Cofemer Cofemer MAB-GLS-EHR-CLS-B0000174240

De: Antonio Sanchez Rodriguez <neosanro@hotmail.com>
Enviado el: viernes, 6 de octubre de 2017 12:49 p. m.
Para: Cofemer Cofemer
Asunto: Comentarios a los lineamientos de biocombustibles - KMoore Consulting 2
Datos adjuntos: Biodiesel KMoore Comments to SENER Oct 2017 ES-MX (2).pdf

A quien Corresponda:

Hago uso de este medio para que se suba el documento adjunto, con información complementaria, como segundo comentario que hago a los Lineamientos por los que se establecen las especificaciones de calidad y características para etanol anhidro (bioetanol), biodiésel o bioturbosina puros.

De antemano gracias.

Atentamente,

Kristin Moore

KMoore Consulting

"AÑO DEL CENTENARIO DE LA PROMULGACIÓN DE LA CONSTITUCIÓN POLÍTICA DE LOS ESTADOS UNIDOS MEXICANOS" "La información de este correo así como la contenida en los documentos que se adjuntan, puede ser objeto de solicitudes de acceso a la información"

4 de octubre de 2017

Lineamientos por los que se establecen las especificaciones de calidad y características para etanol anhidro (bioetanol), biodiésel o bioturbosina puros.

A quien corresponda:

Me complace ofrecerle consideraciones técnicas para apoyar en la introducción del biodiésel como una fuente nueva y más limpia de energía en México. Siendo mi foco de atención durante los últimos diez años el etanol en todas las aplicaciones, anteriormente me desempeñé como experta de apoyo técnico para un importante fabricante de biodiésel. Produjimos biodiésel en los Estados Unidos, Canadá y Alemania a partir de diversas materias primas. Mi área de especialización era la producción, la distribución y la combinación de biodiésel con combustible diésel a lo largo y ancho de los Estados Unidos, en todos los climas y con diversas concentraciones de mezcla, desde el 5 % hasta el 20 % de biodiésel por volumen.

El biodiésel es una gran adición al suministro de combustibles en México, ya que reduce significativamente las emisiones nocivas, incrementa la duración de las reservas de combustibles, mejora el índice de cetano y añade lubricidad que es muy necesaria. El desarrollo de una industria sólida de biodiésel en México apoya la meta de la Conferencia C40 de diciembre de 2016: mejorar drásticamente las emisiones de los motores de encendido por compresión. El biodiésel puede ser un componente menor o mayor al mezclarse con combustible diésel; además, el biodiésel puede reemplazar completamente al combustible diésel.

El biodiésel ofrece muchas ventajas para mejorar la calidad del aire. El biodiésel arde de modo más limpio y eficiente que el combustible diésel convencional. Las emisiones de biodiésel contienen menos combustible sin quemar y menos energía potencial desperdiciada. Esto incluye una reducción del 67 % en hidrocarburos (HC) no quemados, una reducción del 48 % en monóxido de carbono (CO), una reducción del 47 % en partículas de materiales ($PM_{2.5}$), una reducción del 80 % en hidrocarburos aromáticos policíclicos (HAP), una reducción del 90 % en HAP nitrados y una reducción del 50 % en el potencial de ozono de hidrocarburos específicos.[1]

Un análisis de ciclo de vida realizado por Argonne National Laboratory ha determinado que el biodiésel ofrece una reducción del 80 % en gases de efecto invernadero (greenhouse gases: GHG) con comparación con el diésel a base de petróleo.[2] La Junta de Recursos del Aire de California también ha determinado que el biodiésel ofrece reducciones significativas en GEI, y el biodiésel será el componente principal para reducir la intensidad de carbono de los combustibles para motores en California.

[1] *USEPA 2002; A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions; EPA420-P-02-001*

[2] *National Biodiesel Board, Biodiesel Industry Overview & Technical Update. Marzo de 2017.*

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En el borrador actual, los Lineamientos que describen las especificaciones para el biodiésel son problemáticos. Tengo serias inquietudes con respecto a los Lineamientos para biodiésel tal como se proponen actualmente. Estas inquietudes son tan significativas que justifican una revisión formal de esta propuesta para el uso de biodiésel en México, ya que eliminará muchas opciones de suministro para México sin mejorar el rendimiento de combustible.

Recomiendo enfáticamente que se adopte la especificación de norma internacional ASTM D6751 para biodiésel como una especificación comprobada para uso en todas las elevaciones y en todos los cambios climáticos estacionales en México. Esta norma fue desarrollada en 1999 y se utiliza exclusivamente en los Estados Unidos, donde se producen y utilizan más de 5935 miles de millones de litros (1568 millones de galones).[3] Esta especificación incluye los detalles necesarios para las concentraciones de mezcla de biodiésel. En los Estados Unidos, las mezclas más comunes van desde un 5 % por volumen a más de un 20 % por volumen de biodiésel mezclado con combustible diésel. El biodiésel es homogéneo en combustible diésel, añade cetano y mejora la lubricidad. El biodiésel casi no tiene azufre ni hidrocarburos aromáticos.

Se requieren las siguientes modificaciones para permitir que fluya un suministro abundante de biodiésel entre México y los Estados Unidos.

- Adoptar la definición formal del biodiésel como: un combustible compuesto por ésteres monoalquílicos de ácidos grados de cadena larga derivados de aceites vegetales o de grasas animales, designado como B100.
    - El biodiésel se produce a partir de cualquier grasa o aceite (por ejemplo, aceite de soya) mediante un proceso de refinamiento llamado transesterificación. El biodiésel producido mediante este proceso es un combustible para motores legal en los Estados Unidos y existen cientos de publicaciones de investigación que demuestran su rendimiento en motores de encendido por compresión. Sin embargo, el aceite vegetal crudo (no procesado) no puede cumplir con las especificaciones del combustible biodiésel y debe prohibirse que se mezcle con combustible diésel.
- Eliminar los parámetros restrictivos de materias primas, como contenido de yodo, alcoholes o éster de ácido linoleico y ésteres de alcohol poliinsaturados. Estas pruebas únicamente limitan las materias primas que pueden utilizarse para producir biodiésel sin beneficios para el rendimiento del biodiésel en motores de encendido por compresión. El biodiésel derivado de aceites vegetales o de grasas animales de diversas fuentes tiene un rendimiento comprobado en motores de combustión en altas y bajas altitudes y en climas variados.
- Eliminar los límites especificados de diglicéridos y triglicéridos; el límite especificado por ASTM D7651, de un máximo de glicerina total del 0.240 % por masa, es un límite de rendimiento comprobado.

[3] *Administración de Información de Energía de los Estados Unidos, informe mensual de producción de biodiésel, con datos para junio de 2017 y agosto de 2017.*

- Modificar el límite de residuos de carbono a un máximo de 0.050 % por masa, en lugar de los 0.3 mg/kg propuestos. Se desconoce dónde se originó el valor propuesto.
- Modificar el límite de estabilidad de oxidación a un máximo de 3 horas para garantizar una estabilidad suficiente para el suministro y almacenamiento. México tiene una cadena de abastecimiento de combustible muy corta, que elimina la necesidad de contar con un límite exagerado en la especificación de estabilidad de oxidación.
- Corregir el error tipográfico en los métodos de prueba para determinar el cetano a partir "ASTM 7 D976", a fin de reflejar el método de prueba estándar ASTM D613 para el número de cetano del combustible diésel.[4] No hay métodos de prueba ASTM identificados simplemente por el número "7".

Existen muchos recursos disponibles para apoyar el éxito de la introducción y el uso del biodiésel en México. Uno de estos documentos es la "Guía de manejo y uso de biodiésel" (Biodiesel Handling and Use Guide) de la Oficina de Eficiencia Energética y Energía Renovable del Departamento de Energía de los Estados Unidos,[5] la cual se encuentra ya en su 5ª edición. Este documento es un excelente recurso para obtener información técnica sobre el almacenamiento y el equipo de manejo, así como detalles sobre la calidad del combustible.

He trabajado en la industria del biodiésel desde 2005, con un enfoque en el desarrollo de especificaciones de biodiésel e información técnica para guiar los requisitos de almacenamiento y manejo. Animo a SENER a continuar con la adopción de las especificaciones de combustible internacional para asegurar un abundante suministro de combustibles para motores.

Atentamente,

Kristin Moore
KMoore Consulting

[4] *El método de prueba estándar internacional ASTM está disponible aquí: https://www.astm.org/Standards/D613.htm*
[5] La Junta Nacional de Biodiésel pone este documento a disposición en su sitio web: http://biodiesel.org/docs/using-hotline/nrel-handling-and-use.pdf?sfvrsn=4 . Accedido el 19 de septiembre de 2017.

Apéndice:

Comparación de especificaciones de biodiésel: ASTM D6751 y lineamentos mexicanos para biodiésel					
Parámetro	Unidades	ASTM D6751-16	Lineamientos propuestos por la SENER	Métodos de prueba ASTM	Método de prueba de la SENER
Aspecto	---	Sin agua no disuelta, sedimentos o materiales suspendidos.	Limpio y brillante	---	No se especifica un método.
Contenido de ésteres	%	---	96 máx.	---	EN14103
Densidad	20 °C	---	860 a 900	---	ISO3675, ISO12185
Contaminación total	mg/kg	---	24		EN12662
Contenido de yodo		---	120		EN14111
Éster de alcohol de ácido linoleico		---	12 %		EN14103
Esteres de alcohol poliinsaturados		---	1 %		EN15779
Azufre, grado 1B	% por masa	0.0015 máx.	15 y 500 ppm por peso	D5453, D7039	D5453
Capacidad de filtrado con remojo en frío	segundos	200 máx.	200 o 360	D7501	D7501
Contenido de monoglicéridos	% por masa	0.4 máx.	0.4	D6584, EN14105	D6584
Contenido de diglicéridos	% por masa	---	0.2		D6584
Contenido de triglicéridos	% por masa		0.2		D6584
Calcio y magnesio, combinados	ppm	5 máx.	5 máx.	EN14538	EN14538
Punto de inflamación, vaso cerrado	°C, min	93 min	100 min	D93	D93
Control de alcohol, debe cumplirse el contenido de metanol O el límite de punto de inflamación:					
Contenido de metanol	% por masa	0.2 máx.	0.2 máx.	EN14110	EN14110
Punto de inflamación	°C	130 min		D93, D3828, D6450	
Agua y sedimentos	% por volumen	0.050 máx.	0.05	D2709, D1796	D2709

Viscosidad cinética	mm²/s, 40 °C	1.9 - 6.0	2.0 - 5.0	D445	D445
Cenizas sulfatadas	% máx.	0.020 máx.	0.005	D874	D874
Corrosión de tira de cobre	---	Núm. 3 máx.	Núm. 3 máx.	D130	D130
Número de cetano	---	47 min	48 min	D613, D6890, D7668	ASTM 7 D976
Punto de nebulización	°C	Informe	Informe	D2500, D5771, D5772, D5773, D7397, D7689, D3117	D2500
Residuos de carbón	% por masa	0.050 máx.	0.3 máx. mg/kg	D4530, D189, D524	ISO10370
Número ácido	mg KOH/g	0.50 máx.	0.5	D664, D3242, D974	D664
Glicerina libre	% por masa	0.020 máx.	0.02	D6584	D6584
Glicerina total	% por masa	0.240 máx.	0.25	D6584	D6584
Contenido de fósforo	% por masa	0.001 máx.	0.001	D4951	D4951
Temperatura de destilación, temperatura atmosférica equivalente, 90 % recuperado.	°C	360 máx.	360	D1160, D7344, D7345	D1160
Sodio y potasio, combinados.	ppm	5 máx.	5	EN14538	EN14538
Estabilidad de oxidación	horas	3 máx.	6 horas a 110 °C	EN15751	

This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D6751 – 15c$^{\varepsilon 1}$

Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels[1]

This standard is issued under the fixed designation D6751; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Subsection X1.3.1 was corrected editorially in February 2016.

1. Scope*

1.1 This specification covers four grades of biodiesel (B100) for use as a blend component with middle distillate fuels. These grades are described as follows:

1.1.1 *Grade No. 1-B S15*—A special purpose biodiesel blendstock intended for use in middle distillate fuel applications which can be sensitive to the presence of partially reacted glycerides, including those applications requiring good low temperature operability, and also requiring a fuel blend component with 15 ppm sulfur (maximum).

1.1.2 *Grade No. 1-B S500*—A special purpose biodiesel blendstock intended for use in middle distillate fuel applications which can be sensitive to the presence of partially reacted glycerides, including those applications requiring good low temperature operability, and also requiring a fuel blend component with 500 ppm sulfur (maximum).

1.1.3 *Grade No. 2-B S15*—A general purpose biodiesel blendstock intended for use in middle distillate fuel applications that require a fuel blend component with 15 ppm sulfur (maximum).

1.1.4 *Grade No. 2-B S500*—A general purpose biodiesel blendstock intended for use in middle distillate fuel applications that require a fuel blend component with 500 ppm sulfur (maximum).

1.2 This specification prescribes the required properties of diesel fuels at the time and place of delivery. The specification requirements may be applied at other points in the production and distribution system when provided by agreement between the purchaser and the supplier.

1.3 Nothing in this specification shall preclude observance of federal, state, or local regulations which may be more restrictive.

NOTE 1—The generation and dissipation of static electricity can create problems in the handling of distillate fuel oils with which biodiesel may be blended. For more information on the subject, see Guide D4865.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

D189 Test Method for Conradson Carbon Residue of Petroleum Products

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products

D613 Test Method for Cetane Number of Diesel Fuel Oil

D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration

D874 Test Method for Sulfated Ash from Lubricating Oils and Additives

D974 Test Method for Acid and Base Number by Color-Indicator Titration

D975 Specification for Diesel Fuel Oils

D976 Test Method for Calculated Cetane Index of Distillate Fuels

D1160 Test Method for Distillation of Petroleum Products at Reduced Pressure

D1266 Test Method for Sulfur in Petroleum Products (Lamp Method)

D1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.E0 on Burner, Diesel, Non-Aviation Gas Turbine, and Marine Fuels.

Current edition approved Dec. 1, 2015. Published January 2016. Originally approved in 1999 as PS 121 – 99. Adopted as a standard in 2002 as D6751 – 02. Last previous edition approved in 2015 as D6751 – 15b. DOI: 10.1520/D6751-15CE01.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

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D2274 Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)
D2500 Test Method for Cloud Point of Petroleum Products and Liquid Fuels
D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
D2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge
D2880 Specification for Gas Turbine Fuel Oils
D3117 Test Method for Wax Appearance Point of Distillate Fuels (Withdrawn 2010)[3]
D3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D3242 Test Method for Acidity in Aviation Turbine Fuel
D3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
D4530 Test Method for Determination of Carbon Residue (Micro Method)
D4737 Test Method for Calculated Cetane Index by Four Variable Equation
D4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D4951 Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry
D5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D5771 Test Method for Cloud Point of Petroleum Products (Optical Detection Stepped Cooling Method)
D5772 Test Method for Cloud Point of Petroleum Products (Linear Cooling Rate Method)
D5773 Test Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method)
D6217 Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration
D6450 Test Method for Flash Point by Continuously Closed Cup (CCCFP) Tester
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D6584 Test Method for Determination of Total Monoglycerides, Total Diglycerides, Total Triglycerides, and Free and Total Glycerin in B-100 Biodiesel Methyl Esters by Gas Chromatography
D6890 Test Method for Determination of Ignition Delay and Derived Cetane Number (DCN) of Diesel Fuel Oils by Combustion in a Constant Volume Chamber
D7039 Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry
D7344 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Mini Method)
D7345 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)
D7397 Test Method for Cloud Point of Petroleum Products (Miniaturized Optical Method)
D7501 Test Method for Determination of Fuel Filter Blocking Potential of Biodiesel (B100) Blend Stock by Cold Soak Filtration Test (CSFT)
D7668 Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Ignition Delay and Combustion Delay Using a Constant Volume Combustion Chamber Method
D7689 Test Method for Cloud Point of Petroleum Products (Mini Method)

2.2 *Government Standard:*

40 CFR Part 79 Registration of Fuels and Fuel Additives Section 211(b) Clean Air Act[4]

2.3 *Other Documents:*

AOCS Standard Procedure Ck 2-09[5] Determination of Various Properties of Biodiesel by the QTA System Method[6]
UOP 389 Trace Metals in Oils by Wet Ashing and ICP-OES[7]
UOP 391–91 Trace Metals in Petroleum Products or Organics by AAS[7]
EN 14105 Fat and Oil Derivatives—Fatty Acid Methyl Esters (FAME)—Determination of Free and Total Glycerol and Mono-, Di-, Triglyceride Contents (Reference Method)[8]
EN 14110 Fat and Oil Derivatives—Fatty Acid Methyl Esters (FAME)—Determination of Methanol Content[8]
EN 14112 Fat and Oil Derivatives—Fatty Acid Methyl Esters (FAME)—Determination of Oxidation Stability (Accelerated Oxidation Test)[8]
EN 14538 Fat and Oil Derivatives—Fatty Acid Methyl Esters (FAME)—Determination of Ca, K, Mg and Na Content by Optical Emission Spectral Analysis with Inductively Coupled Plasma (ICP OES)[8]
EN 15751 Automotive Fuels—Fatty Acid Methyl Ester (FAME) Fuel and Blends with Diesel Fuel—Determination of Oxidation Stability by Accelerated Oxidation Method[8]

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

[5] Available from AOCS Headquarters, 2710 S. Boulder, Urbana, IL 61802–6996. Download Product Code: MC-CK209 from www.aocs.org.

[6] QTA is a registered trademark of the Cognis Corporation, 5051 Estecreek Drive, Cincinnati, OH 45232-1446.

[7] Available from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA. Visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org.

[8] Available from the National CEN Members listed on the CEN website (www.cenorm.be) or from the CEN/TC19 secretariat (astm@nen.nl).

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3. Terminology

3.1 *Definitions:*

3.1.1 *biodiesel, n*—fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100.

3.1.1.1 *Discussion—biodiesel*, as defined above, is registered with the U.S. EPA as a fuel and a fuel additive under Section 211(b) of the Clean Air Act (40 CFR Part 79). There is, however, other usage of the term biodiesel in the marketplace. Due to its EPA registration and the widespread commercial use of the term biodiesel in the U.S. marketplace, the term biodiesel will be maintained for this specification.

3.1.1.2 *Discussion*—Biodiesel is typically produced by a reaction of a vegetable oil or animal fat with an alcohol such as methanol or ethanol in the presence of a catalyst to yield mono-alkyl esters and glycerin, which is removed. The finished biodiesel derives approximately 10 % of its mass from the reacted alcohol. The alcohol used in the reaction may or may not come from renewable resources.

