A Biodiesel Primer:

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Market & Public Policy Developments, Quality, Standards & Handling

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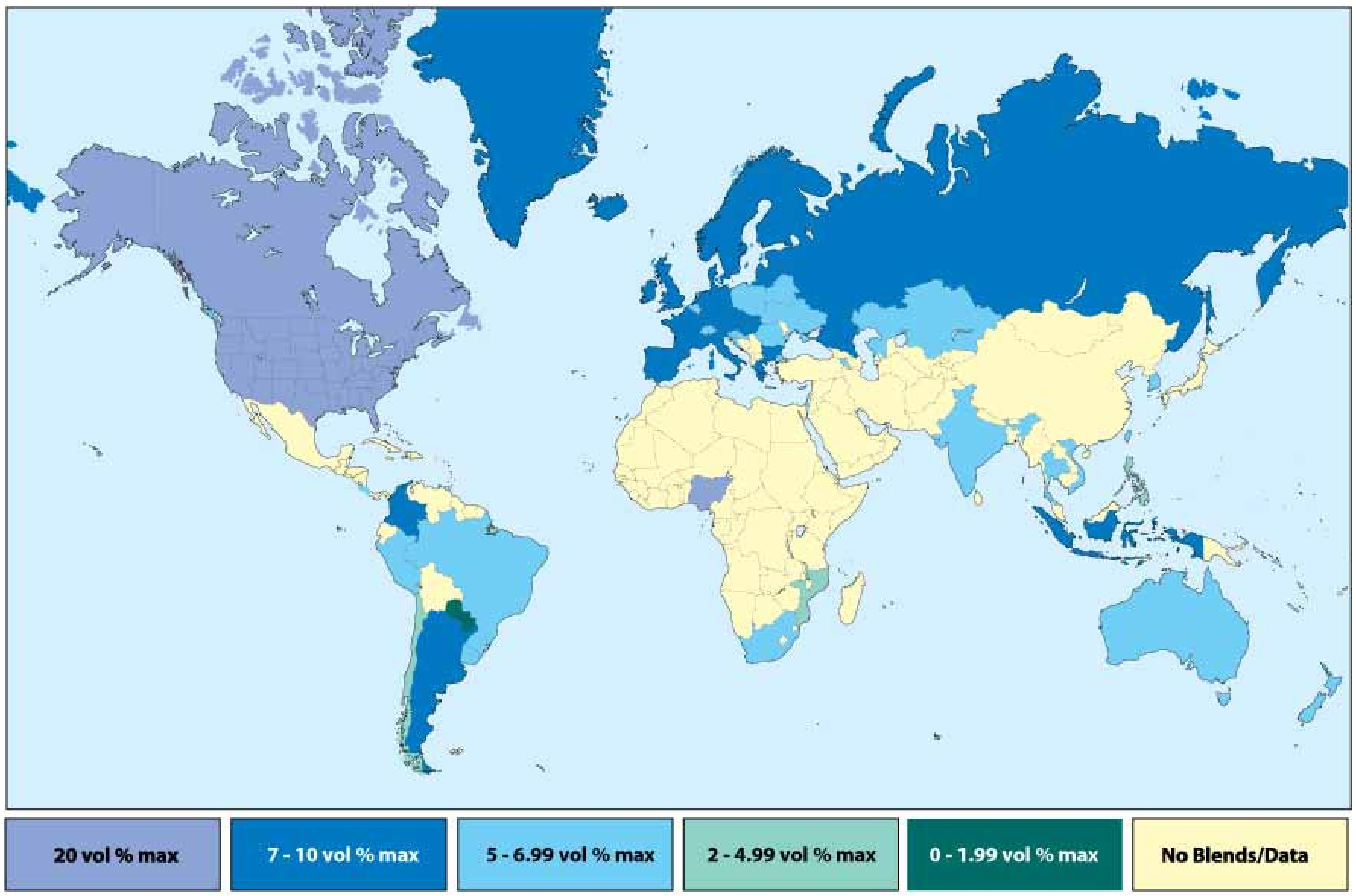
A. Introduction

When it comes to biodiesel, we are living in exciting times! Never before has the production and use of biodiesel captivated the interest of such a diverse range of groups, including governments around the world, biodiesel producers, auto and engine manufacturers, methanol producers, petroleum refiners and the end-users themselves. The enthusiasm and interest in producing and using biodiesel is not limited to the United States – many countries around the world have developed or are in the process of developing biodiesel programs. Notably, many European countries have been producing and using biodiesel since the early 1990s.

Figure 1: Global Maximum Biodiesel Limits



Note: These are the maximum allowable blends. Other blends may be available on the market.

Source: Hart Energy's Global Biofuels Center, December 2012.

