



Markets & Technologies, Biodiesel & Renewable Diesel Trends & Developments

Lawrence D. Sullivan

Chief Technology Officer

Kreido Biofuels, Inc.

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Biography Lawrence D. Sullivan

Lawrence Sullivan is Chief Technology Officer of Kreido Biofuels, a renewable energy company. Mr. Sullivan has over 25 years of experience leading technology transfer efforts for companies such as ICI, Conoco/Dupont, Cargill, Betchel, UOP, BP, Chemstar and GE Osmonics. Sullivan's professional background includes former Manager, Biodiesel Business Development for Delta-T Corporation; director of Crown Iron Works strategic marketing initiatives for biodiesel and oilseed crushing integration technologies; and advisor in critical market negotiation for World Energy, part of Gulf Oil Group. He led Chemstar Products on starch chemical marketing, Cargill on novel genetic canola TMP ester base oils, and developed at Osmonics the market for new water treatment processes and products for oil and gas operations. Sullivan positioned Dover's RPA refinery process business on hydrocracker feed filters with Chevron and UOP; assisted in the Bechtel UOP start-up with Saudi Aramco's Ras Tanura hydrocracker. He developed new vapor phase corrosion inhibitor markets using soy methyl ester amidoamine technology for BP with Cortec Corporation in 2000. Sullivan led strategic development for Conoco and Dupont's European integration efforts of refinery and petrochemical intermediates. He managed new technology for oil and gas drilling projects with ICI Petroleum in the U.K. and completed the RCRA hazardous waste planning for the EPA and the State of Texas. He began his career with Dresser Europe. Sullivan earned his BA from the University of Texas at Austin and MA from Arizona State University. He completed graduate school in Geosciences at Texas A & M University; earned his MBA at England's Warwick University and Refinery Engineering at St. Catherine's College of Oxford University.



The Big Two US Fuels: Ethanol and Biodiesel: Gasoline for Cars and Diesel for Trucks

Ethanol

(ethyl alcohol from plant matter)

- 72 million acres (12 billion bushels) of corn represented by the NCGA. 2007 planting increased 19% over 2006!
- 17% of crop used in ethanol.
- 140 billion gallon gasoline market that is 99% defined as a retail purchase.
- 111 plants on line, 54 in progress.
- RFA Trade Association.
- Issues: butanols (BP/Dupont).
- ASTM D4806 - 98 (denatured fuel ethanol for blending with gasoline for use in automotive spark-ignition engine fuel).
- Ethanol is protected by tariff in the EU and US markets

Biodiesel

(mono-alkyl esters of long chain fatty acids derived from vegetable oils and animal fats)

- 72 million acres (3 billion bushels) of soybeans represented by the ASA. 2007 planting dropped 14% over 2006.
- Over committed by 140% (700 million gallons of carry-over and 2.3 billion in announced plants) Soybeans are for meal, not soybean oil!
- Four Major Crushers (ADM, AGP, Bunge, Cargill) with very few coops and independents.
- 70 billion gallon "middle distillate" market that comprises a majority of B2B purchases.
- 72% of the 70 billion gallons is "on-the-road" trucking and heating oil is next at 11%.
- 53 plants on line, 123 in progress!
- NBB Trade Association.
- Issues: Renewable Diesel.
- ASTM D6751-06a (Biodiesel for blend stock).

U.S. Middle Distillate Markets:

70 Billion Gallons per year (10 Billion more in Canada)

- On-the-Road Trucking (taxed)
 - 48 Billion (72% of the market, most price sensitive!)
- Residential, Industrial, Commercial Heating (no road taxes, some sales and use)
 - 10 Billion (16% of the market, NE US, Seasonal)
- Farm (non-taxed)
 - 4 Billion (Big Driver for Biodiesel, Seasonal)
- Others:
 - Construction (off the road, non-taxed) 3 Billion
 - Railroads 3 Billion
 - Marine (Vessel Bunkering) 2 Billion

Notes: Source is U.S. DOE EIA (Middle Distillates are a narrow range compared to Distillates which covers both kerosenes and the heavy fuel oils used in ocean shipping).