3.1.2 *biodiesel blend (BXX), n*—blend of biodiesel fuel with diesel fuel oils.

3.1.2.1 *Discussion*—In the abbreviation BXX, the XX represents the volume percentage of biodiesel fuel in the blend.

3.1.3 *biodiesel fuel, n*—synonym for *biodiesel*.

3.1.4 *diesel fuel, n*—middle petroleum distillate fuel.

3.1.5 *free glycerin, n*—a measure of the amount of glycerin remaining in the fuel.

3.1.6 *Grade S15 B100, n*—a grade of biodiesel meeting ASTM Specification D6751 and having a sulfur specification of 15 ppm maximum.

3.1.7 *Grade S500 B100, n*—a grade of biodiesel meeting ASTM Specification D6751 and having a sulfur specification of 500 ppm maximum.

3.1.8 *middle distillate fuel, n*—kerosines and gas oils boiling between approximately 150 °C and 400 °C at normal atmospheric pressure and having a closed-cup flash point above 38 °C.

3.1.9 *monoglyceride, n*—a partially reacted fat or oil molecule with one long chain alkyl ester group on a glycerin backbone.

3.1.10 *total glycerin, n*—the sum of the free glycerin and the glycerin portion of any unreacted or partially reacted oil or fat.

4. Requirements

4.1 The biodiesel specified shall be mono-alkyl esters of long chain fatty acids derived from vegetable oils and animal fats.

4.2 Unless otherwise specified, samples for analysis shall be taken by the procedure described in Practices D4057 or D4177.

4.3 The biodiesel specified shall conform to the detailed requirements shown in Table 1.

NOTE 2—A considerable amount of experience exists in the U.S. with a 20 % blend of biodiesel, primarily produced from soybean oil, with 80 % diesel fuel (B20). Experience with biodiesel produced from animal fat and other oils is similar. Experience with B20 and lower blends in other applications is not as prevalent. Although biodiesel (B100) can be used, blends of over 20 % biodiesel with diesel fuel (B20) should be evaluated on a case by case basis until further experience is available.

NOTE 3—The user should consult the equipment manufacturer or owner's manual regarding the suitability of using biodiesel or biodiesel blends in a particular engine or application.

5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following methods.

5.1.1 *Flash Point*—Test Methods D93, except where other methods are prescribed by law. Test Methods D3828 or D6450 can also be used. The precision and bias of Test Methods D3828 and D6450 with biodiesel is not known and is currently under investigation. Test Methods D93 shall be the referee method.

5.1.2 *Water and Sediment*—Test Method D2709. Test Method D1796 may also be used. Test Method D2709 shall be the referee method. The precision and bias of these test methods with biodiesel is not known and is currently under investigation.

5.1.3 *Viscosity*—Test Method D445.

5.1.4 *Monoglycerides*—Test Method D6584, Test Method EN 14105, and AOCS Standard Procedure Ck 2-09 may be used. Test Method D6584 shall be the referee test method.

5.1.5 *Sulfated Ash*—Test Method D874.

5.1.6 *Oxidation Stability*—Test Method EN 15751. Test Method EN 14112 may also be used. See X1.19.1 for further information. Test Method EN 15751 shall be the referee test method.

5.1.7 *Sulfur*—Test Method D5453. Test Method D7039 may also be used. Other test methods may also be suitable for determining up to 0.05 % (500 ppm) sulfur in biodiesel fuels such as Test Methods D1266, D2622, D3120 and D4294 but may provide falsely high results (see X1.5) although their precision and bias with biodiesel is unknown. Test Method D5453 shall be the referee test method.

5.1.8 *Corrosion*—Test Method D130, 3 h test at 50°C.

5.1.9 *Cetane Number*—Test Method D613. Test Method D6890 or D7668 (see Note 4) may also be used. In case of dispute, Test Method D613 shall be the referee method.

NOTE 4—Precision from Test Method D7668 were obtained from results produced by laboratories using externally obtained pre-blended calibration reference material.

5.1.10 *Cloud Point*—Test Method D2500. Test Method D5771, D5772, D5773, D7397, D7689, or AOCS Standard Procedure Ck 2-09 may also be used. Test Method D3117 may also be used because it is closely related. Test Method D2500 shall be the referee test method. The precision and bias of Test Method D3117 for biodiesel is not known and is currently under investigation.

5.1.11 *Acid Number*—Test Method D664. Test Methods D3242 or D974 may also be used. Test Method D664 shall be the referee test method.

5.1.12 *Carbon Residue*—Test Method D4530. A 100% sample shall replace the 10 % residual, with percent residue in the original sample reported using the 10 % residual calculation (see X1.9.1). Test Methods D189 or D524 may also be used. Test Method D4530 shall be the referee method.

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TABLE 1 Detailed Requirements for Biodiesel (B100) Blend Stocks

Property	Test Method[A]	Grade No. 1-B S15	Grade No. 1-B S500	Grade No. 2-B S15	Grade No. 2-B S500
Sulfur,[B] % mass (ppm), max	D5453	0.0015 (15)	0.05 (500)	0.0015 (15)	0.05 (500)
Cold soak filterability, seconds, max	D7501	200	200	360[C]	360[C]
Monoglyceride content, % mass, max	D6584	0.40	0.40	...	...
			Requirements for All Grades		
Calcium and Magnesium, combined, ppm (µg/g), max	EN 14538	5	5	5	5
Flash point (closed cup), °C, min	D93	93	93	93	93
Alcohol control					
One of the following shall be met:					
1. Methanol content, mass %, max	EN 14110	0.2	0.2	0.2	0.2
2. Flash point, °C, min	D93	130	130	130	130
Water and sediment, % volume, max	D2709	0.050	0.050	0.050	0.050
Kinematic viscosity,[D] mm^2/s, 40 °C	D445	1.9-6.0	1.9-6.0	1.9-6.0	1.9-6.0
Sulfated ash, % mass, max	D874	0.020	0.020	0.020	0.020
Copper strip corrosion, max	D130	No. 3	No. 3	No. 3	No. 3
Cetane number, min	D613	47	47	47	47
Cloud point,[E] °C	D2500	Report	Report	Report	Report
Carbon residue,[F] % mass, max	D4530	0.050	0.050	0.050	0.050
Acid number, mg KOH/g, max	D664	0.50	0.50	0.50	0.50
Free glycerin, % mass, max	D6584	0.020	0.020	0.020	0.020
Total glycerin, % mass, max	D6584	0.240	0.240	0.240	0.240
Phosphorus content, % mass, max	D4951	0.001	0.001	0.001	0.001
Distillation temperature, Atmospheric equivalent temperature, 90 % recovered, °C, max	D1160	360	360	360	360
Sodium and Potassium, combined, ppm (µg/g), max	EN 14538	5	5	5	5
Oxidation stability, hours, min	EN 15751	3	3	3	3

[A] The test methods indicated are the approved referee methods. Other acceptable methods are indicated in 5.1.
[B] Other sulfur limits may apply in selected areas in the United States and in other countries.
[C] For additional cold weather considerations, see Appendix X3.
[D] See X1.3.1. The 6.0 mm^2/s upper viscosity limit is higher than petroleum based diesel fuel and should be taken into consideration when blending.
[E] The cloud point of biodiesel is generally higher than petroleum based diesel fuel and should be taken into consideration when blending.
[F] Carbon residue shall be run on the 100 % sample (see 5.1.12).

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5.1.13 *Total Glycerin*—Test Method D6584. AOCS Standard Procedure Ck 2-09 may also be used. Test Method D6584 is the referee method.

5.1.14 *Free Glycerin*—Test Method D6584. AOCS Standard Procedure Ck 2-09 may also be used. Test Method D6584 is the referee method.

5.1.15 *Phosphorus Content*—Test Method D4951.

5.1.16 *Distillation Temperature*—Test Method(s) D1160 (reduced pressure method), or D7344, or D7345 may be used. When using Test Method D7344, correct for observed bias by adding 3 °C to the temperature result before comparing the result to the Table 1 requirement and report the Test Method D7344 value as "bias-corrected." Test Method D1160 shall be the referee test method.

5.1.17 *Calcium and Magnesium, combined*—Test Method EN 14538. Test Method UOP 389 may also be used. Test Method EN 14538 shall be the referee test method.

5.1.18 *Sodium and Potassium, combined*—Test Method EN 14538. Test Method UOP 391 may also be used. Test Method EN 14538 shall be the referee test method.

5.1.19 *Cold Soak Filterability*—Test Method D7501. B100 intended for blending into diesel fuels that is expected to give satisfactory vehicle performance at fuel temperatures at or below –12°C shall comply with a cold soak filtration limit of 200 s maximum.

5.1.20 *Methanol Content*—Test Method EN 14110. AOCS Standard Procedure Ck 2-09 may also be used. Test Method EN 14110 shall be the referee test method.

6. Workmanship

6.1 The biodiesel fuel shall be visually free of undissolved water, sediment, and suspended matter.

7. Keywords

7.1 alternative fuel; biodiesel fuel; diesel fuel oil; fuel oil; renewable resource

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APPENDIXES

(Nonmandatory Information)

X1. SIGNIFICANCE OF PROPERTIES SPECIFIED FOR BIODIESEL FUEL

X1.1 Introduction

X1.1.1 The properties of commercial biodiesel fuel depends upon the refining practices employed and the nature of the renewable lipids from which it is produced. Biodiesel, for example, can be produced from a variety of vegetable oils or animal fats which produce similar volatility characteristics and combustion emissions with varying cold flow properties.

X1.1.2 The significance of the properties in this appendix are based primarily on the commercial use of biodiesel in on-road and off-road diesel engine applications. Some of the properties may take on other significance if biodiesel is used as a fuel or blending component in other applications. See the respective finished product specifications for additional information on significance of properties of those applications.

X1.2 Flash Point

X1.2.1 The flash point, as specified, is not directly related to engine performance. It is, however, of importance in connection with legal requirements and safety precautions involved in fuel handling and storage that are normally specified to meet insurance and fire regulations.

X1.2.2 The flash point for biodiesel has been set at 93 °C (200 °F) minimum, so biodiesel falls under the non-hazardous category under National Fire Protection Association codes.

X1.3 Viscosity

X1.3.1 For some engines it may be advantageous to specify a minimum viscosity because of power loss due to injection pump and injector leakage. Maximum allowable viscosity, on the other hand, is limited by considerations involved in engine design and size, and the characteristics of the injection system. The upper limit for the viscosity of biodiesel (6.0 mm^2/s at 40 °C) is higher than the maximum allowable viscosity in Specification D975 Grade 2-D and 2-D low sulfur (4.1 mm^2/s at 40 °C). Blending biodiesel with diesel fuel close to its upper limit could result in a biodiesel blend with viscosity above the upper limits contained in Specification D975.

X1.4 Sulfated Ash

X1.4.1 Ash-forming materials may be present in biodiesel in three forms: (*1*) abrasive solids, (*2*) soluble metallic soaps, and (*3*) unremoved catalysts. Abrasive solids and unremoved catalysts can contribute to injector, fuel pump, piston and ring wear, and also to engine deposits. Soluble metallic soaps have little effect on wear but may contribute to filter plugging and engine deposits.

X1.5 Sulfur

X1.5.1 The effect of sulfur content on engine wear and deposits appears to vary considerably in importance and depends largely on operating conditions. Fuel sulfur can also affect emissions control systems performance and various limits on sulfur have been imposed for environmental reasons. B100 is essentially sulfur-free.

NOTE X1.1—Test Method D5453 should be used with biodiesel. Use of other test methods may provide falsely high results when analyzing B100 with extremely low sulfur levels (less than 5 ppm). Biodiesel sulfur analysis from RR:D02-1480[9], *Biodiesel Fuel Cetane Number Testing Program, January-April, 1999*, using Test Method D2622 yielded falsely high results due to the presence of the oxygen in the biodiesel. Sulfur results using Test Method D2622 were more accurate with B20 than with B100 due to the lower oxygen content of B20. Potential improvements to Test Method D2622 may provide more accurate values in the future.

X1.6 Copper Strip Corrosion

X1.6.1 This test serves as a measure of possible difficulties with copper and brass or bronze parts of the fuel system. The presence of acids or sulfur-containing compounds can tarnish the copper strip, thus indicating the possibility for corrosion.

X1.7 Cetane Number

X1.7.1 Cetane number is a measure of the ignition quality of the fuel and influences white smoke and combustion roughness. The cetane number requirements depend on engine design, size, nature of speed and load variations, and on starting and atmospheric conditions.

X1.7.2 The calculated cetane index, Test Methods D976 or D4737, may not be used to approximate the cetane number with biodiesel or its blends. There is no substantiating data to support the calculation of cetane index with biodiesel or biodiesel blends.

X1.8 Cloud Point

X1.8.1 Cloud point is of importance in that it defines the temperature at which a cloud or haze of crystals appears in the fuel under prescribed test conditions which generally relates to the temperature at which crystals begin to precipitate from the fuel in use. Biodiesel generally has a higher cloud point than petroleum based diesel fuel. The cloud point of biodiesel and its impact on the cold flow properties of the resulting blend should be monitored by the user to ensure trouble-free operation in cold climates. For further information, consult Appendix X4 of Specification D975.

X1.9 Carbon Residue

X1.9.1 Carbon residue gives a measure of the carbon depositing tendencies of a fuel oil. While not directly correlating with engine deposits, this property is considered an approximation. Although biodiesel is in the distillate boiling

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1480.

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range, most biodiesels boil at approximately the same temperature and it is difficult to leave a 10 % residual upon distillation. Thus, a 100 % sample is used to replace the 10 % residual sample, with the calculation executed as if it were the 10 % residual. Parameter E (final weight flask charge/original weight flask charge) in 8.1.2 of Test Method D4530-93 is a constant 20/200.

X1.10 Acid Number

X1.10.1 The acid number is used to determine the level of free fatty acids or processing acids that may be present in biodiesel. Biodiesel with a high acid number has been shown to increase fueling system deposits and may increase the likelihood for corrosion.

NOTE X1.2—Acid number measures a different phenomenon for biodiesel than petroleum based diesel fuel. The acid number for biodiesel measures free fatty acids or degradation by-products not found in petroleum based diesel fuel. Increased recycle temperatures in new fuel system designs may accelerate fuel degradation which could result in high acid values and increased filter plugging potential.

X1.11 Free Glycerin

X1.11.1 The free glycerin method is used to determine the level of glycerin in the fuel. High levels of free glycerin can cause injector deposits, as well as clogged fueling systems, and result in a buildup of free glycerin in the bottom of storage and fueling systems.

X1.12 Total Glycerin

X1.12.1 The total glycerin method is used to determine the level of glycerin in the fuel and includes the free glycerin and the glycerine portion of any unreacted or partially reacted oil or fat. Low levels of total glycerin ensure that high conversion of the oil or fat into its mono-alkyl esters has taken place. High levels of mono-, di-, and triglycerides can cause injector deposits and may adversely affect cold weather operation and filter plugging.

X1.13 Monoglycerides

X1.13.1 See information provided in Appendix X3.

X1.14 Phosphorus Content

X1.14.1 Phosphorus can damage catalytic converters used in emissions control systems and its level must be kept low. Catalytic converters are becoming more common on diesel-powered equipment as emissions standards are tightened, so low phosphorus levels will be of increasing importance. Biodiesel produced from U.S. sources has been shown to have low phosphorus content (below 1 ppm) and the specification value of 10 ppm maximum is not problematic. Biodiesel from other sources may or may not contain higher levels of phosphorus and this specification was added to ensure that all biodiesel, regardless of the source, has low phosphorus content.

X1.15 Reduced Pressure Distillation

X1.15.1 Biodiesel exhibits a boiling point rather than a distillation curve. The fatty acids chains in the raw oils and fats from which biodiesel is produced are mainly comprised of straight chain hydrocarbons with 16 to 18 carbons that have similar boiling temperatures. The atmospheric boiling point of biodiesel generally ranges from 330 to 357°C, thus the specification value of 360°C is not problematic. This specification was incorporated as an added precaution to ensure the fuel has not been adulterated with high boiling contaminants.

NOTE X1.3—The density of biodiesel meeting the specifications in Table 1 falls between 0.86 and 0.90, with typical values falling between 0.88 and 0.89. Since biodiesel density falls between 0.86 and 0.90, a separate specification is not needed. The density of raw oils and fats is similar to biodiesel, therefore use of density as an expedient check of fuel quality may not be as useful for biodiesel as it is for petroleum based diesel fuel. This section has been added to provide users and engine interests with this information.

NOTE X1.4—In certain items of fuel injection equipment in compression ignition engines, such as rotary/distributor fuel pumps and injectors, the fuel functions as a lubricant as well as a source for combustion. Blending biodiesel fuel with petroleum based compression-ignition fuel typically improves fuel lubricity.

X1.16 Alcohol Control

X1.16.1 Alcohol control is to limit the level of unreacted alcohol remaining in the finished fuel. This can be measured directly by the volume percent alcohol or indirectly through a high flash point value.

X1.16.2 The flash point specification, when used for alcohol control for biodiesel, is intended to be 100°C minimum, which has been correlated to 0.2 vol % alcohol. Typical values are over 160 °C. Due to high variability with Test Method D93 as the flash point approaches 100°C, the flash point specification has been set at 130 °C minimum to ensure an actual value of 100 °C minimum. Improvements and alternatives to Test Method D93 are being investigated. Once complete, the specification of 100 °C minimum may be reevaluated for alcohol control.

X1.17 Calcium and Magnesium

X1.17.1 Calcium and magnesium may be present in biodiesel as abrasive solids or soluble metallic soaps. Abrasive solids can contribute to injector, fuel pump, piston, and ring wear, as well as to engine deposits. Soluble metallic soaps have little effect on wear, but they may contribute to filter plugging and engine deposits. High levels of calcium and magnesium compounds may also be collected in exhaust particulate removal devices, are not typically removed during passive or active regeneration, and can create increased back pressure and reduced time to service maintenance.

X1.18 Sodium and Potassium

X1.18.1 Sodium and potassium may be present in biodiesel as abrasive solids or soluble metallic soaps. Abrasive solids can contribute to injector, fuel pump, piston and ring wear, and also to engine deposits. Soluble metallic soaps have little effect on wear, but they may contribute to filter plugging and engine deposits. High levels of sodium or potassium compounds may also be collected in exhaust particulate removal devices, are not typically removed during passive or active regeneration, and they can create increased back pressure and reduced period to service maintenance.

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X1.19 Oxidation Stability

X1.19.1 Products of oxidation in biodiesel can take the form of various acids or polymers, which, if in high enough concentration, can cause fuel system deposits and lead to filter clogging and fuel system malfunctions. Additives designed to retard the formation of acids and polymers can significantly improve the oxidation stability performance of biodiesel. See Appendix X2 for additional information on long-term storage. It is recommended that EN 15751 be utilized for measurement of biodiesel oxidation stability, because EN 14112 may be withdrawn in the future as an option for testing biodiesel and biodiesel blends.