There are many reasons, or "drivers," behind the worldwide enthusiasm for biodiesel fuel. It is viewed as:

- A mechanism to reduce dependence on imported oil and extend diesel fuel supplies. This is a major issue for many countries that are "net importers" of crude oil and/or fuel supplies.
- An environmentally friendly alternative to diesel.
- An alternative option to reduce greenhouse gas (GHG) emissions such as CO_2, as well as carbon monoxide (CO), particulate matter (PM) and hydrocarbon (HC) emissions. For example, this is a major driver for the countries of Europe, which are subject to the Kyoto Protocol and thus required to reduce GHG emissions.

- Able to be used in existing diesel engines with proper care and attention.
- Compatible with the existing fuel distribution infrastructure.
- Able to help stimulate agricultural markets and reduce poverty in rural areas by providing jobs for the poor. In fact, this is the primary reason Brazil has opted to develop and implement a national biodiesel program – to help develop the agricultural sector in the north of Brazil and provide jobs for millions of the landless poor.

The Methanol Institute and Hart Energy's Global Biofuels Center have put together this paper to provide the reader with:

- A better understanding of what biodiesel is and how it is produced;
- The role that methanol plays in the production of biodiesel; \
- Public policy initiatives that have been undertaken around the world to promote biodiesel production and use;
- The importance of assuring quality in biodiesel;
- Warranty issues for diesel engines and vehicles; and
- The safe handling of biodiesel and methanol.

B. What Is Biodiesel?

Biodiesel is a clean-burning diesel replacement fuel that can be used in compression-ignition (CI) engines and blended with home heating oil. It is manufactured from the following renewable, non-petroleum-based sources:

- Virgin vegetable oils such as soy, mustard, canola, rapeseed and palm oils;
- Animal fats such as poultry offal, tallow, and fish oils; and
- Used cooking oils and trap grease from restaurants

Biodiesel is produced in pure form (100% biodiesel or B100), but is usually blended with diesel at low levels, between 2% (B2) to 20% (B20) in the U.S., but at higher levels in other parts of the world, particularly in Europe, where higher-level blends of up to B100 are used.

Blends of biodiesel higher than B5 in the U.S. and B7 in Europe may require special handling and fuel management as well as vehicle equipment modifications, such as the use of heaters and changing seals/gaskets that come in contact with fuel. The level of care needed depends on the engine and vehicle manufacturer.[1]

Experiments with biodiesel date back to the 1850s, even before Rudolf Diesel invented the CI engine. Diesel's first engine was powered by peanut oil. In a 1912 speech, he said that "the use of vegetable oils for engine fuels may seem insignificant today, but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time." Diesel engine manufacturers altered their engines in the 1920s to accommodate the lower thickness, or viscosity, of petroleum-based diesel as compared with vegetable oils. That development, combined with diesel's lower cost, effectively ended (at least temporarily) the concept of using renewable vegetable oils for diesel engines.

Though farmers around the world continued to use vegetable oils to power their equipment and machinery, biodiesel's real "revival" began in the 1990s in Europe as commercial plants opened in France, Germany, the Czech Republic, Sweden and Austria.