Market Shares:

Million Gallons per Year (mmgy)

- Renewable Energy Group (REG)
 - Reported 200 mmgy, more likely less
 - West Central Coop, EDF & Man Holdings, Todd & Sargent, Bunge
- World Energy Alternatives (WEA)
 - Controls 40 mmgy, produces 25 mmgy
 - Part of Gulf Oil, LP
- TransMontaigne
 - Trades 30 mmgy
 - Morgan Stanley
- Others (Cargill, ADM, Dreyfus, AGP, Minnesota Soybean Processors, et al)
 - Balance but expected to grow once they come on line, especially Dreyfus.
 - Many small players face need to meet stronger standards

Notes: 2006 market was near 300 million gallons with capacity of 530 million gallons. Not all capacity goes to biodiesel as many producers are oleochemical firms (Stepan, Huish, Dow, Eastman, Peter Cremer).

REG is an integrated franchise model. World Energy uses toll processing and a logistics model. TransMontaigne is a distribution model. Over capacity is likely to remain a factor in market.

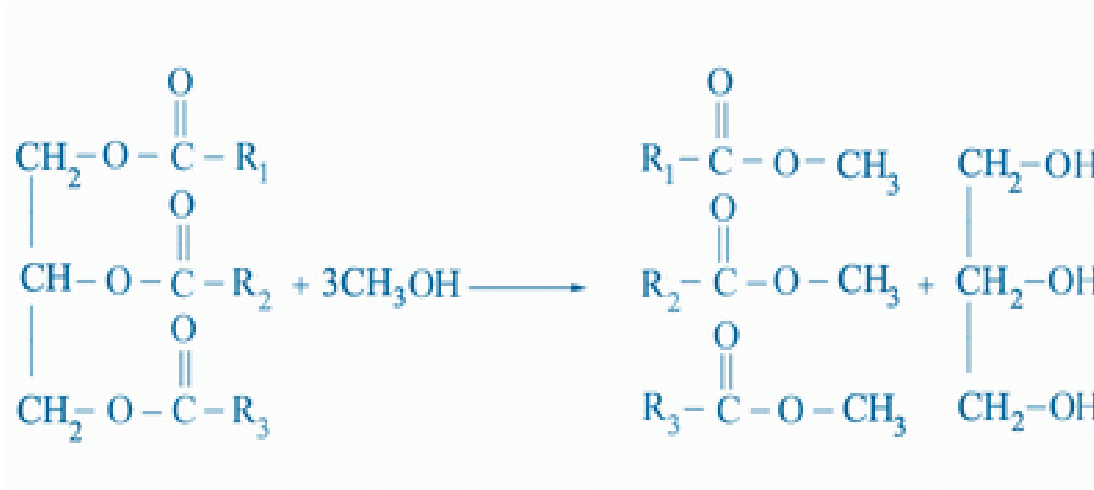
Many small producers sell direct to local petroleum terminals. National Biodiesel Board collects fees from member producers but does not report volumes. Plant capacities reported are misleading. Some use volumes in their own fleets.

Foundations of the Business

- Biodiesel is defined by the US as ASTM D6751-07a and in the EU as CEN14214 as a “mono-alkyl ester of a long chain fatty acids.” Other technologies produce high cetane products from hydroprocessing (or hydrocracking). These hydroprocessed or “thermal depolymerized” oils and fats receive a US\$1/gallon tax credit if blended under Section 1346 of the Energy Policy Act of 2005 as does ASTM D6751-06a product.
- The most significant lipid volumes are based upon oilseeds in the Asia, North and South America as well as the EU (approximately 69% of world fat and oil volumes).
- North Americans produce approximately 13 million tons of plant oil (3.5 billion gallons) and 6 million tons (1.6 million gallons) of animal fats each year. Balance is waste fryer oils often counted twice since these originated as plant oils and sometimes animal oils.
- Many governments have mandated use of renewable content in existing transportation fuels (gasoline and diesel) to reduce consumption of imported petroleum and petroleum products.

Basic Reaction

3:1 mole methanol to triglyceride (lipid) yields 3 methyl esters (biodiesel) and 1 glycerin. Hydrocracking is horizontal without methanol and biodiesel is vertical with alcoholysis.



1000 lbs. soybean oil + 96 lbs. methanol = 1005 lbs. methyl esters (biodiesel) + 125 lbs. crude glycerin (85% active with 15% w/w reaction byproducts like fats, salts, water). Process catalysts can be homogeneous or heterogeneous, energy inputs low or high. Glycerin can be refined to 98% pure or higher.

