Biodiesel Progress: ASTM Specifications and 2nd Generation Biodiesel

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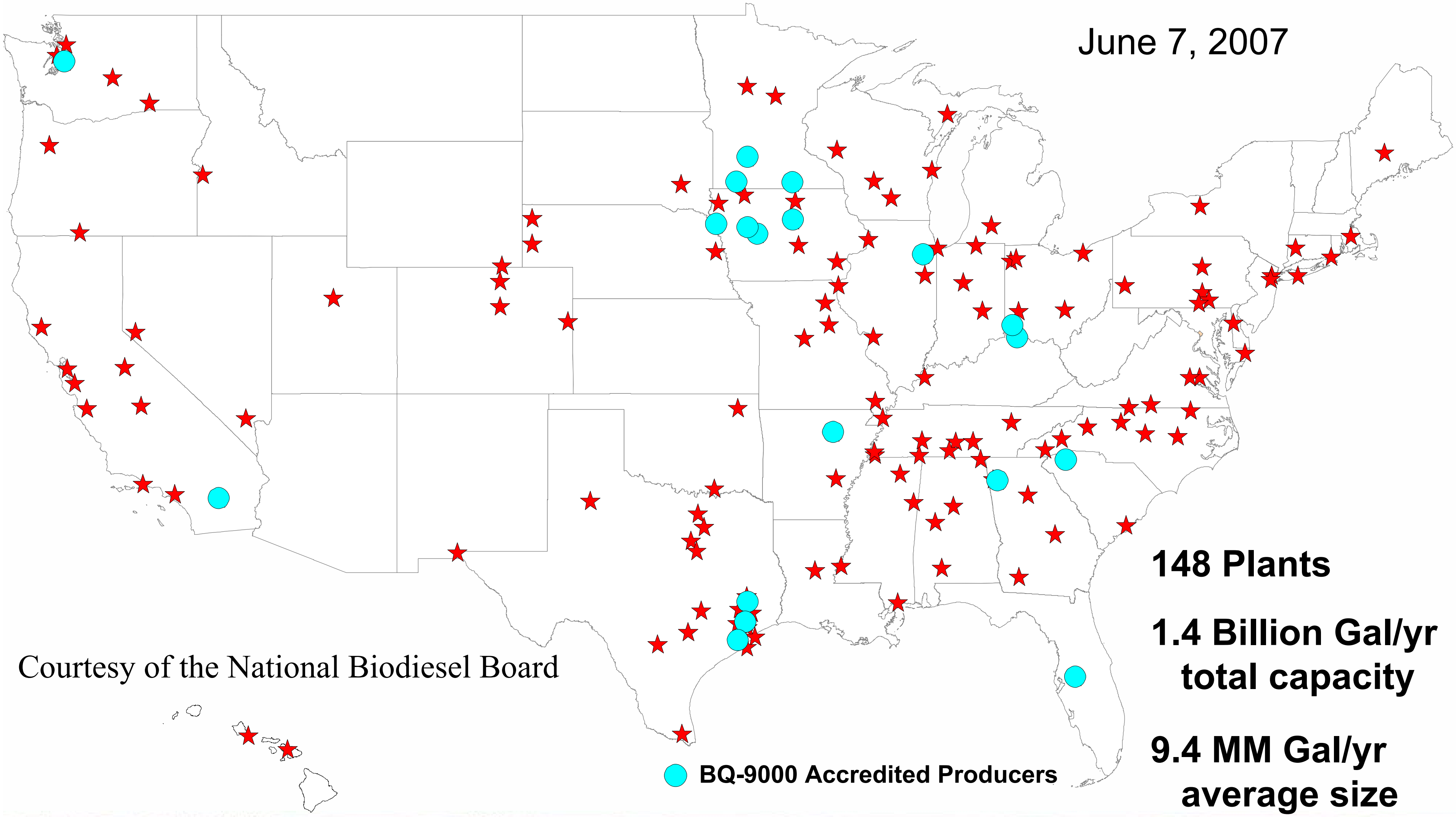
Today's Topics

- Biodiesel Industry Status in the US
- Summary of ASTM Biodiesel Efforts
- 2nd Generation Biodiesel