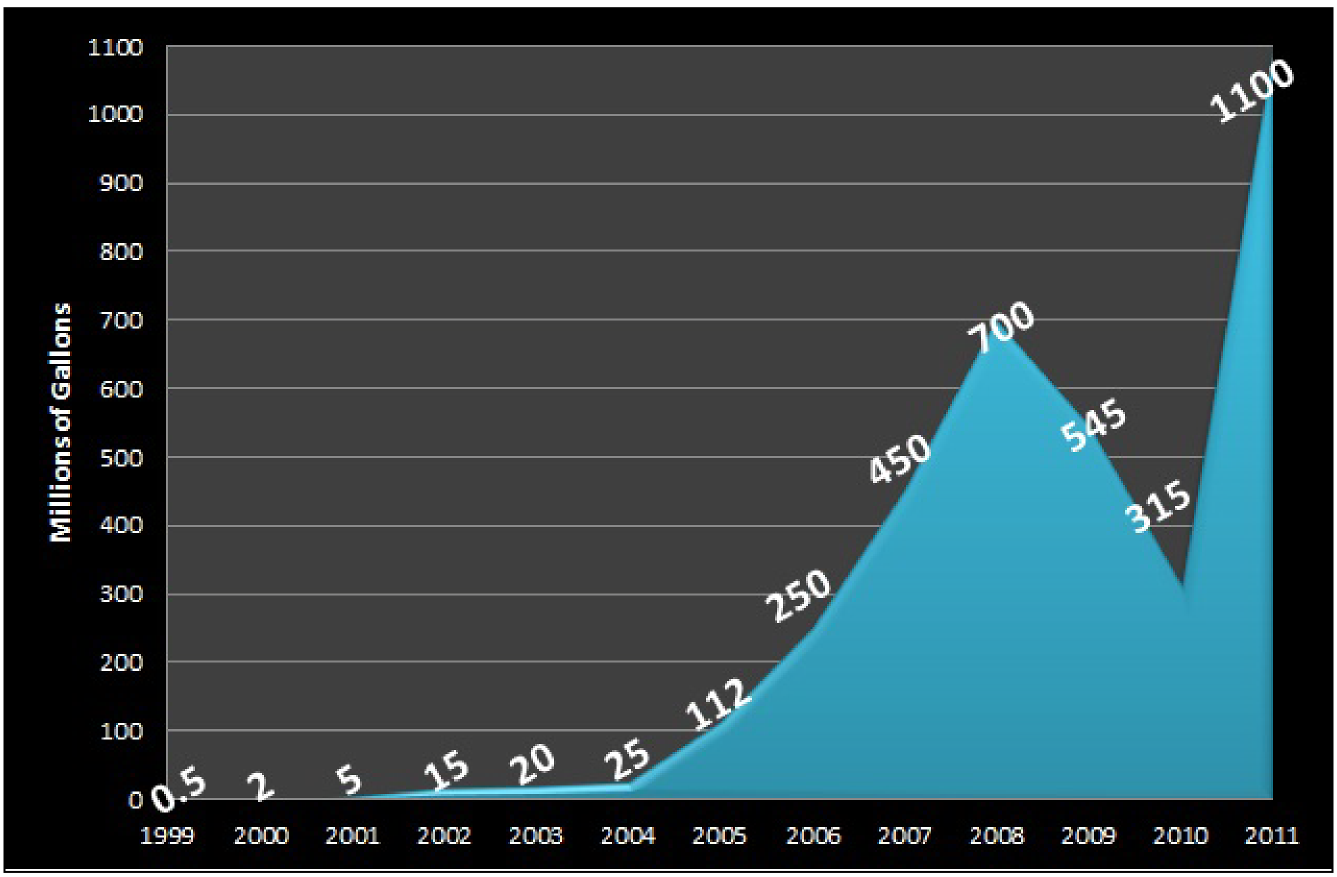
[1] See National Renewable Energy Laboratory, *Biodiesel Handling and Use Guide*, Fourth Edition, available at http://www.biodiesel.org/docs/ffs-performace_usage/handling-and-use-guide.pdf?sfvrsn=4

C. Federal and State Public Policy Initiatives to Spur the Production and Use of Biodiesel in the United States

In the U.S. there are currently 124 operating production facilities and another 28 in construction stages, according to December 2012 estimates from the Global Biofuels Center. Some of these facilities produce small quantities of biodiesel (less than 1 million gallons/year), though there are a number of larger plants in the 30+ million gallon range currently operating.

Nearly 1.1 billion gallons of biodiesel were produced in the U.S. in 2011. A combination of state and federal incentives, described in more detail below, have created a boom in production and use of biodiesel in the U.S. over the last decade. In 1999, biodiesel production was just 500,000 gallons, while in 2005, 75 million gallons were estimated to have been produced, according to the National Biodiesel Board (NBB). [2]

Figure 2: U.S. Biodiesel Production, 1999-2011



Source: National Biodiesel Board, 2012

Various agencies of the federal government as well as U.S. states have implemented initiatives that have been instrumental in stimulating the production and use of biodiesel. While the U.S. Department of Agriculture's (USDA's) Commodity Corporation Credit (CCC) program has expired, other policy and fiscal incentives remain in play. The biodiesel tax credit enacted in 2004 was retroactively renewed for 2012 and 2013 after expiring at the

[2] *See* National Biodiesel Board, Production Statistics, available at http://www.biodiesel.org/production/production-statistics (last visited Dec. 20, 2012)

end of 2011, enabling the biodiesel industry to claim tax benefits for the year-long gap between its expiration and reactivation. The *Energy Policy Act of 1992* (EPAct 1992) is still in effect, while the *Energy Policy Act of 2005* (EPACT 2005) has been superseded by the *Energy Independence and Security Act of 2007*. These federal public policy programs are the most notable efforts to encourage biodiesel production and use. Nearly every state has also instituted several different initiatives as well. These policies are referred to in greater detail in the following passage, including links to a current database of active and expired provisions.

1. Energy Policy Act of 1992 (EPAct)

There is no question that the *EPAct* program, run by the U.S. Department of Energy (DOE) has had a profound effect on the development of the biodiesel market in the U.S.[3] *EPAct* requires government fleet operators to use a certain percentage of alternatively fueled vehicles (AFVs). *EPAct* established a goal of replacing 10% of motor fuels with non-petroleum alternatives by 2000, increasing this share to 30% by 2010. Under the act, 75% of all federal vehicles purchased are required to have alternative fuel capability to set an example for the private automotive and fuel industries.

