Biodiesel Technology, Economics & Case Studies

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Agenda

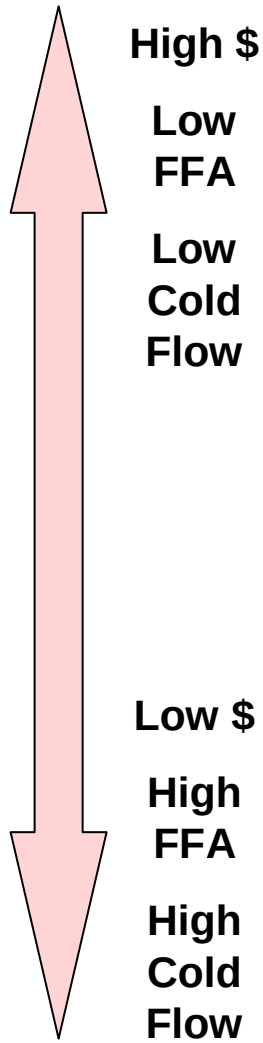
- Feedstock overview
- Biodiesel technology
- Fuel quality highlights
- Capital and operating costs
- Prices
- Incentives
- Margins
- Biodiesel Demand and Production
- Feedstock Supply
- Summary

What is Biodiesel ?

- A clean burning renewable fuel made from agricultural products
- Blends with petroleum diesel up to 20%
  - B100 is pure fuel
  - BXX is blend

Feedstocks

- **"Virgin" vegetable oils**
  - Soy, Canola, Corn, Mustard, Palm, Refined tall oil
  - Peanuts, Olive, Sesame, Hemp, etc.
- **Animal Fats**
  - Poultry (chicken, turkey, geese, ducks, etc.)
  - Fish oil
  - Lard and pork grease (pigs)
  - Tallow (beef, sheep, goat, camel, llama, etc.)
- **Recycled Grease**
  - Used cooking oils
  - Trap Grease



Biodiesel Benefits

- Reduces air pollution
- Reduces air toxics
- Non toxic, biodegradable, safe
- Reduces CO2
- Displaces fossil petroleum and foreign oil
- Produced in US by farmers and recyclers
- Blends in any fraction
- No changes to vehicles or infrastructure

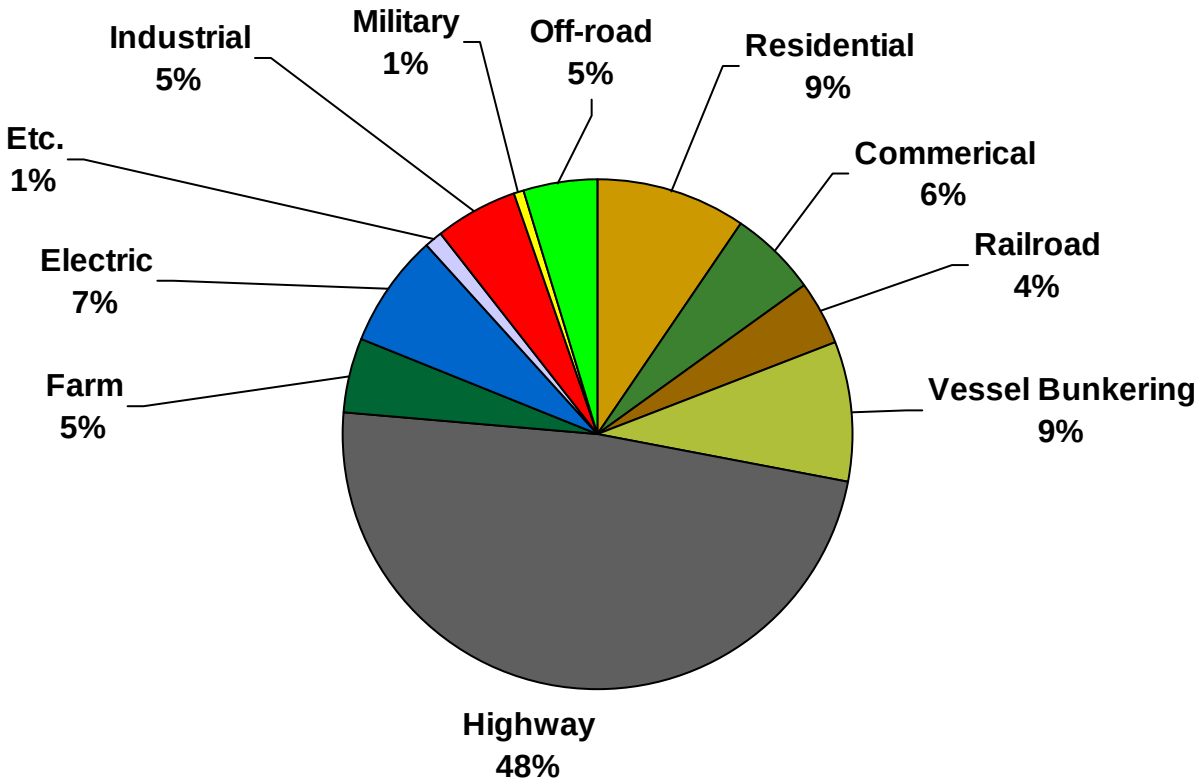
Biodiesel Markets

- **B100 - pure biodiesel**
  - Expensive, technical limitations,
  - Not recommended for use
- **B20 - 20% biodiesel, 80% petroleum diesel**
  - Bulk fuel fleets, primarily government, some retail
  - High cost offset by emission benefits
- **B5-B10 Heating oil, Boil Fuels**
  - Emission benefits
- **B2 - 2% biodiesel, 98% petroleum diesel**
  - Commercial as premium diesel
  - Lubricity value, fuel diversity

Distillate Industry (Diesel)

75.4 Billion gallons/yr

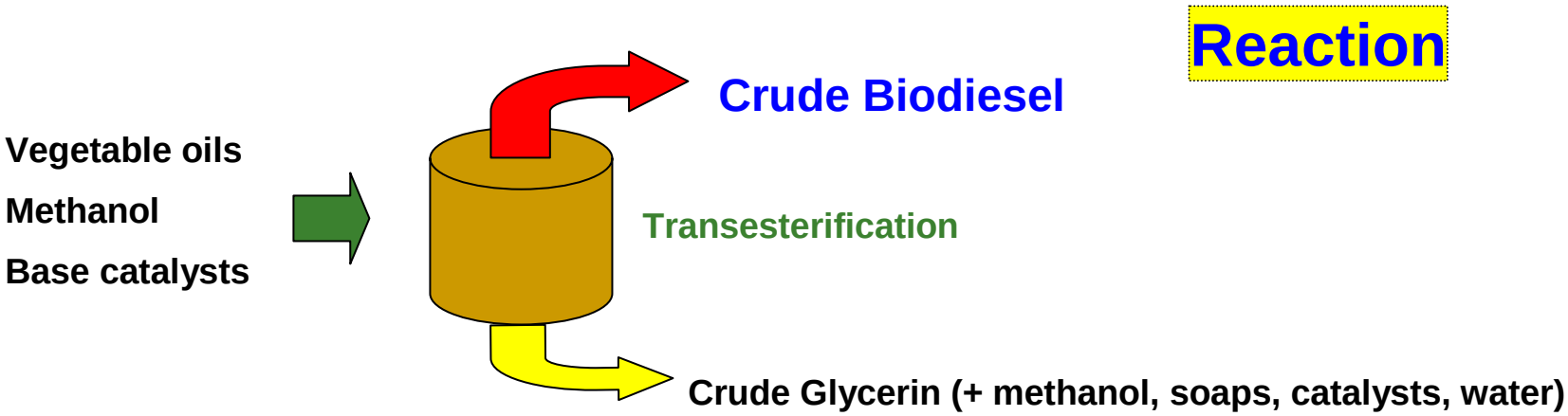
2% of that is 1.5 Billion, 5% is 3.8 Billion gallons/yr