B100 Plants: Production Locations

June 7, 2007



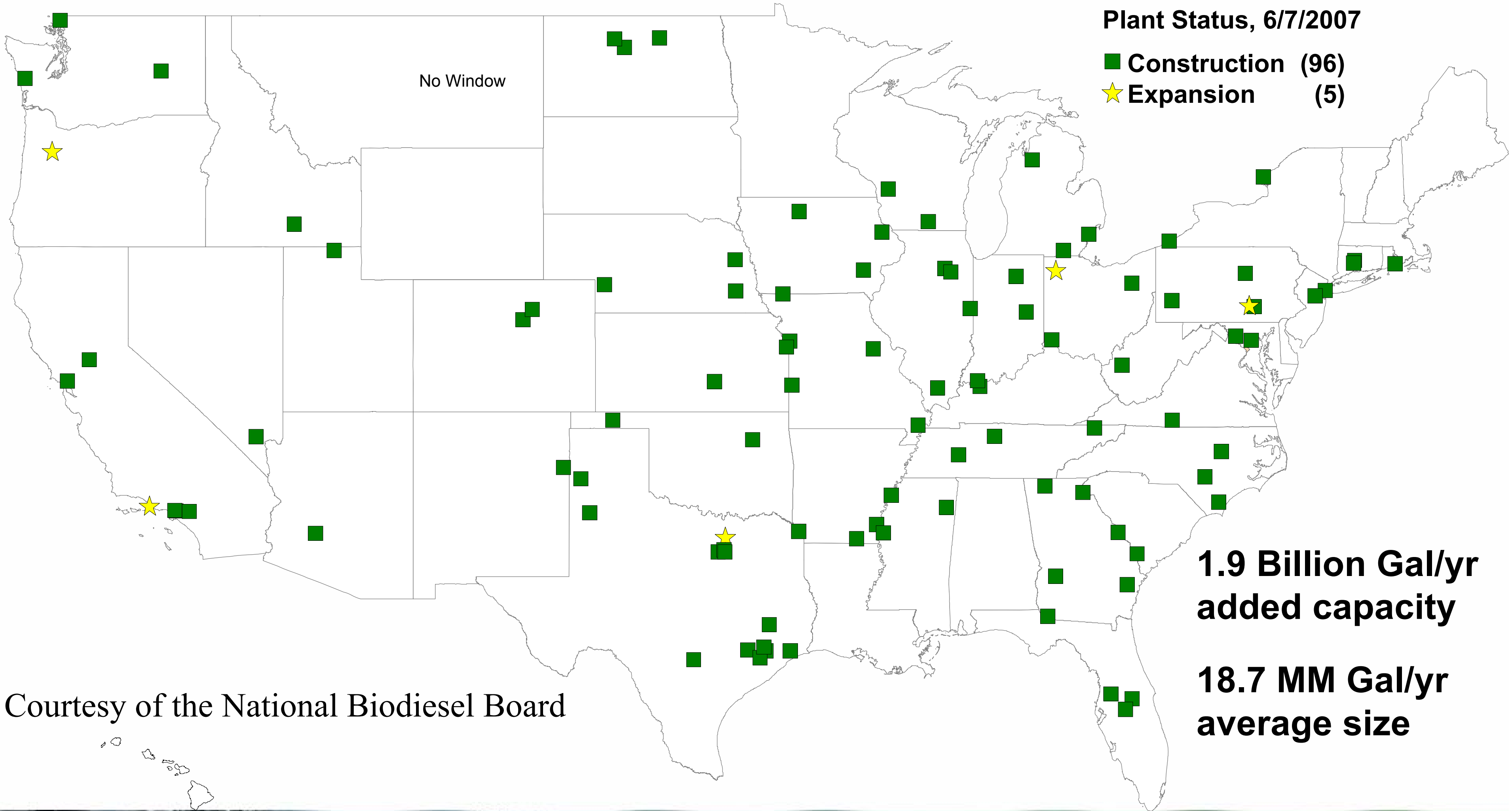
Courtesy of the National Biodiesel Board