Under the *Energy Conservation Reauthorization Act of 1998* (which amended Title III of the *Energy Policy Act of 1992*), vehicle fleets that are required to purchase AFVs (e.g., government fleets) can generate credit toward this requirement by purchasing and using biodiesel in a conventional vehicle. There are few cost-effective options for purchasing heavy-duty AFVs, meaning that federal and state fleet providers can meet up to 50% of their heavy-duty AFV purchase requirements with biodiesel.

The biodiesel fuel use credit allows fleets to purchase and use 450 gallons of biodiesel in vehicles in excess of 8,500 pounds gross vehicle weight instead of AFVs. Fleets must purchase and use the equivalent of 450 gallons of pure biodiesel in a minimum of a 20% blend to earn one AFV credit. Covered fleets earn one vehicle credit for every light-duty vehicle (LDV) AFV they acquire annually beyond their base vehicle acquisition requirements. Credits can be banked or sold. Compliance with *EPAct 1992* requirements is why the Defense Department is the largest purchaser of biodiesel in the U.S.

In September 2006, DOE proposed to modify the EPAct goal of achieving 30% utilization of replacement fuels (calculated by energy content) by 2010, extending the date to 2030. Replacement fuels include ethanol, compressed natural gas (CNG), hydrogen, electricity and biodiesel. DOE determined that, based on forecast data supplied by its Energy Information Administration, the 2010 deadline could not be met and that 2030 was a more realistic target.

i. Tax Incentives for Small Agri-Biodiesel Producers, EPACT Sec. 1345

The legislation created a new tax credit for small agri-biodiesel producers with production capacity not in excess of 60 million gallons or US$0.10 per gallon for the first 15 million gallons of agri-biodiesel produced.

2. 2005 EPAct

Congress enacted *EPACT 2005* in August 2005, including a number of provisions meant to spur the production and use of biodiesel.[4] In particular, *EPACT 2005* provisions included biodiesel as part of the "applicable volume" in the renewable fuels standard (RFS) (discussed in the next section). *EPACT 2005* also extended the biodiesel

[3] *See* U.S. Department of Energy, Energy Efficiency and Renewable Energy Office, *Energy Policy Act (EPAct)*, http://www1.eere.energy.gov/vehiclesandfuels/epact/ *last updated* Dec. 12, 2012

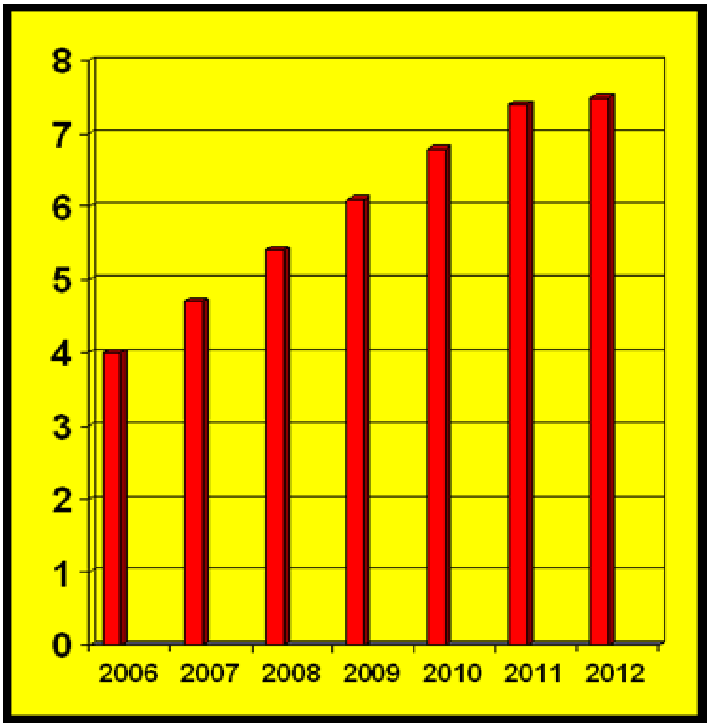
[4] U.S. House of Representatives, Committee on Energy & Commerce, Energy Policy Act of 2005 (Pub. L. 109-58) *available at* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_public_laws&docid=f:publ058.109 *last visited* Jan. 16, 2013.

tax credit to 2008 from 2006 and included a new tax credit for renewable diesel. These and other important biodiesel-related provisions are linked below.

i. The Renewable Fuels Standard Rulemaking

The RFS required a specific amount of renewable fuel, the "applicable volume" to be used in the nationwide gasoline pool. The volume was mandated to increase each year, as shown in Figure 5:

Figure 3: U.S. Motor Fuel RFS Targets
(billion gallons/year)



Source: Compiled by Global Biofuels Center, citing EPAct 2005

ii. Renewable Diesel, 2005 EPAct Section 1346

This provision clarified that renewable diesel is to receive the same tax treatment as biodiesel under the tax code, thus it will receive US$1.00/gallon credit. "Renewable diesel" is defined as diesel fuel derived from biomass using a thermal depolymerization process that meets EPA's fuels and fuel additive registration process and meets the ASTM standard for diesel, D 975, or for fuel oils, D 396. This provision is effective with respect to fuel sold or used after Dec. 31, 2005.

