

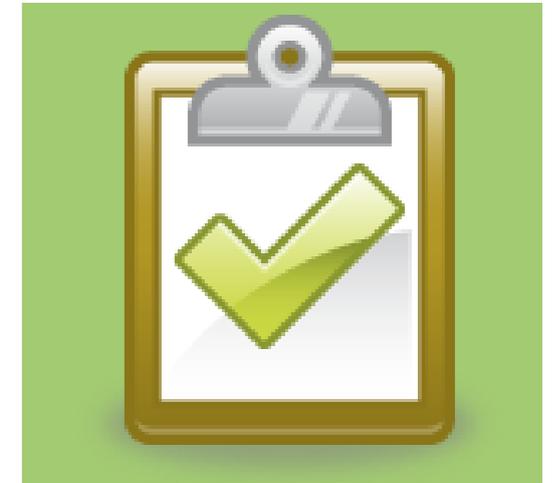


**Biodiesel Industry and  
ASTM Standards for:  
*Washington State DOT*  
*March 22, 2012***

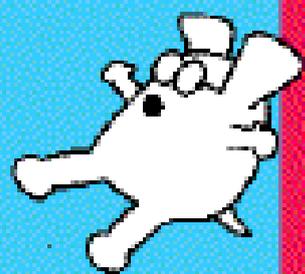
Presented by:  
**Steve Howell**  
**MARC-IV/NBB**



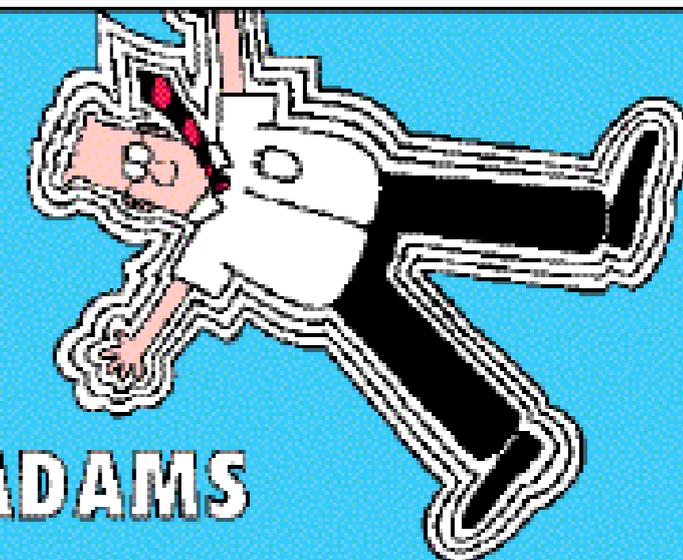
# Topics for Today:



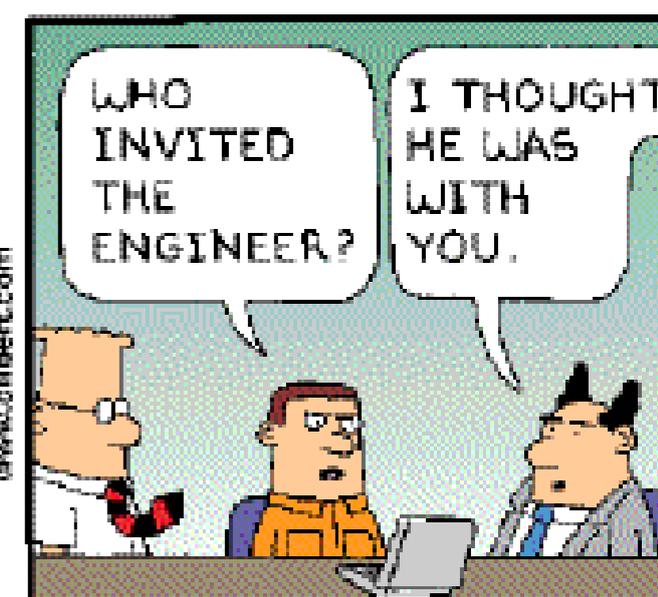
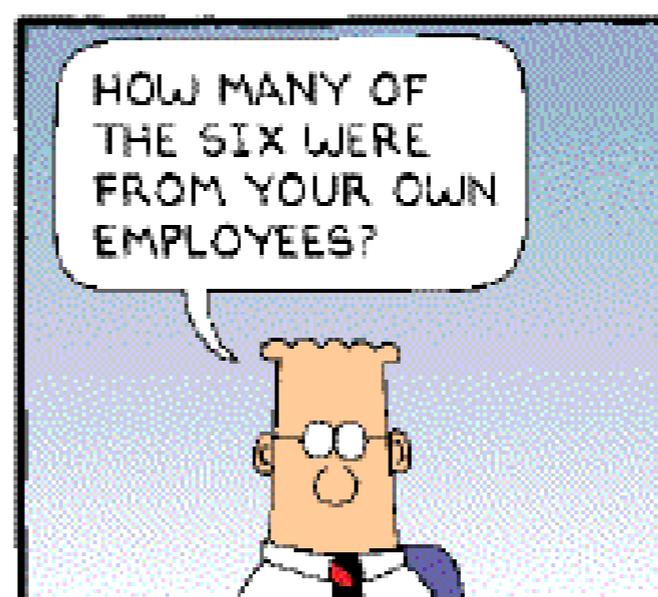
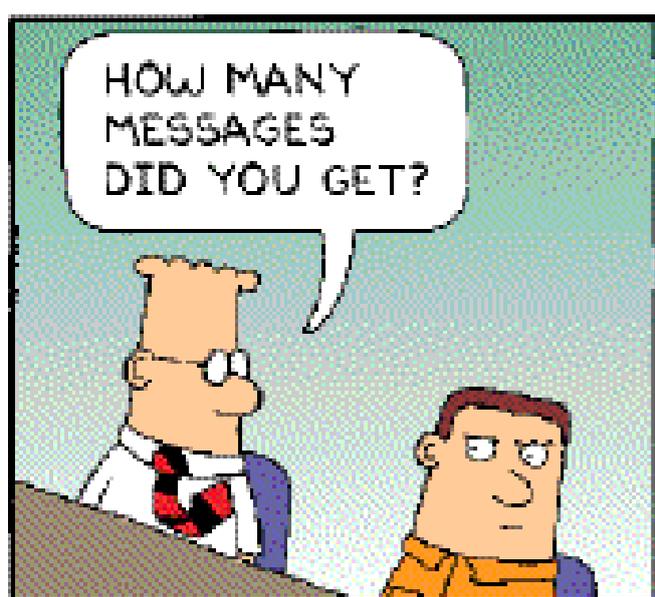
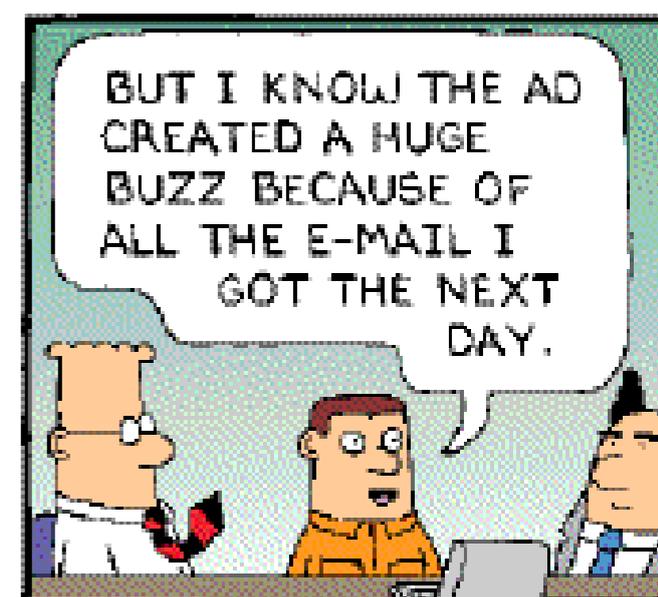
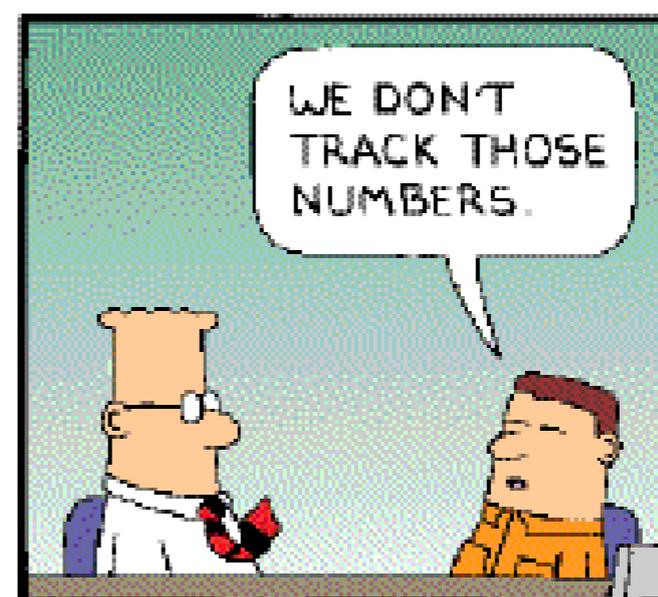
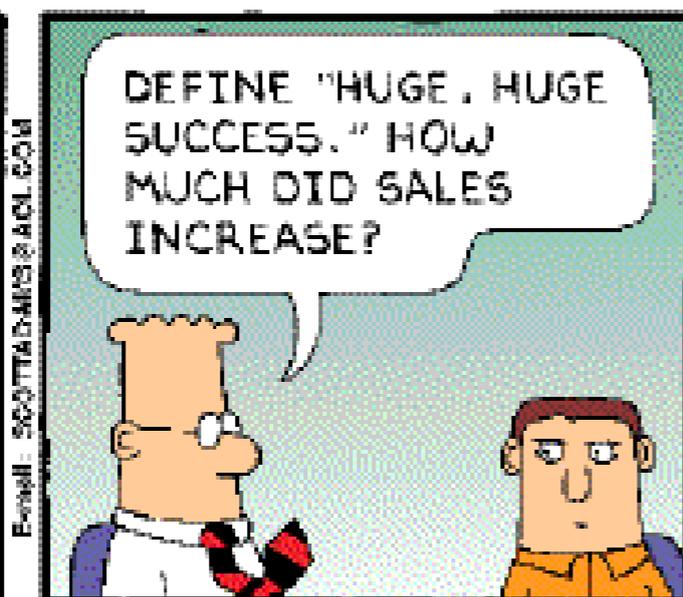
- Biodiesel Industry Vision and Current Status
- Why Biodiesel?
- Engine/Vehicle Manufacturer Support for Biodiesel
- RFS2 as a Major Driver for the Biodiesel Industry
- ASTM Standards
- Cold Flow Status and Options