148 Plants

1.4 Billion Gal/yr total capacity

9.4 MM Gal/yr average size

B100 Plants: Construction/Expansion



1.9 Billion Gal/yr added capacity

18.7 MM Gal/yr average size

Courtesy of the National Biodiesel Board

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Biodiesel Driving Forces

- Heightened awareness of the vulnerability of the US to our dependence on oil
- High prices for crude oil and its products
- Tax Incentives, both Federal and State
- Current Renewable Fuel Standard (RFS)
- A Variety of New Federal and State RFS's
- Global Warming: Life Cycle CO2 reductions
- Ease of use in existing engines and stations

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ASTM Summary for Biodiesel

Biodiesel Process

(Catalyst)

100 pounds	+	10 pounds	=	10 pounds	+	100 pounds
Triglyceride		Alcohol		Glycerine		Mono-Alkyl Esters
(Soy Oil)		(Methanol)				(Biodiesel)

- Raw Oil and Fats are NOT Biodiesel!
- Other ‘Renewable Products’ are NOT Biodiesel
- Must be long chain mono alkyl esters of fats and oils and meet ASTM D 6751
- This tight definition needed to secure OEM approvals and encourage testing

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Spec Background

- ASTM B100 spec based on existing specs for #1 and #2 petrodiesel in ASTM D 975
- If #1 and #2 meet specs, blends are OK
  - No separate set of specs for blends of #1/#2
- If B100 meets D 6751 and diesel meets D 975, up to 20% biodiesel may be used
  - Blends up to B20 are approved
  - No separate set of specs for the blend
- This has worked well in the marketplace

ASTM D 6751-07a

Property	Test Method	Limits	Units
Calcium & Magnesium	EN 14538	5 max	ppm (ug/g)
Alcohol control			
either Flash Point	**D 93**	**130 min.**	**Degrees C**
or GC methanol	**EN 14110**	**0.2**	**% Volume**
Flash Point	D 93	93 min.	Degrees C
Kin. Viscosity, 40C	D 445	1.9 - 6.0	mm^2/sec.
Sulfated Ash	D 874	0.02 max.	% mass
Sulfur	**D 5453**	**0.05 max (500)**	**% mass (ppm)**
S15	**D 5453**	**0.0015 max (15)**	**% mass (ppm)**
Copper Corrosion	D 130	No. 3 max.	
Cetane number	D 613	47 min.	
Cloud Point	**D 2500**	**Report**	**degrees C**
Carbon Residue	D 4530	0.05 max.	% mass
Acid Number	**D 664**	**0.50 max.**	**mg KOH/g**
Free Glycerin	**D 6854**	**0.020**	**% mass**
Total Glycerin	**D 6854**	**0.240**	**% mass**
Phosphorous content	D 4951	0.001 max	% mass
Distillation, T90 AET	D 1160	360 max	degrees C
Na/K, combined	EN 14538	5 max	ppm (ug/g)
Oxidation Stability	**EN 14112**	**3 min**	**hours**
(Visual Appearance)	**D 4176**	**Free of un-dissolved water, sediment and suspended matter**	

BOLD = BQ-9000 Critical Specification Testing Once Production Process Under Control

Spec Background

- Some users, regulators and OEM's wanted blended fuel specs for biodiesel blends
  - What do you measure if the parent fuel quality is not known? Bid specs, enforcement easier
- Blended fuel specifications are being set so blends will always be in-spec if two good parent fuels are used
- The key is getting B100 that meets D 6751
- Buying from BQ-9000 companies provides added assurance B100 will meet D 6751

BIODIESEL ASTM Current Status

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- ASTM D 6751 is the approved standard for B100 to be used for blending up to B20 in the US
  - ASTM has approved D6751 for B100 use only for up to B20 in the final blend
  - Higher blends upon consultation with the OEM
- B5 being balloted into the petrodiesel specifications: D 975, D 396 (heating oil)
  - No changes to D975, D 396
  - B100 must meet D 6751 prior to blending
- B6 to B20 for on/off road diesel engines will be a stand alone specification
  - Widest of #1/#2 specifications, T-90 5 C increase
  - Addition of stability and acid number for final blend

ASTM D 6751 Activity

- Changes to D 6751 so that no change is needed for B5 in D 975, D 396
  - Completed: lower acid number; add stability parameter, add Ca/Mg, Na/K
- Precipitate above the cloud point issue identified in the market in 2005:
  - Most due to out of specification biodiesel
  - Small portion could be caused by minor components not controlled in the spec
- ASTM is in process of adding a specification to D 6751 that will address this issue in D 6751
- Once addressed, blended fuel ballots can move forward for approval