3. 2007 Energy Independence and Security Act (EISA)

With the passage of the *Energy Independence and Security Act* (EISA) in 2007, the U.S. Congress revised and changed several important aspects of the original Renewable Fuel Standard program (the new program is commonly called RFS2). Not only did the legislation increase renewable fuel uptake requirements substantially and over a longer time frame (e.g., 7.5 billion gallons of renewable fuel by 2012 to 36 billion gallons of renewable fuel by 2022), it also created new requirements for specific types of renewable fuels. These fuels include:

renewable fuel, advanced biofuels, biomass-based diesel and cellulosic biofuels. Congress set targets for each of these categories in the *EISA* legislation.

In addition, these four renewable fuel types also have specific GHG emission reduction targets, ranging from 20% to 60% compared with petroleum baseline gasoline or diesel fuel. EPA was also directed by Congress to look at both direct and significant indirect emissions in the life-cycle assessments (LCA) that ultimately would determine which renewable fuel types from which feedstocks qualify toward meeting the RFS2 targets.

Essentially, the original RFS1 program applied primarily to corn-based ethanol (though other types of renewable fuels could be used to meet program requirements) and individual targets for refiners and other obligated parties (i.e., their renewable volume obligation or RVO) were set based on gasoline demand. The new RFS2 requirements under *EISA* required expansion of coverage to all transportation fuels, including gasoline and diesel (highway and non-road). The legislation exempts jet fuel, marine vessel fuel and heating oil from the renewable biofuels requirements.

The RFS2 program became effective on July 1, 2010. The renewable fuel standards continue to be expressed as a volume percentage that each refiner, blender or importer uses to determine respective renewable volume obligations.

The applicable biomass-based diesel volumes are specified in Table 1. The EPA defines biomass-based diesel as "renewable fuel that is biodiesel as defined in section 312(f) of the Energy Policy Act of 1992 (42 U.S.C. 13220(f)) and that has lifecycle greenhouse gas emissions, as determined by the Administrator, after notice and opportunity for comment, that are at least 50 percent less than the baseline lifecycle greenhouse gas emissions."

Biodiesel is defined as "the monoalkyl esters of long chain fatty acids derived from plant or animal matter that meet: the registration requirements for fuels and fuel additives under 40 CFR Part 79; and the requirements of the American Society for Testing and Materials standard D6751."

For an obligated party to demonstrate compliance with the RFS2, the percentage standards would be converted into the RVO that each obligated party is required to satisfy. Because there are four separate standards under the RFS2 program, there are likewise four separate RVOs applicable to each refiner, importer or other obligated party and would apply for both gasoline and diesel.

Obligated parties have to show by Feb. 28 of each successive year that they obtained sufficient Renewable Identification Numbers (RINs) to satisfy their RVOs for each of the four renewable fuel categories.[5] The formula by which individual obligated parties calculate their RVOs is under § 80.1407 of the final RFS2 rulemaking.

[5] The U.S. Department of Agriculture defines a RIN as "a 38-character numeric code that corresponds to a volume of renewable fuel produced in or imported into the United States. RINs remain with the renewable fuel through the distribution system and ownership changes. Once the renewable fuel is blended into a motor vehicle fuel, the RIN is no longer required to remain with the renewable fuel. Instead, the RIN may then be separated from the renewable fuel and used for RFS compliance, held for future compliance, or traded. The RFS mandates are prorated down to "obligated parties – individual gasoline and diesel producers and/or importers – based on their annual production and/or imports. Each year, obligated parties are required to meet their prorated share of the RFS mandates by accumulating RINs, either through fuel blending or by purchasing RINs from others." For more information on RINs, the USDA report can be reviewed here: http://www.ers.usda.gov/media/138383/bio03.pdf

Table 1: Biomass-Based Diesel Volume Requirements for RFS2 Under *EISA*

Year	Biomass-based Diesel Billion Gallons
2009	0.50
2010	0.65
2011	0.80
2012	1.00
2013	1.28
2014	(1)
2015	(1)
2016	(1)
2017	(1)
2018	(1)
2019	(1)
2020	(1)
2021	(1)
2022	(1)
2023+	(2)

Source: Hart Energy Global Biofuels Outlook to 2025, September 2012

Notes:

(1) Reflects the minimum volume of 1 billion gallons required by *EISA*. The actual volume will be determined by EPA through future rulemaking.

(2) Volume requirements to be determined by EPA in future rulemaking.