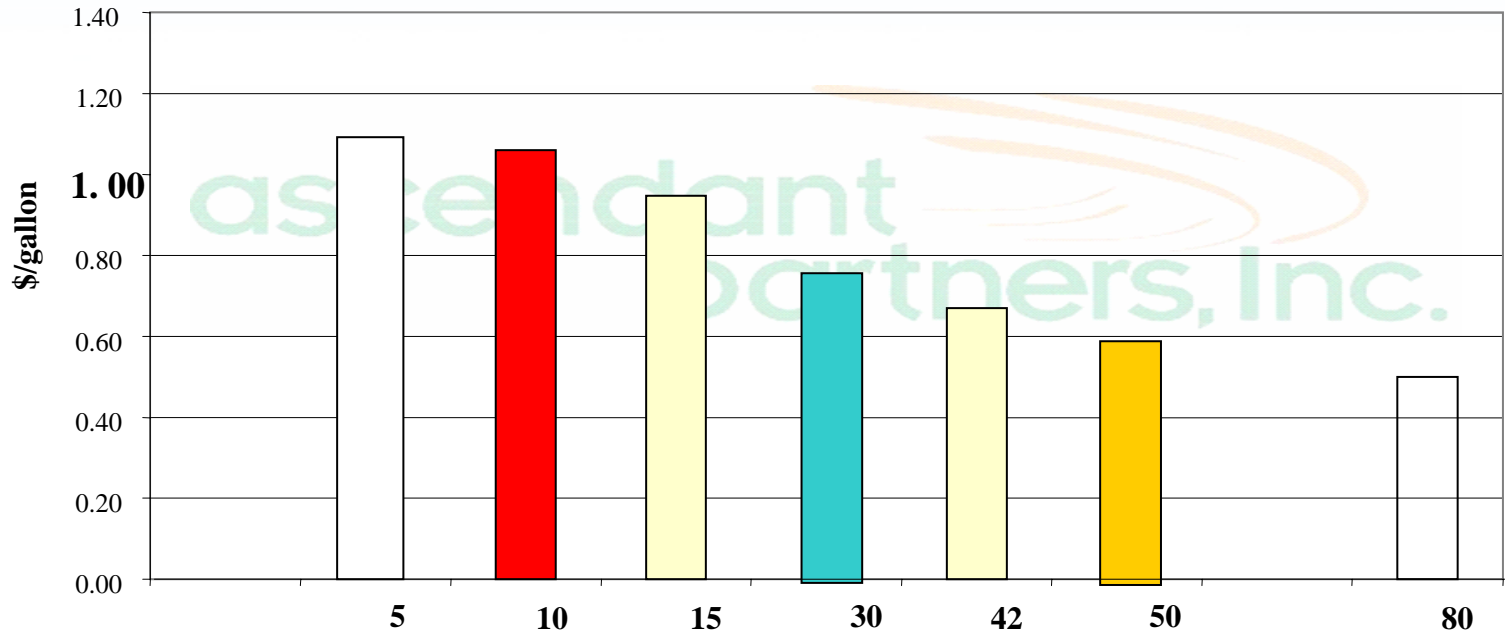
Stand Alone Plant 2005



Prices for Integrated Plants

Capital Costs - million gallons per year (mmgy)

The 5-10 mmgy are modular, while the 15 mmgy plants are fixed facilities.



Integrated Oilseed Extraction And Biodiesel Plant



Conventional Integrated Biodiesel Plant Operational Costs

100,000 Metric Ton/Yr Capacity (approximately 30 mmgy) 7.5 lbs/gallon

Product	US\$/lb	US\$/gallon	US\$/kg	Unit	Notes	US\$/lb	US\$/ton
Feedstock (pure lipid)	\$ 0.25	\$ 1.90	\$ 0.55		99.9% pure	\$ 0.315	\$ 694.575
Methanol (99.9%)	\$ 0.29	\$ 1.78	\$ 0.65			\$ 0.011	\$ 24.08
Catalyst (25% MeOH)	\$ 0.61	\$ 4.81	\$ 1.35			\$ 0.024	\$ 53.80
NaOH (50% Active)	\$ 0.15	\$ 1.91	\$ 0.33			\$ 0.001	\$ 1.65
HCl (35% Active)	\$ 0.05	\$ 0.50	\$ 0.11			\$ 0.001	\$ 2.76
Chemical Sub-Total						\$ 0.352	\$ 776.865
LP Steam				lbs	US\$/ton		
Process Water				gallons	US\$/ton		
Chilled Water				gallons	US\$/ton		
Nitrogen				lbs	US\$/ton		
Electricity				kWh	US\$0.05/kWh	\$ 0.0004	
Process Sub-Total							
Plant Depreciation	\$ 0.010	\$ 0.07				\$ 0.010	\$ 21.29
Plant Capital Recovery	\$ -					\$ -	\$ -
O&M, QA/QC Laboratory	\$ 0.008	\$ 0.06				\$ 0.008	\$ 18.25
Management/Labor	\$ 0.008	\$ 0.06				\$ 0.008	\$ 18.25
Plant Total Operational Costs						\$ 0.3784	\$ 834.655