X2. LONG-TERM STORAGE OF BIODIESEL

X2.1 Scope

X2.1.1 This appendix provides guidance for consumers of biodiesel (B100) who may wish to store quantities of fuels for extended periods. Consistently successful long-term fuel storage requires attention to fuel selection, storage conditions, and monitoring of properties prior to and during storage. This appendix is directed toward biodiesel (B100) and may be more or less applicable to blends of biodiesel with petroleum based diesel fuel.

X2.1.2 Normally produced biodiesel has adequate stability properties to withstand normal storage without the formation of troublesome amounts of insoluble degradation products, although data suggests some biodiesel may degrade faster than petroleum based diesel fuel. Biodiesel that is to be stored for prolonged periods should be selected to avoid formation of sediments, high acid numbers, and high viscosities that can clog filters, affect fuel pump operation or plug combustor nozzles or injectors. The selection of biodiesel should result from supplier-user discussions.

X2.1.3 These suggested practices are general in nature and should not be considered substitutes for any requirement imposed by the warranty of the distillate fuel equipment manufacturers or by federal, state, or local government regulations. Although they cannot replace knowledge of local conditions or good engineering and scientific judgment, these suggested practices do provide guidance in developing an individual fuel management system for the biodiesel fuel user. They include suggestions in the operation and maintenance of existing fuel storage and handling facilities and for identifying where, when, and how fuel quality should be monitored.

X2.2 Terminology

X2.2.1 *bulk fuel*—fuel in the storage facility in quantities over 50 gallons.

X2.2.2 *combustor fuel*—fuel entering the combustion zone of the burner or engine after filtration or other treatment of bulk fuel.

X2.2.3 *fuel contaminants*—foreign materials that make fuel less suitable or unsuitable for the intended use. Fuel contaminants include materials introduced subsequent to the manufacture of fuel and fuel degradation products.

X2.2.4 *fuel-degradation products* —those materials formed in fuel after it is produced. Insoluble degradation products may combine with other fuel contaminants to reinforce deleterious effects. Soluble degradation products (acids and gums) may be more or less volatile than the fuel and may cause an increase in injector and nozzle deposits. The formation of degradation products may be catalyzed by contact with metals, especially those containing copper and, to a lesser extent, iron.

X2.2.5 *long-term storage*—storage of fuel for longer than 6 months after it is received by the user.

X2.3 Fuel Selection

X2.3.1 The stability properties of biodiesel are not fully understood and appear to depend on the vegetable oil and animal fat sources, severity of processing, and whether additional production plant treatment has been carried out or stability additives are present.

X2.3.2 The composition and stability properties of biodiesel produced at specific production plants may be different. Any special requirements of the user, such as long-term storage, should be discussed with the supplier.

X2.4 Fuel Additives

X2.4.1 Available fuel additives appear to improve the long term storage of biodiesel. Most additives should be added as close to the production site as possible to obtain maximum benefits.

X2.4.2 Biocides or biostats destroy or inhibit the growth of fungi and bacteria which can grow at fuel-water interfaces to give high particulate concentrations in the fuel. Available biocides are soluble in the fuel phase or the water phase, or both. Refer to Guide D6469 for a more complete discussion.

X2.5 Tests for Fuel Quality

X2.5.1 Test methods for estimating the storage stability of biodiesel (B100) are being developed. Modifications of Test Method D2274 to use glass fiber filters, varying times and temperatures, and the measurement of pre-test and post-test acid number and viscosity appear promising. However, correlation of this test with actual storage stability is unknown, and may depend upon field conditions and fuel composition.

X2.5.2 Performance criteria for accelerated stability tests that ensure satisfactory long-term storage of biodiesel (B100) have not been established.

X2.6 Fuel Monitoring

X2.6.1 A plan for monitoring the quality of bulk fuel during prolonged storage is an integral part of a successful monitoring program. A plan to replace aged fuel with fresh product at established intervals is also desirable.

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X2.6.2 Stored fuel should be periodically sampled and its quality assessed. Practice D4057 provides guidance for sampling. Fuel contaminants and degradation products may settle to the bottom of a quiescent tank although detrimental changes to biodiesel can occur (rising acid value) without causing sediment formation. A *Bottom* or *Clearance* sample, as defined in Practice D4057, should be included in the evaluation along with an *All Level* sample.

X2.6.3 The quantity of insoluble fuel contaminants present in biodiesel can be determined using Test Method D6217 with glass fiber filters and abundant washing although no precision or bias testing has been performed with biodiesel using Test Method D6217.

X2.6.4 The acid value of biodiesel appears to exceed its specified maximum before other deleterious fuel property changes occur. A conscientious program of measuring the acid value of biodiesel may be sufficient for monitoring biodiesel stability.

X2.7 Fuel Storage Conditions

X2.7.1 Contamination levels in fuel can be reduced by storage in tanks kept free of water, and tankage should have provisions for water draining on a scheduled basis. Water promotes corrosion, and microbiological growth may occur at a fuel-water interface. Refer to Guide D6469 for a more complete discussion. Underground or isothermal storage is preferred to avoid temperature extremes; above-ground storage tanks should be sheltered or painted with reflective paint. High storage temperatures accelerate fuel degradation. Fixed roof tanks should be kept full to limit oxygen supply and tank breathing. The use of airtight sealed containers, such as drums or totes, can enhance the storage life of biodiesel.

X2.7.2 Copper and copper-containing alloys should be avoided with biodiesel due to increased sediment and deposit formation. Contact with lead, tin, and zinc can also cause increased sediment levels that can rapidly plug filters and should be avoided.

X2.7.3 Appendix X3 of Specification D2880 discusses fuel contaminants as a general topic. The discussion in Specification D2880 pertains to gas turbine combustion which may or may not be applicable to diesel engine combustion.

X3. LOW TEMPERATURE OPERABILITY OF BIODIESEL BLENDS

X3.1 General Considerations

X3.1.1 The cold flow properties of biodiesel (B100) meeting Specification D6751 depend mainly on the number of carbons in the fatty acid chains, the degree of saturation of the fatty acid chains, and the alcohol to which the fatty acid chains are esterified. Residual constituents from biodiesel raw materials and production processes can affect fuel filter operation with biodiesel and biodiesel blends as fuel temperatures become colder, as can contaminants that accumulate during fuel storage and distribution. The concentration of biodiesel inclusion can also affect the cold flow properties of the finished blend.

X3.1.2 It is unrealistic to specify low temperature properties of biodiesel blends that will ensure satisfactory operation at all ambient conditions in all storage situations. In general, cloud point, Low Temperature Flow Test (LTFT), and Cold Filter Plugging Point (CFPP) might be used as estimates of operating temperature limits for biodiesel blends, although precision data may not be available for biodiesel blends in all of these test methods. However, equipment design, operating conditions, and the use of flow-improver additives can allow satisfactory operation of the biodiesel blend below its cloud point.

X3.1.3 Due to fuel delivery system, engine design, and test method differences, low temperature operability tests may not provide the same degree of protection in all biodiesel blend applications or storage situations. Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use of the biodiesel blend and the expected ambient temperatures.

X3.2 Influence of Residual Constituents and Contaminants

X3.2.1 Residual non-mono-alkyl ester constituents in biodiesel that remain from biodiesel raw materials and production processes can contribute to fuel filter fouling over time especially if biodiesel blends are stored at low temperatures. Certain residual constituents have been found on fouled biodiesel blend filters in the field. For example, sterol glucosides, monopalmitin, and monostearin have been identified in elevated quantities on biodiesel blend dispenser filters that fouled at temperatures above the cloud point of the blended fuel. Water in poorly maintained diesel distribution systems can interact with the residual constituents in biodiesel to increase the likelihood of filter clogging.

X3.2.2 Specification D6751 on B100 blend stock restricts some residual constituents and contaminants either directly or indirectly. The limit on Test Method D6584 total glycerin indirectly controls monoglycerides and related derivatives. Limits on Test Method D874 sulfated ash and EN 14538 for combined calcium/magnesium and combined sodium/potassium indirectly control soap levels. Test Method D2709 limits water and sediment content. Additionally, Test Method D7501 is a performance based filtration test that provides an assessment of the aggregate impact of residual constituents and contaminants on the filter clogging potential of the finished blend.

X3.2.3 Fuel contaminants found in distribution systems can also contribute to low temperature filter clogging with biodiesel and biodiesel blends.

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X3.3 Low Temperature Operability Considerations

X3.3.1 In establishing low temperature operability requirements for biodiesel and biodiesel blends, consideration should be given to the following factors:

X3.3.1.1 Temperature guidelines such as those in Specification D975, Appendix X5, Tenth Percentile Minimum Ambient Air Temperatures for the United States (Except Hawaii).

X3.3.1.2 Short term local weather conditions (unusual cold periods do occur).

X3.3.1.3 Elevation (high locations are usually colder than surrounding lower areas).

X3.3.1.4 Specific engine design or other application.

X3.3.1.5 Fuel system design (for example, fuel recirculation rate, filter location, filter capacity, filter porosity).

X3.3.1.6 Fuel viscosity at low temperatures.

X3.3.1.7 The specific characteristics of the middle distillate fuel with which the biodiesel will be blended.

X3.3.1.8 Type of blending that will be used (in-line or splash).

X3.3.1.9 Temperature and volume of both the diesel and biodiesel to be blended.

X3.3.1.10 Equipment add-ons (engine heaters, radiator covers, fuel line and fuel filter heaters, exterior fuel filters, etc.).

X3.3.1.11 Types of operation (extensive idling, engine shutdown, or unusual operation).

X3.3.1.12 Low temperature flow improver additive effectiveness.

X3.3.1.13 Geographic area for fuel use and movement between geographic areas.

X3.3.1.14 General housekeeping (dirt, water, or both, in fuel or fuel supply system).

X3.3.1.15 Impact of failure for engine to start or run effectively (critical vs. non-critical application).

X3.3.2 Some biodiesel residual constituents might not come out of solution in a biodiesel blend unless exposed to cold temperature for an extended period of time. These constituents may come out of solution above the measured cloud point of the blend and might or might not go back into solution when the blend is warmed to a higher temperature. Specification D6751 contains requirements such as cold soak filterability and total glycerin to reduce the potential influence of such constituents on low temperature operability.

X3.3.3 Work in the area of low temperature operability is ongoing by several organizations in 2010, such as the Coordinating Research Council (CRC) Diesel Performance Group and the ASTM Biodiesel Task Force. These groups include representatives from the engine and filter equipment manufacturers, fuel injection equipment manufacturers, fuel producers and additive suppliers. These groups are investigating field reports involving filter plugging of distribution system filters and vehicle filters, causal factors for filter plugging with biodiesel blends, and controlled laboratory analysis of vehicle performance under cold conditions.

SUMMARY OF CHANGES

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D6751 – 15b) that may impact the use of this standard. (Approved Dec. 1, 2015.)

(1) Added Test Method D7344 to Section 2, Referenced Documents, and to subsection 5.1.16.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D6751 – 15a) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Added Test Method D7345 to Section 2, Referenced Documents, and to subsection 5.1.16.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D6751 – 15) that may impact the use of this standard. (Approved June 1, 2015.)

(1) Added Test Method D7689 to Section 2, Referenced Documents, and to subsection 5.1.10.

Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D6751 – 14) that may impact the use of this standard. (Approved Jan. 1, 2015.)

(1) Revised subsection 5.1.9 to include Test Method D7668.

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Subcommittee D02.E0 has identified the location of selected changes to this standard since the last issue (D6751 – 12) that may impact the use of this standard. (Approved Oct. 1, 2014.)

(1) Revised footnote C of Table 1.

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BIODIESEL®

America's Advanced Biofuel

March 2017

Biodiesel Industry Overview & Technical Update

Topics for Today:

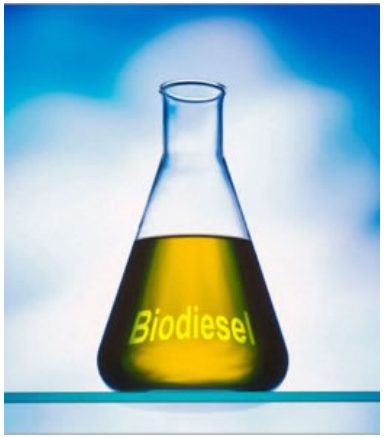
- Biodiesel Industry Overview
- Benefits of Biodiesel
- Biodiesel ASTM Fuel Specifications & Quality
- Legislative Updates Impacting Biodiesel Demand
- OEM & Fleet Support for Biodiesel
- Biodiesel Resources

What is Biodiesel?

- A clean, domestic, sustainable, renewable fuel for diesel engines made from fats and oils, such as soybean oil and used cooking oil
- A high quality Advanced Biofuel
- Made through a chemical reaction called transesterification, meeting ASTM D6751 standards
- B20 and lower blends – and even B100 in some cases – have been used successfully in existing older diesel engines as well as new models coming off the production line

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.

- This tightly specified definition was instrumental in achieving OEM support

Biodiesel and the RFS: Advanced Biofuel Defined

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.

What's NOT Biodiesel?

- Raw vegetable oil/SVO
- Recycled cooking oil
- Ethanol
- Ethanol, methanol, or water blended with diesel and an emulsifier
- Other "Renewable Fuels"

Biodiesel Reaction

Reacting:

100 Lbs. Vegetable Oil or Animal Fat

+

10 Lbs. Alcohol

Methanol or Ethanol

In the Presence of a Catalyst

Sodium Hydroxide or Potassium Hydroxide

Yields:

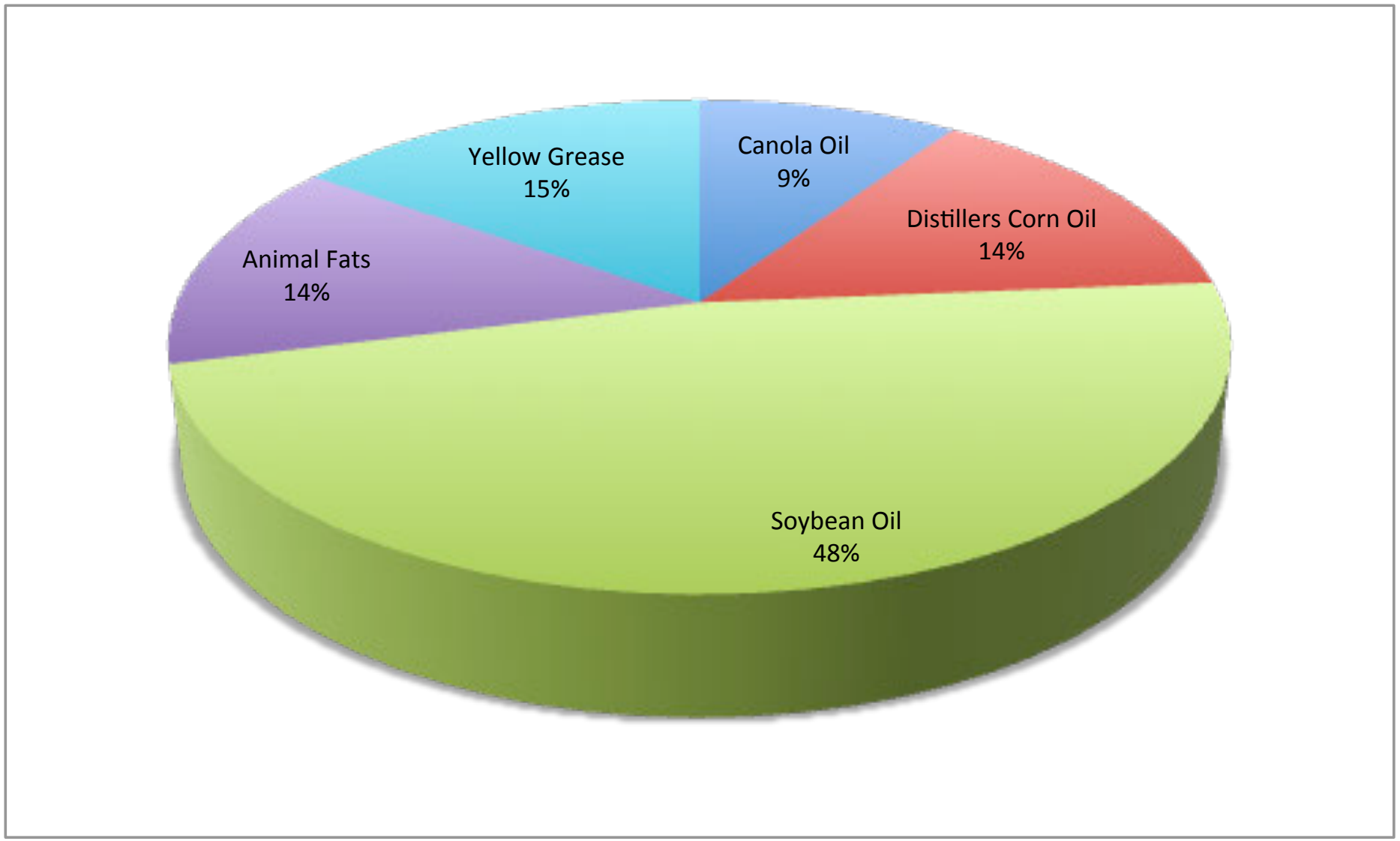
100 Lbs. Biodiesel

+

10 Lbs. Glycerine

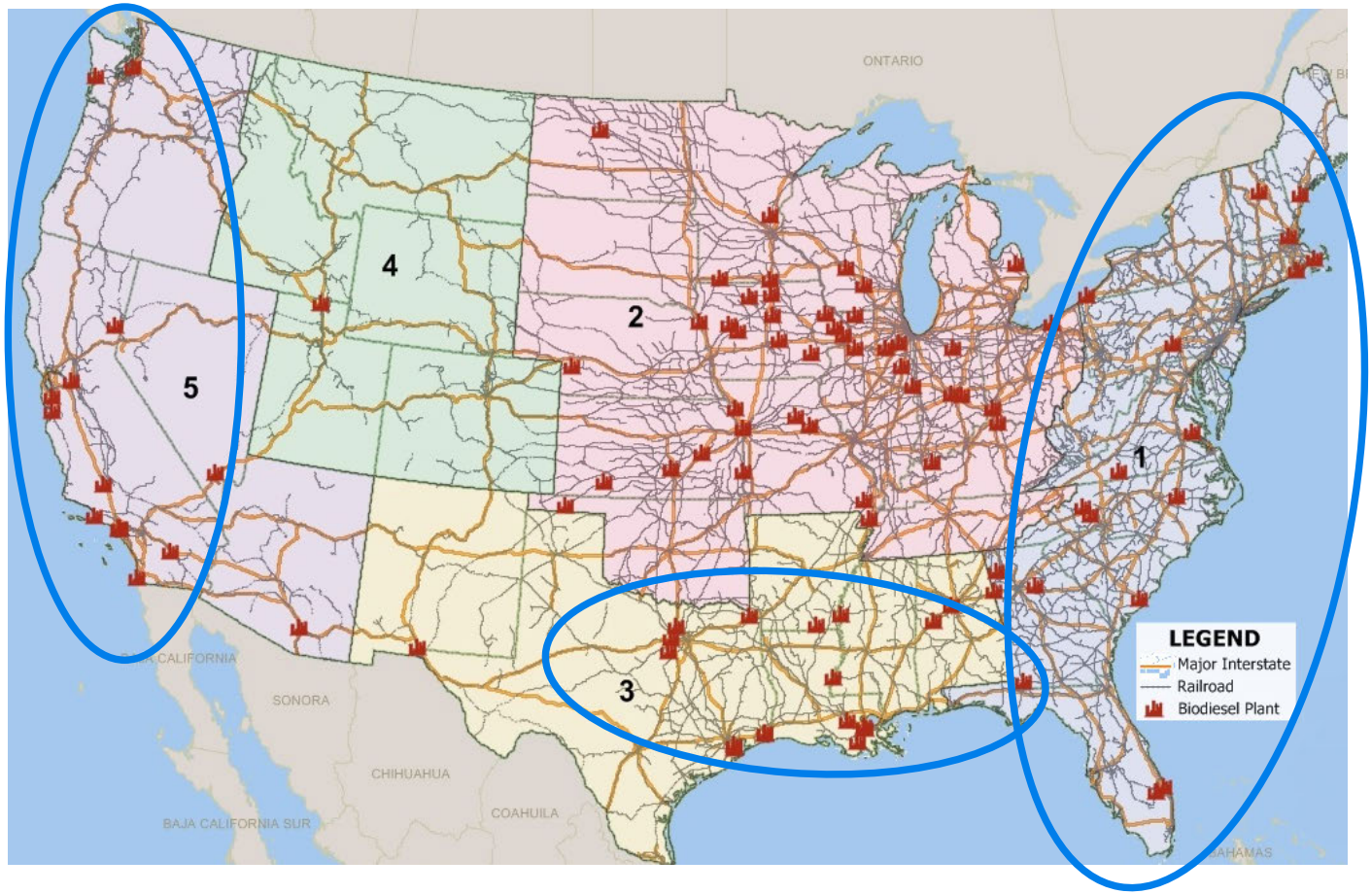
Transesterification process produces mono-alkyl esters – chemically similar to diesel fuel

