.

R. McCormick: When you have equipment that sits idle for several weeks at a time (as was stated by Kent Bullard), it is "strongly" recommended that you make a specific request for a stability additive. ASTM specifications aren't necessarily focused on fuel that will sit around for more than one or two months.

C. Weaver: Considering engine manufacturers design their systems around diesel fuel, but perform emissions tests on CARB diesel fuel, there are two things California could do to move forward: 1) set a "date certain" by which the state will move to B5 in all diesel fuel; and 2) set B5 as the emissions certification fuel.

4.5 Key Factors Affecting Supply and Costs

Q: What are the key factors affecting supply and costs?

M. Jackson: It seems (the panel's input is) that biodiesel is more expensive than diesel, but with tax credits, the price for B20 is competitive. However, there is a question of long term sustainability.

K. Bullard: The costs are driven by feedstock costs. There are certain embedded costs that increase the cost of biodiesel over petroleum.

K. Kimura: The only way to transport fuel from production sites east of the Rockies is by train. This is a very unreliable method for meeting high-volume demands. The cost of train transport is adding to costs.

M. Jackons: This (type of transportation system) seems to work with ethanol.

R. Organ: Ethanol expansion is limited by rail. Rail capacity limits any further expansion of ethanol use.

K. Kimura: You are also going to compete with ethanol to transport biodiesel by rail and further strain this infrastructure, along with trade routes that are increasing.

P. Wuebben: It seems there will be additional competition among feedstock. As we move nationally to higher levels of renewable fuel compliance, there is going to be increasing

demand for corn production. One logical change could be to transition towards (more available feedstock).

Q: Have pipeline issues been sorted out with transporting biodiesel by flushing it out with diesel, or is that still a problem?

R. Organ: Biodiesel is surface active so it trails back into jet fuel supplies. Because it can be detected in trace amounts, jet fuel buyers will reject the fuel if it contains biodiesel components. As a result, some pipelines are refusing to transport fuels that have a bio component. The costs associated with pipelines and transmix generation is significant and very different between the US and Europe. In Europe, they flush the pipeline with other products (e.g., kerosene/heating oil) before transporting jet fuel. In the US, it is different because we don't have all these extra other materials we can use to segregate the biodiesel. Because of the trace specifications being put in place, biodiesel is functioning as a contaminant whether or not it actually causes any harm.

K Kimura: One difference in the U.S. compared to Europe is that we have much longer pipe lines. The links here are much longer and result in larger transmixes.

K. Bullard: The 75 million gallons of B100 made nationally last year would get California to a B5.4 for on-road diesel use in California only. Mandates are good but I like the concept of incentives.

C. Weaver: We can have both of those and tax incentives are another way to do it. You can charge more taxes on diesel and less taxes on biodiesel. You can also define trade standards. Given enough time, the oil and refining industries are capable of responding as they did with ethanol.

S. Brown: Is the incremental cost of biodiesel an issue to implementation in the field? Is the federal tax credit enough to offset that additional cost?

K. Bullard: Even though we are a National Park, we still have to pay for the fuel as it comes to us. Biodiesel prices at the USA stations have been constant for the last year at $3.25 a gallon. If I had my choice people would make an environmental choice and pay the same amount at the pump for diesel or any biodiesel blend.

R. LaRoche: The additional cost at B20 levels is pretty small, 5-7 cents/gallon. Over the last year we have paid less for B20 than diesel. The tax credit helps make it equal or cheaper.

R. Sikes: My experience is that the tax credits offset the additional costs.

4.6 Needed Tests and Evaluations

Q: What vehicle and supply test data and evaluations are needed going forward?

R. Gault: Things are changing quickly, and getting ahead of the curve is difficult because (engine) manufacturers are working with prototypes closer to release dates. Because so much is changing, prototypes are extremely valuable to the manufacturers. This is one reason why the engines haven't been available for (biodiesel) testing. If you want to test technologies like SCR, independent of the engine, then it is much easier to do. **But testing a vehicle with a technology that is coming down the road will very difficult to achieve**.

M. Jackson: Are any of the fleets running tests with particulate traps combined with biodiesel?

R. LaRoche: We (Glendale) are not.

R. Sikes: By the end of December, we (Santa Monica) will have six trap equipped vehicles that have been approved by the PM trap manufacturer (to use biodiesel blends).

K. Bullard: The evaluation that needs to go forward also includes the 300,000 million gallons a month we are using in our off-road (vehicle)s. We are concentrating a lot on our on-road segment. But I think we could have a lot more significant effect on our environment by enforcing the use of biodiesel in our off-road segment.

C. Weaver: Kent is quite right. If you look at the projected 2010 PM emissions in the South Coast, PM emissions from the off-road segment are actually greater than that of the on-road trucks. The technology for controlling that is coming a lot more slowly than for on-road.

4.7 Policies That AQMD Should Pursue for Future Biodiesel Use

Q: What policies should AQMD pursue with regard to future use of biodiesel?

D. Simeroth: Should we be considering mandates, incentives, quality standards? Yes. Quality is probably first but hardest. The policies are in place with AB32, 1007, etc. We need the technical information and development to mature to follow through on the policies.

S. Brown: I couldn't agree more. We've done a lot on the policy side in the last year and a half. Based on what I've heard it doesn't sound like we need a technology breakthrough to put biodiesel into the consumer market place. If we can increase production, economies of scale should help bring down costs. We need to tailor our feedstock production to what can be grown here.

S. Brown (in response to a comment about mandating B5): I don't think California can mandate B5, without an act of legislature. But it has been tried in the past.