BIODIESEL ASTM Activity

- New ‘Blended and Alternative Fuels’ category for D 975 and D 396
- All non-petroleum fuels would fall into this category, which would identify:
  - ASTM spec for the blend component
  - Maximum allowable concentration
  - Test method for measuring the component
- No parameters added and none changed compared to current D 975 or D 396

ASTM Activity

- Category was needed to address deficiencies in blend stocks not covered by D 975 or D 396
  - i.e. 5% raw vegetable oil could be blended into D 975 and meet properties of D 975 but could have severe problems not prevented by existing D 975 parameters
  - Biodiesel is covered through meeting D 6751 prior to blending
- Issue: Where do mostly hydrocarbon fuels like FT and hydrotreated oils/fats fall?
  - Are they already 'covered' by existing D 975 or D 396?
  - Do they need an ASTM spec prior to blending?
  - Are there minor components in these fuels that can cause problems which are not covered by D 975 or D 396?
- Task Force set up by ASTM to address these questions
  - Larger issue than just biodiesel, FT, hydrotreated oils/fats
  - Avoid one bad apple spoiling it for all renewables

2^{nd} Generation Biodiesel

Biodiesel Then…..

- Biodiesel originally developed as a niche, high value added product
- Early 1990's, Soybean Farmer Research:
  - Excess soy oil was drain on soybean prices
  - If biodiesel could reach 30 million gallons per year, it could raise soybean prices 5 to 9 cents per bushel
- Raw oils cause problems, efforts focused on low cost processing (i.e. methyl esters) and setting specifications for existing oils/fats
  - No optimization of for oil yields or oil profile
  - Volumes insufficient to drive new, better fats/oils

Biodiesel Now…..

- 148 plants, over 1.4 billion gal/yr capacity
- Over 100 more plants on the horizon
- Potential annual capacity over 3 billion gpy
- President's '20 in 10' would like to see more
- Existing and planned capacity, combined with government signals for the future, are sufficient to consider optimizing crops and their make-up for biodiesel

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NREL, Aug. 2007

- Biodiesel from traditional oilseed crops, fats, and waste oils can be significant
  - Entire US soybean crop could supply ~6% of 60 billion gallon diesel market
- But a '2nd Generation' biodiesel is needed to help meet the Presidents '20 in 10' goals
  - Optimistic scenarios up to 25% of diesel fuel
  - This would require 15 billion gallons of biodiesel
- The oils/fats industry needs to begin to immediately focus on growing more oils/fats

Source: Bob McCormick, National Renewable Energy Laboratory

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"2nd Generation Biodiesel"

- A new biodiesel industry initiative that is just at the beginning stages
- Optimize existing 'traditional' crops for higher oil content and modified fatty acid profile to improve stability and cold flow
- Investigate non-traditional crops for higher oil output and improved fatty acid profile
- Look at novel crops or other sources for oils/fats, i.e. biodiesel's 'cellulosic ethanol'

NREL, Aug. 2007

Crop	Oil Yield Gallons/acre
Corn	18
Cotton	35
Soybean	48
Mustard seed	61
Sunflower	102
Rapeseed/Canola	127
Jatropha	202
Oil palm	635
Algae	"10,000"

Source: NREL; Wikipedia.org

Micro-Algae for Biodiesel

- Existing crops will continue to be used and need to increase oil production and improve FA profile
- New crops like algae will be investigated and have much promise for the future:
  - Much greater per-acre productivity possible with algae
  - Non-food resource
  - Use otherwise non-productive land
  - Can utilize saline water
  - Can utilize waste CO_2 streams
- Micro-algae could be biodiesel's version of cellulosic ethanol

The Ideal Path Forward

- Biodiesel presents a way forward to meet performance, environmental, economic, and energy security needs
- Oilseeds contain both food (i.e. soy meal) and fuel (biodiesel from soy oil)
  - Food vs. fuel is not a major factor for biodiesel
- Legumes (soybeans) are nitrogen fixing and no-till planting practices can be used
  - Minimizes environmental issues of farming
  - Use agricultural land in production for years