EPA determined in the final rule that the following biodiesel fuels meet the required GHG emissions reduction thresholds:

- Biodiesel from canola/rapeseed oil;
- Biodiesel from soybeans;
- Biodiesel and renewable diesel from algal oil;
- Biodiesel from waste fats/greases;

EPA uses the statutory definition of biodiesel, which is a diesel fuel substitute produced from nonpetroleum renewable feedstock. This statutory definition differs from ASTM D 6751, which defines biodiesel to only include esters made from renewable feedstock. In the final RFS regulation, EPA used the biomass-based diesel definition to include ester biodiesel and non-ester renewable diesel. EPA defines these two renewable fuels as follows:

- **Biodiesel**: 1) meets the registration requirements for fuels and fuel additives established by the EPA; 2) is a mono-alkyl ester; 3) meets ASTM specification D-6751-02a; 4) is intended for use in engines that are designed to run on conventional, petroleum-derived diesel fuel, and 5) is derived from nonpetroleum renewable resources including, but not limited to, animal wastes, including poultry fats and poultry wastes, and other waste materials, or municipal solid waste and sludges and oils derived from wastewater and the treatment of wastewater.
- **Non-Ester Renewable Diesel**: The term "non-ester renewable diesel" means a motor vehicle fuel which: 1) meets the registration requirements for fuels and fuel additives established by EPA; 2) is not a mono-alkyl ester; 3) is intended for use in engines that are designed to run on conventional, petroleum-derived diesel fuel; and 4) is

derived from nonpetroleum renewable resources including, but not limited to, animal wastes, including poultry fats and poultry wastes, and other waste materials, or municipal solid waste and sludges and oils derived from wastewater and the treatment of wastewater.

Under RFS2, refiners, importers and blenders (other than oxygenate blenders) are responsible for meeting an RVO. The required volume of renewable fuel is determined by multiplying their annual gasoline production by a percentage standard specified by EPA.

Each individual obligated party is responsible for meeting its RVO through the acquisition of RINs. These RINs are be assigned to each batch of renewable fuel and serve as documentation to help facilitate a credit trading program.

EPA has also established equivalence values (EVs) for renewable fuels to facilitate a credit trading program. EVs are assigned based on the renewable content of the fuel. Ethanol is assigned a value of “1” even though ethanol fuel contains 5% petroleum-based denaturants. While the methanol content of biodiesel fuel is considered to be “non-renewable,” the rounding of EVs and the placement of the various fuels into “bins” assures that the mono-alkyl esters are not penalized. Further, with its greater energy content, biodiesel fuel is assigned a value or credit of “1.5,” providing an added incentive for refiners to sell biodiesel fuel blends.

Table 2: Equivalence Values for Some Renewable Fuels

Renewable Fuel	Equivalence Value (EV)
Ethanol from corn, starches, sugar	1.0
Biodiesel (ester)	1.5
Non-ester renewable diesel	1.7
Butanol	1.3

Source: Environmental Protection Agency

4. Other Incentive Programs Offered at the Federal and State Levels

Aside from these incentives, both federal and state governments offer a broad range of other incentives to spur the production and use of biodiesel. A current listing of federal and state incentives can be found at the Department of Energy’s Alternative Fuels Data Center.

5. Expired Provisions

A list of Expired, Revealed, and Archived Federal Incentives and Laws, including the Biodiesel Income Tax Credit, the Biodiesel Mixture Excise Tax Credit and other measures instrumental to the growth of the biodiesel industry can be found on the Department of Energy’s Alternative Fuels Data Center.

6. Fraud and Renewable Identification Numbers in the RFS2 Program

The U.S. EPA’s Office of the Inspector General (IG) announced in November 2012 that it will initiate “preliminary research” into the RIN system that was designed under the RFS to spur commercial production of biofuels. The IG noted that “improperly created (RINs) have been created and sold without any manufacture of corresponding biofuels, resulting in millions of dollars of fraud.” The goal of its preliminary research effort is to determine “whether EPA’s (RFS) program has established controls to manage (RINs) and whether those controls are effective.”

Obligated parties under the RFS have been pressing EPA to address the fraudulent RINs problem and develop a mechanism to give refiners and fuel blenders some protection in cases when good-faith efforts were made to obtain valid RINs. In April 2012, companies agreed to a court settlement with EPA requiring them to pay US$3.65 million in penalties for purchasing fraudulent RINs. The EPA has been working with industry and recently issued a notification of its plan to develop a quality assurance program run by third-party auditors to mitigate the potential for future fraud cases.

