Sustainable Options for Biofuels

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Analysis of Opportunities and Barriers To A Sustainable Generation of Low Carbon Fuels

Current & Future Biofuels

- Rapid changes are occurring in biofuels industry from high feedstock cost, Co2 & sustainability
- Shifts in government policy to both support higher biofuel levels & scrutinize benefits
- Development of next generation biofuel processes or use of new feedstocks offers some solutions
- Future competition between alternative fuels likely to revolve on issues of Co2 & sustainability and competitive position relative to petroleum

Challenges; Biodiesel

- Historically high canola, rape, sun, soy, palm prices have led to low biodiesel capacity use & poor profits
- Prices of biodiesel held in check only by imports where double dipping of subsidies (USA, Argentina)
- Mixing of agriculture & energy policy has resulted in problems with optimizing feedstock supply & Co2
- High veg. & petro oil prices are leading to significant investments in oil projects & alternative feedstocks (palm, native oil trees, camelina, algae, etc.)
- Lots of pressure to improve sustainability & Co2

Challenges; Ethanol

- 40% of EU passenger cars use gasoline so ethanol is important in defining broader alt. fuel policy
- Reliance on corn ethanol in US and sugar beet & wheat in EU increased some commodity costs
- Only small portion of total crop biomass used to make ethanol & high heat required = poor Co2
- Ethanol from sugar cane with pipeline access & use of bagasse for electricity = excellent Co2
- EU still keeping Brazilian sugar cane out of EU
- Large project to produce ethanol from algae; MX

Carbon & Biofuels

- Biofuels have very different life cycle Co2 benefits
- Corn based ethanol has at best 20% Co2 reduction
- Sugar cane ethanol in Brazil has a 90% Co2 reduc.
- Soy biodiesel USDA study shows 78% Co2 reduction but this may not stick in further studies
- Canola/rape biodiesel Co2 about 60% but contested. Camelina might have better Co2 & economics
- Palm biodiesel is highly variable depending on how calculated & sustainability standard met
- Algae high yields could mean very good Co2 #'s

2nd Generation Biofuels & Co2

- Much better Co2 reductions from ethanol if made from cellulosic materials (= to Brazil)
- Co2 reductions from renewable diesel may be higher or lower than biodiesel
- Much better Co2 if fuels moved by pipeline
- Much better Co2 if gasify entire biomass into bio-crude & then convert to Biomass to Liquid
- Opportunities to blend 1st & 2nd generation fuels (BioGTL, BioBTL)

BioGTL & BioBTL

Combining Biodiesel & Gas to Liquid or Biomass to Liquid Fuel

Gas to Liquid (GTL)

- Petro SA and Sassol have been producing GTL for a decade in S. Africa in multi-chemical output process
- Evaluation of some new technologies to produce primarily diesel with problems & cost overruns
- New developments & technology will lower capital cost and make future projects more profitable
- Major reserves for gas are in Qatar, Russia, Nigeria, Indonesia & Americas
- Uncertainties in Co2 benefits (-20 to +35%)

Projects Underway

- Several projects underway in Qatar (main one is Qatar Petroleum/Sassoil JV)
- Indonesia considering large project to utilize gas reserves
- Nigeria is being studied as possible site with some investors
- Numerous projects being discussed in Russia
- We are working with partners on site with 14 trillion cu. ft. gas in the Americas

Why GTL/BTL Favored by Auto?

- Resulting fuel is identical to gasoline or diesel and has higher cetane and no sulfur/aromatics
- Leads to improved fuel economy or performance (4% according to Shell Studies)
- Cetane enhancement is main ingredient in Shell and BP Premium performance diesels
- Cost could be lower than current petroleum prices in large volume production
- GTL and BTL are identical chemically allowing for easy transition & joint production efforts

Biomass to Liquid (BTL)

- BTL involves gassification or pyrolysis of biomass and then same Fischer Trope & refining as GTL
- Higher the calorific content of biomass the better it is for BTL production
- Main EU effort is joint venture of VW, Daimler and Choren (Sun Biofuels)
- ADM & Connoco in JV to develop both fast pyrolysis at remote sites and FT/refining at port
- BioPure Fuels working on similar plan in Brazil

Coal to Liquid (CTL) w/ Biofuel

- Coal is largest remaining fossil fuel with reserves in some countries for 200-300 years (US, China)
- Air pollution is much lower with CTL but Co2 emissions almost double
- Many projects looking at carbon capture & storage but there are problems w/ pollution & leaks
- In some locations it may be possible to sequester carbon with algae ponds & harvest for oil and biomass for biofuel production

