UCONN Biofuels Symposium

Biodiesel Quality, Standards and Certification

January 11, 2007

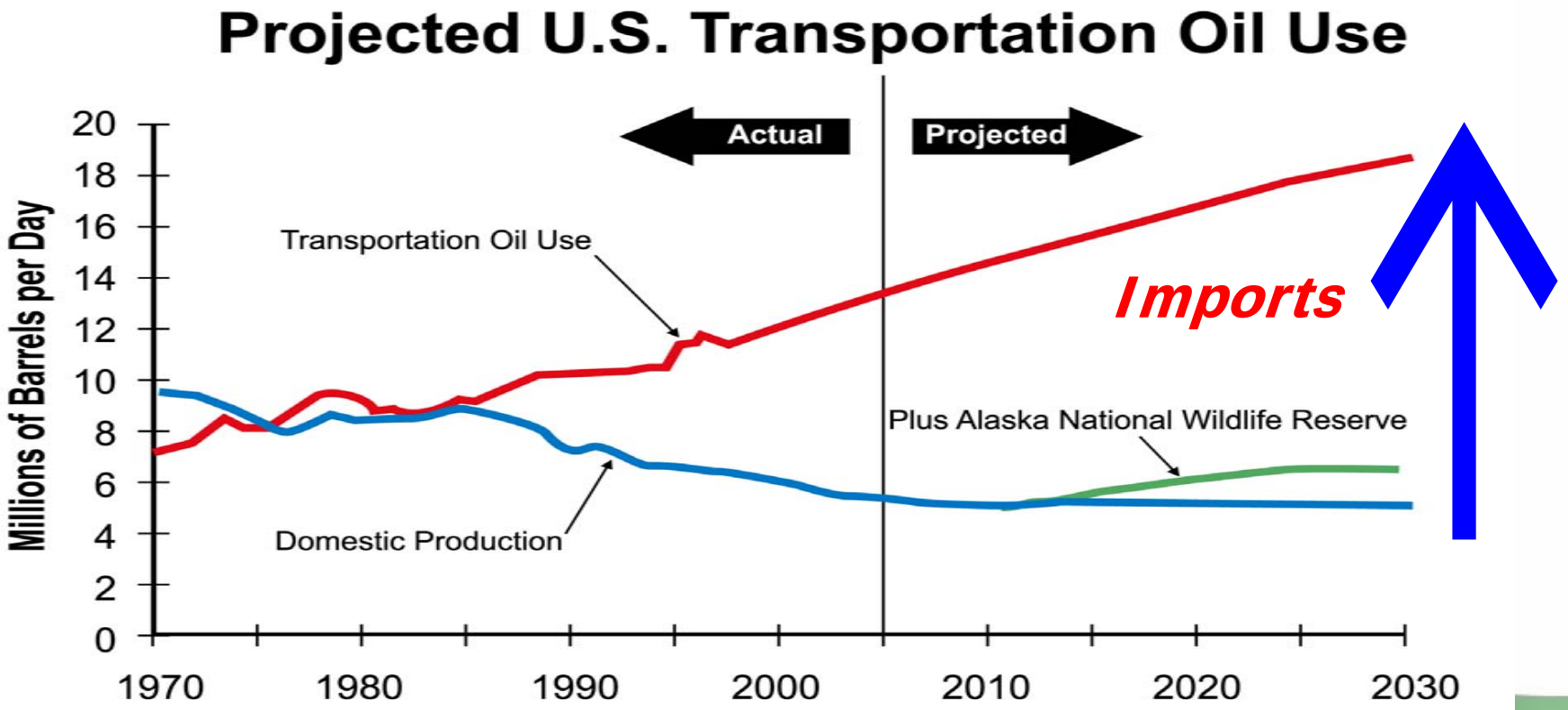
- Presented By -

Paul Hoar
AgriFuels LLC
&
National Biodiesel Board
(Richard Nelson)

Contact-Us: Info@AgriFuels.com

Liquid Fuel Energy Picture for the United States

- The United States currently uses ~20 million barrels of oil per day (world consumption ~80 million barrels).
- The United States currently imports ~ 60% of its petroleum needs - projected to be 70% + by 2025.
- The cost of petroleum imports to the United States is at least 700 million dollars per day!