Issues and Players

Steps in Alternative Diesels	-	EU, US EPA and RFA
Current Diesels (5% FAME)	-	WWFC
ULSD (Ultra-Low Sulfur Diesel) in US and EU	-	2006 - 2007
Biodiesel(s) \$1/gal v. \$0.50/gal (yellow grease)	-	Tax Credits
Renewable Diesels	-	Section 1346
Biomass to Liquids	-	DOE Biorefinery
Gasification and Pyrolysis Technologies	-	DOE Biorefinery
GTL and CTL (HTL)	-	DOE Biorefinery
Hydrogen	-	Long Term
Financials	-	Return on Capital

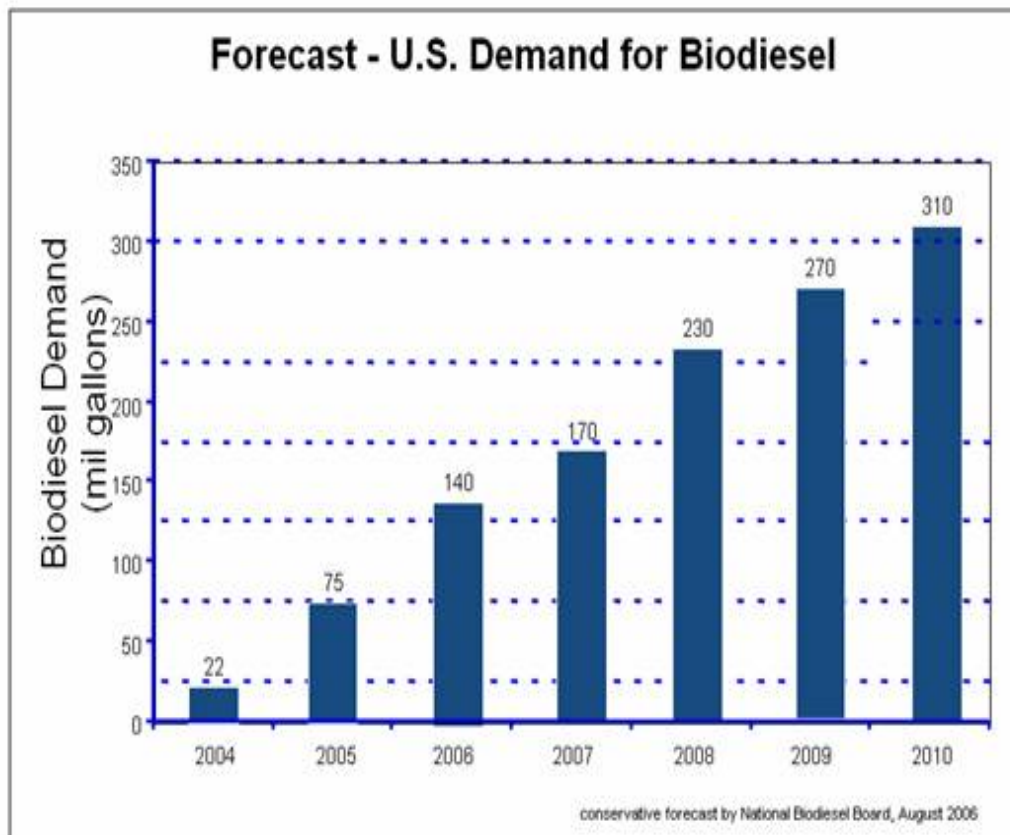
Issues and Players: Agri-Business

Oilseed Oil Extraction Economics

- Oil is extracted from oil seeds to levels of 95-98% yield (crude oil and refined oils are traded).
- Meal is produced from the oilseed extraction and is sold as animal feed.
- Solvent hexane extraction plants remain acceptable (GRAS, FDA, EPA, OSHA), but are under more rigorous regulatory reviews. Newer plants can process a wide volume, but technologies are less economic than n-hexane solvent extraction. Biodiesel production slows the move of this industry to offshore locations, an analogue to petroleum refining.
- Like petroleum refining, two types of soybean plants succeed: Production greater than 4,000 ton/day or geographically isolated and protected small (2,000 ton/day) plants. Soybean Crush is traded on CBOT in addition to soybeans, soybean oil and soybean meal. Crush is generally a 10% upgrade in value added.
- Historic ROCE is 6.5% (1980 to 2005).
 - 2,000 ton/day (120,000 bu/day) 55 mile oilseed radius, 35% crop land with rotation
 - 3,000 ton/day (180,000 bu/day) 75 mile oilseed radius, 35% crop land with rotation
 - 3,500 ton/day (210,000 bu/day) 90 mile oilseed radius, 35% crop land with rotation
- 120 mile radius starts running against land transportation costs and warrants water transport (Mississippi, Ohio, Missouri Rivers, coastal areas). 12,000 ton/day plants in South America!

US Demand Expected to 2010

Current Market is now near 300 Gallons!