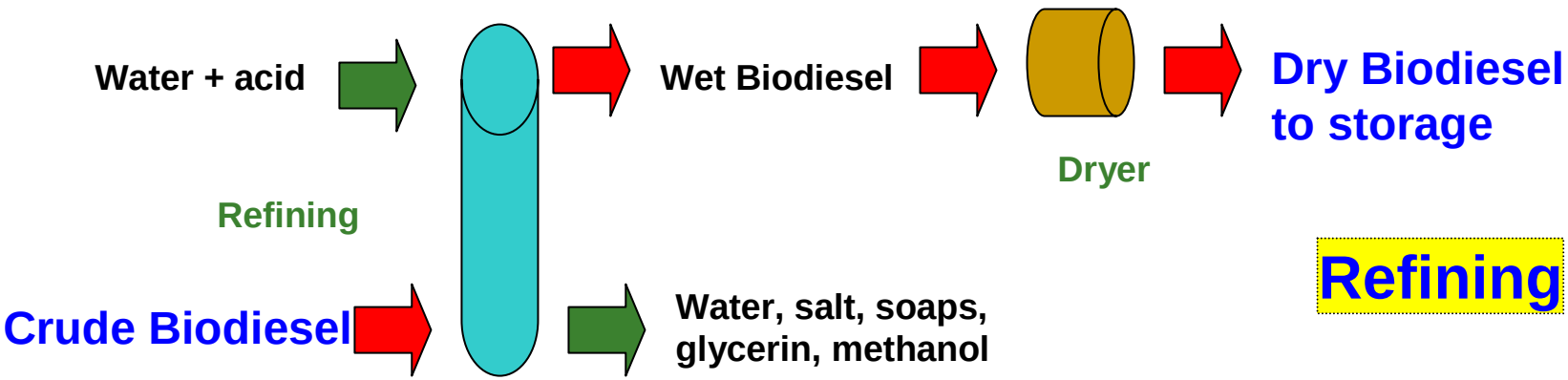


Theoretical Inputs and Outputs

- **Inputs**
  - 100 lbs refined vegetable oil
  - 10 lbs anhydrous methanol (or ethanol)
    - (practical usage is 30-60 lbs methanol)
  - 1-3 lbs catalyst
- **Outputs**
  - 100 lbs biodiesel
  - 10 lbs crude glycerin
  - 1-3 lbs spent catalyst
  - Recovered excess alcohol, original use minus10 lbs

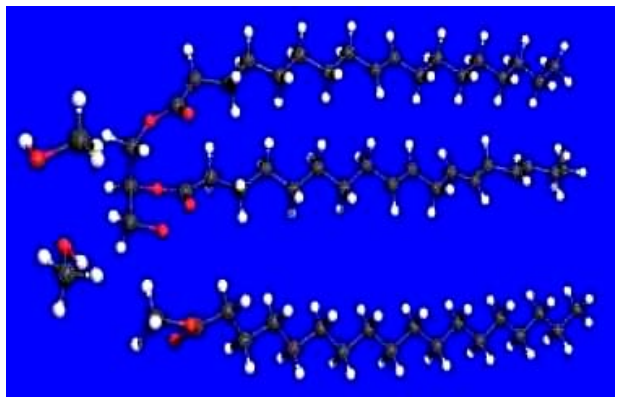
Basic Transesterification





Good Production Technology

- **Complete Reaction**
  - Transforms 99% (or more) of fats and oil molecules to fatty acid esters
  - Minimizes unreacted or partially reacted fatty acids
- **Removes Contaminants**
  - Catalysts
  - Methanol
  - Glycerin
  - Soaps
  - Water
  - Sulfur, metals, etc.



ASTM D 6751 -- B100 for Blending

Property	ASTM Method	Limits	Units
Flash Point	93	130.0 min.	degree C
Water & Sediment	2709	0.05 max.	vol.%
Carbon Residue (100%)	4530	0.050 max.	wt. %
Sulfated Ash	874	0.020 max.	wt. %
K. Viscosity, 40C	445	1.9-6.0	$mm^2/sec.$
Sulfur	5453	0.0015 max.	wt. %
Cetane	613	47 min.	
Cloud Point	2500	By Customer	degree C
Copper Corrosion	130	No. 3 max.	
Acid Number	664	0.50 max.	mg KOH/g
Free Glycerin	6584	0.020	wt. %
Total Glycerin	6584	0.240	wt. %
Phosphorus	4951	0.0010 max	wt, %
Magnesium & Calcium		0.0005 max.	wt, %
Sodium & Potassium		0.0005 max.	wt, %
Vacuum distillation	1160	T-90 $\leq$ 360	^oC max

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Biodiesel Quality is Vital

- **Fuel Specifications**: ASTM D 6751, D 975
- **Legally Producing Biodiesel**: US EPA registration
- Biodiesel producer has **on-site laboratory** and regular **quality control testing program**
  - **BQ9000 Certified or NBAC Certified Marketer**
- Ensure Biodiesel Supplier will stand behind their fuel
  - **Liability Bond**

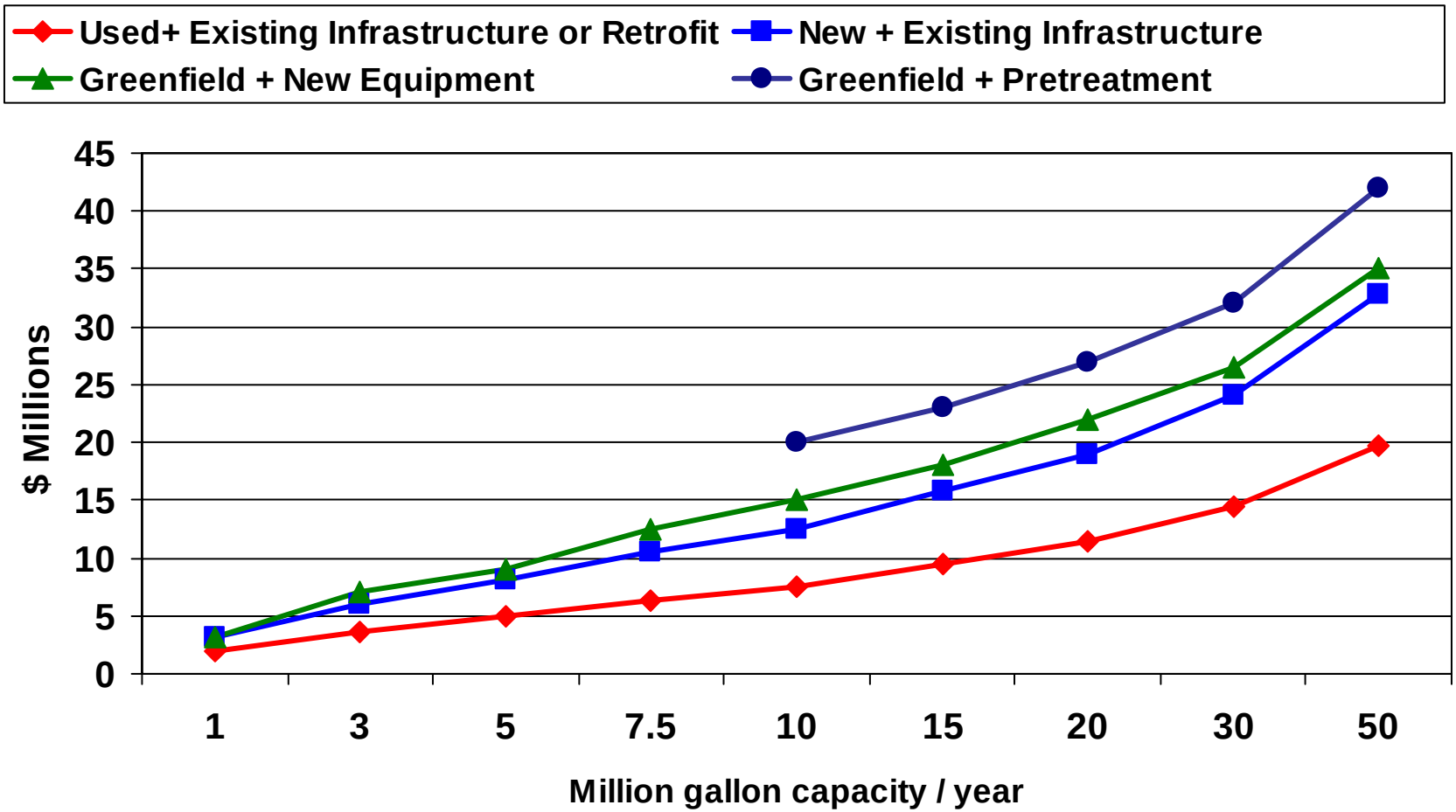
Technology Depends on Scale and Economics

- Batch
  - 155°F and ambient pressure
  - One batch requires 8 hrs or more
  - Up to 10 MMGY (million gallons per year)
  - Many use hybrid continuous and batch systems
  - Good quality control in questionable feedstocks
- Continuous
  - Higher temperatures (180-260°F) and moderate pressures
  - Pressurized piping rather than pressure vessels
  - Needs consistent quality feedstock
  - Reduces conversion time
  - 10-80 MMGY

Capital Costs

- Minor impacts on technology vendor and design (+/- 5-15%)
- Pretreatment can add 25% capital cost
- Significant savings with existing infrastructure
- Significant savings with shared infrastructure, shared utilities, and/or shared labor available
- 20-30 MMGY retro fitted into chemical plants or petroleum facilities reduced capital cost to $3-8 million

Capital Cost vs Scale



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Technology Vendors

- Proven/Experienced
- Multiple Facilities
- Large Scale (10-80 MMGY)
- High Quality
- Multiple Feedstocks
  - Desmet Ballestra
  - Lurgi PSI
  - Cimbria Sket
  - Renewable Energy Group
  - BDI International

- All others
- First commercial plant or only pilot plant
- Small (2-5 MMGY)
- Never built a large plant
- “Novel” or “Patented”
- “Multifeedstock”
- “Less than 20 ¢/gal”
- Partial methanol recovery
- Build your own