Renewable Jet Fuel

- Highest value market for GTL, BTL & CTL is as a "renewable" jet fuel
- Fuel quality is better, cold flow improved and lower emissions from GTL/BTL
- Sir Richard Branson has committed Virgin to use of renewable jet fuel in next 5 years
- Co2 Star is initiating "Co2 Air Star" to get airlines to commit to use of renewable fuel
- Could also involve Co2 Credits for tree planting

Biofuel & Efficiency Technologies

- Biofuel & efficiency technologies can be combined. Results in fuel savings to offset cost of biodiesel & benefits such as reduced engine wear, reliability, lower emissions
- Anti-friction treatment can improve efficiency up to 7% + double oil change intervals (adds 20% to cost)
- Fuel additives for diesel/biodiesel improve efficiency by 3% and lower particulate emissions so trucks are "smoke-free"

Fuel Additive = 3% Fuel Savings

Test Results of Southwest Research Institute

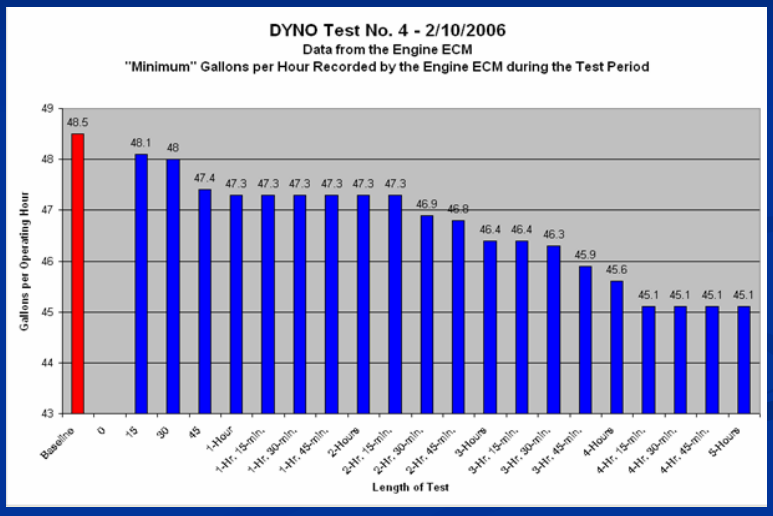
(Following J1321 Fuel Efficiency Test Protocols)

Table 1 – Percent Improvement in Fuel Economy Compared to the Baseline

		% Improvement in Fuel Economy		
	Diesel Fuel	Test Truck 415568	Test Truck 415572	Avg. of 2 Test Trucks
Baseline Segment	Commercially available #2 diesel			
Test Segment	Commercially available #2 diesel fuel with Clean Boost™*	3.63%	2.49%	3.06%

Lube Additive = 7% Fuel Savings

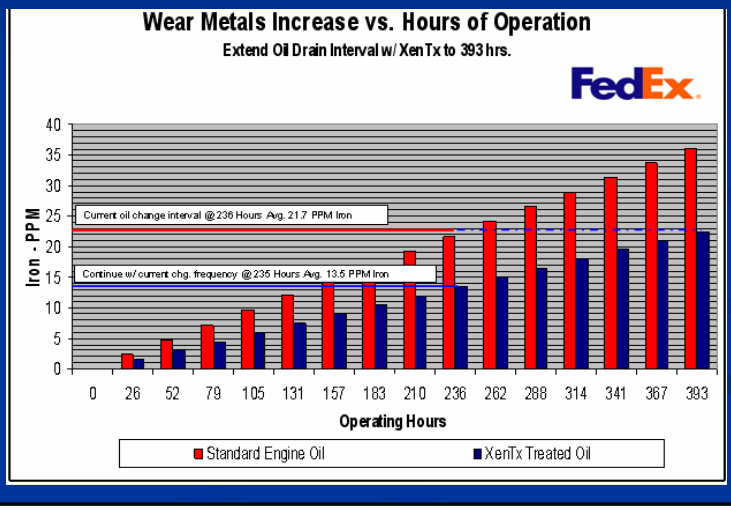
Dyno Test = 7% Fuel Savings after 5 hours