Presentation Outline

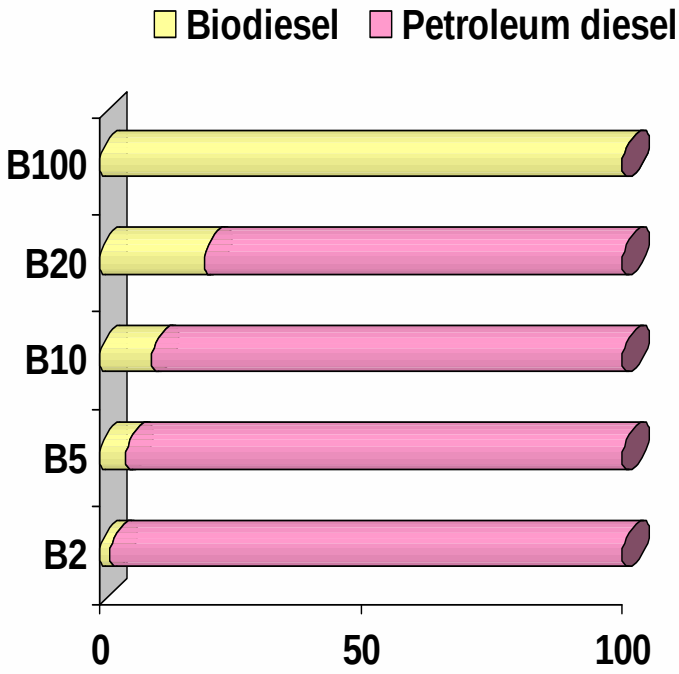
- Biodiesel Basics and Fuel Properties
- Production Status
- Biodiesel Standard ASTM D 6751
- BQ 9000 Certification

Biodiesel Defined

- Biodiesel, n. -- a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, **and meeting the requirements of ASTM D 6751.**
- **Include definition in all state rules and regulations**
- CT Biodiesel Standard: ASTM PS 161-99

General Concepts

- Biodiesel is a **domestic, renewable** fuel for diesel engines derived from fats and oils such as soybeans and animal fats.
- Biodiesel can be used in any concentration with petroleum-based diesel fuel in existing diesel engines with little or no modification.



- **Biodiesel is *not* raw vegetable oil!**
  - Biodiesel ***must*** be produced by a chemical process that removes glycerin from the oil.

Biodiesel blend, n. -- a blend of biodiesel fuel meeting ASTM D 6751 with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

B100 Properties

- High Cetane (averages >50)
- High Lubricity (<300 HFRR) – (HFRR, High Frequency Reciprocating Rig, accepted ASTM test standard)
- BTU Content (7-9% lower than #2)
  - Some users see better fuel economy with B20 —this is most likely due to the cleaning effect of B20
- Cold Flow (3-10^{o} F > for soy-based B20)
- Flash Point (>260^{o}F vs 117^{o} F)
- No nitrogen or aromatics
- Biodegradable, non-toxic, renewable and sustainable
- 78% Life Cycle CO2 Reduction and high energy balance (3.2 to 1)

Biodiesel Lowers Emissions

Emission Type	B100	B20	B2
Total Unburned Hydrocarbons	-67%	-20%	-2.2%
Carbon Monoxide	-48%	-12%	-1.3%
Particulate Matter	-47%	-12%	-1.3%
Oxides of Nitrogen (NO_X)	+10%	+2% ***	+.2%