The Ideal Path Forward

- Independent USDA/DOE life cycle study shows biodiesel from soybeans has:
  - Fossil energy balance of 3.2 to 1
  - Life cycle CO2 reduction of 78%
- 10% oxygen in biodiesel (B100) has benefits that pure hydrocarbons don't:
  - Imparts lubricity at low concentrations
  - Biodegradable, non-toxic
  - Significant Particulate Matter (PM) reductions
  - Reduced temperatures needed for PM trap regeneration due to character of biodiesel soot

BIODIESEL — The Ideal Path Forward

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- Optimize the fatty acid profile
  - Plant selection, breeding, genetics
- Totally saturated is not desirable
  - Cold flow issues but good stability and cetane
- Totally un-saturated is not desirable
  - Stability issues but good cold flow and cetane
- Optimize for mono-unsaturated
  - Excellent stability, cetane and cold flow
  - Also desirable for edible applications

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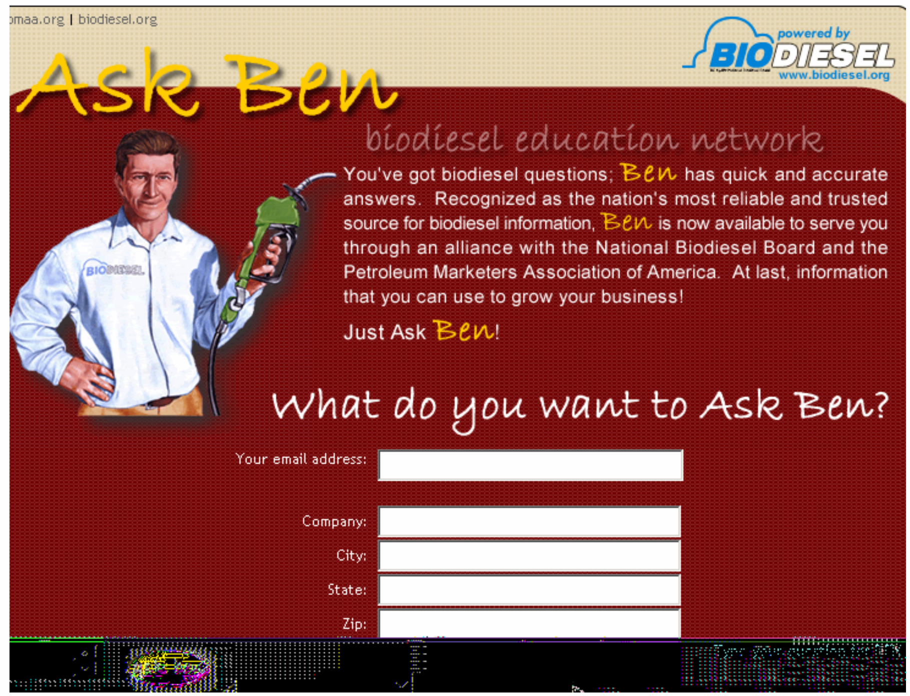
The Ideal Path Forward

- Methyl ester process has low capital, operating and energy costs compared to other processes
  - Glycerine by-product further displaces crude oil products
- Medium size, decentralized plants are possible, compared to huge petroleum refineries
  - Adds new refining capacity, higher number of plants
  - High paying manufacturing JOBS
  - In rural parts of the country that are hurting
  - More companies involved, reduces monopolies
- More plants helps to insure energy security by minimizing impact if one plant becomes inactive
  - Natural disaster (hurricanes on the gulf, flooding, etc.)
  - Man made disaster (terrorist attack or bombing)
  - 'Normal' accidents or shut downs

Educational Resources

- BEN: Biodiesel Education Network
- Web-based resource specifically for petroleum marketers
- Partnership between NBB/PMAA
- www.pmaa.org
- www.biodiesel.org



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Other Biodiesel Resources

- Biodiesel Magazine
  - A **MUST HAVE'** magazine
- Biodiesel Industry Directory On-Line

NBB Resources

- www.biodiesel.org
- Technical Library
- Biodiesel Bulletin
- Educational Videos Available
- Informational Resources
- Technical Resources
- On-line Database & Spec Sheets