2016 Biomass Based Diesel Feedstocks



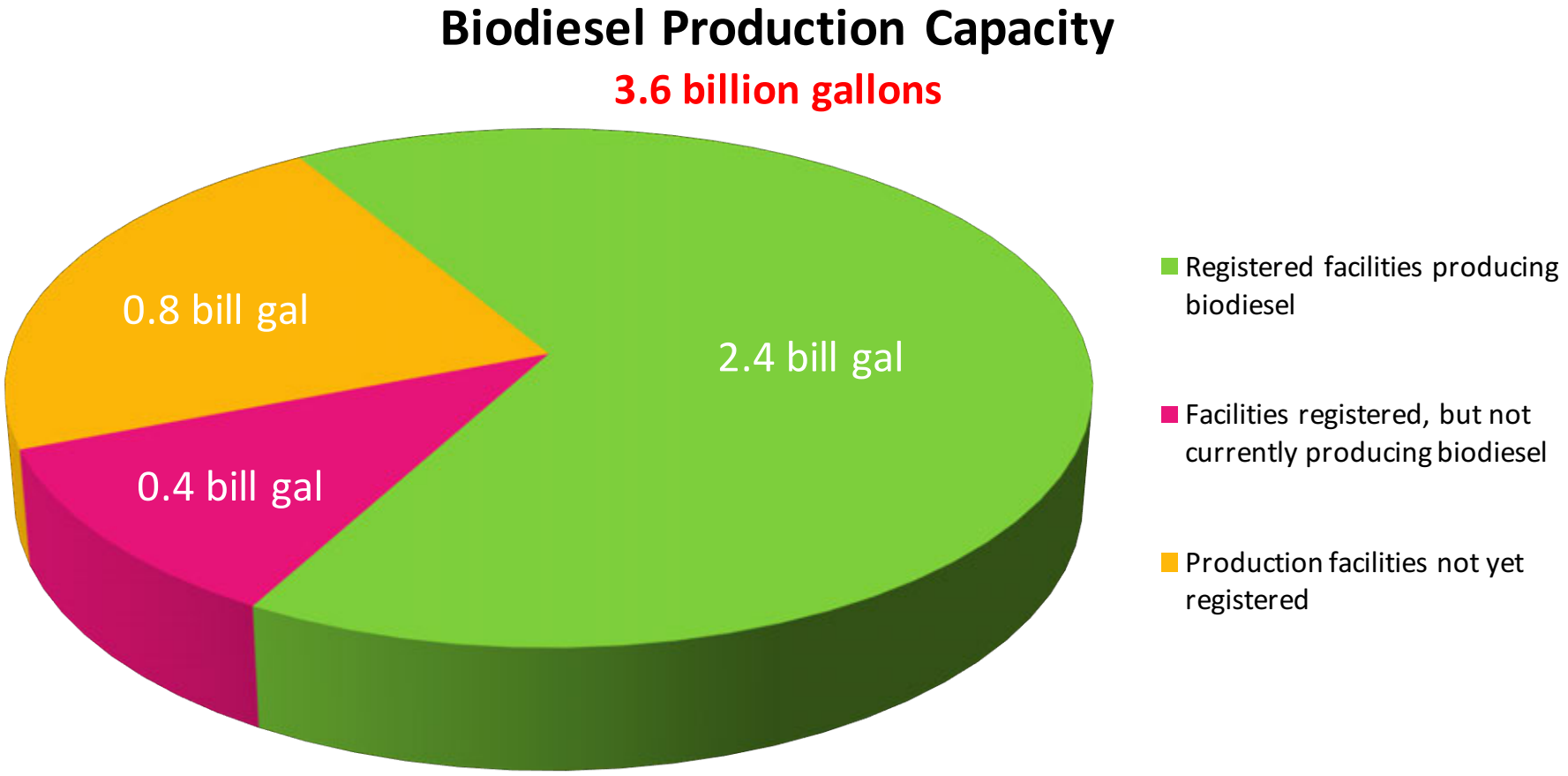
Biodiesel Has Expanded and Diversified Production Capacity

- Biodiesel production has expanded beyond the Midwest
- New capacity closer to other markets uses diversified feedstocks



Source: NBB

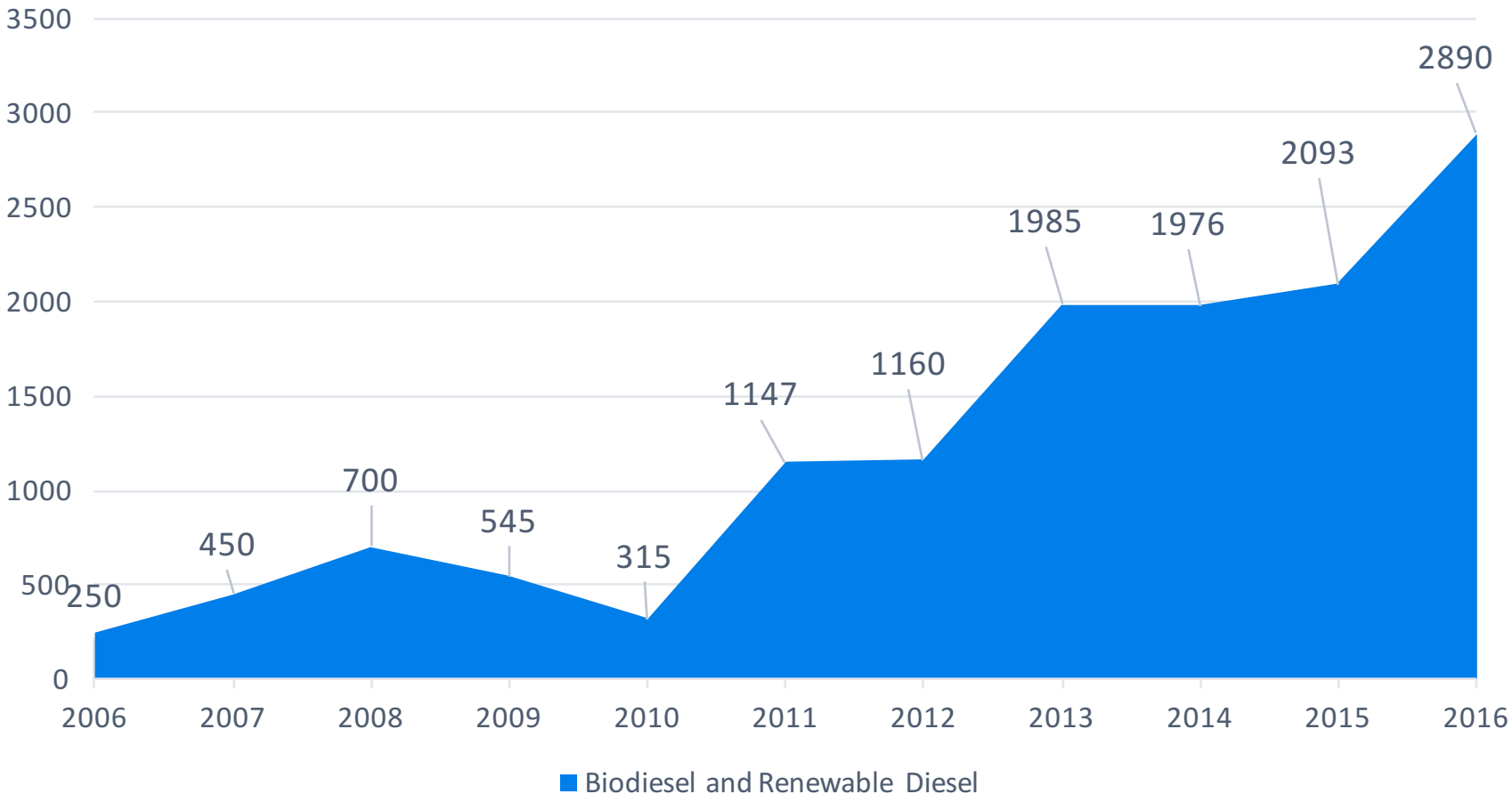
Biodiesel production increases are not constrained by available biodiesel capacity



Source: Biodiesel plant list 2-6-13 from Docket EPA-HQ-OAR-2013-0479; numbers are from a combination of NBB, EIA, and EPA databases.

U.S. Biodiesel & Renewable Diesel Market

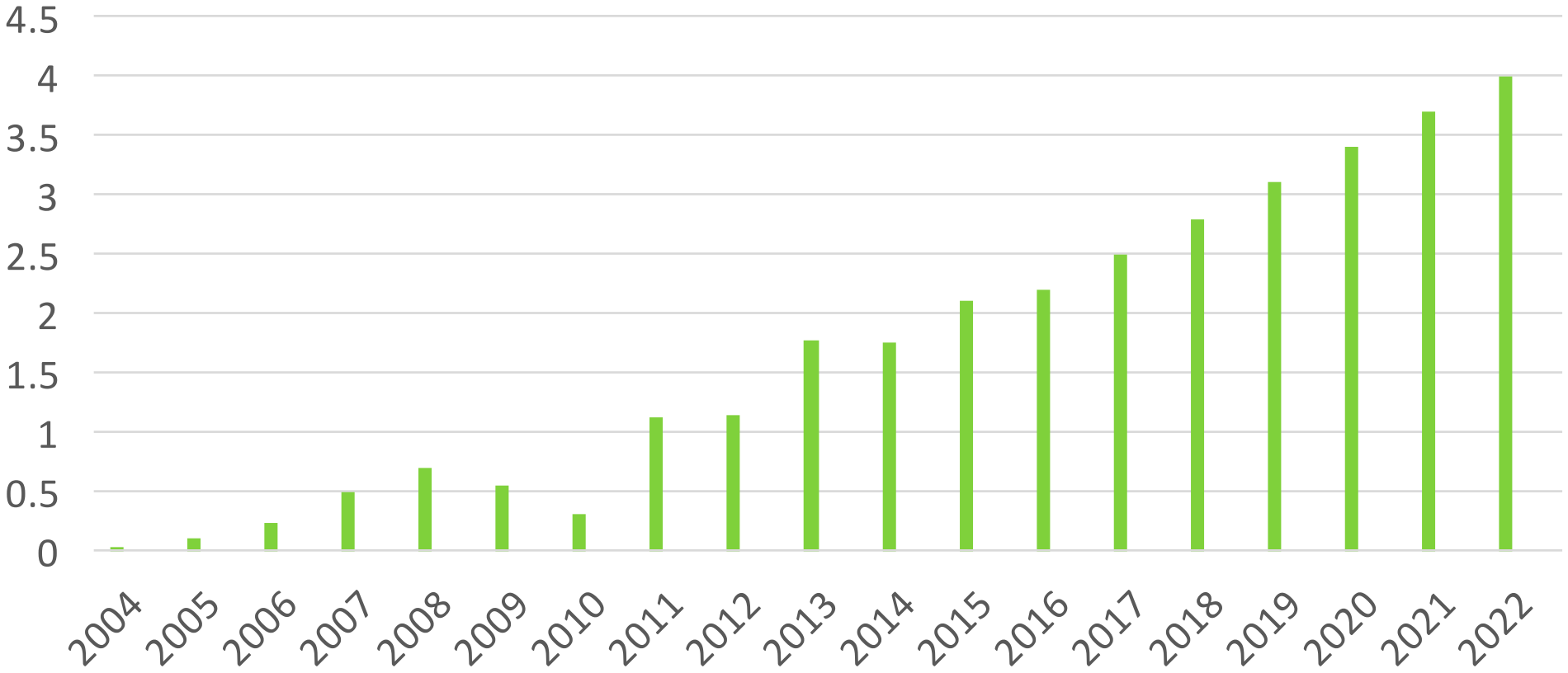
(millions of gallons)
Source: EPA EMTS*



*Volumes reported under the RFS in the D4, D5, and D6 categories.

Biodiesel Production Goal:

4 Billion Gallons by 2022



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Biodiesel Infrastructure

- Biodiesel and biodiesel blends available nationwide at more than 2,000 public locations
- Existing trucks, tanks, dispenser pumps and blending facilities can be used for B20 and lower

Biodiesel Production and Distribution Network Where Fuel Demand Is High

- Biodiesel is produced and widely distributed where vast majority of highway fuel is consumed
- "Thin" distribution only in states with less demand (PADD 4)

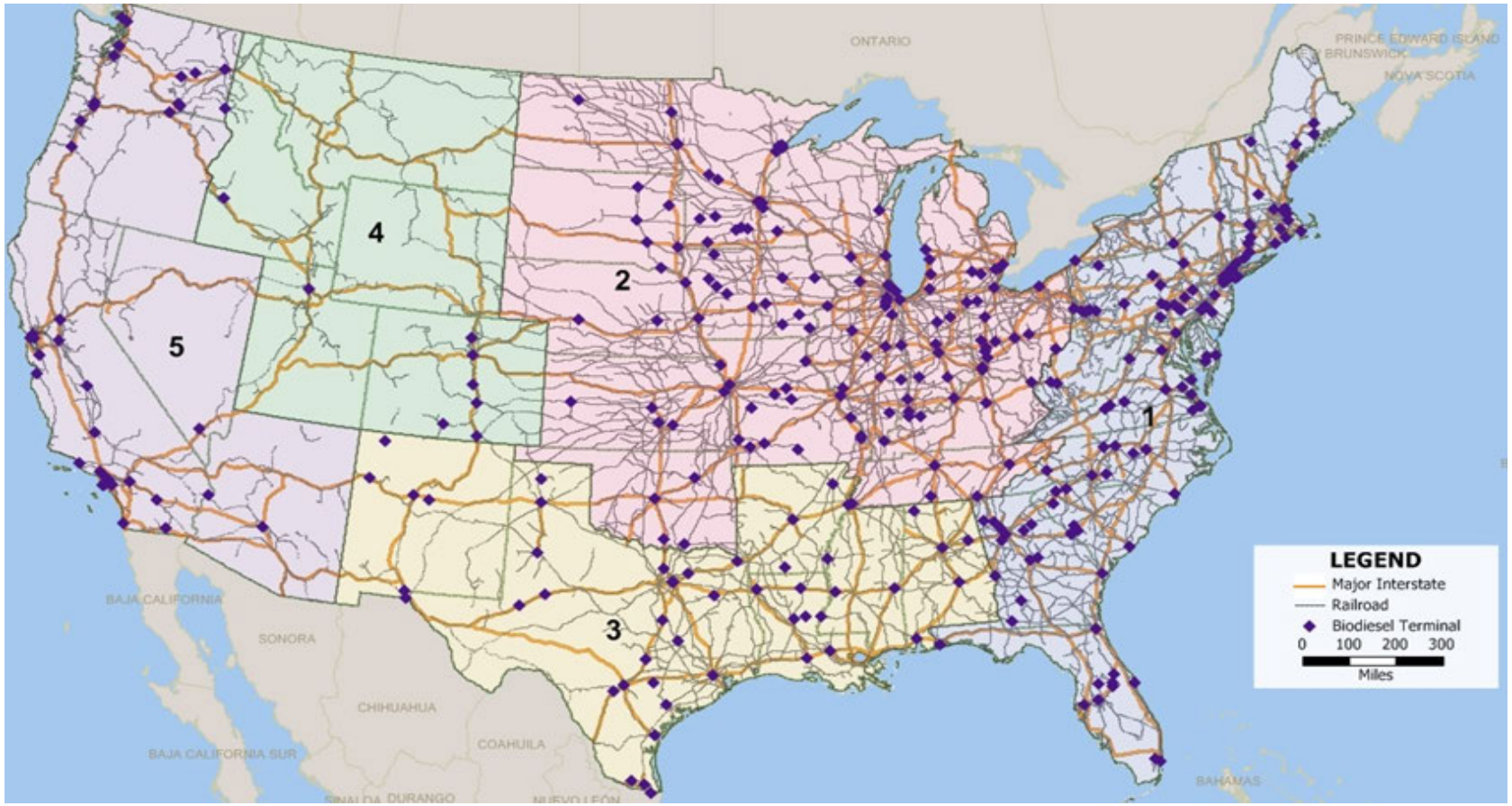
Freight Flows by Highway, Railroad and Waterway

Source: USDOT (2010)

Biodiesel Is Widely Available at Bulk Terminals

- Biodiesel is available at terminals in 369 cities, compared to 453 cities with terminals providing petroleum fuels