# DILBERT®



BY  
SCOTT ADAMS



# Biodiesel Industry Vision and Current Status



# Biodiesel Industry Vision: 2015

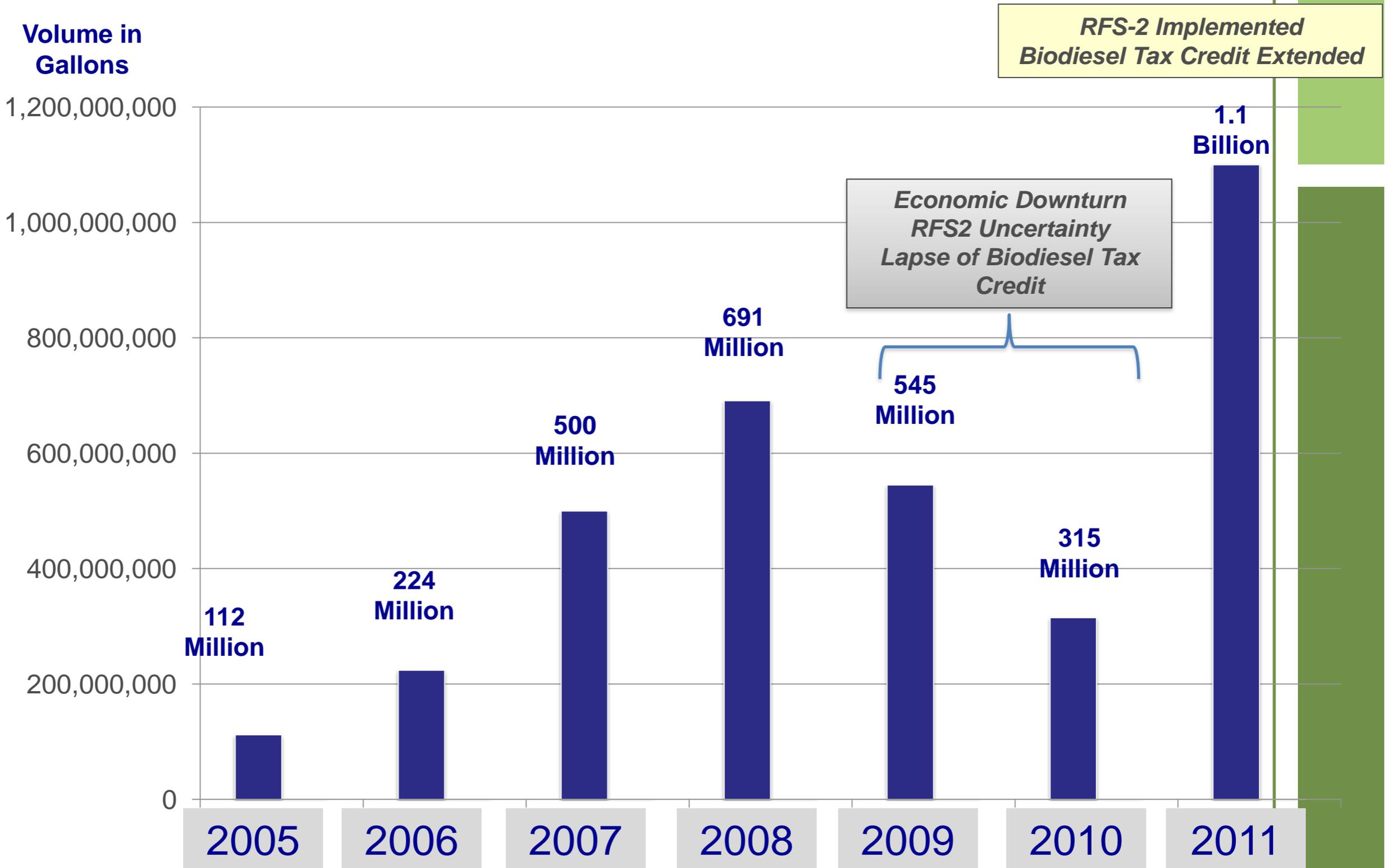


- By 2015, biodiesel will be viewed as an integral component of a national energy policy which increasingly relies on clean, domestic, renewable fuels. Positive market dynamics coupled with federal policy will support a significant and stable market. **Sales, primarily in the form of low level biodiesel blends, will replace 5% of diesel demand by 2015.** Energy security and environmentally driven uses, such as B20, remain a significant and visible source of demand. Grassroots involvement remains a strong & vital strength of the industry.