C. Liu: There is an issue about what position agencies should take on biodiesel. AQMD has nothing in place that says this fuel cannot be used as diesel fuel. The three drivers behind biodiesel are energy, global warming concerns, and air quality concerns. Clearly, the first two are positively impacted by use of biodiesel. In terms of air quality issues, there are many good qualities to this fuel as well. But we also have a concern (e.g, the NOx issue). At this time, we have a preference for low biodiesel blends, but we are open minded. Through events like today and other discussions, we will be looking at how we may need to change our

position on this fuel. Certainly, I don't want to convey that the AQMD is negative on this fuel.

4.8 Potential to Displace Diesel in the U.S.

Q: What is the potential to replace diesel with biodiesel fuel in the U.S.?

M. Jackson: Our potential capacity will be 2 billion gallons (per year?) across the US to produce biodiesel, if all the plants get built. This is small compared to total diesel consumption. We are limited by supply and feedstock.

R. Gault: There has been some research into algae production of biodiesel, which could significantly increase supplies. The potential is there for it to increase by more than an order of magnitude production per acre. If the technology comes to fruition there is potential to greatly exceed the 5% blend levels.

P. Wuebben: If gasification technologies improve, cellulosic sources could also expand biodiesel capacity.

4.9 R&D Focus for Regulatory Agencies

Q: What should be the technical R&D focus on biodiesel for air agencies like AQMD?

D. Simeroth: We (ARB) will be holding a workshop next month to discuss our test programs to identify the source of NOx increase. How do you offset the NOx increase? We will also kick off multimedia tests. DOE is laying out what research should be done for the next 20 years in combustion, and biofuels are a part of that. The quality issue keeps coming back. It won't be one single agency that (addresses all biodiesel quality issues).

K. Bullard: If the state starts enforcing ASTM standard 6751 then it would send a message to the biodiesel industry that we are serious about the quality issues.

D. Simeroth: Enforcement is a resource issue. It isn't that the state doesn't want to enforce the standard. It is a question of resources. They are directing resources to the other 99.5% of the fuels.

C. Weaver: Looking at AQMDs resources, you should (focus on) work combining biodiesel at (various blend levels) with emission control equipment (e.g., diesel particulate filters). This is especially important for non-road equipment.

K. Bullard: One additional place we could combine biodiesel research is worker safety (e.g., construction workers working around backhoes with high PM emissions). It is a workplace health issue.

5. Public Comment

The following individuals provided comments during the "public comment" portion of the forum.

Art Bulla, Biosphere Energy

Question to panel and particularly ARB: is B20 acceptable for non fleet use?
Dean Simeroth: Yes, if it meets all the labeling and other requirements.
Mr. Bulla: The supply will be there for B5 if the barriers are removed. My company will be producing 150 million gallons within three years. I've also listened to Robert McCormick say NOx isn't an issue with B20, but it is still being discussed. I hope this issue gets clarified soon.

Russ Teal – President, Biodiesel Industries

Our company builds, owns, and operates biodiesel plants. There is an absence of actual biodiesel producers at this forum. The refiners don't actually make biodiesel and the manufacturers have their own prospective. We encourage AQMD to invite the actual biodiesel producers.

Product liability coverage carried by fuel manufacturers serves as a backup for users when / if OEMs reject warranties. We've had product liability for the last ten years and haven't had a single claim. One aspect of biodiesel that needs more attention is that it is the only fuel that has gone through Tier 1 and Tier 2 health effects testing. Our company has been working with the Navy (Ventura) on evaluating different feedstock. We've looked closely at what feedstock are available and will be available in the future. There are adjustments in the marketplace that will be made as biodiesel competes for feedstock. However, byproducts from biodiesel can help replace the feedstock (extract oil, replace with glycerine in animal feedstock). NREL publication on best practices for handling and use should be followed.

Because the feedstock are distributed, biodiesel is more suitable to decentralized production, reducing needs for pipeline transport of the fuel. Consider using feedstock that utilize poor soil and low water levels (eg Canola).

Peter Cantle – Santa Barbara Air Pollution Control District

CARB's ACTM needs to allow flexibility for biofuels.[6] Applying toxicity based emissions standards derived for petroleum fuels is not reasonable. PM levels from biodiesel don't have the same toxicity as PM emissions from HDVs on conventional diesel.

[6] Under ARB's Airborne Toxic Control Measures (ATCM) to reduce particulate matter (PM) emissions from compression ignition/diesel engines, fleets must use BACT retrofit technology. Biodiesel in most instances is not approved for use with emission controls verified under ARB's Diesel Emissions Control Strategies

Cal Hodges – NESTE Oil

Mr. Hodges of NESTE Oil provided a handout[7] that includes a "definition of biodiesel." He explained how his company makes a "NExBTL Renewable Diesel" that is a non-ester type of biodiesel with a high cetane number and very low sulfur and aromatics. This fuel reduces NOx, PM, HC, and CO emissions by >15%, >25%, >20%, and >5%, respectively. In addition, toxicity of the exhaust gas is reduced, and GHG emission are reduced by >60% on a life-cycle basis compared to conventional diesel.

Verification Program (DECSVP). CARB staff is working with PM emission control equipment manufacturers to verify their equipment with biodiesel, and ARB's Biodiesel Working Group is working with the industry to develop American Society for Testing and Materials (ASTM) approved methods for fuel specifications.

[7] The handout included a hardcopy of Mr. Hodges' Powerpoint presentation, which could not be scanned into a readable digital format. More information about NESTE Oil's biodiesel fuel can be obtained from: **http://www.nesteoil.com/default.asp?path=1,41,539,7516**