U.S. Cities with Fuel Terminals Providing Biodiesel

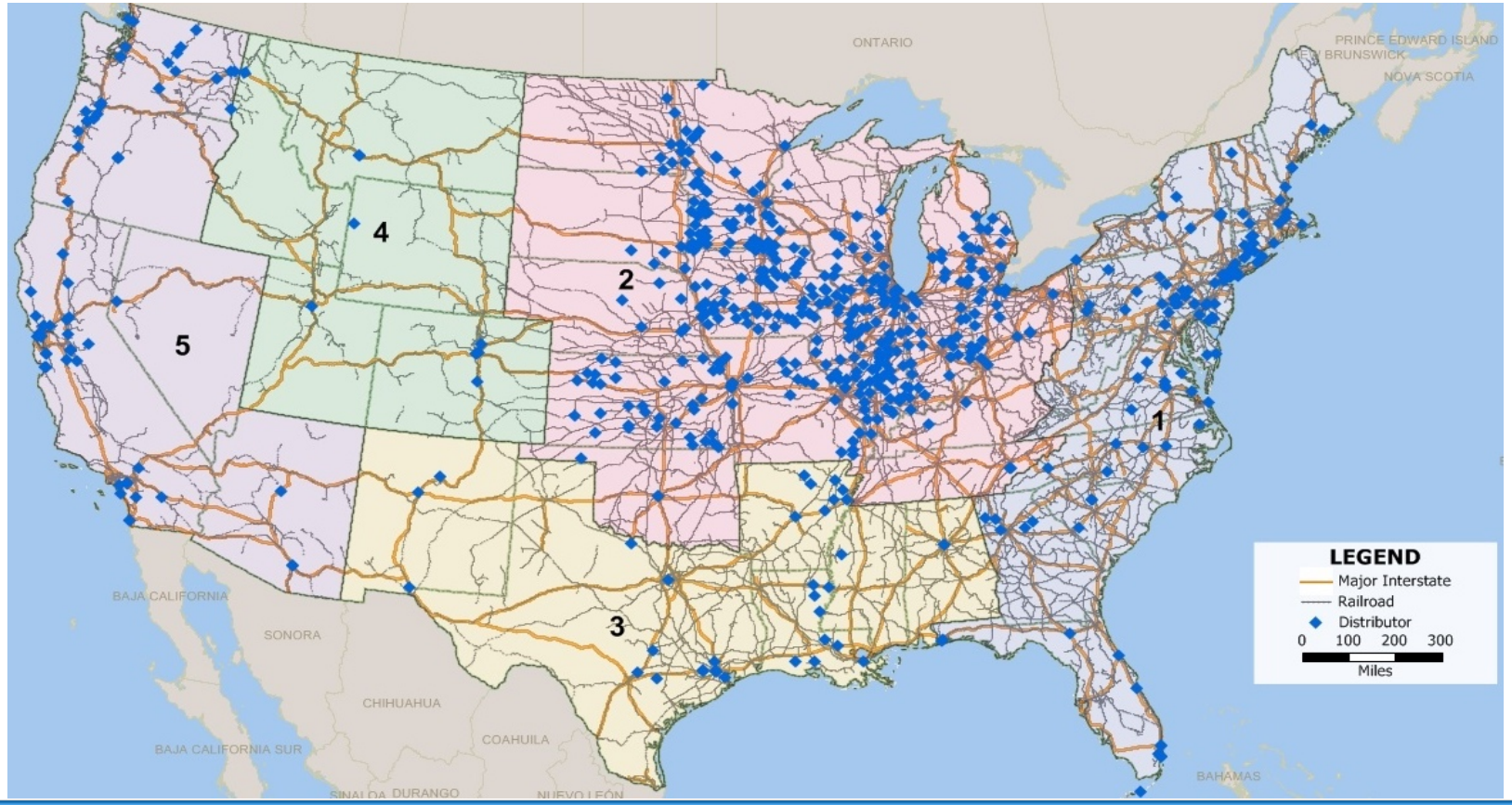


Source: OPIS

Bulk Biodiesel Distributors and Jobbers Span the U.S.

- Distributors/wholesale jobbers are concentrated near demand centers
- Distributors/jobbers supplement availability of biodiesel at 2nd level of fuel distribution network

U.S. Bulk Distributors of Biodiesel

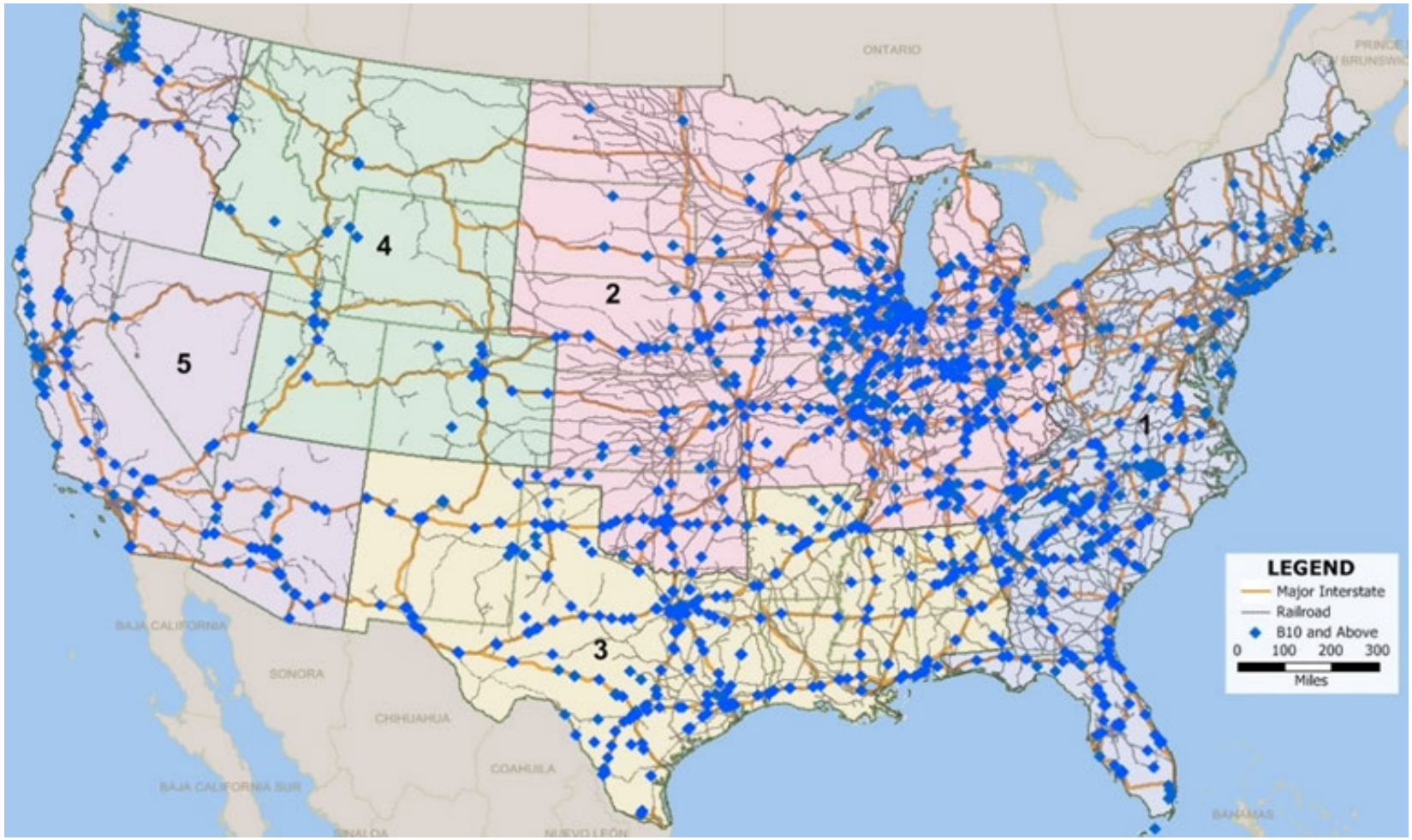


Source: NBB

Higher Blends Available Nationwide, Often Blended by Major Retailers

- Retailers nationwide sell B10 - B20 blends, esp. on main truck routes
- Large retailers often have store-level blending, by-passing terminals

U.S. Retailers Selling Biodiesel Blends of B10 to B20



Source: NBB; Company websites

Improved Pipeline Access for Biodiesel Blends

- Recent ASTM spec changes will allow increased distribution of biodiesel through multi-product pipelines
- Lower transportation costs/increased breadth of distribution

Major U.S. Petroleum Product Pipelines

Source: EIA

Top Reasons Why Smart Customers Are Using Biodiesel

Biodiesel Does Good Things:

- Provides high quality fuel from domestic, sustainable resources
- Reduces imports and power of oil cartels
- Supports 64,000 U.S. Jobs
- Generates $11.42 Billion total Economic Impact
- Reduces Particulates, Carbon Monoxide, and Unburned Hydrocarbons from Older Engines
- **Reduces Green House Gas Emissions**
- **Best Carbon Footprint of any U.S. Produced Fuel**

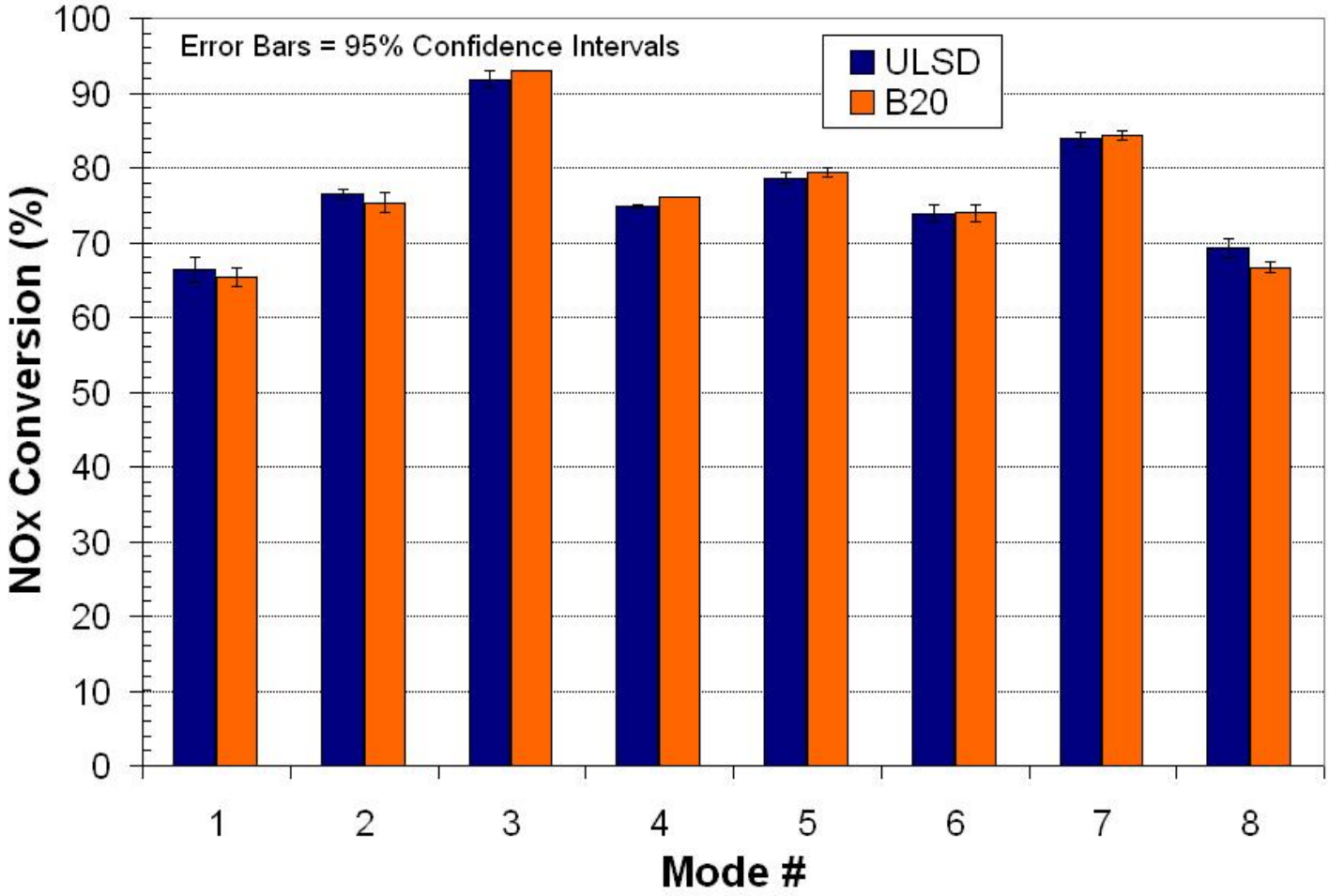
Emissions Reductions With…

Emissions Reduced	B100	B20
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
Polycyclic Aromatic Hydrocarbons	-80%	-13%
Ozone Potential	-50%	-10%

A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions
http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf

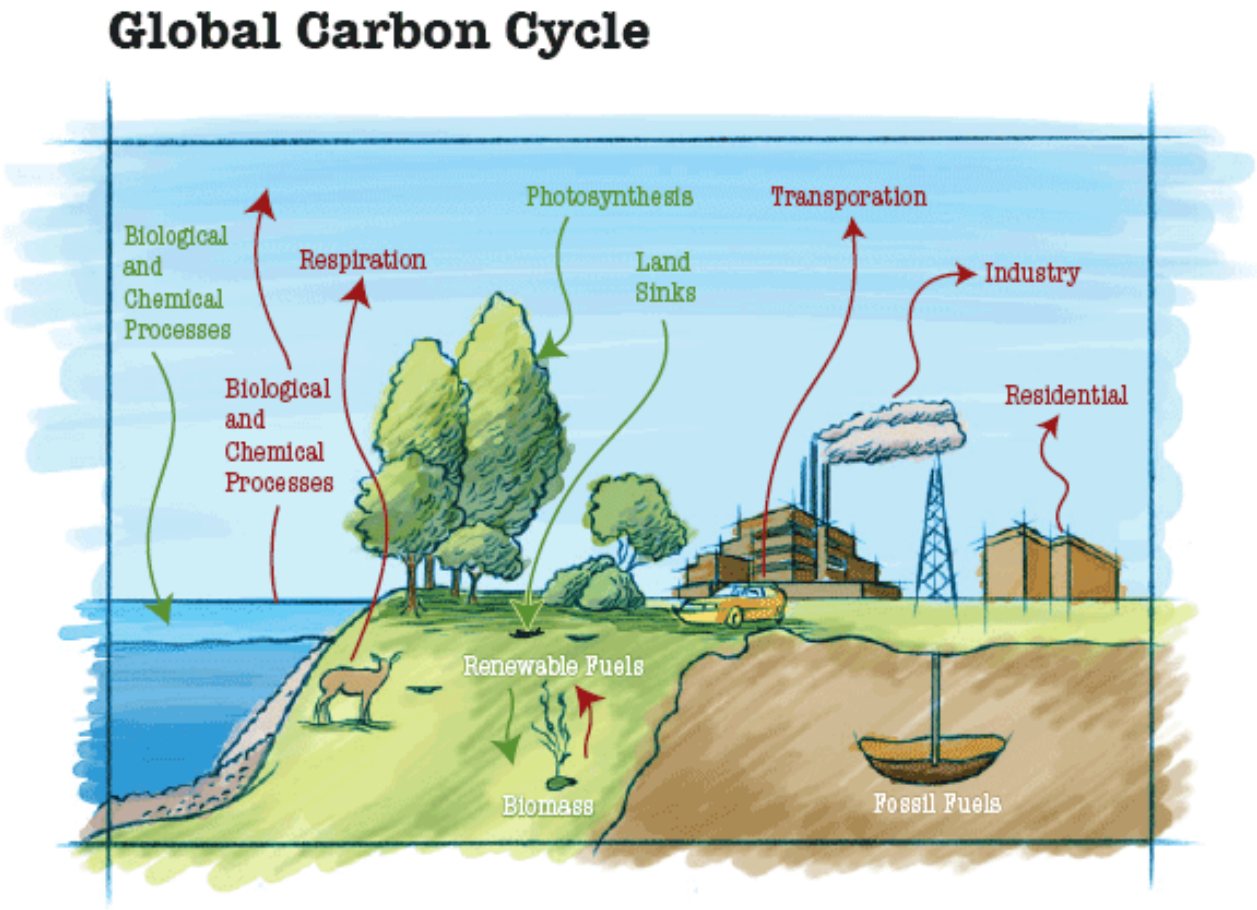
ULSD vs B20 in SCR Systems

- No statistical difference in NOx Conversion with B20 across the entire engine map



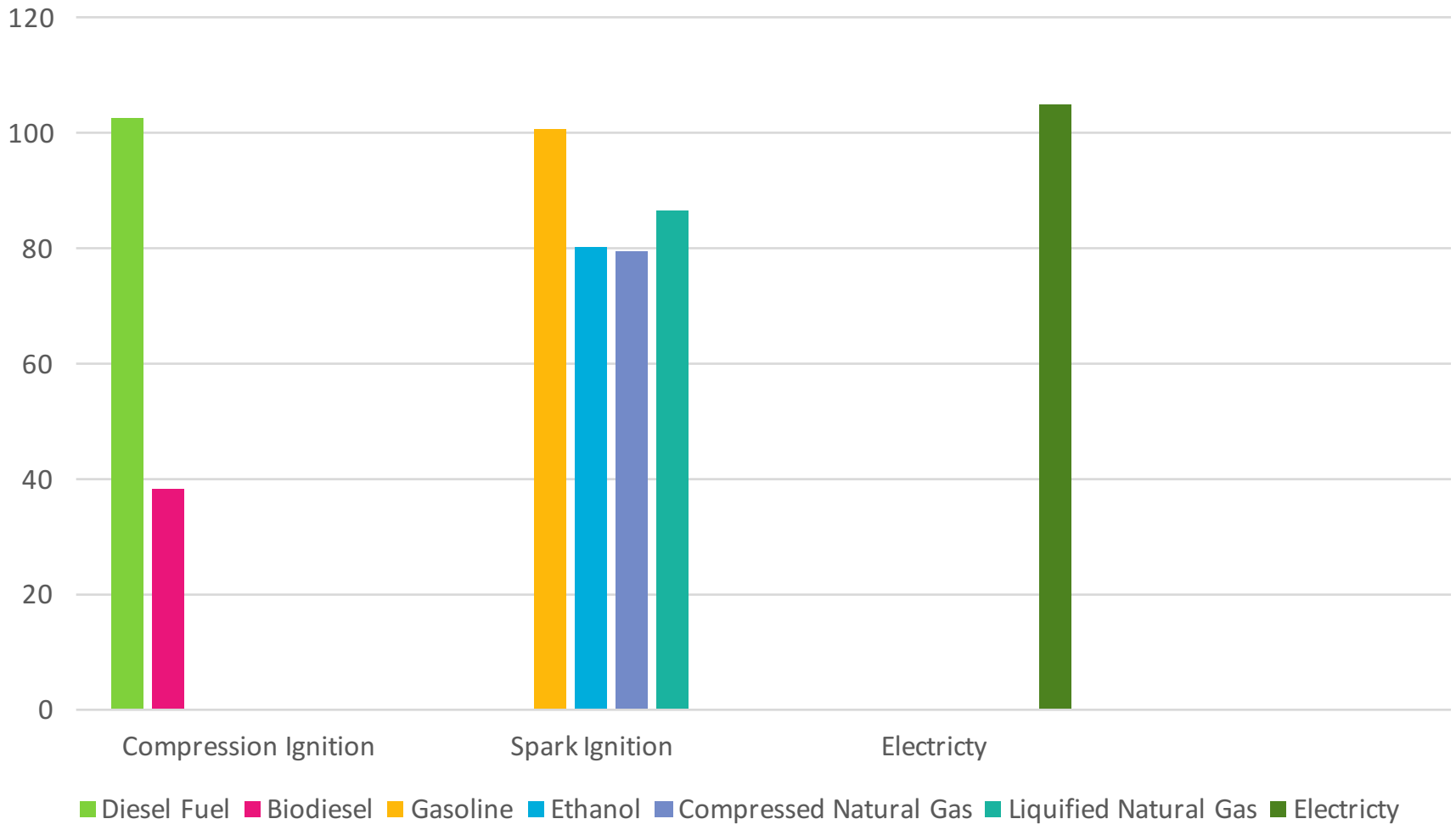
Green House Gas Benefits: Biodiesel Reduces Carbon Footprint