# Significant Impact

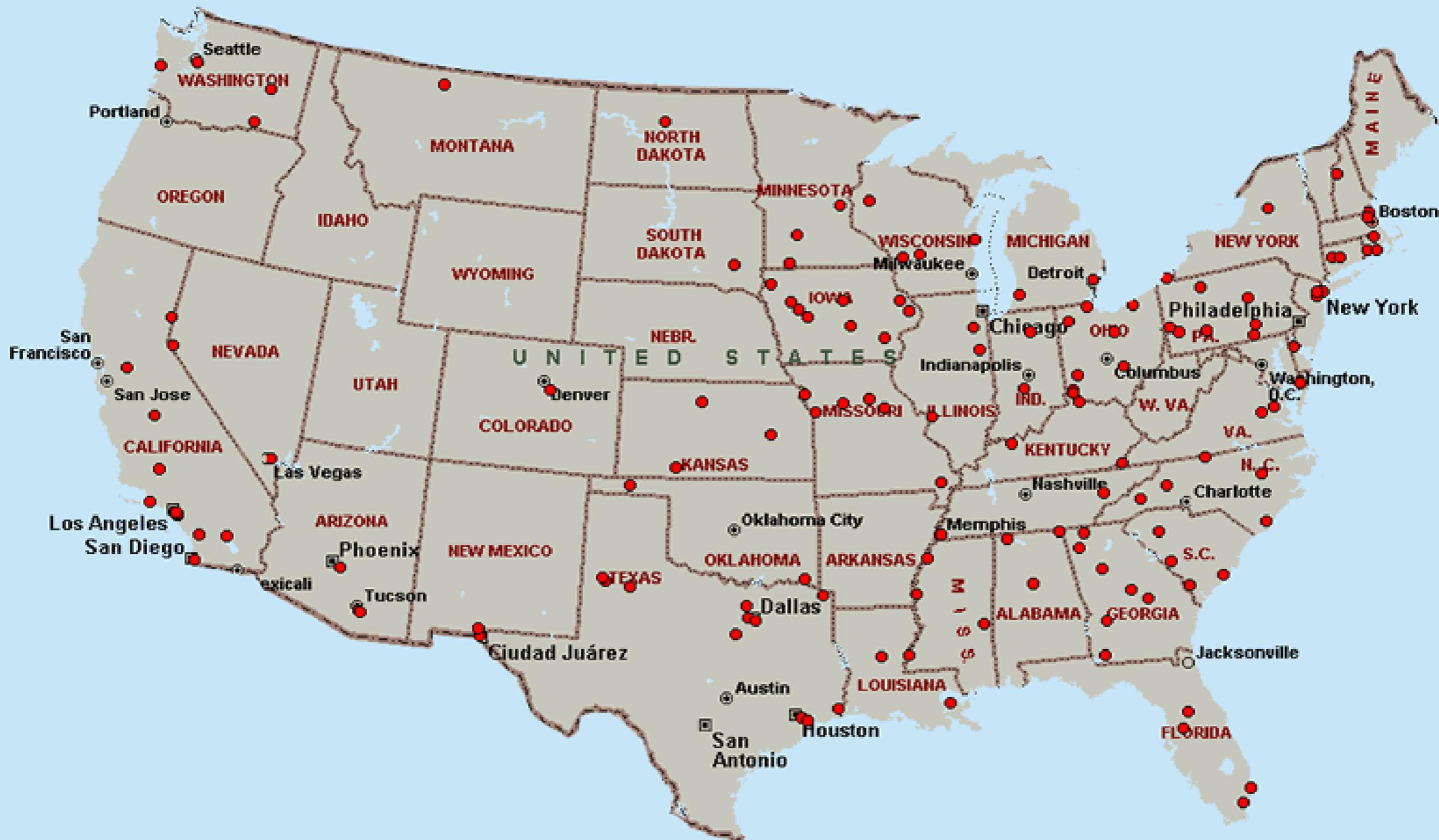
- Five year average of on-highway diesel fuel demand in the U.S. is 37.8 billion gallons
  - Replacing 5% with biodiesel = 1.88 billion gallons of biodiesel
- In 2010, the United States imported 1.93 billion gallons of ULSD from other countries
- In 2010, the United States imported the equivalent of 1.52 billion gallons of diesel from Iraq crude oil and 3.6 billion gallons from Venezuela crude oil.

# Estimated U.S. Biodiesel Production by Calendar Year



# Biodiesel: An “Advanced Biofuel” Available Now

205 EPA-Registered plants nationwide with over 3.08 Billion GPY Capacity



# Producing Biodiesel

Reacting:

In the presence of a catalyst

Yields:

**100 Pounds  
Vegetable Oil  
or  
Animal Fat**

**+**

**10 Pounds  
Alcohol**



**100 pounds  
Biodiesel**

**+**

**10 pounds  
Glycerine**

# Domestic Feedstocks



Cottonseed Oil



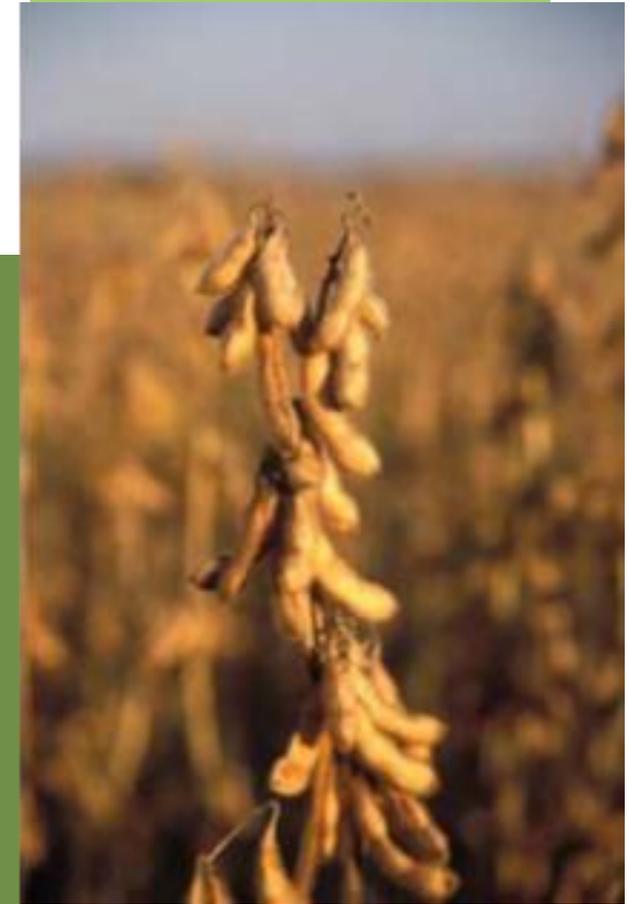
Yellow Grease



Animal Fats



Corn Oil from DGS



Soybean Oil



Canola Oil



Brassica Juncea



Camelina Oil

**Catalyst:**  
Sodium Hydroxide  
Potassium Hydroxide

**Alcohol:**  
Methanol  
Ethanol

# Why Biodiesel?



# Biodiesel Performance

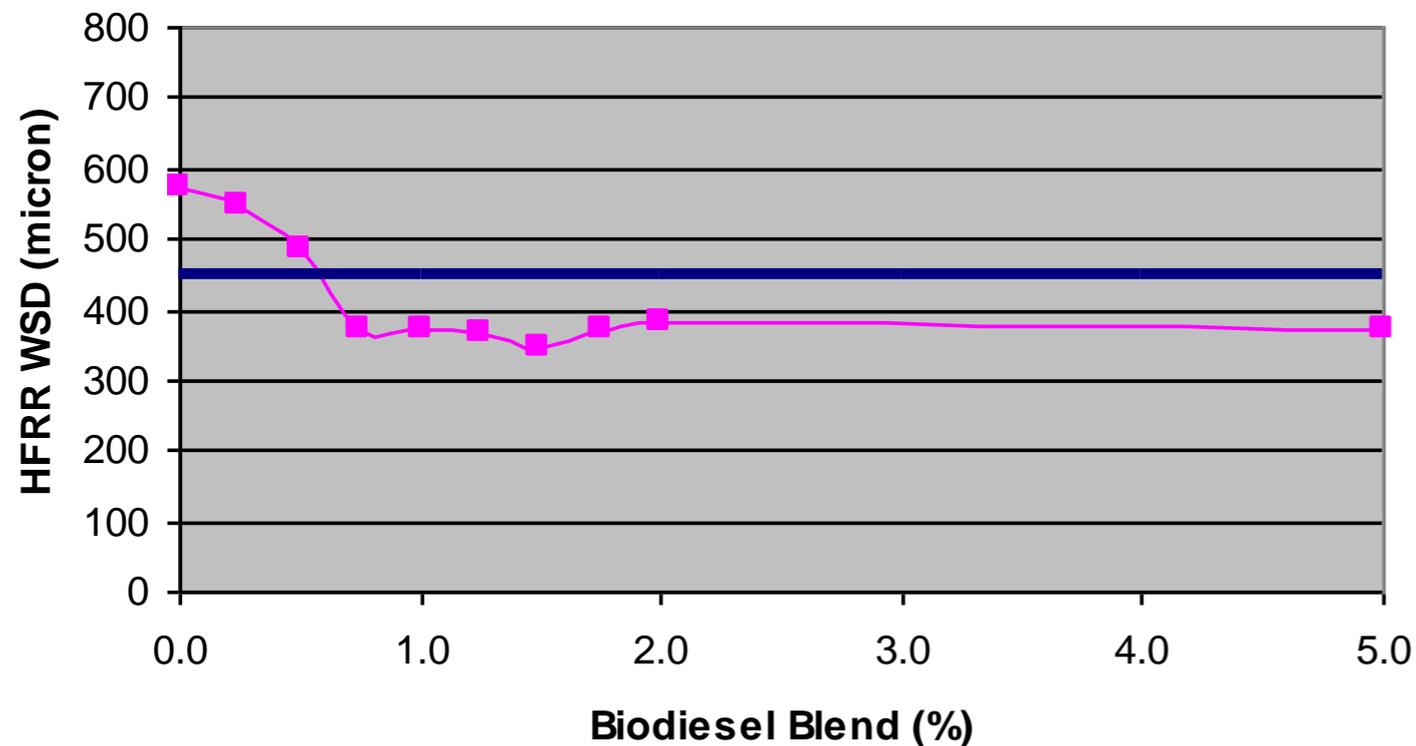
- Ultra Low Sulfur avg < 2 ppm
- B100 High Cetane (avg. over 50)
- Biodiesel blends up to B20 can be used in diesel engine without modification, according to manufacturers' recommendations
  - Some OEMs only recommend up to B5 blends
- B20 provides similar horsepower, torque, towing capability and fuel economy