Biodiesel Production

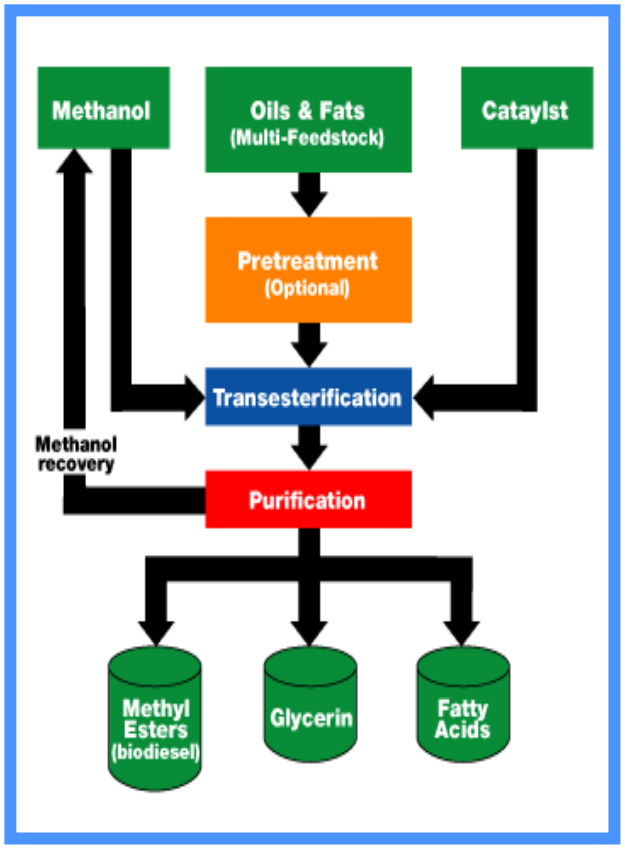
Transesterfication (the biodiesel refining process)

Combining

Vegetable Oil or
Animal Fat
(100 lbs.)
+
Methanol or
Ethanol
(10 lbs.)