- **U.S. biodiesel on average provides an 80% Reduction in Carbon Emissions compared to petroleum diesel**
  - Full life cycle from soil to tailpipe
  - Includes latest indirect land use impacts for biodiesel used in the United States
- **Energy Balance 5.5 to 1**

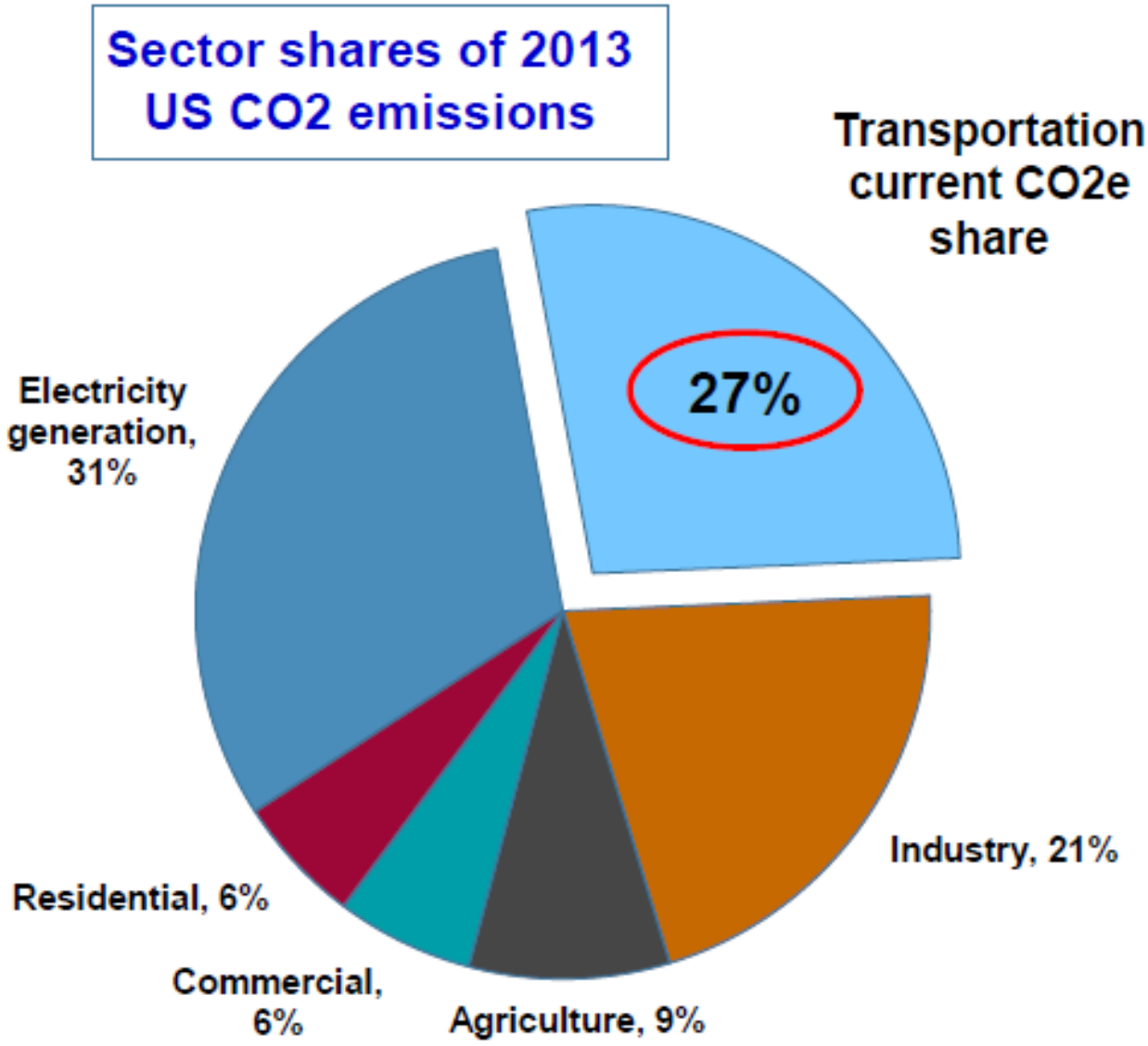


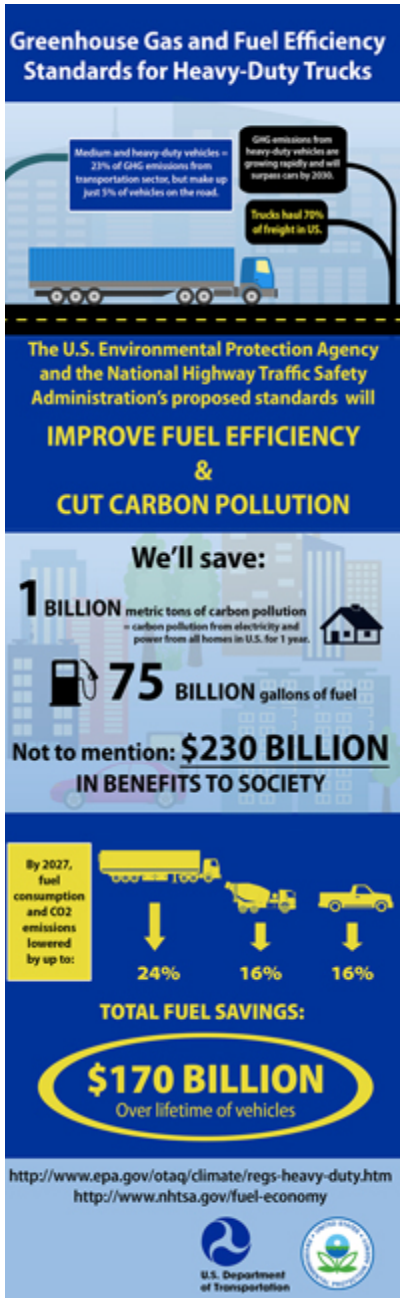
Carbon Intensity of Fuels

grams CO2e/MJ



- Transportation is the most carbon intensive sector
- Fuel Refining captured in Industrial sector





Transportation GHG Reductions

- EPA proposes to increase efficiency in Heavy Duty transportation by 24% by 2027.
  - Cumulative GHG savings of 1 Billion tons CO2

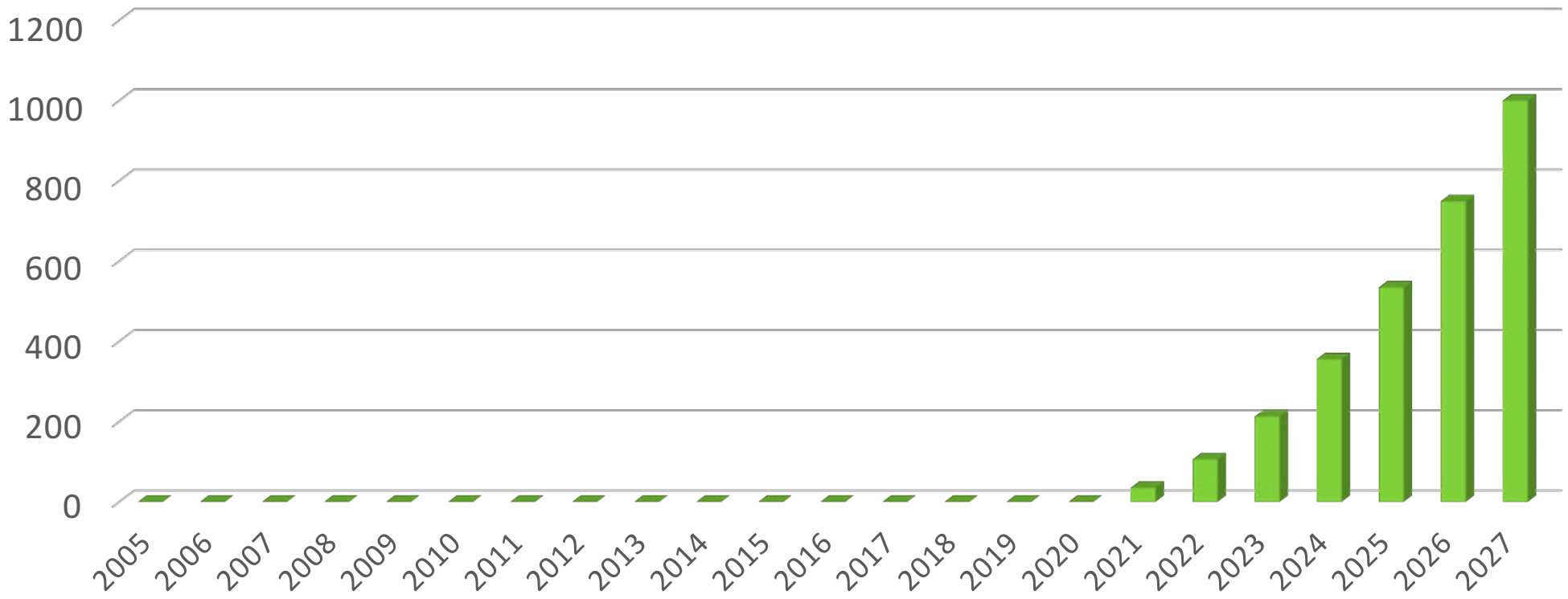
Transform the Entire Fleet

From this…

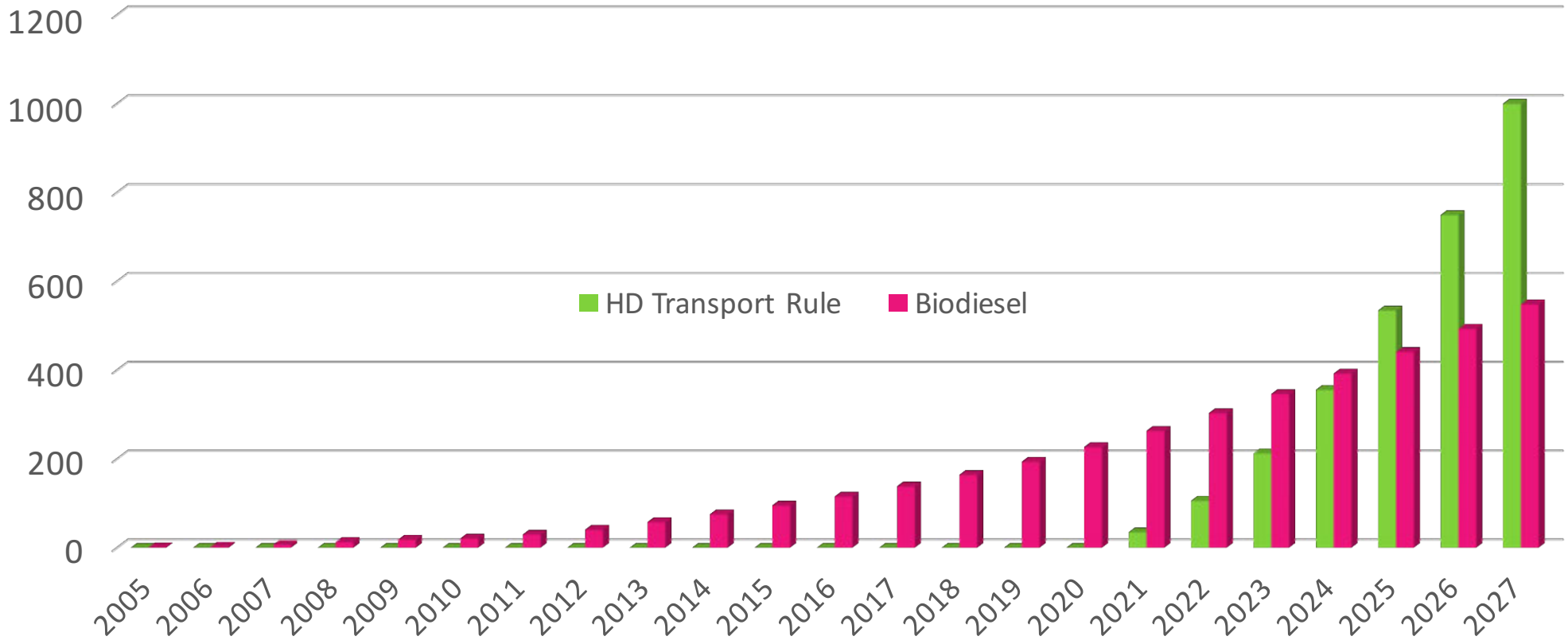
Transform the Entire Fleet

To this…

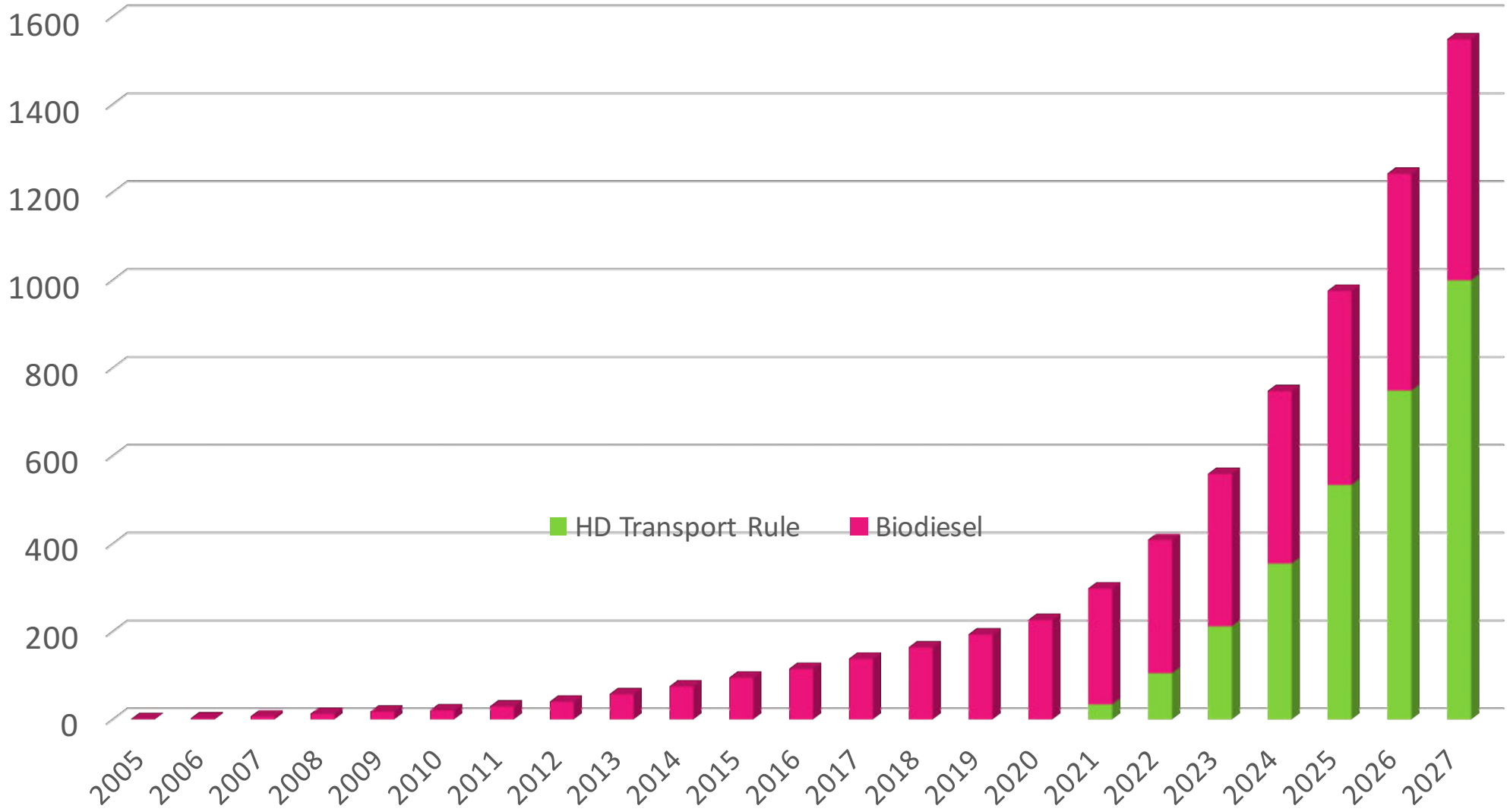
GHG Reduction Potential of EPA's Heavy Duty Truck Rule
Million Tons CO2e cumulative



GHG Reduction Potential of Biodiesel
Million Tons of CO2e cumulative



GHG Reduction Potential of EPA's Heavy Duty Truck Rule Plus Biodiesel - Million Tons CO2e cumulative



Biodiesel Works

In this..