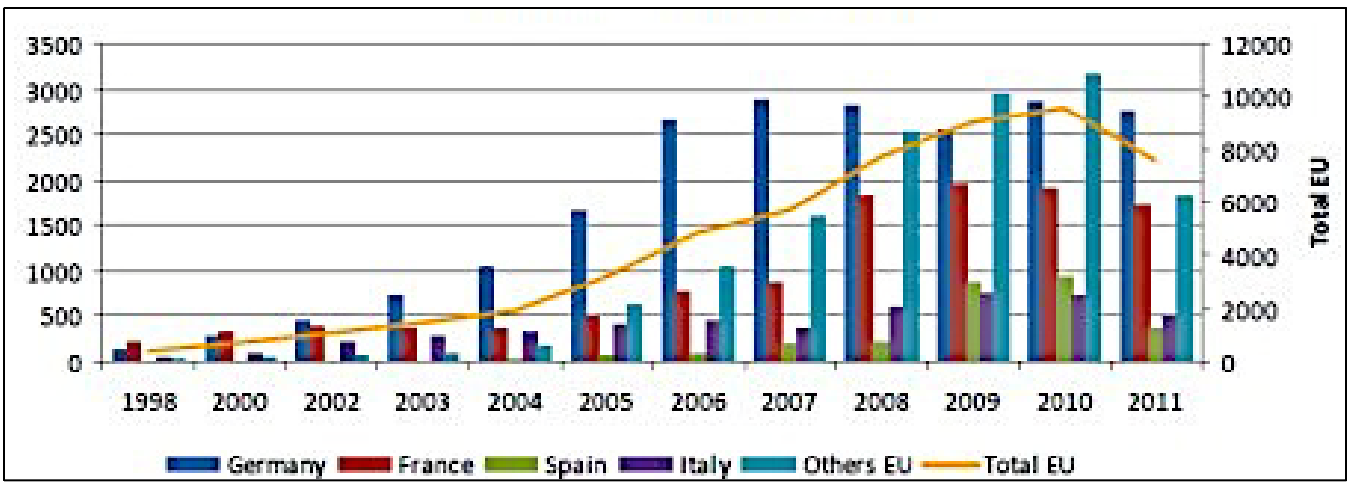
D. International Biodiesel Developments and Public Policy Initiatives

Other countries have also instituted public policy initiatives to encourage biodiesel production and use, and have done so generally through a combination of fiscal incentives and mandates or voluntary targets.

In Europe today, there are more than 255 facilities in operation. Some are small plants as well, but there are several large biodiesel production facilities in operation with capacities as large as 120+ million gallons.

Over 2.6 billion gallons of biodiesel were produced in Europe in 2010, half of it in Germany and France.[6] European countries today, particularly Germany, remain the largest producers and users of biodiesel, as the following graph shows:

Figure 4: EU Biodiesel Production, 1998-2011



Note: 2011 Figures are only estimations

Source: European Biodiesel Board, 2012

While biodiesel production in the EU commenced with small-scale facilities producing less than 10,000 metric tons per annum (mtpa), the expansion in the market and the involvement of multinational organizations (some with backward integration into oilseed crushing) has resulted in plant size increasing significantly, first through 100,000 mtpa and now to 250,000 mtpa and beyond.

Biodiesel in the EU is largely derived from rapeseed with an 85% market share quoted by Fediol (the European Vegetable Oil Producers and Processors Federation). The remaining feedstocks consist of palm, soybean and sunflower oils together with a limited quantity of waste cooking oils and tallow. This is as a result of the current EN14214 biodiesel specification (discussed in more detail below), which effectively limits the amount of soybean, palm and sunflower oil feedstocks that can be utilized as a blend with rapeseed oil due to the amount of

[6] *See* European Biodiesel Board, Statistics, available at http://www.ebb-eu.org/stats.php (last visited Dec. 20, 2012)

unsaturation present in the fatty acids contained in these oils and the resulting iodine value.[7] The current EN14214 allows national standardization bodies to choose oils more saturated than rapeseed if their total monoglyceride level is sufficiently low.

Though rapeseed oil is the current feedstock of choice for the EU biodiesel industry, the resulting competition with the food sector and other traditional applications for the oil has driven up the price. This, together with the desire of the EU to take a “balanced approach” to biofuel imports and to ensure that biofuels are produced in a sustainable way, resulted in 2009 in the adoption of the RED and FQD, which imposed stringent sustainability criteria for biofuels. Fuels and biofuels suppliers must ensure that biofuels emit 35% (50% beginning in 2018) less GHG emissions than fossil fuels, and that they are not obtained from areas with high biodiversity value, high carbon stock or peat lands. Moreover, certain social criteria should be respected during the production of biofuels. In addition, the law includes beneficial rules for biofuels feedstocks which do not compete with food production, i.e., double-counting of energy content of certain feedstocks (e.g., waste). This policy has resulted in a growing trend of utilizing more waste-based biodiesel.

Even before these rules fully entered into force in all EU Member States, the European Commission, prompted by numerous studies and increasing concern about biofuels sustainability, revised its policy pertaining to biofuels. In October 2012, it proposed a revision of the RED in which a 5% cap is placed on biofuels produced from food crop feedstocks, such as starch-rich crops, sugars and oil crops. This cap should be considered in the context of the EU overall target for the renewable energy in transport sector, which should be 10% by energy content by 2020. If only 5% can consist of first-generation biofuels, the rest should be produced from advanced feedstocks (non food crop-based feedstocks), which may result in bigger volumes of biodiesel produced from waste or tallow at the expense of “traditional” European feedstocks such as rapeseed. This also creates an opportunity for renewable methanol to be used as a feedstock for biodiesel production.