Soy, Tallow, Waste Grease, Sunflower, Cottonseed, Canola

in the presence of a catalyst

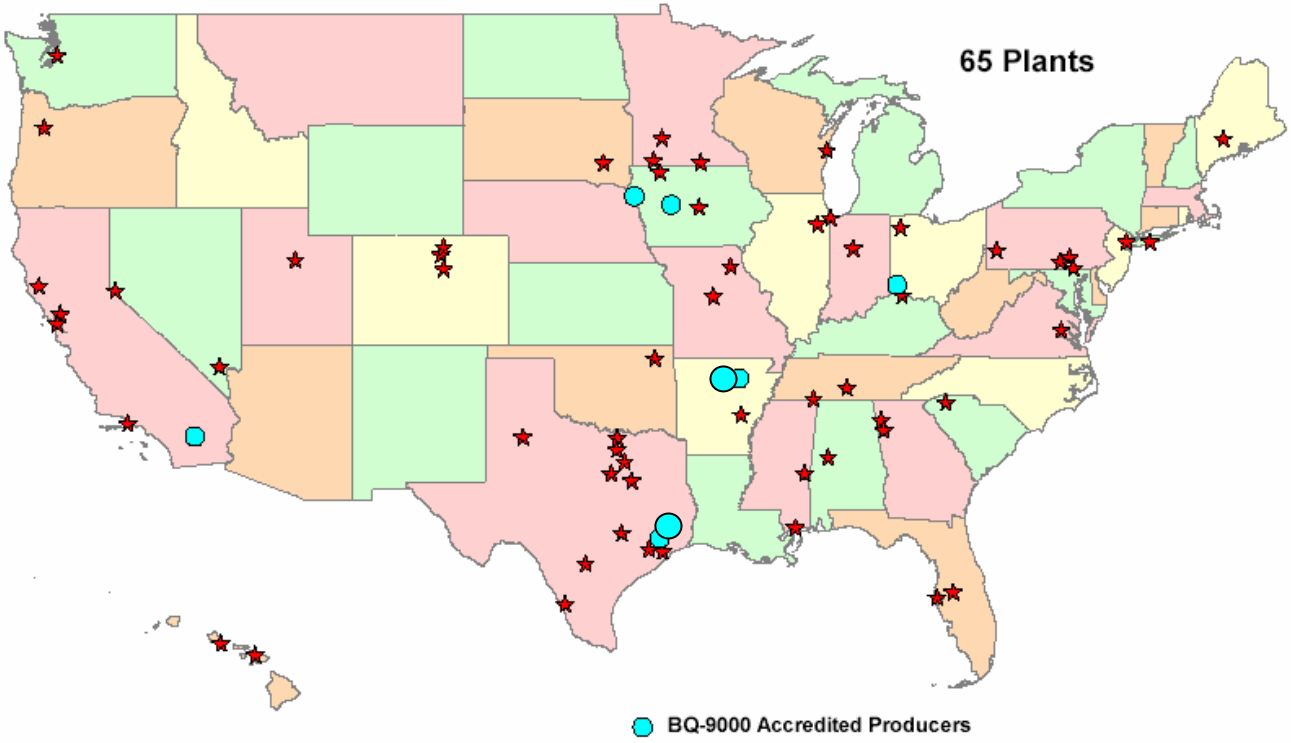


Yields

Biodiesel
(100 lbs.)
+
Glycerine
(10 lbs.)

Current Biodiesel Plants

Current Production Capacity (6M): 594,000,000 Gal



Future Biodiesel Plants (18M)

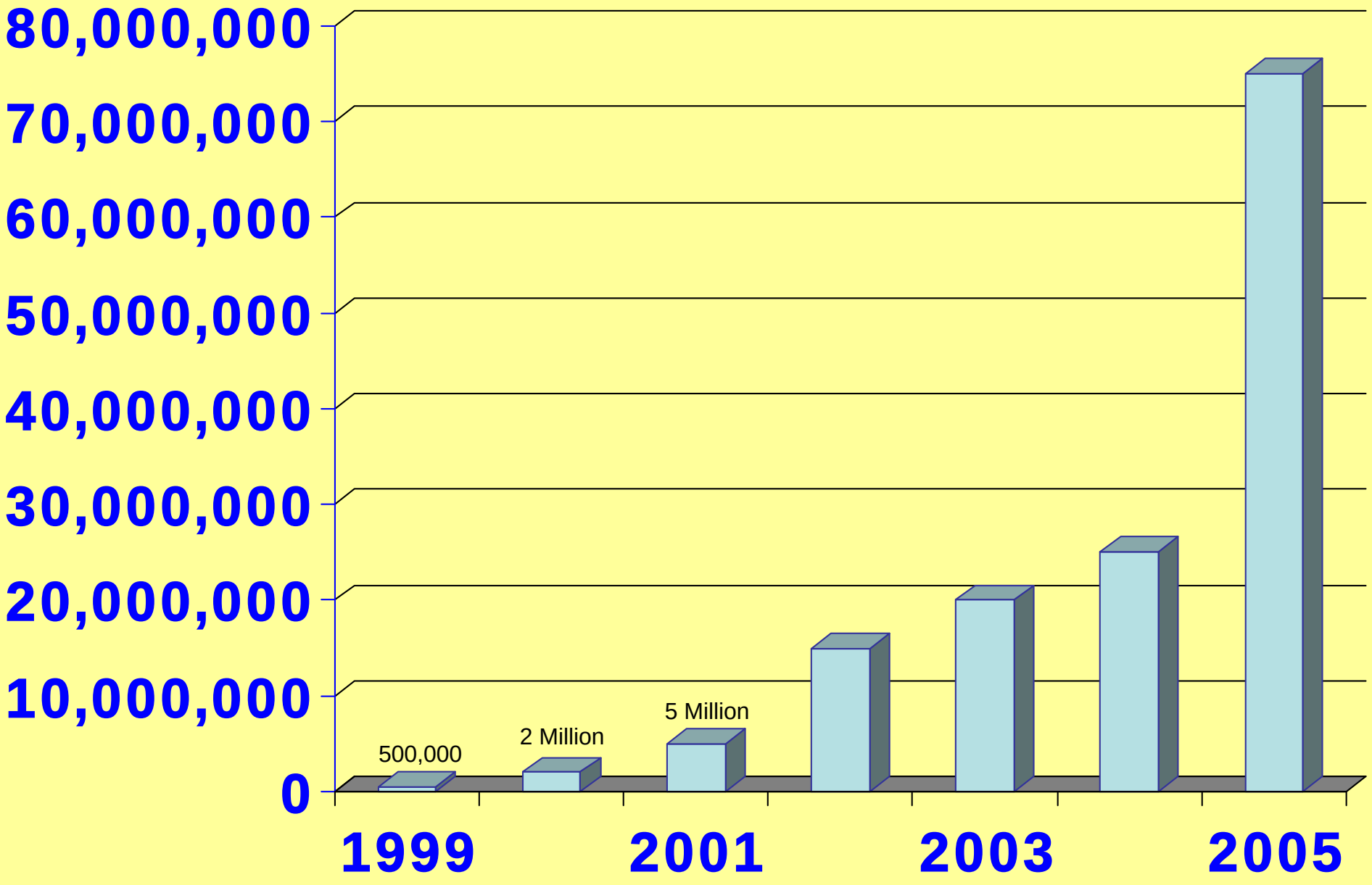
8 Plants under expansion:	91 MGPY
36 Plants under construction:	879 MGPY