Or this…

Or this…

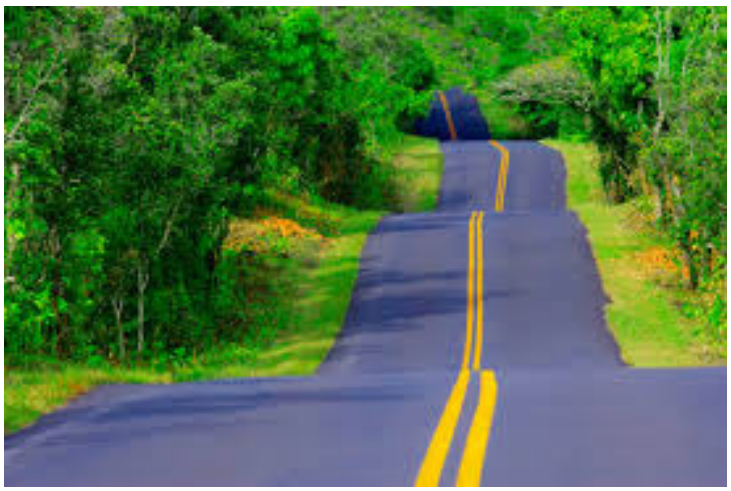
Biodiesel is Making a Difference

The 2.9 Billion Gallons of Biodiesel and Renewable Diesel Used in 2016:

- Reduced Carbon Emissions by 24.7 Million Metric Tons

Which is Equivalent to:

- Removing 5.2 Million Cars from America's Roadways
- Planting 641 Million Trees
- Preserving 23.4 Million Acres of Mature Forests
- 80% Less Lifecycle Greenhouse Gas than Petroleum Diesel



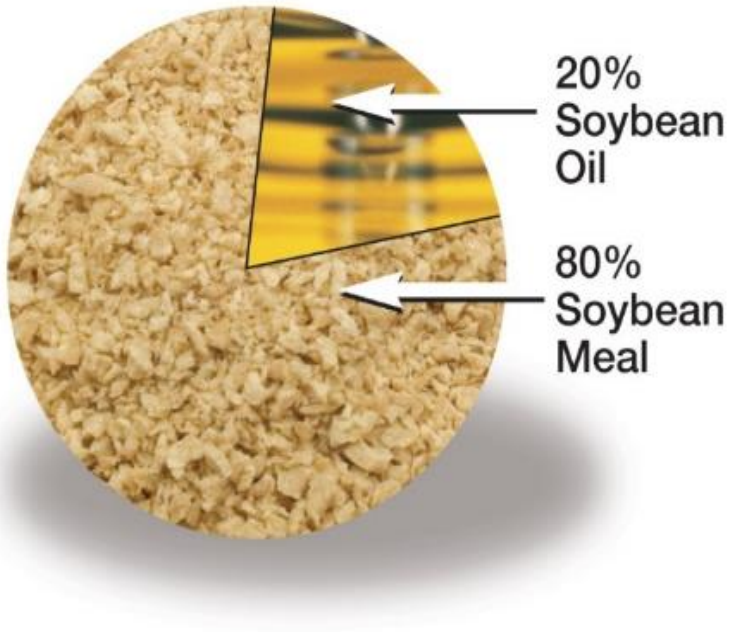
Sustainability

- Biodiesel is produced from a variety of renewable resources, such as plant oils, animal fats, recycled grease, and even algae, making it one of the most sustainable fuels on the planet.

- With biodiesel, **food isn't sacrificed for fuel.** Oils and fats for biodiesel are a minor by-product of producing food for humans and animals.
  - Soybeans are 80% protein, 20% oil
  - No one grows livestock for its fat content
  - No one cooks more fried food to get used oil for biodiesel

THE ORIGINAL MISSION

- Soybeans are grown for protein meal.
- Soybeans are 80% protein meal and 20% oil.
- Beans are crushed to separate oil and meal.
- Protein meal is consumed by humans and animals.
- There is an excess of soybean oil.
- Biodiesel uses the excess oil



By creating a market and value for excess soybean oil,

Biodiesel decreases soy protein meal prices by $20-40 per ton.

Biodiesel Improves Diesel Properties

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- Blends with petrodiesel in any percentage
  - Once it is blended it does not separate back out
- Higher Cetane
  - Over 50 vs. average petrodiesel around 44
  - Smoother, more complete burn
- Higher Lubricity
  - 2% biodiesel 'fixes' even bad diesel
- Virtually Zero Sulfur
  - Meets ULSD limits of 15 ppm or less
- Zero Aromatics Reduces Toxicity and Burns Cleaner
- 11% Oxygen Provides Superior Lubricity and Reduces Black Smoke (Particulates)
- High Flash Point Makes it Safer
  - Non hazardous shipping (over 200 F)

ASTM Specifications and Biodiesel Fuel Quality

Biodiesel 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 five percent biodiesel maximum for on/off road engines; in effect since 2008

D7467 – Covers blends containing six to twenty percent biodiesel (B6-B20) for on/off road engines, in effect since 2008

- Designed so that if B100 meets D6751 and petrodiesel meets D975, then B6 to B20 blends will meet their specifications
- Important quality control is at B100 level

Enforcing Biodiesel Fuel Quality Standards

- 49 States have adopted ASTM D6751 as part of state law and can now legally enforce the ASTM D6751 Biodiesel Standard
  - No efforts are planned for Alaska

- NBB works actively with State Departments of Weights & Measures and other regulating entities (EPA, IRS) to help monitor and enforce biodiesel fuel quality

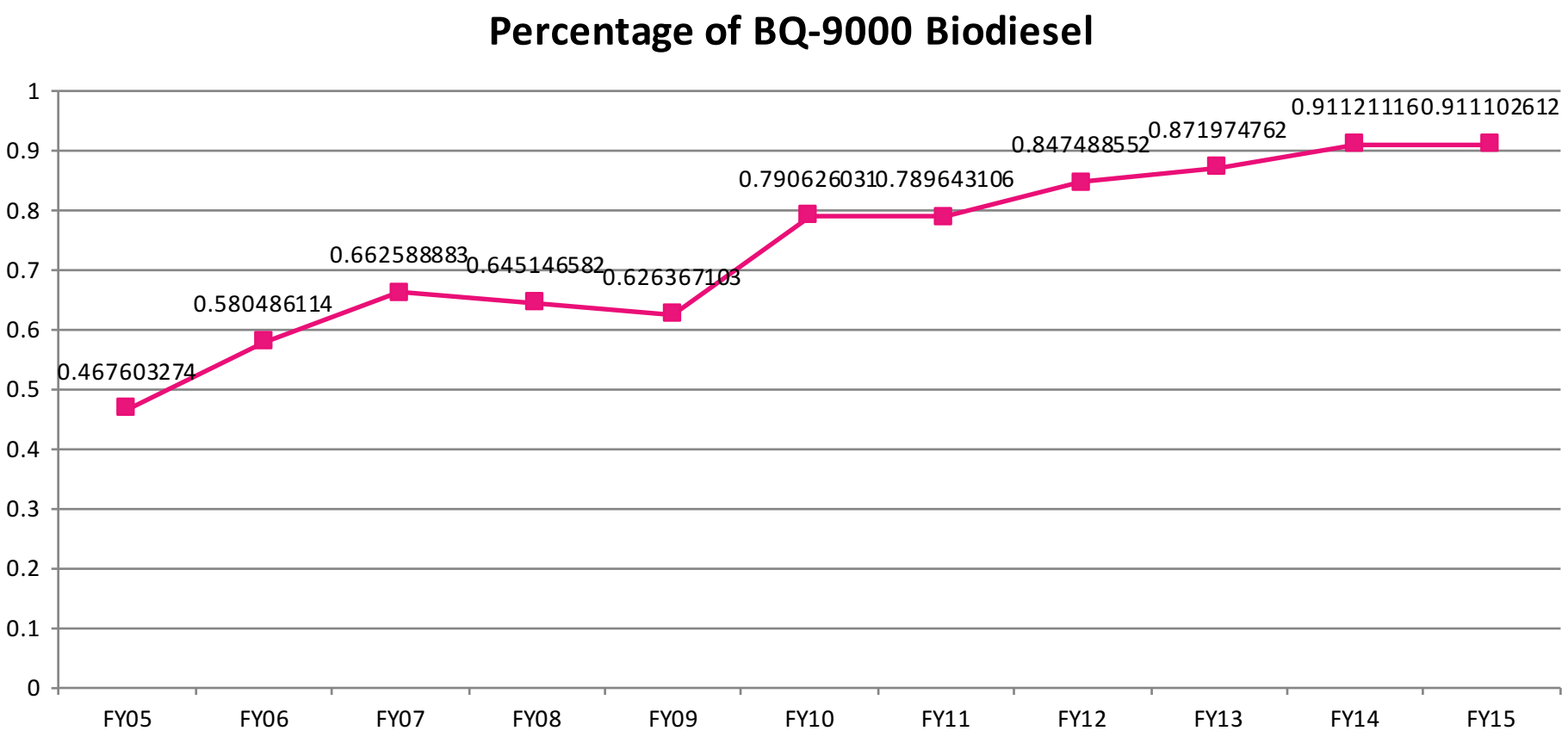
What is BQ-9000?

- Biodiesel Industry's equivalent to an ISO 9000 program for biodiesel production & distribution companies as well as testing labs
- NBB implemented BQ-9000 as a means to help instill confidence in biodiesel with users and equipment companies

- There are now four BQ-9000 designations:
  - Producer (make it to spec)
  - Marketer (buy spec, keep it in spec, blend it right)
  - Certified Laboratories (test the fuel accurately)
  - Retailer (fuel quality management practices)

- Many OEMs are now either requiring or strongly encouraging BQ-9000
- Organizations have seen economic advantages as more bids are requiring the certification

BQ-9000 Volumes Today



As of the end of FY2016, the percentage of gallons produced and being handled by BQ-9000 accredited locations within the marketplace has increased to over 92%.

Legislative Updates Impacting Biodiesel Demand and OEM Support

Biodiesel Policy Update

- Biodiesel qualifies as Advanced Low Carbon RFS fuel
- EPA Released Renewable Fuel Standard Volume requirements for both biodiesel eligible categories:

Year	Biomass Based Diesel (actual gallons)	Advanced, Non-Diff. (ethanol equivalent gal.)
2014 (actual):	1.63 Billion gallons	2.68 Billion
2015 required:	1.73 Billion gallons	2.88 Billion
2016 required:	1.9 Billion gallons	3.61 Billion
2017 required:	2.0 Billion gallons	4.00 Billion
2018 required:	2.1 Billion gallons	Not yet published

Federal Legislation

Other federal legislative incentives that are important to OEMs and fleets:

- Biodiesel Tax Incentive
  - $1.00 per gallon blenders tax credit
  - Biodiesel Blenders Tax Credit ($1/gal) reinstated for 2015-2016, expired 12/31/16
  - Industry seeking switch to domestic producers credit and multi-year extension

- EPACT Credits (Energy Policy Act)
  - Incentive for fleets for B20+ use; most economical option for EPACT compliance

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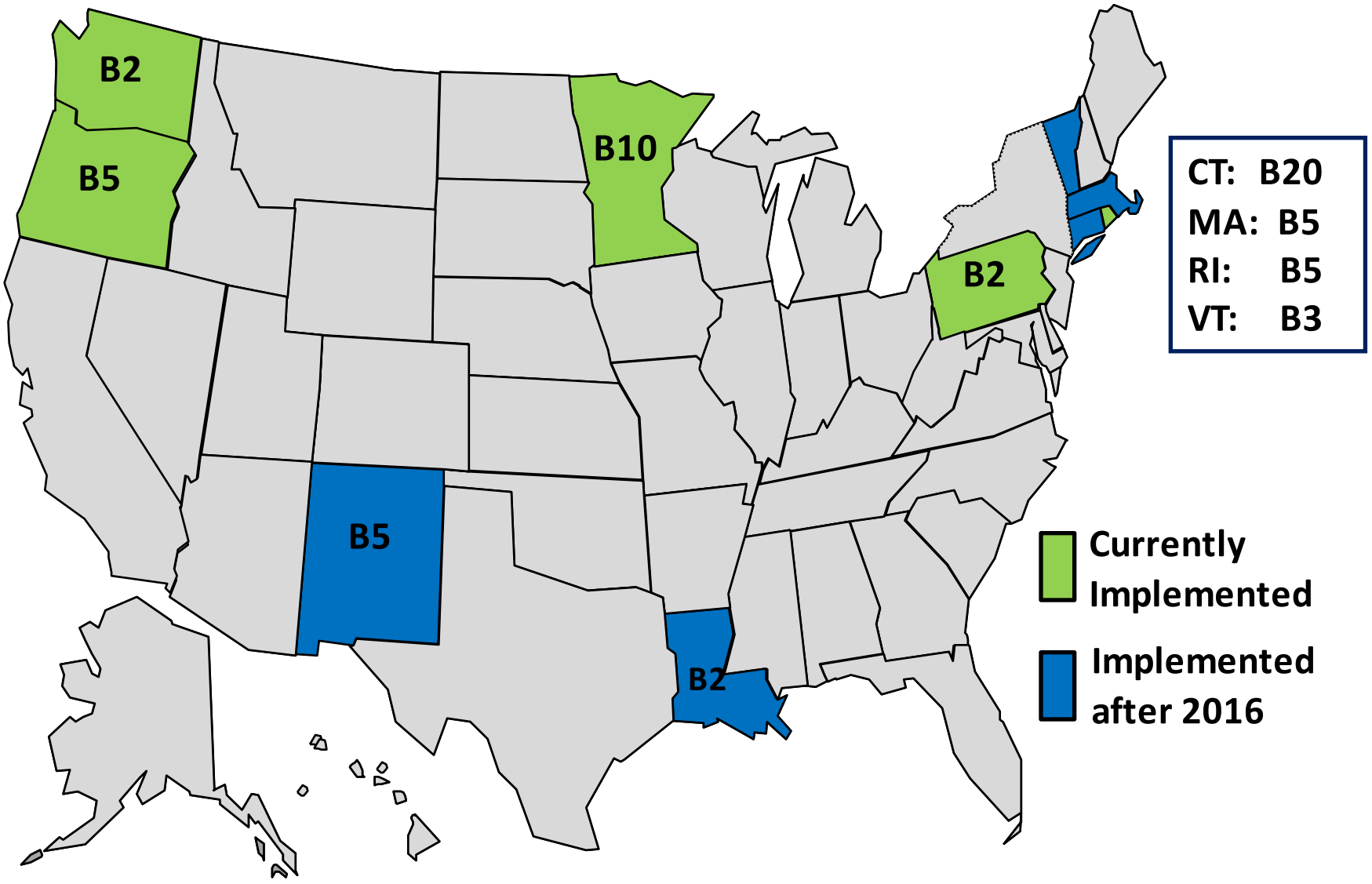
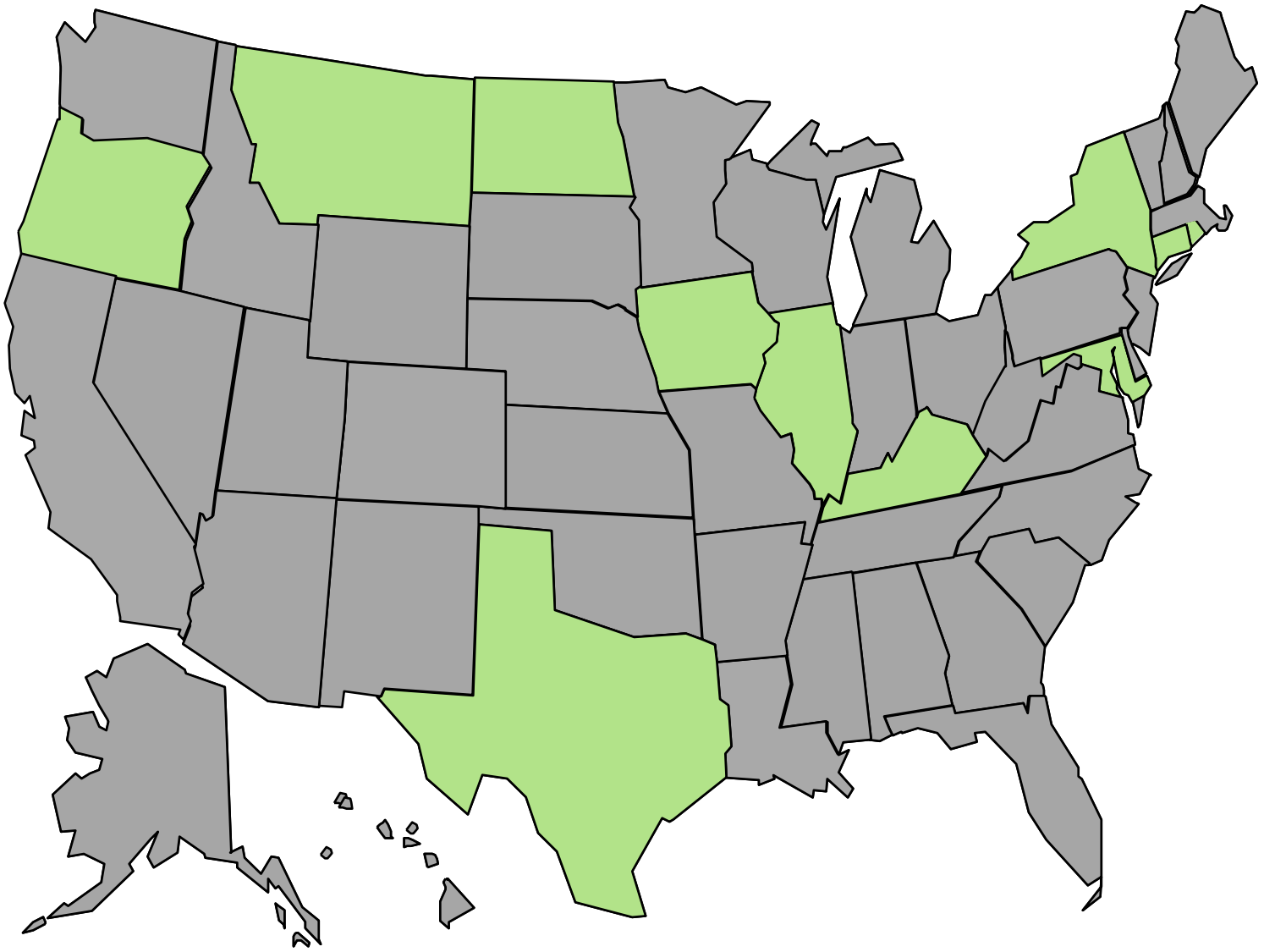
State Policies on Biodiesel

Statewide Requirements



Note: City of New York has a B2 Bioheat® requirement.