**B5: The official fuel of the 2009 Volkswagen Jetta TDI Cup Racing Series.**

# Enhanced Lubricity

Ultra-low Sulfur Diesel



- Engine Makers recommend less than 450 wear scar lubricity
- ASTM specification is 520

- New Ultra Low Sulfur Diesel fuel requires some type of lubricity additive
- Biodiesel Benefits
- B2 has up to 66% more lubricity than #2 Diesel
- Overdosing with conventional lubricity additives can cause problems; No overdosing issues with biodiesel

# Climate Change and Health Benefits

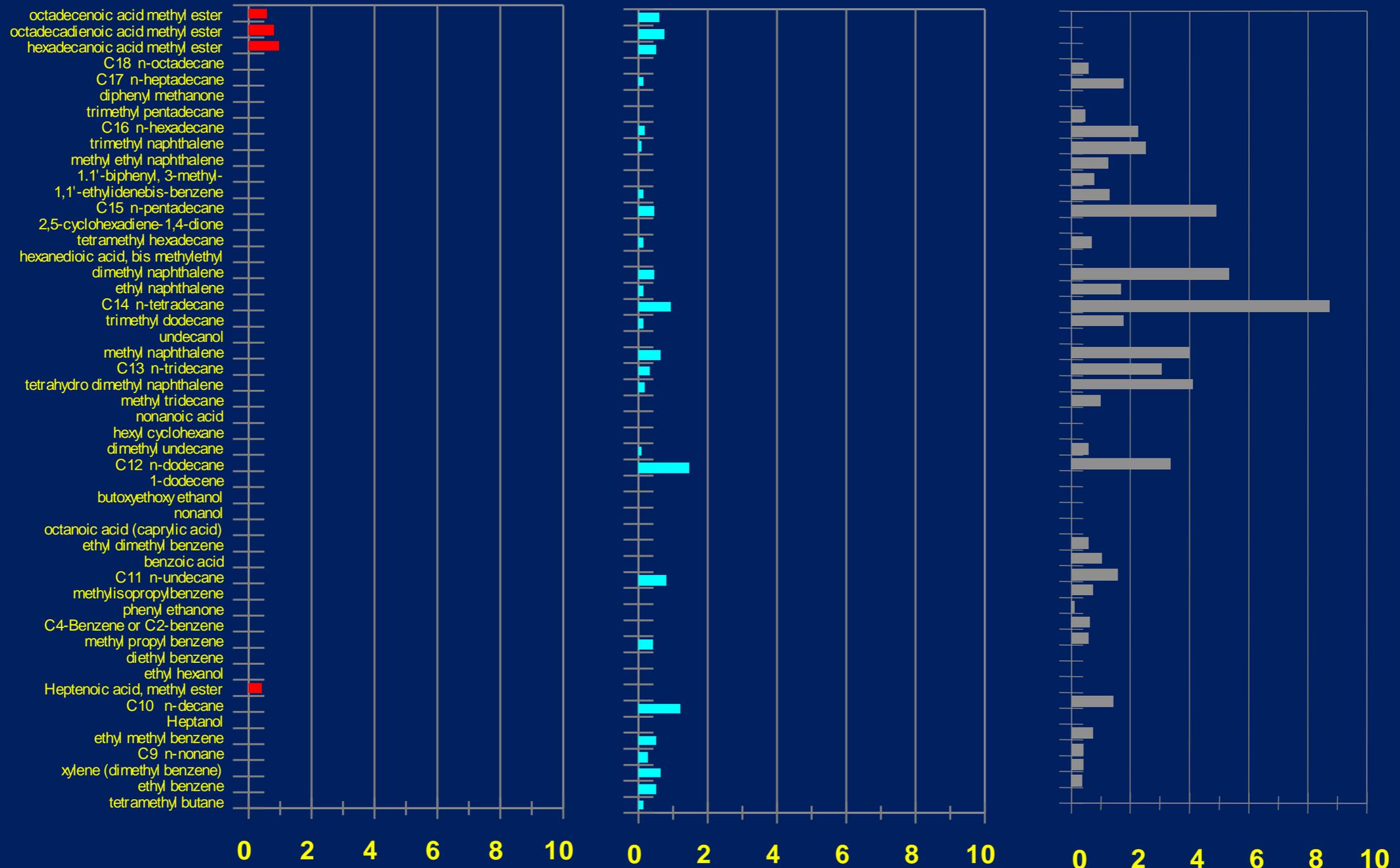


- Closed Carbon Cycle: CO<sub>2</sub> Used to Grow Feedstock is Put Back Into Air
  - 86% Life Cycle Decrease In CO<sub>2</sub>
- Energy Balance 5.54 to 1
- Compression Ignition Platform (i.e. diesel) is 30% More Efficient Than Spark Ignition (i.e. gasoline, CNG, propane)
- Biodiesel reduces engine out PM, HC, and CO emissions
- Biodiesel significantly reduces PAH's linked to cancer