Key Differences in Technology

- Biodiesel Post treatment
  - Water wash biodiesel with water disposal
  - Water wash biodiesel with water recycling
  - Use several commercial adsorbents to remove methanol, water, glycerin, soaps, and other contaminants
  - Ester distillation
- Recycling methanol efficiently to minimize input costs

Byproduct Quality

- Crude Glycerin Byproduct
  - 50% crude glycerin with if added to water, will contain salts
  - 80% crude glycerin if no water is used or if water is recycled out of the crude glycerin
  - Minimum value of crude glycerin = 3 ¢/lb of 100% pure glycerin
- Refined Glycerin
  - Requires additional investment and operating costs
  - Technical grade, 95% + pure
  - USP (Pharmaceutical) grade, 99.8% pure
  - Feedstocks make a difference with customers

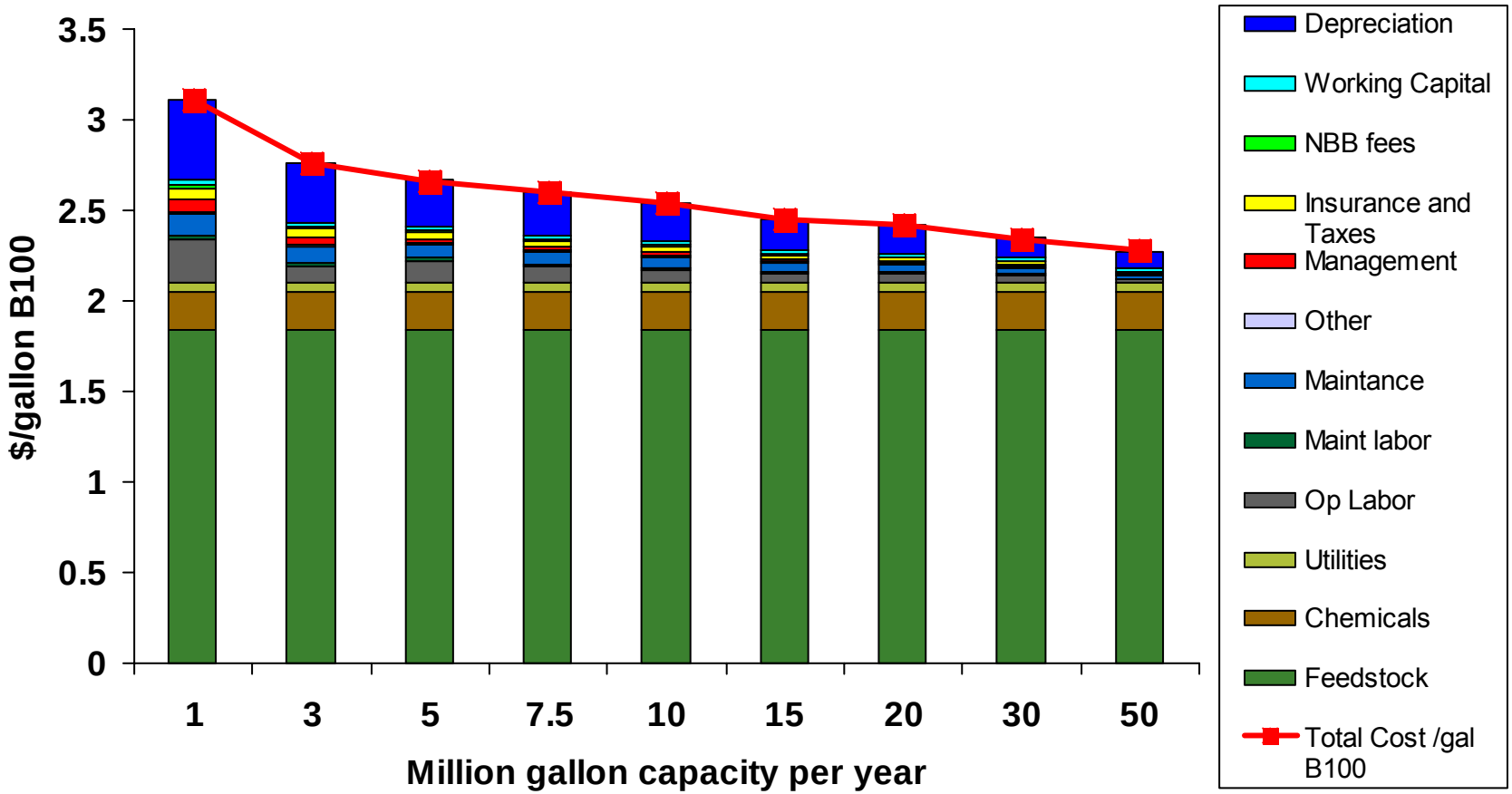
New Technologies

- High temperature and pressure esterification
  - Commercialized
  - Some increase energy costs and reduce time
  - Capital costs can also rise
  - Maintenance costs can be high
- Fixed Catalysts
  - Homogeneous
  - Heterogeneous
  - Consistent feedstock quality will be key
  - Not proven to reduce production costs yet
  - Not proven to reduce energy costs yet
  - Not proven for multiple feedstocks

Key Impacts on Production Costs

- **Yields have substantial impact on Feedstock Cost**
  - Refined oil, 98-99%
  - Crude vegetable oil and 2% FFA oil, 94-96%
  - High FFA oil, 94-96%
- **Methanol recycling critical**
- **Energy Minimization Important but Small**
  - Electricity
  - Natural gas or steam
  - Water use and recycle

Total Production Cost vs Scale



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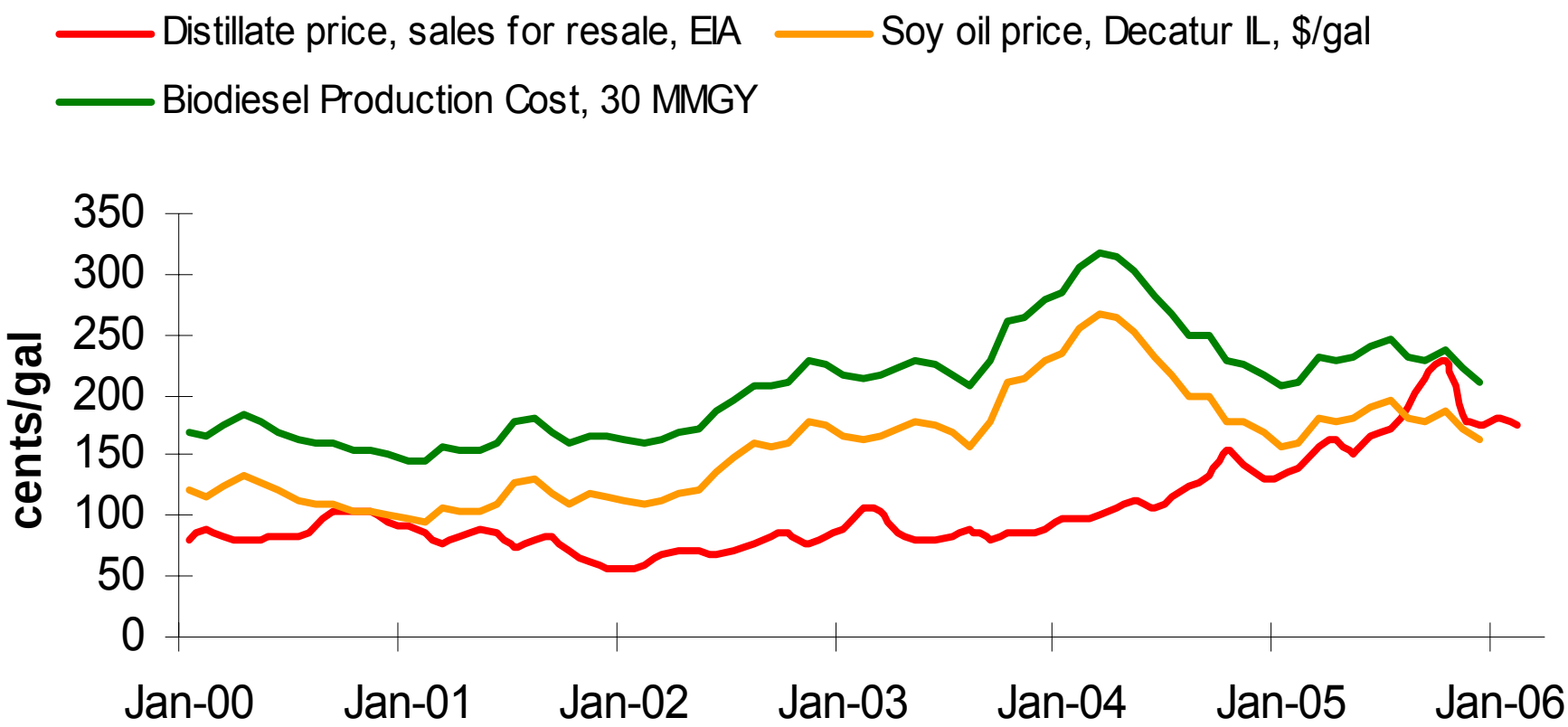
High FFA Feedstocks