Process Equipment

Inside the Plant

State of Art Control Systems

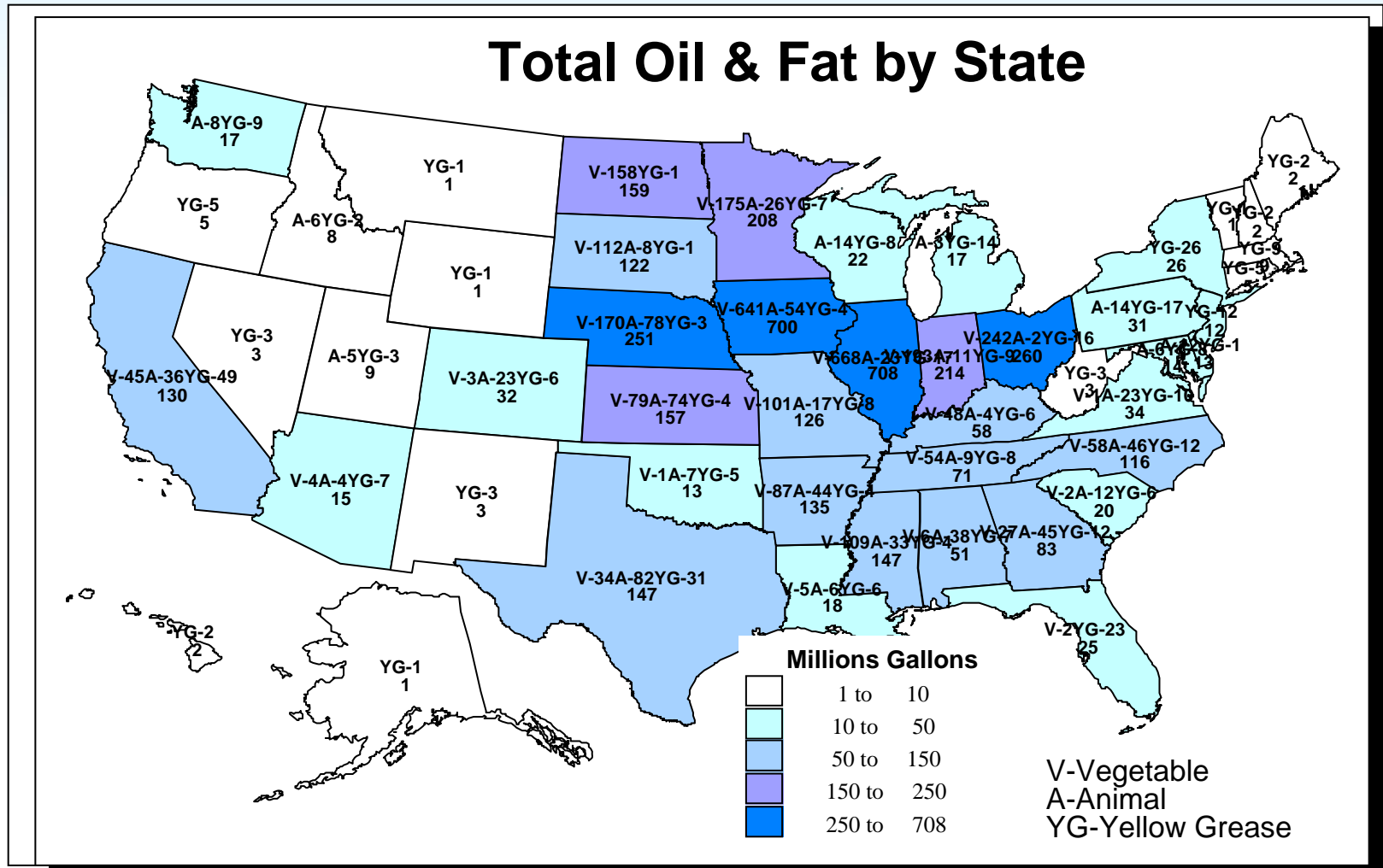


**Safety NFPA - Methanol
Class 1, Division 1
Nitrogen Blanketed**



**Stainless Steels and Duplex,
Fluoropolymer Elastomers
and Plastics, Pumps with
Krytox® greases**

Feedstock Map



Leading Process Technologies

Evolution to Higher Volumes and Lower Unit Costs

The Steps to Better “Middle Distillate Analogues”

- 1st - Esterification and/or Transesterification with Homogeneous Catalyst (NaOCH_3) meets existing ASTM and CEN but needs upgrading (standards and plant processes).
- 1st -Transesterification with Homogeneous Catalyst (Sodium Methylate) with high purity filtration and resin beds. First Generation requires upgrades to meet new ASTM. Transesterification with Mutual Solvents (Biox).
- 2nd - Transesterification with Heterogeneous Catalyst (IFP Axens) in Beatrice, Nebraska.
- 3rd - High energy input via cavitation, shear and turbulence (Hydrodynamics, Kreido, etc.).

Thermo-Chemical Platforms:

- Hydrocracking “Thermal Depolymerization” with Heterogeneous Catalyst (CWT/ConAgra, UOP, CANMET, Neste, BP) defined under Section 1346 of the Energy Policy Act of 2005.
- Gasification of biomass then reactions to primary alcohols & diesel analogues (Delta-T Processes). Fischer-Tropsch Processes.
- EU and US DOE are seeking commercial plants using these platforms.



Capital Investment Expectations

The Agricultural Heartlands and the Petroleum Coasts

Oilseed Production

(Heartland-US, Mato Grosso)

- Historic ROCE less than 10% in the 1980 to Present.
- Feedstock positions - Owners - Transfer Pricing.
- Agricultural Economics, land (Paretian Rent) value and amortization.

Petrochemical Intermediates and Polymers

(Gulf Coast, North Sea and Singapore)

- Historic ROCE more than 10% in the 1980 to present.
- Feedstock Integration between petroleum refining and non-fuel chemical processing.
- Imperial Chemical Industries and Conoco/Dupont had expectations in natural gas, ammonia, PX, methanol at 17% IRR.