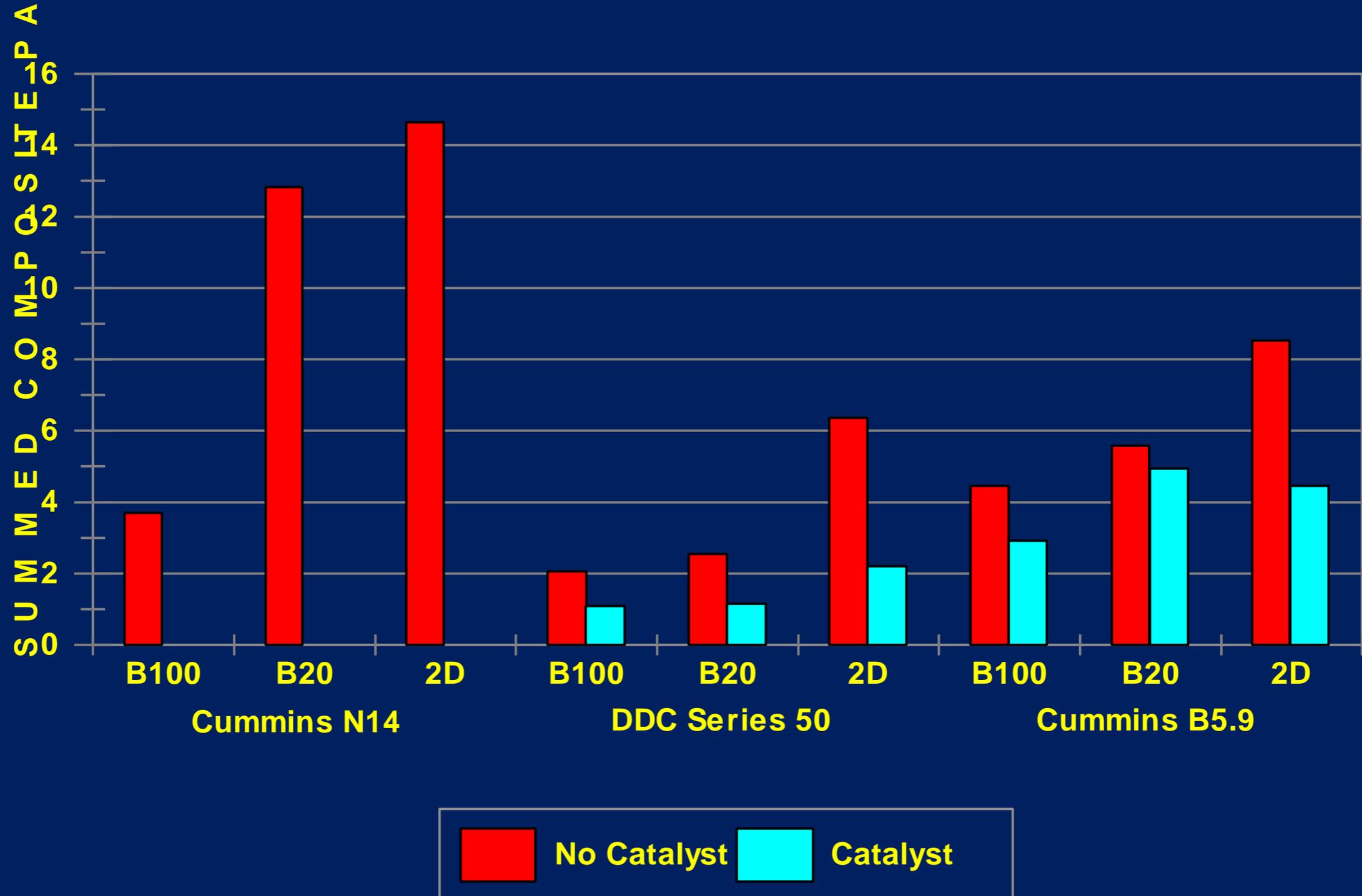
**B100**

**B20**

**2D**



**RELATIVE EMISSION RATE (MG/HP-HR)**



# Biodiesel is Non-Hazardous



- Nontoxic: LD50 = 17.4 g/Kg - less toxic than table salt
- Skin irritation less than that of 4% soap and water solution
- Flash point above 200 Degrees F
- Non-corrosive
- Non-reactive

# Sustainability of Biodiesel



- Biodiesel is made from fats and oils that are a minor by-product of producing food
  - Soybeans are 80% protein, 20% oil
  - No one grows livestock for its fat content
  - No one fries more food to get used oil for biodiesel
- US sources of biodiesel are mostly food, with only a small portion used for biodiesel, no food vs. fuel issues
- There are promising technologies that can increase oils/fats without utilizing any additional farmland

# Net Positive for Food Supply



- All materials used for biodiesel are Ag by-products
- Soybeans are grown based on the demand for their 80% protein meal
- By increasing the value of the 20% oil portion, you are lowering the cost of the healthy protein portion used for food and feed
- In 2009, the soybeans used to make 247 million gallons of soybean oil based biodiesel produced soybean meal for 72 billion rations of protein

# Econometrics

- Biodiesel is a low cost option for turning oils and fats into usable fuel for diesel applications:



- Low capital cost for facilities
- Low processing costs
  - 80% of product cost is from oil/fat
- Processing and technology widely studied and available
- Specifications fully accepted up to B20
- Oxygen (~10%) remains in the fuel
  - Do not lose oxygen in the production process like other oil/fat processing options
- Full use of co-products
  - Glycerin is sold as co-product which can further displace petroleum and reduce climate change impacts



# Biodiesel can be Pipelined

## Biodiesel by Pipeline:



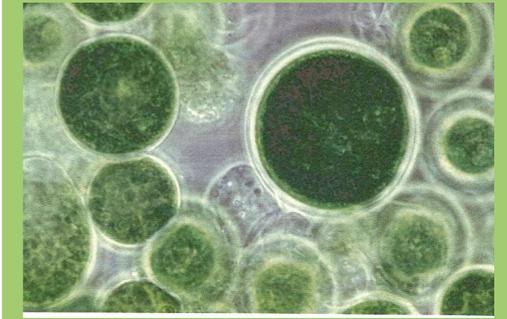
- B5 and lower blends are being transported on existing US pipelines that do not carry jet fuel. Volumes relatively small.
- B5 and lower blends are being transported in Europe on lines that carry jet fuel
  - B100 level in jet fuel must be maintained  $<5$  ppm
- Large project being executed to provide allowance of higher ppm levels of biodiesel in jet fuel
- This would facilitate biodiesel pipeline shipment on all U.S. pipelines— even those with jet fuel

# Confidence You Can Trust

- Biodiesel industry's seal of approval for biodiesel producers, marketers and laboratories
- ASTM Grade Fuel, BQ-9000 Companies
- Over 80% of biodiesel is from BQ-9000 companies



# Optimized Biodiesel



- Higher volumes are spurring on new thinking...
- It is possible to select fatty acid profile for optimized biodiesel:
  - B100 with -20F cloud points or lower
  - B100 with superior stability vs. most petrodiesel
- Optimized biodiesel will eliminate the performance deficiencies of today's biodiesel vs. petrodiesel and allow use of higher blends, B100
- Less expensive than adding processing steps

# OEM Support for Biodiesel



# OEM Warranty Statements & Biodiesel



- All major U.S. OEMs support at least B5 and lower blends, provided they are made with biodiesel meeting ASTM D 6751
  - Most OEMs are also recommending use of a BQ-9000 supplier
- **More than 60% of U.S. manufacturers now support B20 or higher blends in at least some of their equipment;**
- **More than 95% of medium-duty truck market supports B20**
- Use of blends over that recommended by the OEM does not necessarily 'void' the OEM parts and workmanship warranty
- For a complete listing of **OEM position statements on biodiesel**, as well as the **current U.S. Diesel Vehicles List**, visit: <http://www.biodiesel.org/resources/oems>

Biodiesel is compatible with Diesel Particulate Filters in today's new clean diesel technology, and has some distinct advantages:

- Lowers regeneration temperatures
- Less engine out particulate matter
- May provide increased performance and decreased maintenance vs. ULSD alone
- May provide increased fuel economy

- Mike Rowe video here

# Advanced Biofuel – Defined:

## EPA Definition 40 CFR 80.1401 -

**Advanced Biofuel** means renewable fuel, other than ethanol derived from cornstarch, that has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline lifecycle greenhouse gas emissions.



# Volume Standards as Set Forth in RFS2

**Conventional  
Renewable  
Fuels**

+

**Total  
Advanced**

=

**Total  
Renewable  
Fuel**

**Advanced Biomass  
Based Diesel**

+

**Non -Cellulosic  
Advanced**

+

**Cellulosic  
Advanced**

=

**Total Advanced**

Year	Conventional Renewable Fuels (Grandfathered Or 20% Reduction)	Advanced Biofuel NESTED STANDARDS				Total Renewable Fuel
		Biomass-Based Diesel (50% Reduction)	Non Cellulosic Advanced (50% Reduction)	Cellulosic Biofuel (60% Reduction)	Total Advanced Biofuel	
2008	9.00					9.0
2009	10.50	0.5	0.1		0.6	11.1
2010	12.00	0.65	0.2	0.1	0.95	12.95
2011	12.60	0.80	0.3	0.25	1.35	13.95
2012	13.20	1.0	0.5	0.5	2.0	15.2
2013	13.80	1.0	0.75	1.0	2.75	16.55
2014	14.50	1.0	1.00	1.75	3.75	18.15
2015	15.00	1.0	1.50	3.0	5.5	20.5
2016	15.00	1.0	2.00	4.25	7.25	22.25
2017	15.00	1.0	2.50	5.5	9.0	24.0
2018	15.00	1.0	3.00	7.0	11.0	26.0
2019	15.00	1.0	3.50	8.5	13.0	28.0
2020	15.00	1.0	3.50	10.5	15.0	30.0
2021	15.00	1.0	3.50	13.5	18.0	33.0
2022	15.00	1.0	4.00	16.0	21.0	36.0