- Can reduce feedstock cost

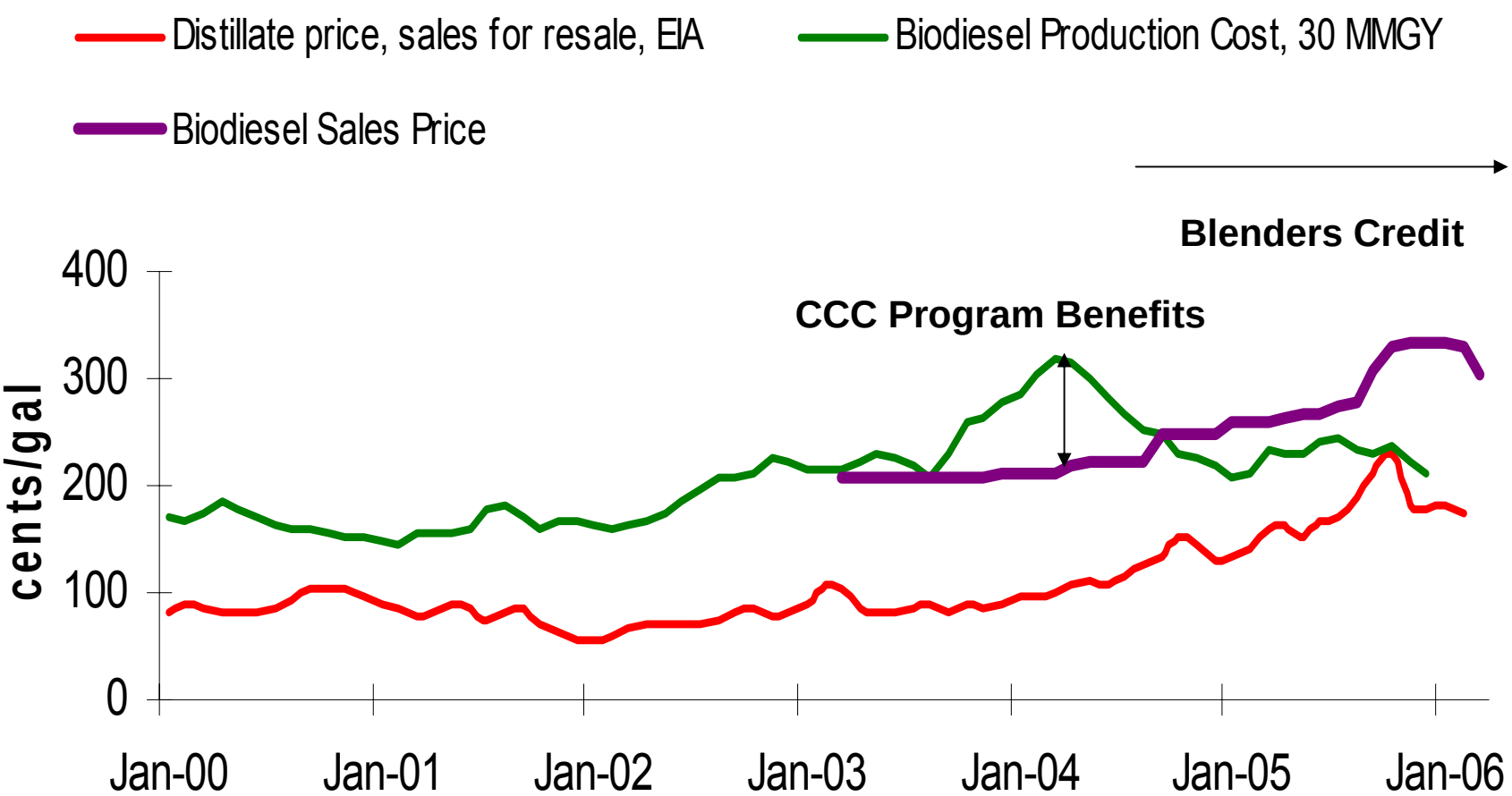
	$/lb	$/gal
Refined soy	0.24	1.81
Crude soy	0.20	1.54
Tallow	0.13	1.01
Poultry Fat	0.12	0.93
Yellow Grease	0.11	0.84

- Raises capital cost by roughly 10%
- Raises energy and chemical costs
- Reduces yields (99% refined, 94-96% Fat)
- **Significantly reduces total production cost**
- Generally smaller facilities (10-20 MMGY)
- Limited by climatic regions and blend percents

B100 Volatility and Petroleum Prices



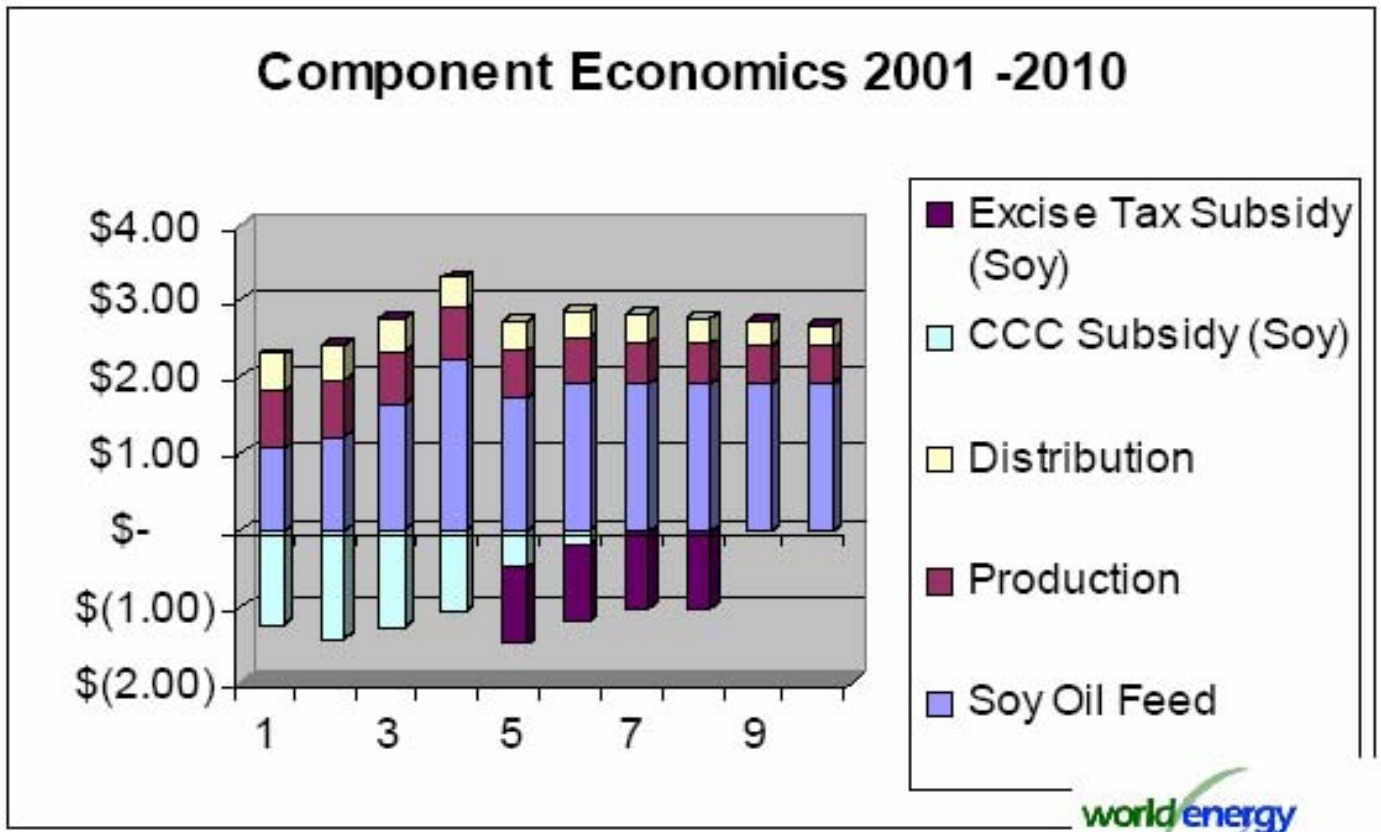
Biodiesel Sales Prices



Key Biodiesel Price Reductions Pre-2005

- **$1.50-$0.25/gal B100 USDA CCC Program**
  - Began 2001 and ends 2006
  - Designed for reducing capital costs
  - Used to reduce price to create biodiesel demand
  - Funding competed with ethanol expansion
  - Appropriations level fell over time
  - 2007 Farm Bill impact unknown