Top 15 Producing States

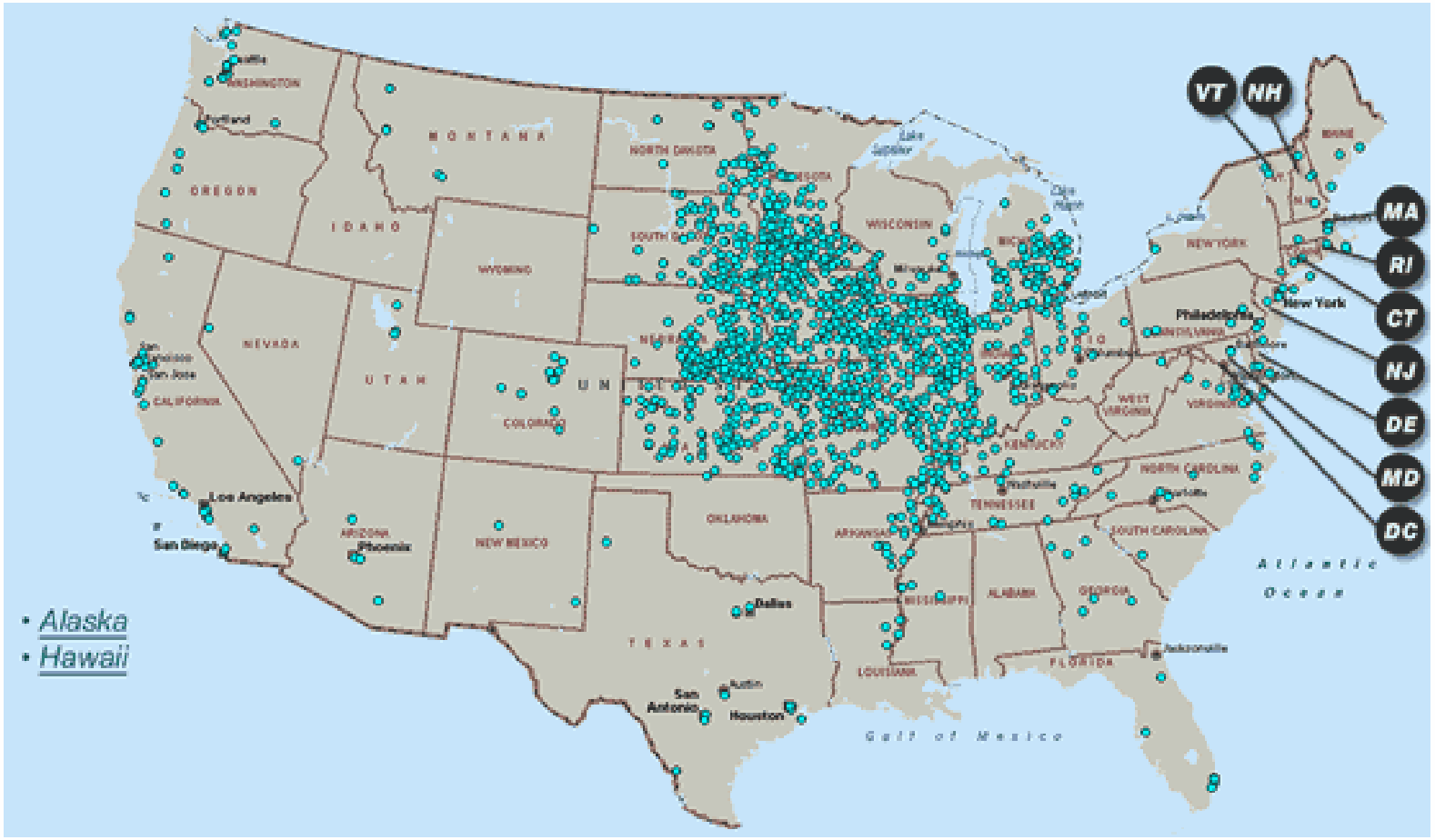
Iowa *	315	105*
Texas *	178	95*
North Dakota	120	0
Indiana *	90	<10*
Missouri *	66	<10*
Illinois*	64	30*
Minnesota *	63	63*
Pennsylvania *	57	<10*
Kentucky	52	0
Nebraska	50	0
South Carolina *	50	<10*
Tennessee *	47	10*
Ohio *	41	35*
Arkansas *	35	25*
Michigan *	35	<10*
#MGPY total (end of 2007) *operational	1,263#	~413*