Return on Capital Employed

The Chase for Value Added (Source is www.BizStats.com 1980-2004)

■ Wholesale Farm – Raw Material Production (Lifestyle)	4.5%
■ Wholesale Agricultural (Oilseed Extraction)	6.5%
■ Wholesale Petroleum and Petroleum Distribution (Critical Supply Chain)	7.8%
■ Production (Petroleum Refining)	10.7%
■ Agricultural and Oilseed Chemicals (Biodiesel)	11.3%
■ Industrial Chemicals, Plastics and Synthetics (Petrochemicals)	12.5%
■ Specialty Chemicals (e.g. Biobased Lubes)	19.4%
■ Soaps, Cleaners and Toilet Goods	33.7%
■ Petroleum Exploration and Production (Paretian Rent)	0-45%

Return on capital employed is based on the entity's book value (equity) for income tax reporting purposes, and is materially affected by the accounting method predominately used within the industry

Biodiesel Production Economics

- The farmer, rancher and the petroleum refiner all share the lowest return on equity. Natural resource extraction yields below or near LIBOR rates, at times. Risk and Reward drive these commodities.
- Assumption is that the cash basis of the land (farming and ranching) and oil & gas extraction is amortized, or the economic concept of “paretian rent.” Often the land that produces the resource is passed from generation to generation and if husbanded well then has value expressed as rent.
- Biodiesel adds value to the “rent” and enhances both the low ROCE of extraction (6.5%) with the higher ROCE of specialty chemicals (19.5%).
- Our estimations are integrated plants will yield between the two, depending upon location, size, dedication of land to production near plant (assumed to be 35%) and other barriers to entry. However, soybean meal could scuttle the economics and more corn DDGs enter the market from ethanol plants.
- Our estimations show a minimum crush size as 2,000 ton/day for a n-hexane plant and smaller size for geographic isolated areas, outside of competitive range.
- Optimal biodiesel starts at 30 mmgy which fits well with current plant size and minimum soybean crush of 2,000 ton/day.