No CCC Mid 06
No Tax Credit End 08



Key Biodiesel Price Reductions Post-2005

- **$1/gal agri-biodiesel on blending B100**
  - Same credit for off-road use (ag, construction, boilers, heating oil, railroad, shipping, electric generation, etc.)
  - Began 1/1/05 and **ends 12/31/08**
  - Recycled feedstock $0.50/gal B100
  - Income tax option (B100 customers)
- **$0.10/gal Income Tax Credit on Small Biodiesel Producers**
  - Less than 60 MMGY is “small”
  - Credit is limited to first 15 MMGY or $1.5 million per year
  - **Expires 12/31/08**

Biodiesel Producer Financials – 30MMGY

- $ 2.34/gal B100 Production cost (no margin)
- $-0.05/gal Small Producer Credit
- $ 0.20/gal B100 transportation (rail and truck)
- $2.80/gal Contract B100 Price
- $0.31/gal Margin or before tax profit
  - 30 MMGY biodiesel plant can net $9.3 million cash flow per year
  - Roughly 3.0 years payback on investment
  - Assumes full utilization

Diesel Blender Financials – Part 1

- $ 2.80/gal Contract B100 Price
- $-1.00/gal IRS credit
- $1.80/gal Net B100 Cost
  - $ 1.74/gal wholesale diesel price before tax

- $1.80/gal Net B100 Cost
- $0.05/gal local transportation
- $0.01/gal marketing costs for biodiesel blends
- $0.04/gal blending depreciation and operating costs
- **$1.90/gal B100 in blended products**

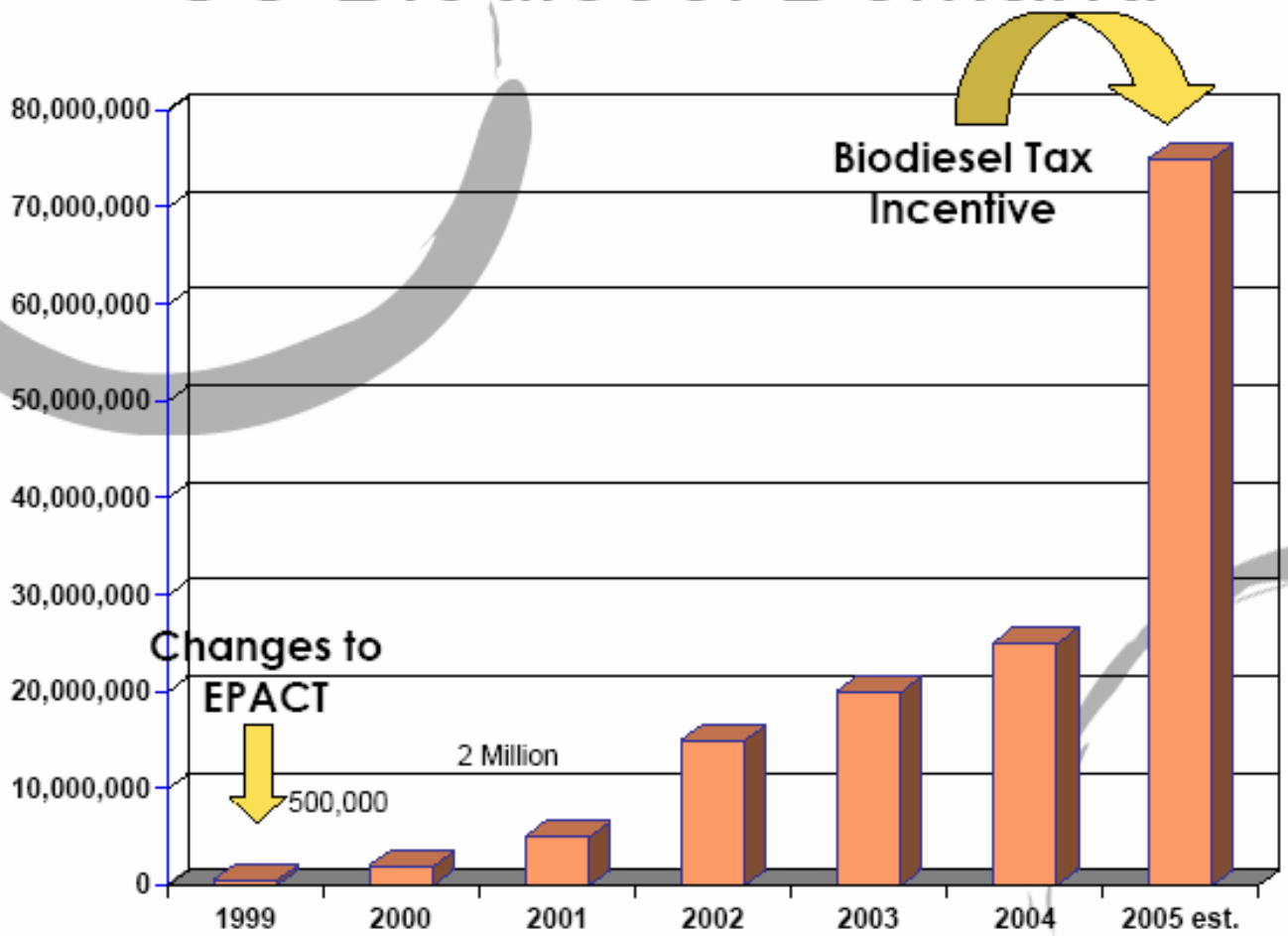
Diesel Blender Financials – B2 Scenario

- $1.90/gal B100 in blended products
- B2 Cost (when diesel is $1.74/gal) = $1.7432
- B2 Price is $1.77/gal B2 (wholesale)
  - Before tax profit to blender is 2.68 ¢/gal B2
  - Before tax profit to blender is $1.34/gal B100
    - 2.68 ¢/gal x 50 gallons of B2

Diesel Blender Financials – B20 Scenario

- $1.90/gal B100 in blended products
- B20 Cost (when diesel is $1.74/gal) = $1.772
- B20 Price is $2.07/gal B20
  - Before tax profit to blender is 29.8 ¢/gal B20
  - Before tax profit to blender is $1.49/gal B100
    - 5 x 29.8 ¢/gal

US Biodiesel Demand



Demand Pull Incentives - Federal

- Energy Policy Act of 1992
  - State, Federal, and public Utility Fleets must use alternative fuel vehicles or alternative fuels
  - B20 was authorized in 1999 and issued as a rule making in 2001
- Executive Order 13149 “Greening the Gov.”
  - Reduce fossil fuel use by 20% by 2005
  - Military use of B20 has skyrocketed
- Total Impact was 30 MMGY