Source: Biodiesel Magazine Nov 06

Biodiesel Sales *(in gallons per year)*



Biodiesel distributors in the U.S. (2005)



Quality Standards

- Fuel Quality
  - ASTM 6751-06a
- B100
- B20 – above and below
- BQ-9000

ASTM D 6751 – Biodiesel Fuel Specification

- Fuel quality is of the ***utmost concern and importance*** to the biodiesel industry.
- ASTM D 6751 is the specification for **biodiesel** fuels irrespective of the feedstock source and/or processing method.
- Standard ensures **safe operation in a compression ignition engine.**

ASTM D6751 = Fuel Quality!!!

ASTM International Specification

D6751: Standard Specification for Biodiesel Fuel

In 2002, ASTM International issued a standard specification for biodiesel fuel called D6751. This specification states that the only form of biodiesel that can be legally resold for commercial operations must meet ASTM specifications.

TABLE 1: Detailed Requirements for Biodiesel (B100)

Property	Test Method	Limits	Units
Flash point (closed cup)	D 93	130.0 min	°C
Water and sediment	D 2709	0.050 max	% volume
Kinematic viscosity, 40°C	D 445	1.9–6.0	mm^2/s
Sulfated ash	D 874	0.020 max	% mass
Sulfur	D 5453	0.05 max	% mass
Copper strip corrosion	D 130	No. 3 max	N/A
Cetane number	D 613	47 min	N/A
*Cloud point	D 2500	Report to customer*	°C
Carbon residue	D 4530	0.050 max	% mass
Acid number	D 664	0.80 max	mg KOH/g
Free glycerin	D 6584	0.020	% mass
Total glycerin	D 6584	0.240	% mass
Phosphorus content	D 4951	0.001 max	% mass
Distillation temperature, atmospheric equiv. temp	D 1160	360 max	°C

B100 meeting D 6751 is *Critical*

- If B100 meets D 6751, then most blends of B20 or lower will meet D 975 parameters
- OEM's are becoming increasingly comfortable with B20
- Almost all problems in the field are from B100 that didn't meet D 6751
  - Minnesota problems were from out of spec fuel
- Its impossible to tell if B100 met spec once it is in blended form, so testing must occur at B100 level
- NBB has active program to encourage enforcement of B100 compliance with D 6751
  - Voluntary quality program, BQ-9000