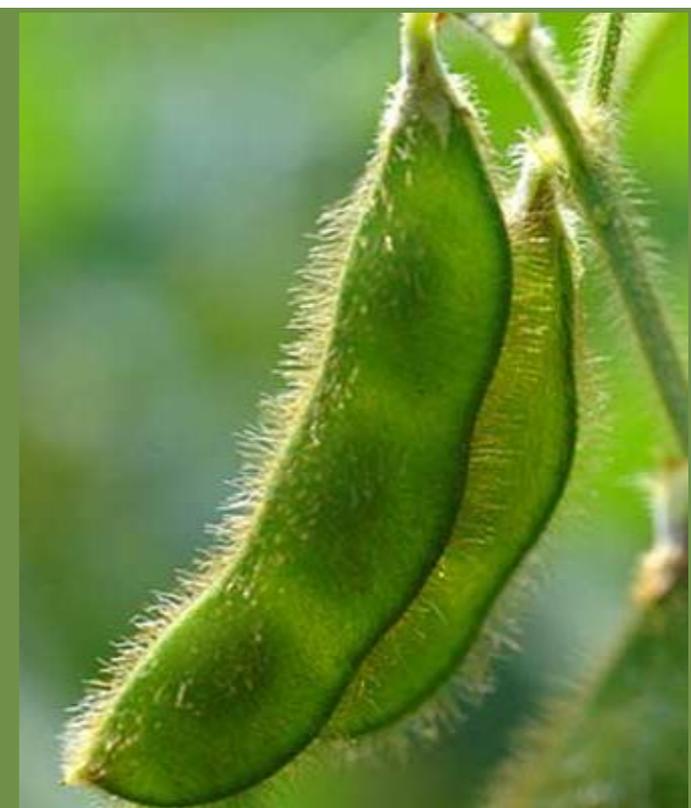
# GHG Requirements: Renewable Biomass and Eligible Biofuels



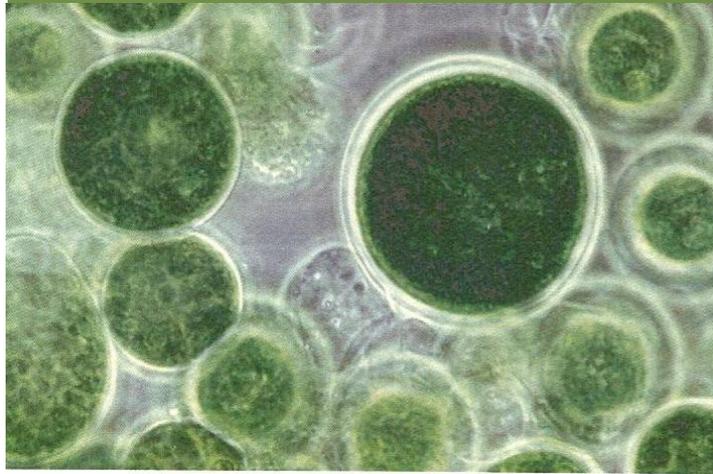
- Lifecycle GHG Emissions Must Be At Least 50% Less Than Diesel Fuel - EPA Approved Pathways:
  - Vegetable Oils derived from Soybeans, Canola and Camelina;
  - Waste Oils / Yellow Grease;
  - Animal fats;
  - DDG Corn Oil derived from the ethanol production process;
  - Algae, and
  - Secondary annual crops planted on existing cropland

# Biodiesel Feedstocks and Production Forecasts

- Based on economic modeling study by Dr. John Kruse and IHS Global Insight:
- “By using demonstrated yield technologies available to farmers today in combination with consistent biofuels policies and the DOE/EIA crude oil price forecast, **biodiesel production can reach 2.5 billion gallons by 2017.** This can be reached with growing global food demand for vegetable oils without dramatic increases in vegetable oil prices.”
- **Note:** This work only evaluated feedstocks that have approved pathways or were under review by EPA; over next 5 years, additional feedstocks may contribute to the overall supply, **potentially reaching 3.3 BGPY by 2022.**



# Future Feedstocks



**Algae**



**Jatropha**



**Halophytes**



**Pennygrass**



**Brown Grease**

*Photo by: Joel Rose*



**Low Ricin Castor**

# ASTM Standards and Cold Flow Information



# Biodiesel Defined

- Biodiesel, n. -- a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, meeting ASTM D 6751, designated B100.
- Biodiesel Blend, n. -- a blend of biodiesel fuel with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

# Biodiesel (B100)

## Definition

- Eliminates:
    - Raw Vegetable Oils and Fats
    - Non-Esterified Oils
    - Partially Esterified Oils
    - Coal Slurries
    - Blends With Diesel
    - Any other 'Biomass Based Diesel'
  - Many of these have caused serious problems in diesel engines in past testing...
- This tight definition was needed in order to secure vehicle, engine and fuel injection equipment company support for biodiesel, as well as to secure ASTM specs

# Important Parameters

Insured  
Through  
ASTM  
D 6751

- \$60 MM research, 225,000 hits: 'Biodiesel Tech Reports'
- Focus on small levels of 'non-diesel' components
- **Complete Reaction/Removal of Glycerin**
  - Insured through total/free glycerin spec
- **Removal of Catalyst**
  - Insured through sulfated ash spec
- **Removal of Alcohol**
  - Insured through flash point spec
- **Absence of Free Fatty Acids**
  - Insured through acid value spec

# Biodiesel ASTM Standards:



**ASTM D6751** is the approved standard for B100 for blending up to B20, in effect since 2001

- Performance-based standard: Feedstock and Process Neutral

**D975** – Covers petrodiesel and blends up to 5% biodiesel maximum for on/off road engines; B5 is now fungible with diesel fuel

**D396** – Covers heating oil and blends up to 5% biodiesel; B5 is now fungible with petro-based heating oil

**D7467** – Covers blends containing 6% to 20% biodiesel for on/off road engines

- Designed so that if B100 meets D6751 and petro diesel meets D975, then B6 to B20 blends will meet their specifications