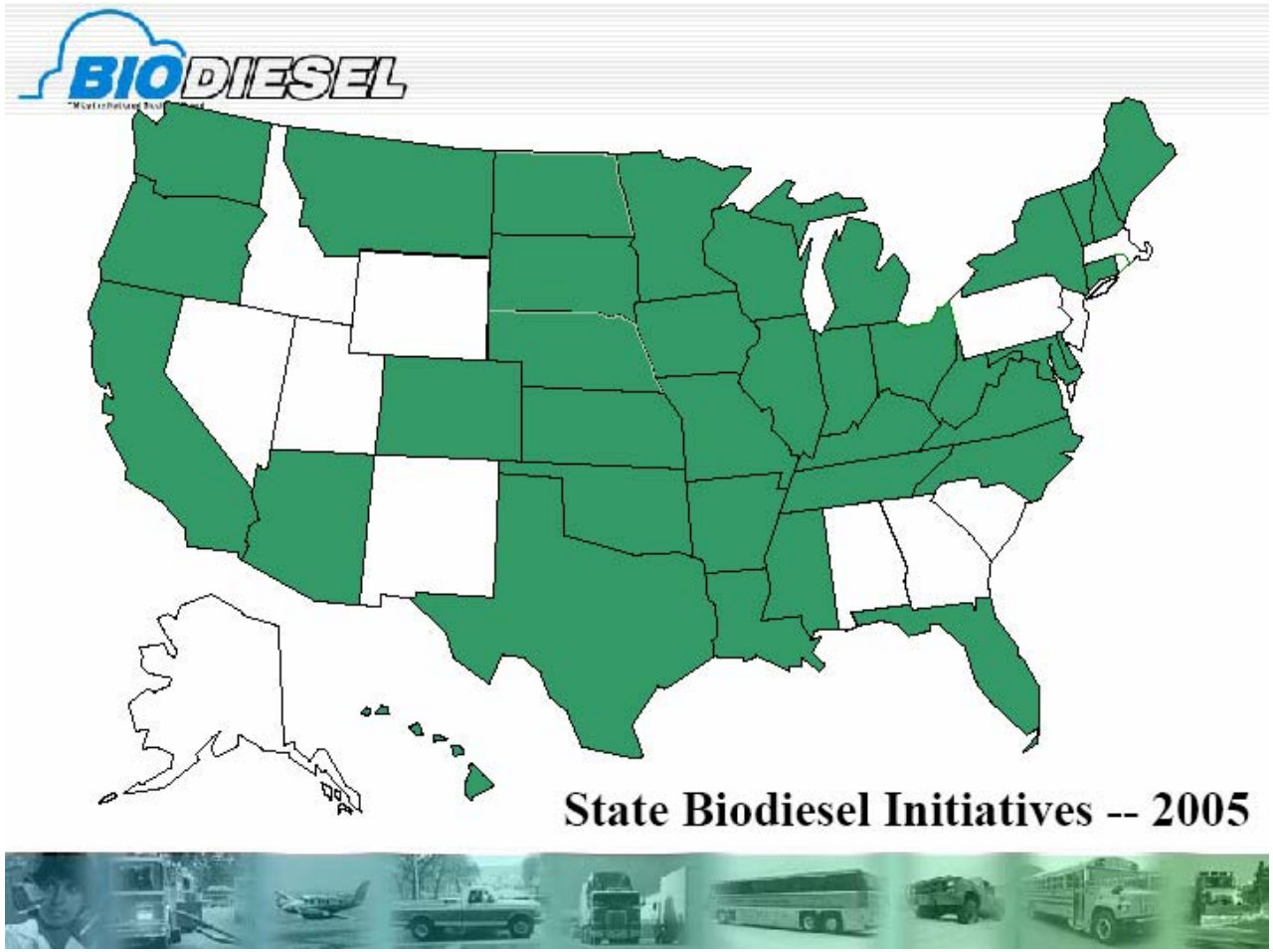
Future Demand Drivers

- Continued IRS Blenders Credit
- State Incentives
- Renewable Fuel Standard
- Alternative Fuel Infrastructure Credits
- Ultra Low Sulfur Diesel Regulations
- New USDA CCC Program for Biodiesel

Key State Incentives

- B2 Mandate in MN, began September 2005
  - Creates roughly 15 MMGY of B100 demand
- IL Sales tax exemption on diesel fuel at B11 or higher blends
  - Can create roughly 22 MMGY of B100 demand
  - If so, may “break the bank” in IL
  - Will probably be modified near term
- B2 Mandate in WA set to begin soon

170 Bills Offered, 31 passed



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State Bills Passed in 2005

2005 Legislative Activity

- States passing biodiesel related initiatives

AR (2)	IN (2)	MS	TN (2)
CA	KY	MT (2)	VA
CO	LA (2)	ND	VT (2)
DE	MD	NH	WI
IA	MN (3)	OK	
IL	MO (2)	SD	

Types of Successful Incentives

2005 Legislative Activity

- AR—Biodiesel blend tax credit.
- IA—Infrastructure incentive.
- IL—Fuel cost differential rebate; infrastrucutre.
- IN—Tax credits.
- KY—Producer/blender tax credits.
- MO—Production incentive funding.

Types of Successful Incentives

2005 Legislative Activity

- MS—Production incentive.
- MT—Tax credits.
- ND—Production; infrastructure incentives.
- OK—Production tax credit.
- TN—Fueling infrastructure incentive.
- WI—School district assistance.

Alternative Fuels Refueling Infrastructure Credits

- Addresses Key barrier to expanding biodiesel blending:
  - Availability of blending infrastructure
  - Complexity of blending needs
    - B2 in retail sales
    - B5 in home heating oil
    - B10 in commercial boilers
    - B20 in fleet customers
    - Higher blends for the environmental customers
- Blending infrastructure goes into the petroleum terminals (e.g., “tank farms”)
  - Can cost up to $250,000 or higher
  - Could be shared by biodiesel investors
- Currently “Splash blended” by jobbers and creating quality issues

Renewable Fuel Standard (RFS)

- Mandates at least 7.5 billion gallons of renewable fuels in the refined petroleum supply by 2012
- Ground zero is equal to 4 billion gals of ethanol in 2006
- Eligible fuels include ethanol and biodiesel
- Ethanol is the only fuel used at this time
- **Biodiesel use is delayed until EPA issues a preliminary rule making to provide a "biodiesel credit"**
  - **Example: 1 gallon of biodiesel = 1.6 gallon of ethanol**

RFS continued

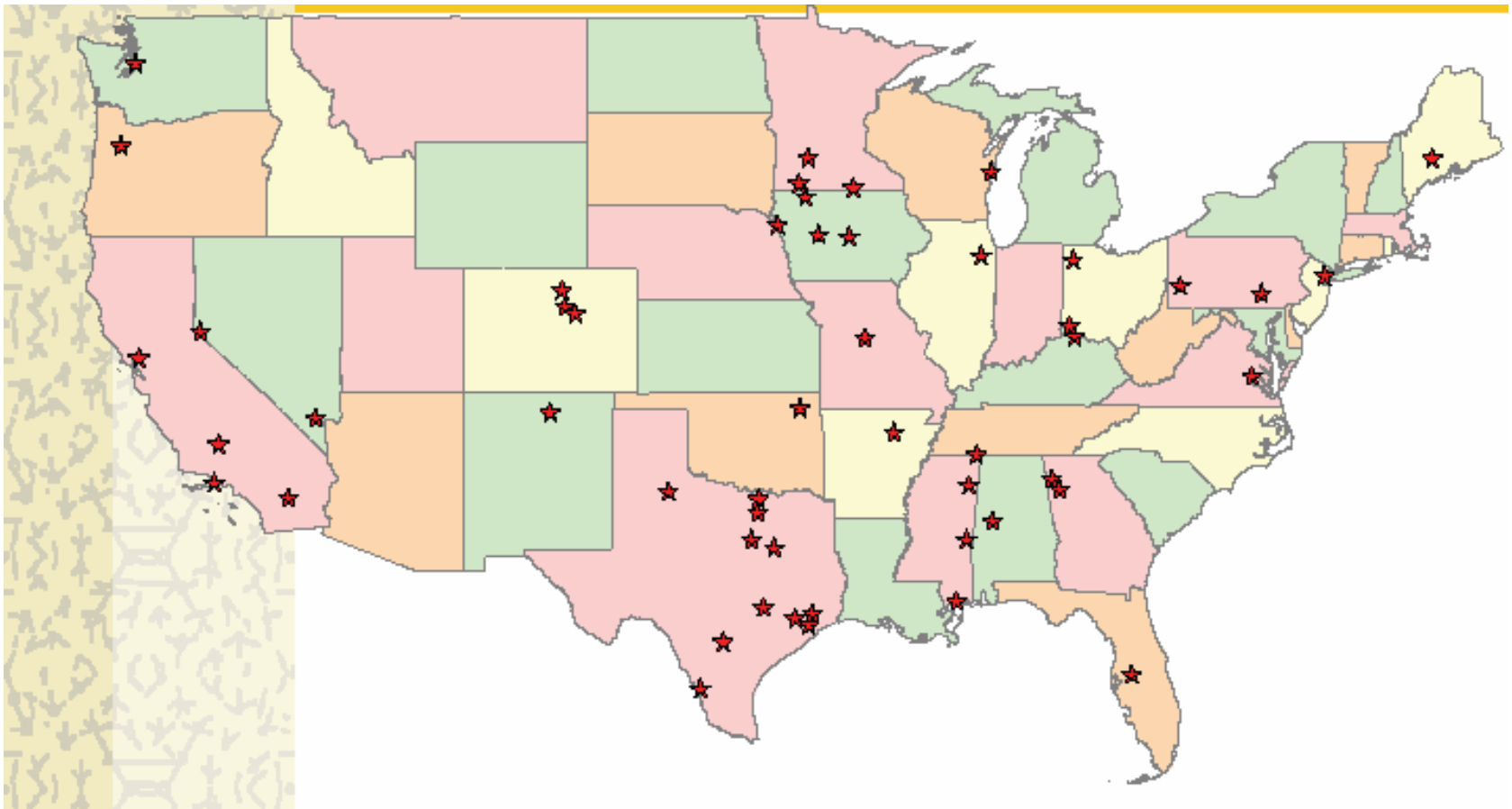
- No back sliding allowed
- RFS schedule:

2006	4.0
2007	4.7
2008	5.4
2009	6.1
2010	6.8
2011	7.4
2012	7.5

Ultra Low Sulfur Diesel

- All refiners' transportation diesel fuel ≤15 ppm Sulfur by June
- ULSD eliminates the natural lubricity of diesel fuel
- B1 or 1% biodiesel can provide sufficient lubricity
- Petroleum industry says that they can use cheaper additives
- Biodiesel (B1 or B2) can be used in pipelines, but creates a logistical nightmare for pipeline industry and customers
- **ULSD will NOT create a big demand for biodiesel**