Consumption Incentives



Low Carbon Policies

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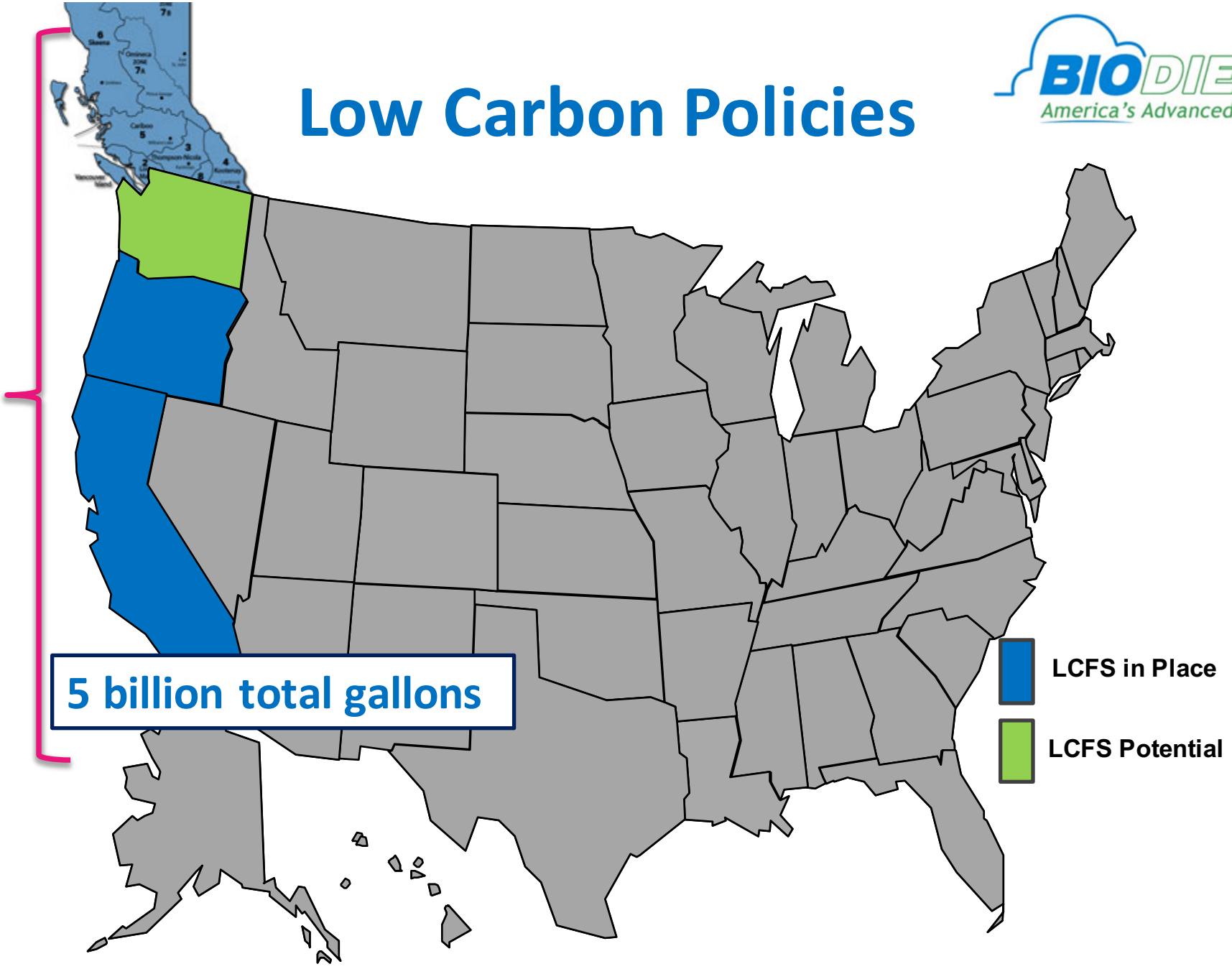


Key Takeaways on State Policy:

- Biodiesel has strong policy support at the state and local levels.
  - 1 billion gallon guaranteed market
- State policies have induced blends in many states into the B11-B20 range
- State policies are beginning to induce blends above B20

OEM & Fleet Support for Biodiesel






OEM & Fleet support for biodiesel continues to grow due to:

- Growing volumes & availability
- Favorable policies – RFS, EPACT, Tax Credits, etc.
- GHG emissions benefits
- Vehicle performance benefits
- ASTM specifications
- BQ-9000 biodiesel quality
- Consumers and fleets want the option
- "Green" competitive advantage - easy way to green your fleet!

OEM Biodiesel Support

- All major OEMs producing diesel vehicles for the U.S. market support at least B5 biodiesel blends
- In the GVW Class 5-8 vehicles that account for 92% of on-road diesel fuel use, nearly 90 percent of the medium- and heavy-duty truck OEMs support B20
- Nearly every major off-road equipment manufacturer supports B20 or higher blends
- For a complete listing of **OEM position statements on biodiesel**, as well as the **current U.S. Diesel Vehicles List**, visit: www.biodiesel.org/using-biodiesel/oem-information

OEMs Supporting B20

OEMs Supporting B20

*

*

*Models equipped with Cummins engines are B20 approved. See NBB website for details.

New in 2016:

- **Full B20 approval in new and legacy model** PACCAR MX-11 and MX-13 engines for Heavy Duty trucks, as well as in PX-7 and PX-9 Engines for Medium Duty trucks.

- Now the entire diesel fleet of Peterbilt and Kenworth Medium and Heavy Duty trucks are approved for use with B20 Biodiesel Blends

New for 2017:

General Motors has announced it will have **20 different diesel vehicle model options** available in the U.S. market in 2017-2018 – **all of which are approved for use with B20**

- **Chevrolet Express** full-size vans (Cargo, Passenger, Cutaway)
- **Chevrolet Low Cab Forward** commercial truck
- **Chevrolet Colorado** mid-size pickup
- **Chevrolet Silverado** (2500HD, 3500HD, Chassis Cab) full-size pickups
- **Chevrolet Equinox** CUV
- **Chevrolet Cruze** (Sedan, Hatchback)
- **GMC Savana** (Cargo, Passenger, Cutaway) full-size vans
- **GMC Sierra** (2500HD, 3500HD, Chassis Cab) full-size pickups
- **GMC Canyon** mid-size pickup
- **GMC Terrain** CUV
- **Class 4/5 conventional cab truck** being developed jointly with Navistar.

Ford: B20 Approved

Ford approves B20 in all its 2011 MY and beyond

Class 2 - 5 Super Duty

&

Class 6,7 Medium Duty Trucks

And in the Ford Transit Van

New Ford F-150 Diesel coming in 2018!
(Biodiesel position TBA)

Fiat Chrysler: B20 Approved

- Fiat Chrysler supports the use of **B20** in the 6.7L Turbo Diesel **Ram 2500/3500/4500 5500 HD** pickups and in the 3.0L **Ram 1500** light duty diesel pickup
- **Ram ProMaster** with 3.0L EcoDiesel I-4 Engine **Approved for B20**
- **Jeep Grand Cherokee Approved for B20**

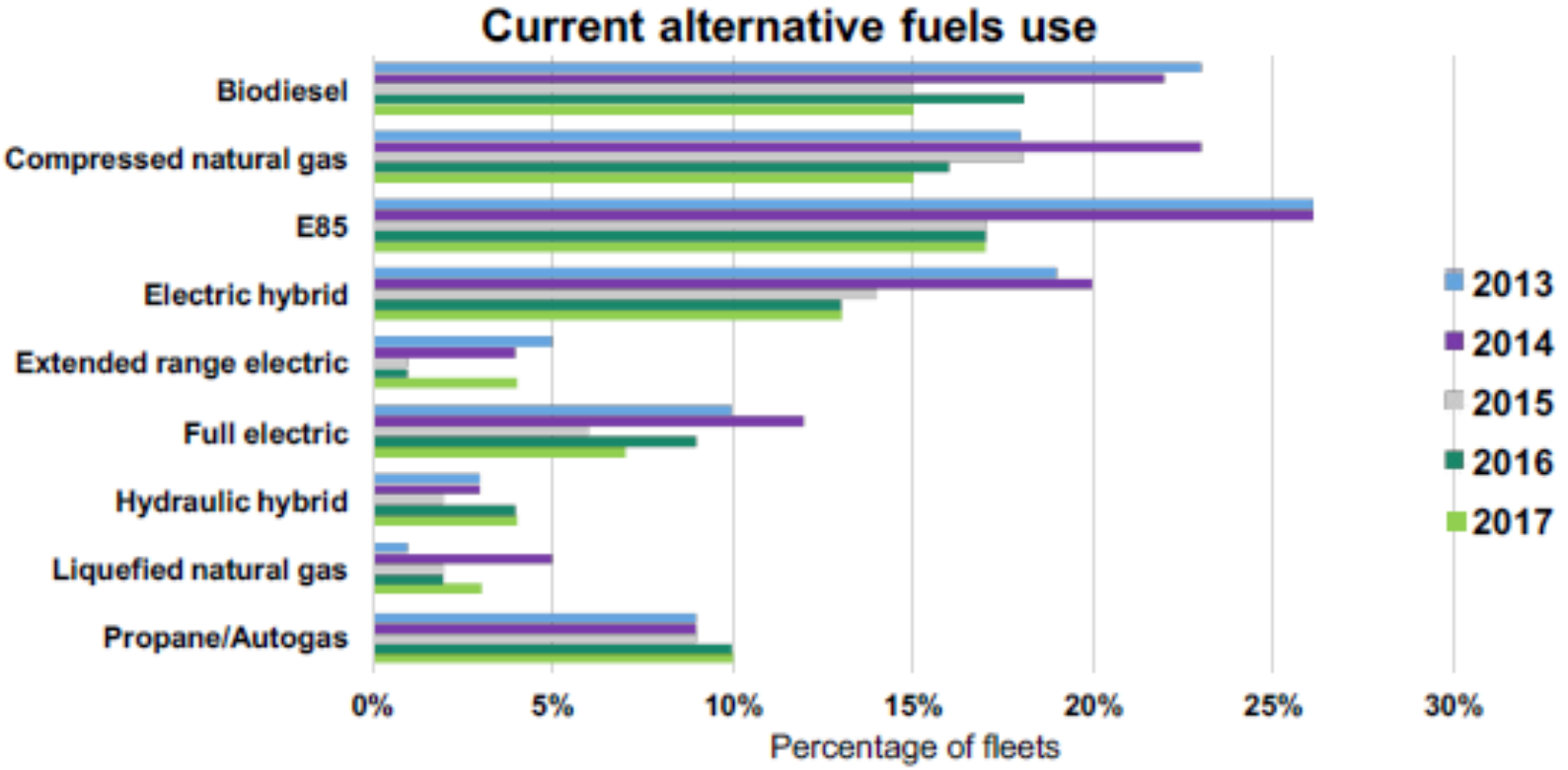
New for 2017:

- **Mazda Motor Corporation** announced that it will offer the SKYACTIV-D 2.2 clean diesel engine in the all-new Mazda CX-5 for North America from the second half of 2017.
- It will be Mazda's first diesel engine model in the North American market.

2017 Mazda CX-5 Diesel
* Biodiesel position TBA

2017 NTEA Fleet Purchasing Outlook

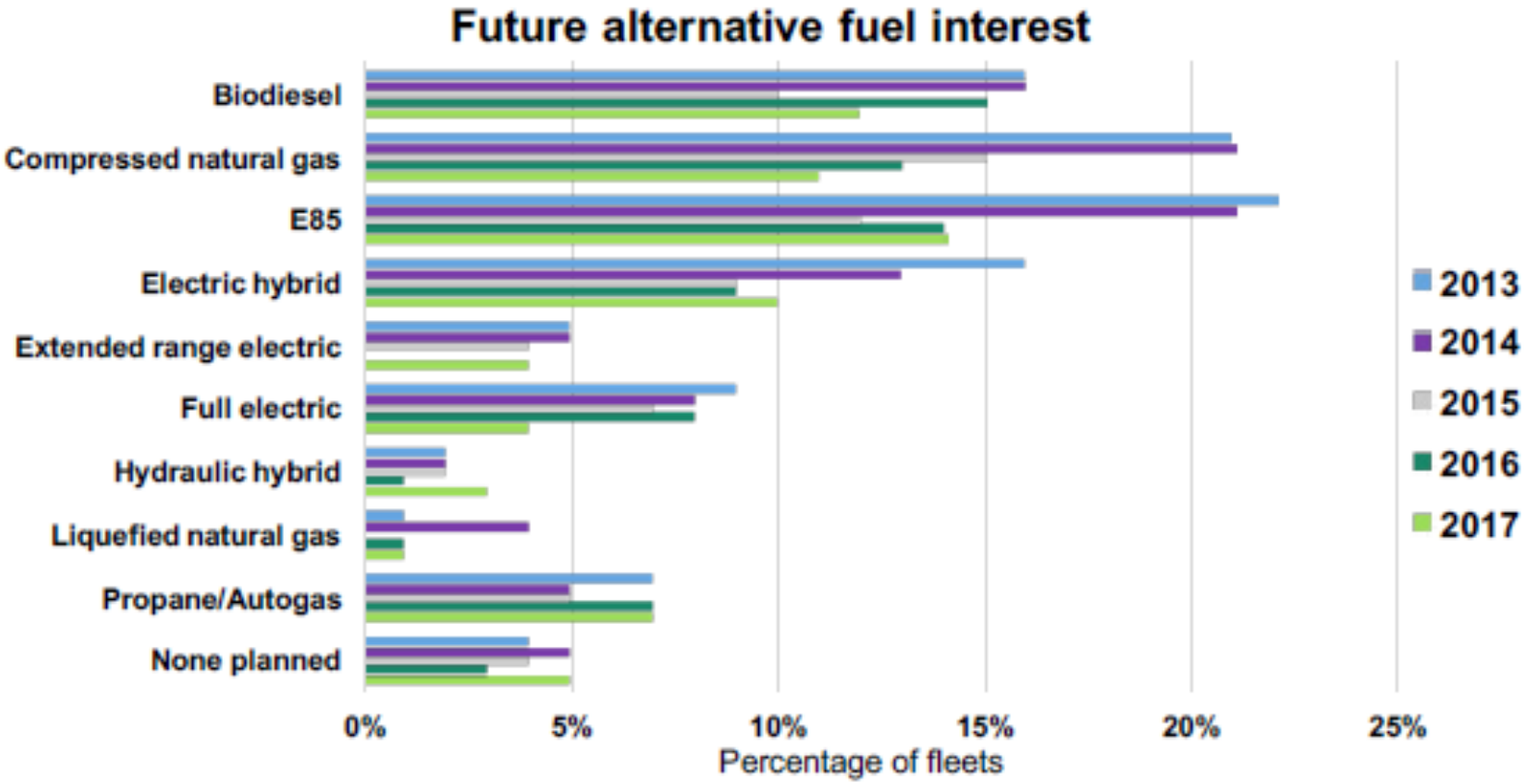
At present, the most widespread alternative fuel preferences are E85, Biodiesel and CNG



Source: NTEA 2013–2017 Fleet Purchasing Outlook Surveys *Figure 32*

2017 NTEA Fleet Purchasing Outlook

Looking ahead, survey participants indicated most interest in E85, Biodiesel and CNG as well



Source: NTEA 2013–2017 Fleet Purchasing Outlook Surveys *Figure 33*

A Sampling of Biodiesel Fleet Users

BIODIESEL
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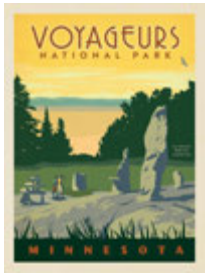
Smithsonian
Institution

COOK-ILLINOIS
CORPORATION



City of
Evanston

FPL

2017: A Banner Year for Biodiesel (And for OEMs and Fleets)

- **Building on Success: The Biodiesel industry set a new record for biodiesel use again in 2016 with nearly 2.9 Billion gallons of biomass based diesel in U.S.**
- Increased RFS Volumes for 2017-2018 are in place
- Growing number of diesel vehicle options for 2017-2018
- OEM & Fleet support continues to grow
- This will provide economic opportunities for marketers, blenders and users of biodiesel, as well as for diesel vehicle/equipment OEMs and dealers

Biodiesel Resources

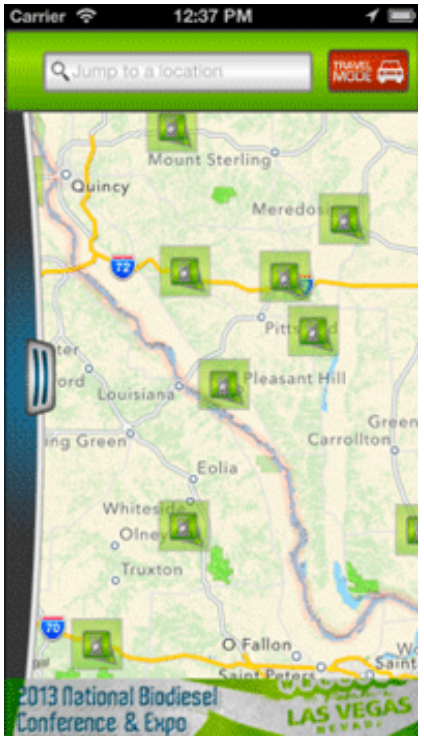
- **www.biodiesel.org**
  - Biodiesel Training Toolkit
  - OEM Support Positions on Biodiesel
  - U.S. Diesel Vehicle List
  - News Releases & Information Resources
  - Technical Library, Spec Sheets & Videos

- **www.americasadvancedbiofuel.com**
  - NBB's national advertising campaign "More is Less"

- **www.nbb.org**
  - Official site of National Biodiesel Board

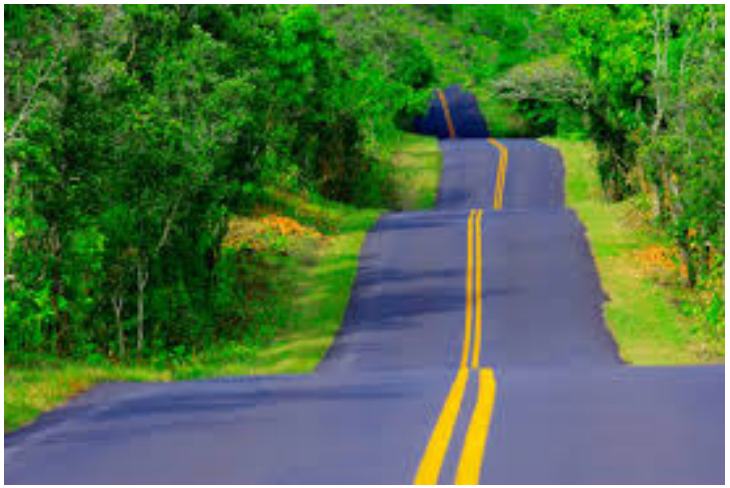
- **www.BQ-9000.org**
  - Listing of BQ-9000 Certified Companies

- **Biodiesel Now Mobile App**
  - Helps locate biodiesel retailers near you



Thank You!

Questions…?



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