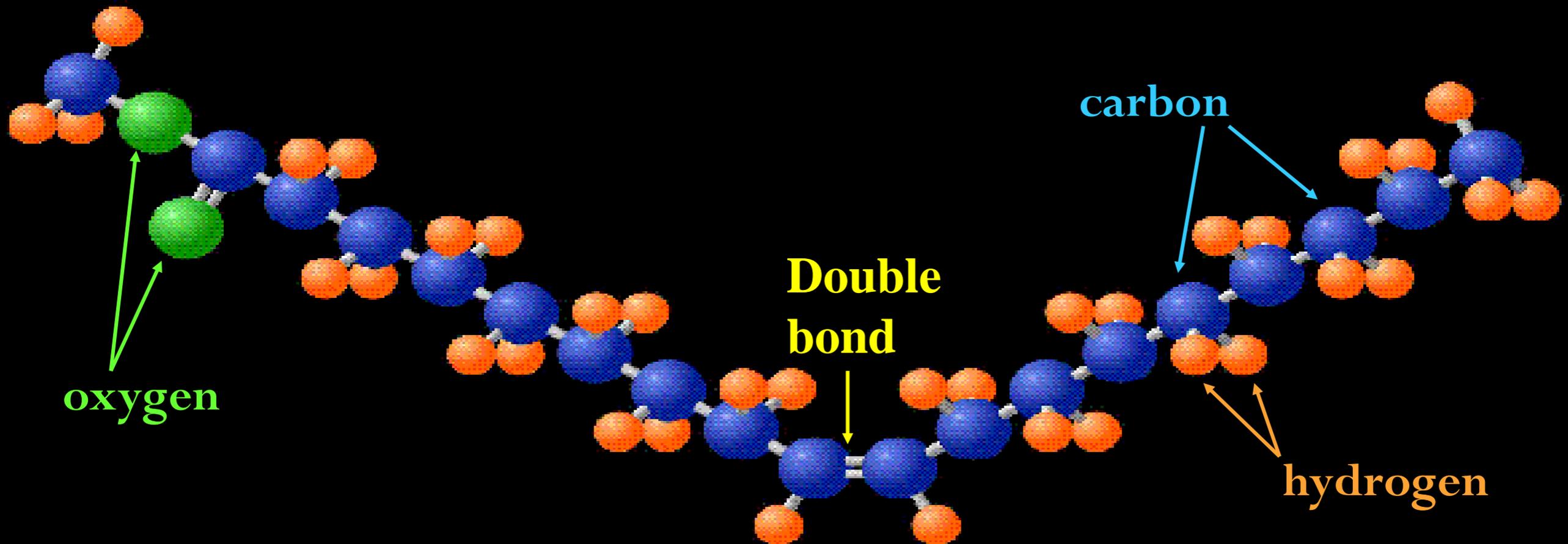
# Continuous Improvement



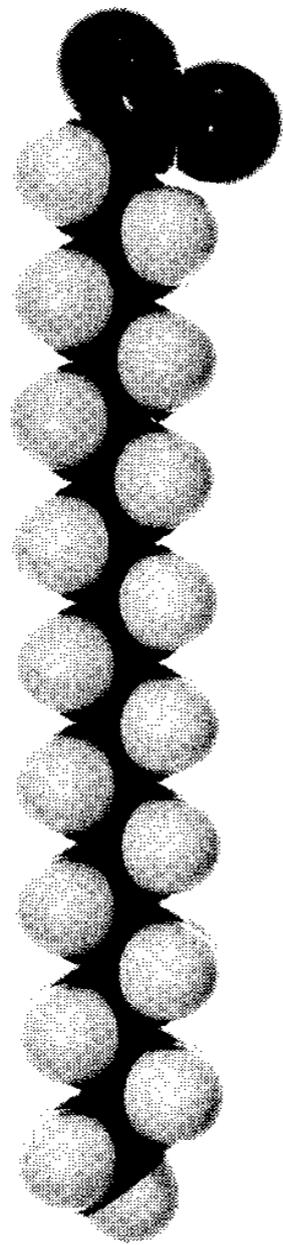
- As with other fuels, D6751 continues to improve and evolve over time
  - Especially as petrodiesel and engines change
- The ULSD today is different than when it was originally introduced and is currently experiencing its own issues, such as internal injector coking or tank corrosion in some cases
- Diesel engine temperatures and pressures are up
  - Clearances are down, filter sizes are smaller
  - After-treatment systems are sensitive to metals that had no impact before
- The biodiesel industry is continually evaluating D6751 to ensure it works well with new petrodiesel and engine technology

# Fatty acid methyl ester (biodiesel molecule)

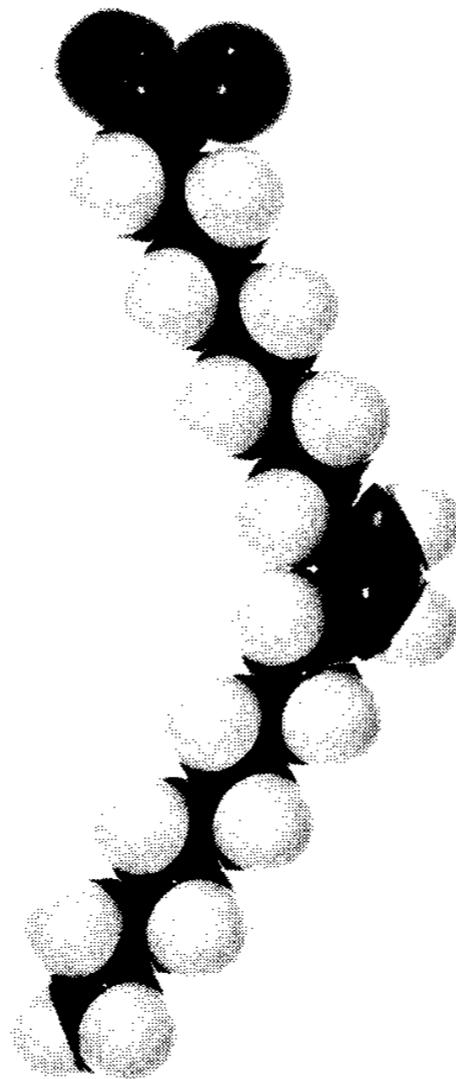
These slides courtesy of the US Department of Energy



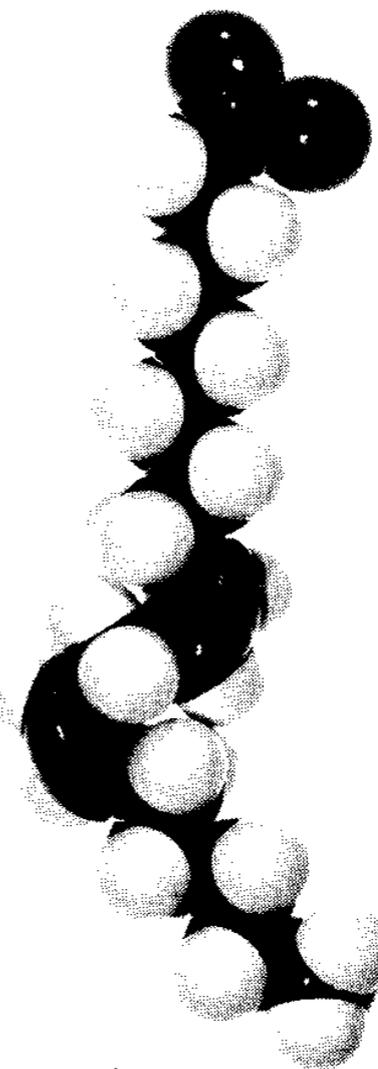
# Other C18 Fatty Acids



Stearic acid



Oleic acid



Linoleic acid

# Biodiesel Composition

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- **Biodiesel is composed of fatty acid esters**
  - **C12:0 and C14:0**
  - **C16:0 and C16:1**
  - **C18:0 , C18:1, C18:2, C18:3**
  - **C20 and C22:1**
- **The different proportions of fatty acids found in feedstocks influence some biodiesel fuel properties**

	Biodiesel, Oil/Fat Type								
							Inedible Tallow &		
<b>Carbon Chains</b>	<b>Soy</b>	<b>Corn</b>	<b>Cotton</b>	<b>Sun</b>	<b>Pork (Lard)</b>	<b>Beef (Tallow)</b>	<b>Yellow Grease</b>	<b>Rapeseed (Canola)</b>	<b>Component Boiling pt AET</b>
<b>14/15</b>	<b>1</b>		<b>0.7</b>		<b>1.5</b>	<b>4.6</b>	<b>1.4</b>		<b>300</b>
<b>16:0</b>	<b>12</b>	<b>12</b>	<b>24</b>	<b>8</b>	<b>23.5</b>	<b>25.8</b>	<b>15.8</b>	<b>5.0</b>	<b>328</b>
<b>16:1</b>			<b>1</b>		<b>3.4</b>	<b>4.3</b>	<b>2.0</b>		
<b>17/17:1</b>					<b>0.8</b>	<b>2</b>	<b>0.4</b>		
<b>18:0</b>	<b>4</b>	<b>2.5</b>	<b>2</b>	<b>3</b>	<b>12</b>	<b>20.4</b>	<b>14.5</b>	<b>2.0</b>	<b>353</b>
<b>18:1</b>	<b>25</b>	<b>29</b>	<b>17</b>	<b>20</b>	<b>44.3</b>	<b>39.1</b>	<b>48.8</b>	<b>63.0</b>	<b>351</b>
<b>18:2</b>	<b>52</b>	<b>56</b>	<b>55</b>	<b>67.8</b>	<b>10.7</b>	<b>2.3</b>	<b>14.5</b>	<b>20.0</b>	<b>347</b>
<b>18:3</b>	<b>6</b>	<b>0.5</b>	<b>0.3</b>	<b>0.5</b>	<b>3.1</b>	<b>1.3</b>	<b>1.6</b>	<b>9.0</b>	<b>345*</b>
<b>20+</b>				<b>0.7</b>	<b>0.7</b>	<b>0.2</b>	<b>1.1</b>	<b>1.0</b>	<b>375*</b>
<b>% of US oil/fat feedstock available</b>	<b>53.8</b>	<b>7.7</b>	<b>2.8</b>	<b>3.2</b>	<b>3.2</b>	<b>5.1</b>	<b>21.3</b>	<b>1.8</b>	
<b>Total: 3.5 bil gal/yr</b>									<b>*estimated</b>

# Cold Flow Properties

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<b>Fuel</b>	<b>Cloud Point °C</b>	<b>Pour Point °C</b>	<b>CFPP °C</b>
No. 2 D	-15 to 5	-35 to -15	-10 to -20
SME	-3 to 2	-7 to -1	-4 to 1
RME	-11 to -4	-15 to -7	-13 to 4
YGME	4 to 8	0 to 6	N/a
TME	12 to 16	6 to 13	11