Incentives and Payback

RENEWABLE DIESEL (\$/gallon)

■ Feedstock Fats or Oils	-	\$0.91
■ Hydrogen	-	0.15 (shared with refinery)
■ Steam	-	0.04 (shared with refinery)
■ Operating Costs	-	0.09 (refinery overheads)
■ Capital Recovery	-	0.21
■ Royalty	-	<u>0.05</u>
■ Costs	-	<u>\$1.45</u>
■ Section 1346 Tax Credit	-	(\$1.00)

Cost of \$0.45/gallon after blending at refinery rack or within refinery battery as a diesel component. This compares with typical 19° API 2% S VGO to hydrocracker diesels at \$1.28/gallon (41% cut or \$0.52/gallon) depending upon age of hydrocracker (capital recovery).

Where Are We Going?

Pros

- U.S. diesel fuel market is growing at 2.4%/year and motor gasoline is only 1.7%/year (0.6% in 2006!) and this assumes no light duty diesel market development!
- Renewable Diesel opens the door to newer technologies for lower cost operations and Biomass to Liquids in 10 years.
- Room for all technologies that provide quality fuels (5 - 10% market share 2015).
- B99.9 gives producer tax credit plus the US\$0.1/gallon producer credit.
- Heating oil earns tax credit.
- Cleaner Air less GHG emissions.

Cons

- Quality! Glycerin
- Quality! Sterols
- Quality! Stability
- Feedstocks will become an issue as market develops. Feedstock control will give more control to those basic in the feedstocks. Delay in Biorefineries.
- Incentives could end 2008.
- ASTM makes obsolete many plants.
- Section 1346 and the NBB.
- CARB and TxLED (NOx) rules.

Market Development 2005-2015

- U.S. EPA expectations are for an **80 billion gallon market** by 2015 from current 2006 market **70 billion gallons** (approximately a 2-3% growth rate).
- EU targets are 10% (btu) renewable content by 2010. Now only at 2.1%!
- EPA is seeking a 5% renewable volume content in petroleum middle distillate or 4 billion gallons. President Bush does not distinguish the two fuels. EPA has not issued RFS rules that would distinguish the ratios and targets. EPA and new Congress will attempt to carve out the two.
- We see 1.5 billion gallons methyl esters, 1.5 billion gallons renewable diesels and balance is FT diesels from biomass (BTL).
- Balance of 95% volume will be: petroleum diesel (ULSD) and FT diesels made from coal, natural gas, petroleum coke. Minor markets remain high and low sulfur (some marine).



Canada, Brazil, EU, SEAsia, China & India

- **Canada** Mandates for Renewable Fuels. Ethanol from US and Brazil. Biodiesel from canola oil. Hydroprocessed likely due to issue around methyl ester (biodiesel) cold weather performance.
- **Brazil** Embraces both methyl esters (biodiesel) from soy and castor oils and hydroprocessed or renewable diesel (Petrobras' H-1 Bio). Just announced up the 20% content from 2013 to 2020!
- **EU** Maxed out with rapeseed based esters. Now embracing the use of hydroprocessed and Biomass to Liquids. Bio-ethanol grow expected now. Changed the 5.75% by energy content to 10% and only reaching 2.6% now!
- **SEAsia** Malaysia endorsed palm oil direct (SVO) and methyl esters. Slower developments in Indonesia and Philippines.
- **China** Slow developments.
- **India** Government use only.

Conclusions

- Petroleum will remain high and unstable.
- Feedstock and Petroleum Cycles could run opposite directions, although biodiesel pricing could be on CBOT and Nymex so spreads could be hedged.
- World oils and fats track petroleum at some point based upon capacity stress.
- Governments support biofuels will remain strong and bipartisan.
- Diesel continues to outpace gasoline and US/Canada light duty market (autos) starts to increase with diesel growing at 3%/year (J.D. Powers 26% market 2015)
- Who is the Customer? Quality fuels sell!



Thank you! Questions and Comments?