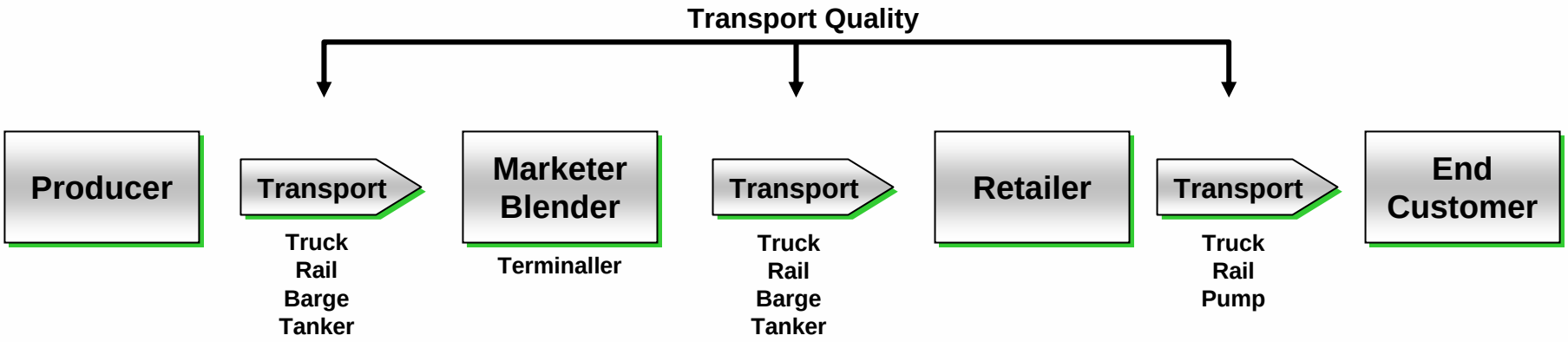
Important Biodiesel Parameters

- Complete Reaction/Removal of Unreacted Components & Glycerine
  - Insured through total/free glycerine
  - Will cause injector coking, filter plugging, sediment formation
  - Shortens shelf life
- Removal of Catalyst
  - Insured through sulfated ash
  - May cause injector deposits and/or filter plugging

Important Biodiesel Parameters

- Removal of Alcohol
  - Insured through flash point or % methanol by GC
  - May cause premature injector failure, safety concern
- Absence of Free Fatty Acids
  - Insured through acid value
  - Will cause fuel system deposits and effect fuel pump and filter operation

Diesel Fuel Chain of Custody Quality Focus



B100 Biodiesel

D6751

Petroleum Diesel

D975

B1-B20 – Biodiesel Blend

D975

D6751

D975

Various Markets

- Consumer @ pump
- Agriculture
- Bioheat
- Industrial
- Off-road
- Municipal
- Marine

Note: EN-14078 … European Std for Blend % (ASTM equivalent soon)

Using B20 and Lower Blends

- B20 operates in conventional engines, just like petroleum diesel
- Few or no modifications needed to engine or fuel system
  - Most common measures include initial fuel storage tank cleaning and/or fuel filter replacement
- Higher cetane and lubricity than diesel
- *Similar horsepower, torque and mileage as diesel*

Going over B20 requires caution

- Cold flow
- Materials compatibility
- Cleaning effect
- Fuel Stability a bigger concern
- Lower BTU content becomes noticeable
- Not supported by OEM's

Proper Handling of Biodiesel – above and below B20

OEM Warranty Statements and Use of Biodiesel Blends Above B5

http://www.biodiesel.org/pdf_files/B5_warranty_statement_32206.pdf

NBB Guidance on Use of Biodiesel Blends Above B20

http://www.biodiesel.org/pdf_files/Biodiesel_Blends_Above%20_20_Final.pdf

OEMs Positions on Biodiesel

OEMs:

- B100 Must Meet ASTM D 6751
- Most OEM HQs have B20 experience:
  - Won't void warranty, but . . . .
  - ***Problems caused by the fuel are the responsibility of the fuel supplier***
  - OEMs want to see additional experience in the field
- Higher blends OK'd based on experience of OEM and their technology

OEM's Don't Make Fuel and OEM's Don't Warranty Fuel

Warrantees

Manufacturer	Position
Engine Manufacturers Association (EMA)	B5 acceptable if it meets D 6751.
Caterpillar	Many engines approved for B100; for others only B5 is acceptable. Must meet D 6751.
Cummins	All engines approved for B5; must meet D 6751.
DaimlerChrysler	B5 acceptable for all vehicles, but must meet D 6751.
Detroit Diesel	B20 approved for all engines/vehicles, but must meet DDC specific diesel fuel specification.
Ford	B5 acceptable for all vehicles, but must meet both D 6751 *and* EN 14214.
General Motors	B5 acceptable for all vehicles, but must meet D 6751.
International Truck and Engine	B20 acceptable for all engines, but must meet D 6751.
John Deere	B5 acceptable for all engines, but must meet D 6751.
Volkswagen	B5 acceptable for all engines, but must meet fuel quality standards (D 6751 or EN 14214).
Fuel Injection Equipment Manufacturer	**Position**
Bosch	B5 acceptable for all vehicles, but must meet EN 14214.
Delphi	B5 acceptable for all vehicles, but must meet D 6751.
Stanadyne	B20 acceptable for all vehicles, but must meet D 6751.