# Figure 6. Biodiesel/Diesel Blend Cloud Point Test Results

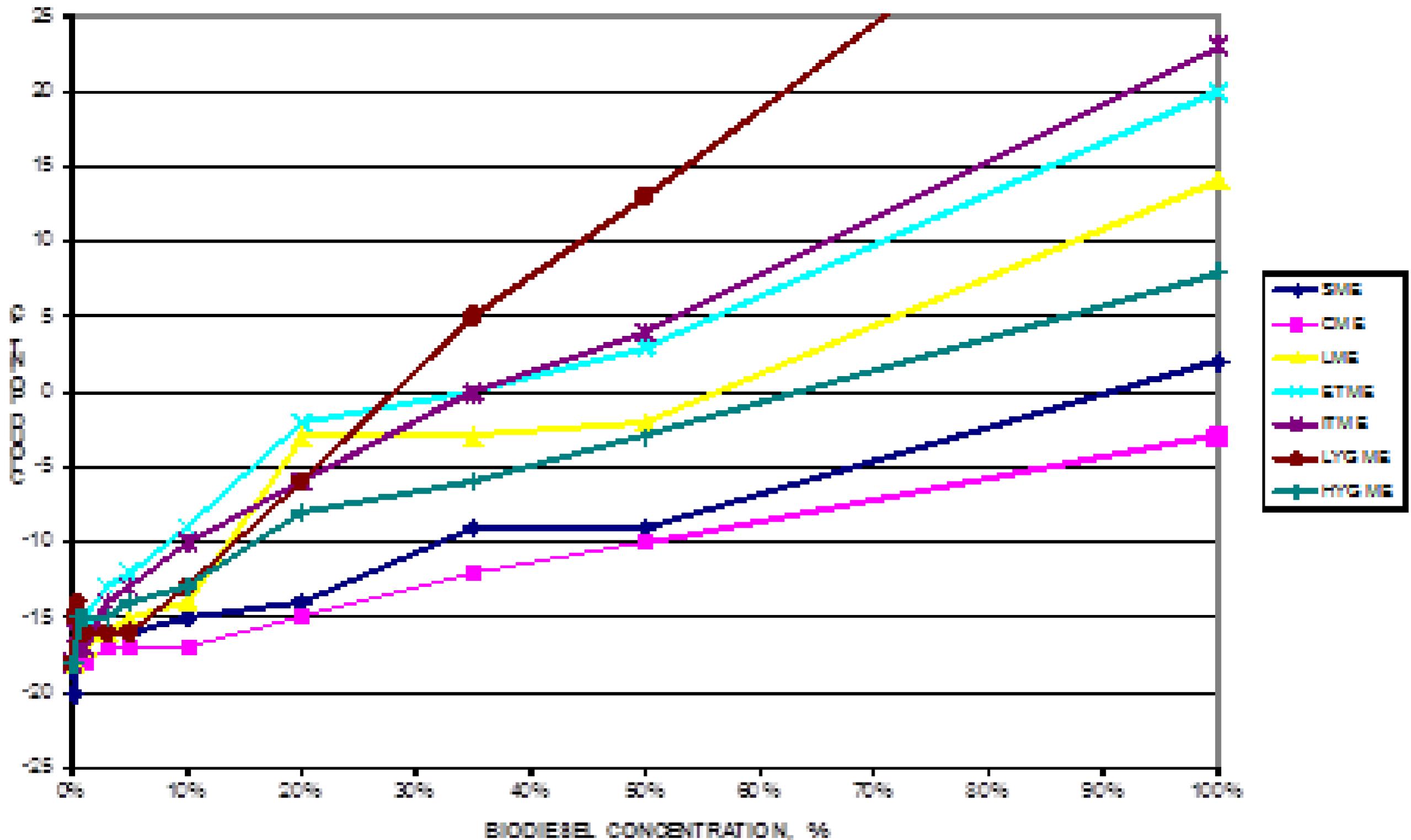
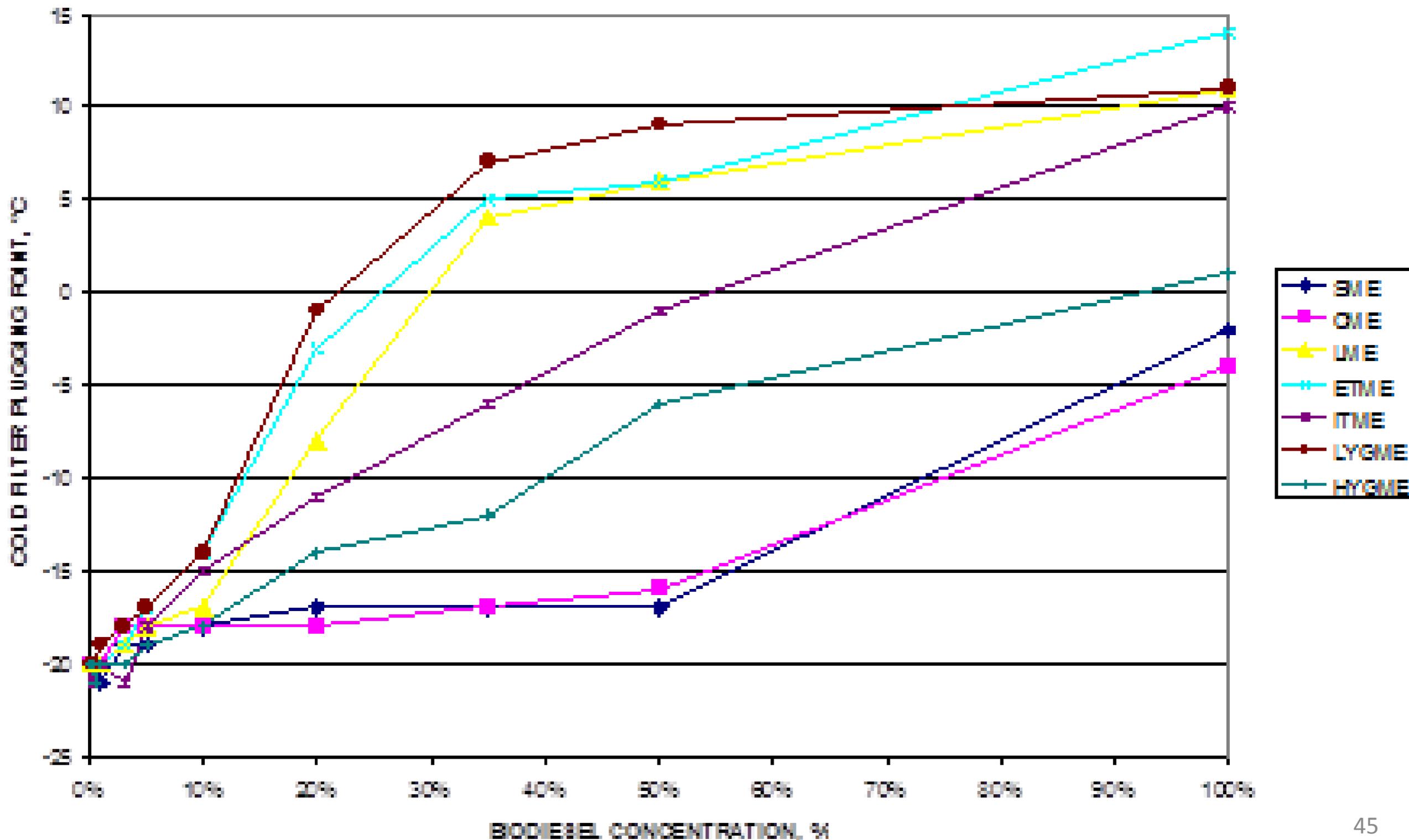


Figure 10. Biodiesel/Diesel Blend Cold Filter Plugging Point Test Results



- The properties of the base biodiesel and petrodiesel are important factors
- The same means for improving cold flow properties of No. 2 petrodiesel work for biodiesel and biodiesel blends:
  - Blend with lower cloud base fuel (i.e. No. 1)
  - Utilize cold flow improving additives
  - Use fuel filter or engine block heaters
  - Recirculate warm fuel back into the fuel tank
  - Store vehicle indoors

# Biodiesel Resources

➤ **Call NBB: 1-800-841-5849**

➤ **[www.biodiesel.org](http://www.biodiesel.org)**

- Biodiesel Training Toolkit
- OEM Warranty Positions on Biodiesel
- U.S. Diesel Vehicle List
- News Releases & Information Resources
- Technical Library, Spec Sheets & Videos

➤ **[www.BQ-9000.org](http://www.BQ-9000.org)**

- Listing of BQ-9000 Certified Companies

➤ **[www.biodieselsustainability.com](http://www.biodieselsustainability.com)**

- Biodiesel Sustainability information and blog

➤ **[www.allthingsbiodiesel.com](http://www.allthingsbiodiesel.com)**

- Biodiesel merchandise, literature, pump labels and more!





**Thank You!**  
**Questions...?**