Existing Biodiesel Producers



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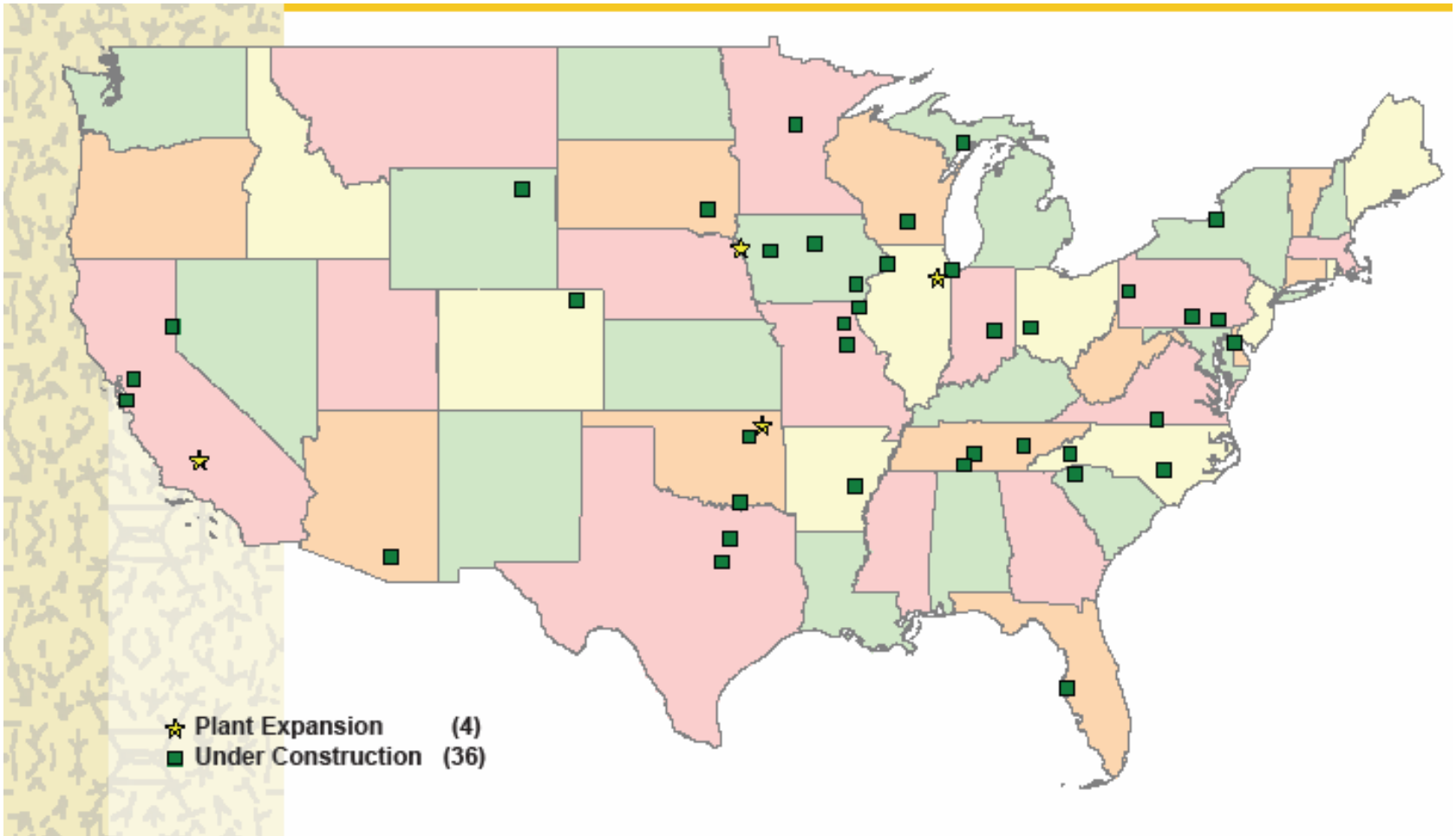
Compliments of the National Biodiesel board, 1/13/06

New Capacity and Expansions



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Projected Biodiesel Capacity

Year	Number of Existing Plants	Biodiesel Sales MMGY
2001	9	50
2002	11	54
2003	16	85
2004	22	157
2005	45	290
2006*	**53**	**354**
2007 est	95	708
2010	150+	1,200
* As of 1/13/06, NBB		

42 Plants under construction at this time, with 354 MMGY new capacity

22 in Pre-Construction with 485 MMGY

200 + in Feasibility and Planning with 1 BGY in new capacity

High risk of low capacity utilization, high production cost, and industry shake out

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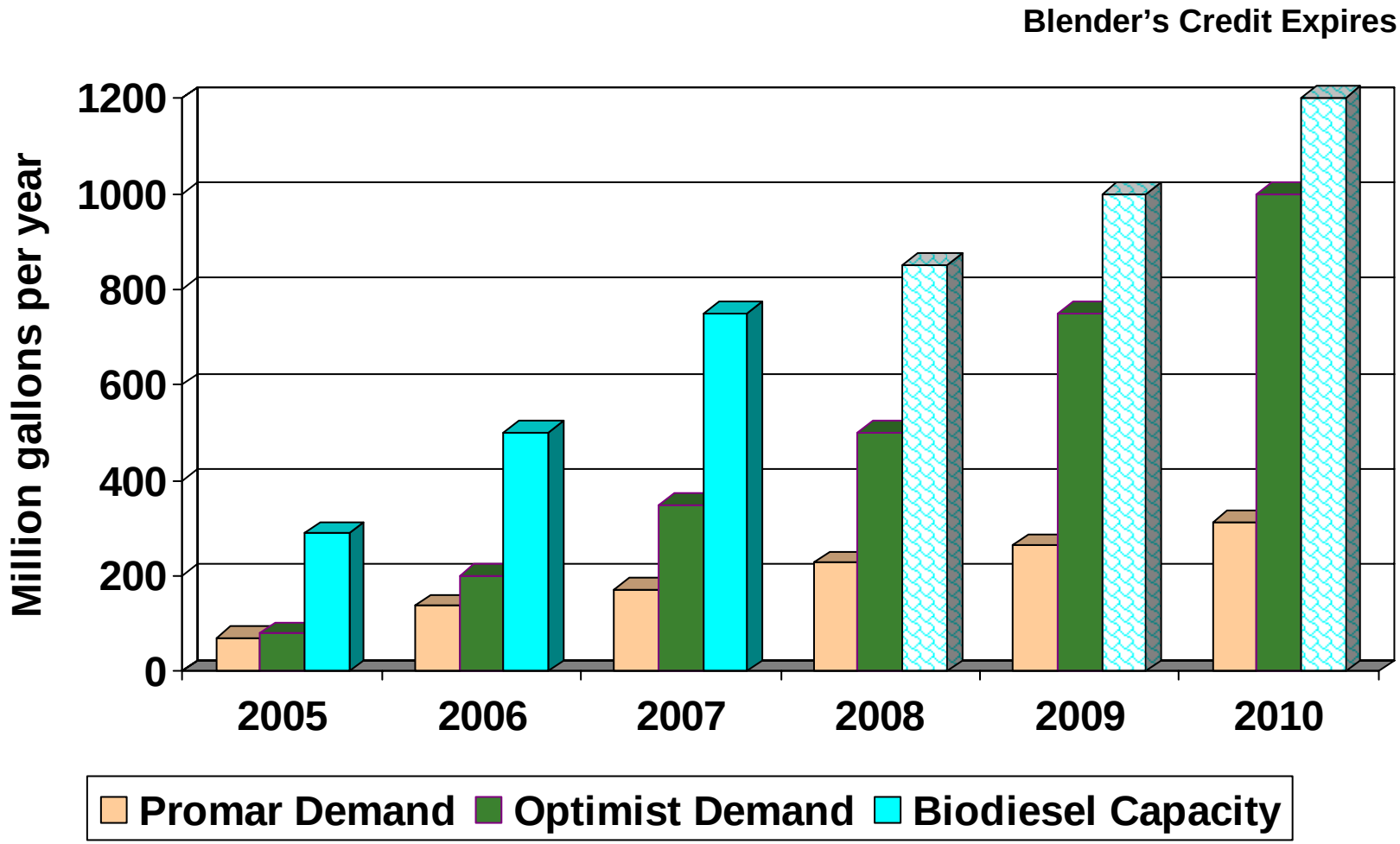
Biodiesel Demand and Supply