Source: IFQC Biofuels Center. See also, NBB, Fact Sheet: Standards & Warranties, available at http://biodiesel.org/resources/fuelfactsheets/standards_and_warranties.shtm.

New 2007 Technology

- Biodiesel provides SIGNIFICANT benefits with new 2007 diesel technology-"Diesel Particulate Filter"
- 2% biodiesel restores the lubricity of the poorest lubricity diesel
- Although similar in size/distribution, B20 particles are different than petrodiesel particles
- Break Even Temperature of PM Traps reduced by 30 to 50 degrees F with B20
  - May increase fuel economy w/ PM traps
  - May lengthen PM trap life
- Engine out PM reduced
  - Helps EGR, reduces engine oil soot levels

Source: National Renewable Energy Laboratory (NREL)

BQ-9000

- To **promote** the commercial success and public acceptance of biodiesel
- To help **guarantee** that biodiesel fuel is produced and maintained at ASTM D 6751 levels
- To **provide** a mechanism to track biodiesel in the distribution system, identifying biodiesel which meets ASTM standards.

- Accredited Producer
- Certified Marketer

www.BQ-9000.org

NBAC BQ 9000 Process

- Submit Application to NBAC with Quality Manual & Quality Procedures
- NBAC Desk Audit
  - Findings remedied in 30 days
- Producer / Marketer
  - Generates Work Instructions
  - Utilizes quality management system for 6 months
  - Schedules on-site audit with NBAC
- NBAC On-Site Registration Audit
  - Findings remedied in 30 days
- NBAC Accreditation / Certification granted
  - 3 Year Certification w/ Annual Surveillance Audits

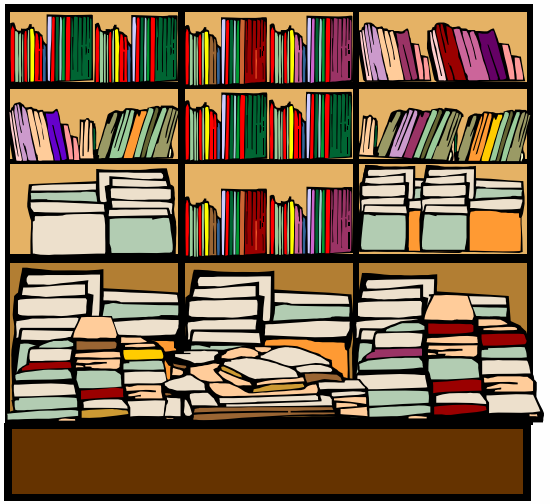
ASTM D 6751-06a

Property	Test Method	Limits	Units
Calcium & Magnesium	UOP 389	5 max	ppm (ug/g)
Flash Point	**D 93**	**130 min.**	**degrees C**
Water & Sediment	**D 2709**	**0.05 max.**	**% volume**
Kin. Viscosity, 40C	D 445	1.9 - 6.0	$mm^2/sec.$
Sulfated Ash	D 874	0.02 max.	% mass
Sulfur S500	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	UOP 391	5 max	ppm (ug/g)

BOLD = BQ-9000 short list

NBB Resources

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



Other web sites:

- www.nationalbiodieseleducation.org
- www.nationalcleancities.org

Biodiesel in CT

- Feedstock-out of state
  - Soybeans, Canola
  - Yellow Grease
- Producers (operational and planned)
  - BioPur, Biodiesel One, Franklin Biofuels, others
- Marketers / Blenders
  - Greenleaf, Santa, Hale Hill, Devine Bros., others
- ASTM Testing Laboratory (opportunity)
  - UCONN / Agricultural Experiment Station
- Suppliers
  - Stanadyne, Perkin Elmer
- Consumers
  - Transportation, Home heating, Fuel Cells (potential)