Lube Add. = Extend Oil Interval

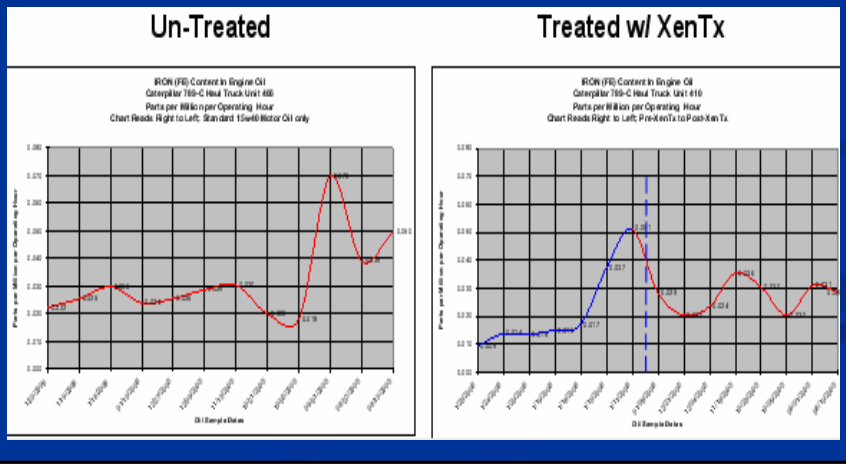
Field Test = FedEx Yard Arm Equipment

extend oil change interval by 40%



Anti-Friction = Less Metal Wear

Field Test = Utah Mine Equipment



Barriers to Additives

- Limited use of fuel and lube additives because of major barriers from test & certification
- In CA all additives must go through several million in health effects test prior to marketing
- Test & certification not uniform globally requiring repeat of tests in each region
- Little emphasis yet on introducing additives in fuel or lubes to reduce carbon emissions
- If efficiency gains, means less fuel sold

New Feedstocks: Algae

- Major R&D and commercialization effort now underway to use algae as feedstock for biofuels
- Co2 Algae Star is being set up to track promising algae technologies & efforts to commercialize
- Largest project underway is in Mexican Sonora desert where $800 million invested in project to put 50,000 hectares of algae ponds for ethanol
- Green Fuel Tech. working with AZ power plant
- Algae biodiesel being used by NFL in Super Bowl

New Feedstocks: Native Palms

- Various native palms have excellent oil properties for biodiesel if produced in certain way
- Co2 Star working with Biodiesel Brasil on evaluation effort and broad planting program
- Best results with Macauba, a tree native to most of Latin America where cold flow -4 C
- Trees can be planted along roadsides, in reserve areas that are now illegally in agriculture, etc.
- Yields are high (4 tons/hect.) so Co2 benefit high

Carbon Sequestration & Biofuels

- UNFCC Protocols developed for reforestation means credits for tree planting = biofuel feedstock
- Carbon credits for afforestation offer opportunity to offset any sustainability impacts of palm oil
- Co2 Star exploring nuts & bolts examples to invest including tropical oil seed trees in Brazil, jotropha plantations & algae ponds at refineries, coal plants

UNFCC & Tree Credits

- UNFCC developing protocols for earning Co2 credits for both tree planting (reforestation) and preserving of jungles (afforestation)
- Process has been extremely slow (14 yrs) but it is finally leading to guidelines, protocols & examples
- Opportunity is to get Co2 credits for planting trees to produce oil seeds for biodiesel or offset the sustainability impacts of biofuels by saving jungles

Co2 Credits for Tree Planting

- Guidelines require development of plan that details the prior use of land, additionality of investment and approval of plan by DNA
- Development requirements are similar to what many governments require when you are planning a large plantation project
- Tree planting in Brazil can provide feedstock for biodiesel if native tree species chosen & careful site selection provides compelling case

Why Native Palms ?

- Planting African palm will not meet "additionality" test since investment justified w/out credits
- Planting native palms consistent with DNA & UNFCC & makes it easier to get protocol approved
- Putting back on the land trees that were originally cut down 20 years ago to create cattle farms
- No issues with "sustainability" & getting blamed for destruction happening elsewhere for other reasons
- Yields are similar & require less rain so no forests cut down as a result of your plantation

Two Types of Native Palms

Carbon Impacts of Fertilizer

- New studies indicating agronomic strategies related to nitrogen & NOX impact GGC netted
- Fertilizer production, levels required, application & soils emissions main factors. Fertilization accounts for more than 50% life cycle emissions
- BioPure forming JV with fertilizer technology company to commercialize technology that has very low emissions from Nitrogen production
- Field trials planned in Canada & MT in 2008

Intercropping Tree Plantations

- One important strategic decision is what crop to plant between oil seed trees
- Minimum option is to continue to have cattle or goats and continue to grow grass
- Various beans can fix nitrogen & offer 2nd crop
- Most interesting option where climate can support it is to grow sugar cane between trees
- Offers opportunity to grow two major bio-crops

Intercropping Yields/Hectare

+

Native Palm	+	Sugar Cane Plantation Brazil
4-5 tons oil	+	60 tons of biomass

Points to Ponder

- Current generation of biofuels & feedstock useful to reach 5% targets but create problems w/ food & sustainability if alternative feedstock not developed
- New feedstock development could alleviate problems and make biofuels very competitive
- Next generation fuels offer potential for both solving problems & making things worse
- Numerous benefits from combining both mature & new feedstock & biofuel conversion technologies and blending the two fuels at the pump

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