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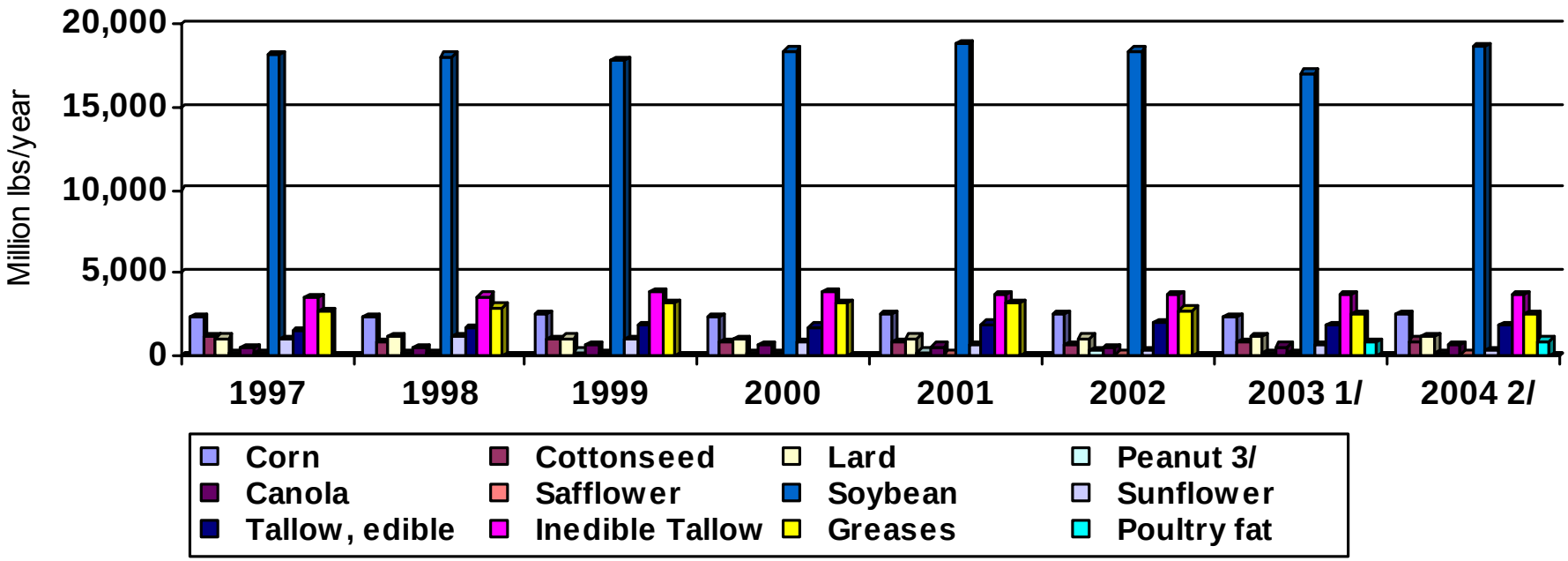
US Oil and Fat Production



Total Production 31-34 billion lbs per year, of which 56% is soy

Or 4.1 to 4.5 Billion Gallons of Biodiesel

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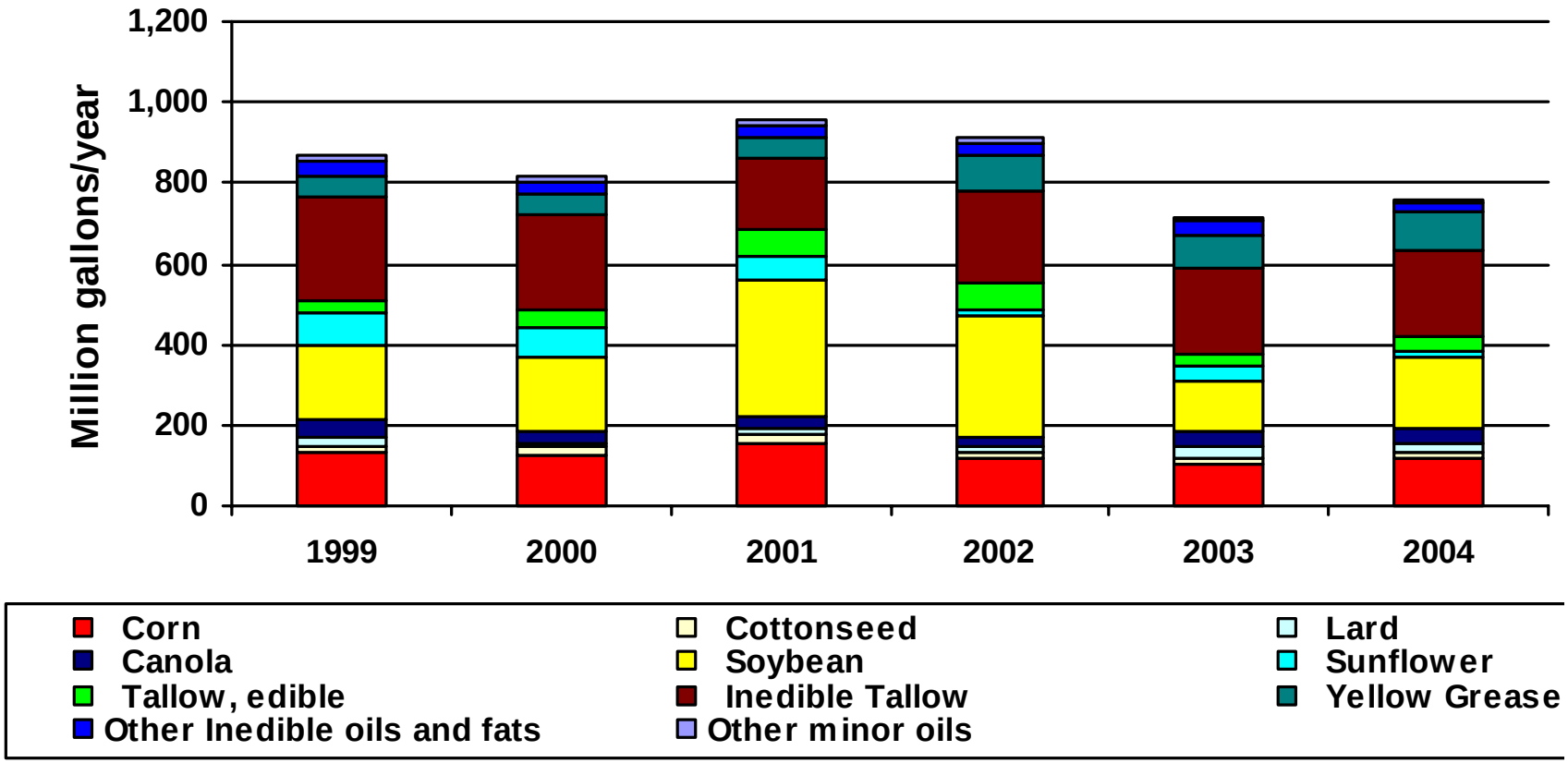
Biodiesel Supply Sources

- Net Exports
- Trans-fatty acid regulations
  - Soy oil
- Expanding crush utilization
  - 85% +
- New crushing capacity
  - Soy
  - Corn oil from dry milling ethanol plants
  - High oil seed – canola and sunflower
  - Algae and other novel crops

US Oil and Fat Exports - Gals



Maximum Export Displacement = 500-700 MMGY

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Trans-Fatty Acid Labeling

- Shifting soy oil out of the food industry
- Replacing soy with palm, coconut, sunflower
- Size of displacement very uncertain
  - See previous slide on soy vs. other crops
- Displacement Estimates: 10-50% of soy consumption
  - **200 MMGY to 1,200 MMGY**
- Soy shifting into biodiesel industry
  - Not sure how much or how fast

Expand Soy Oil Production

- **Crushing utilization averages 85%**
  - Increased to 97% (similar to petro refining)
  - **Add ~375 MMGY soy oil**
- **35% of all soybeans exported**
  - Expand US crushing capacity by 50%
  - **Add ~1,250 MMGY soy oil**
- **Every new 1.0 MMGY soy oil will produced 2,380 tons of meal**
  - MUST need a market for that meal
  - Mature market
  - Cheaper meal produced in Argentina and Brazil

Expand Sunflower & Canola Production

- **Displace 5-10 million acres of CRP and wheat**
  - Average yield of 1,000 lb/A and 40% oil content
  - **Could produce 267 – 533 MMGY oil**
- **1 MMGY of sunflower/canola oil will produce 750 tons of meal**
  - Generally low quality, lower value meal compared to soy meal
- **Need infrastructure development**
  - Grain, rail, meal markets, crushing plants
  - Need farmer education program in new areas

Create New Crops – Algae?

- **Same cost of production as soy oil ($0.25/lb) based on demonstration projects if:**
  - Land costs are low
  - Water is abundant
  - Construction costs are reasonable
  - Long growing season and high solar radiation
  - Warm nights
  - Cheap CO2
  - Cheap fertilizer
- **Fraction of oil vs. meal is similar to soy, sunflower, and canola**
  - MUST find a market for the meal
- **New Industry/Crop, Steep learning curve, Risks commiserate with returns**

Near and Long Term Feedstocks

- Short term
  - Exports
  - TFA
  - Increase existing crusher capacity use
- Long term
  - Build new soy crushers
  - Build other oilseed crushers
  - Algae

- 500-700 if all used
- 200-1200
- 375

- 1,250
- 267-533

- ????

Supply Summary

- **0.7 to 1.2 billion gallons per year**
- Oil & fat prices will rise
- New crops, new meal demand, new crushing capacity all will take time
  - 5-10 years or more
  - This portion will add supply slowly

Industry Risks

- **Biodiesel supply exceeds demand in short term**
  - Need more biodiesel demand
  - Low Capacity utilization raises production costs
- Demand may drop if Federal tax credit expires
- **Rising Feedstock Cost**
  - Need more oil production
  - Need more meal demand!
- Quality control problems may retard demand
- Petroleum prices may fall to historical levels
- **Shake out will eliminate high costs firms, bad management, bad technologies**

Summary

- Margins are currently very high
- Demand is very low compared to production capacity
- Demand is growing
- Feedstock supply is limited
- One shot wonder of an industry
- Future growth limited by meal demand

Contact Information

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