Canada maintains a 2 vol% mandate for biodiesel but plans to exempt heating oil.

Twenty-three of 27 EU Member States have biofuels mandates in place. These mandates were introduced under the Biofuels Directive that contained an indicative target of 5.75% (by energy content) biofuels in road transportation fuels for 2010 in several Member States. The EU-27 has since adopted the Renewable Energy Directive (RED), which mandates the use of 10% by energy content renewable energy in transportation by 2020. Mandates can be met by various types of biofuels, including but not limited to ethanol, ETBE, FAME or renewable diesel, depending on the country.

In addition, Article 7(a) of the amended Fuel Quality Directive (FQD) mandates fuel suppliers in Member States to reduce their GHG emissions per unit of energy from fuel and energy supplied by at least 6% by December 2020. As a result, all EU Member States will likely have biofuels mandates or the equivalent by 2020.

Outside of the EU-27, only Norway has a 3.5% biofuels mandate in place for diesel. Macedonia, Serbia and Switzerland are among the countries that are either considering mandates or will have mandates if they join the EU. Croatia will join the EU in July 2013 and will be required to implement EU directives, including the RED. Biodiesel production in Turkey was halted in 2008 because of high input costs.

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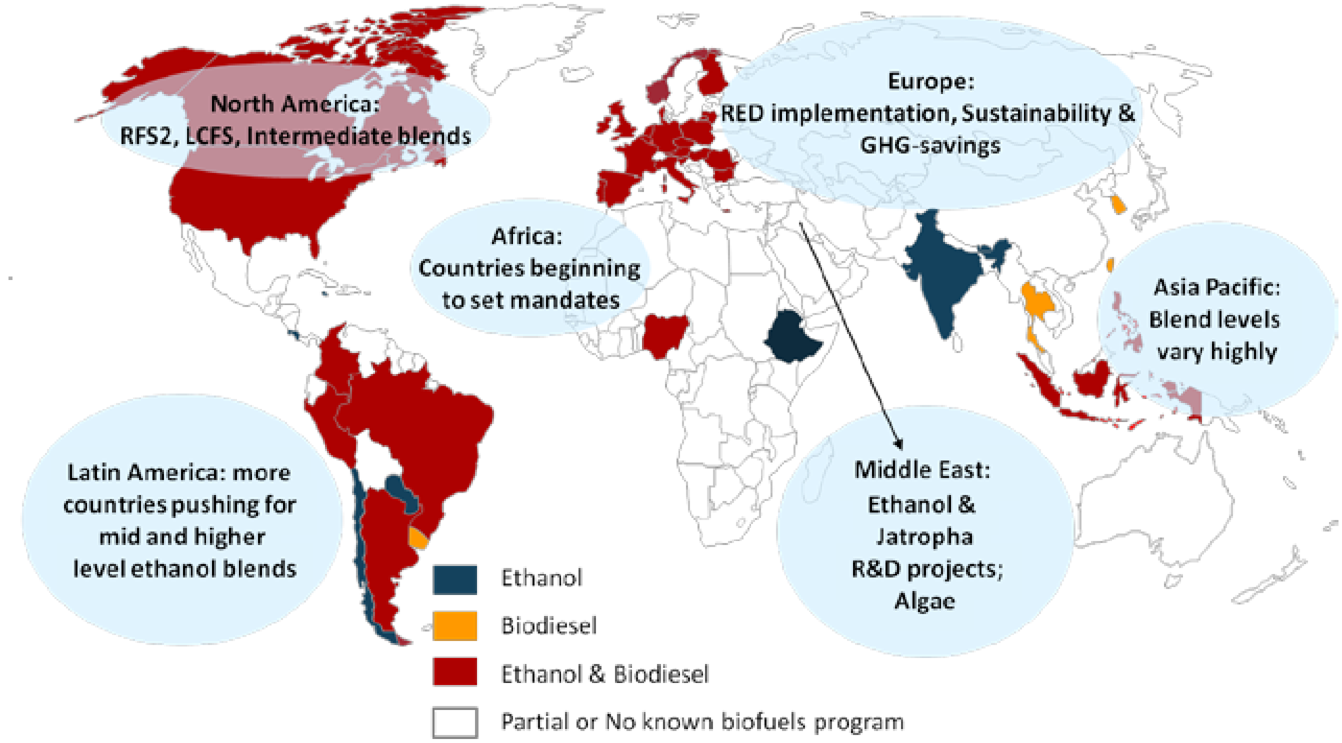
[7] Iodine value is a measure of total unsaturation within a mixture of fatty materials, regardless of the relative shares of mono-, di-, tri- and polyunsaturated compounds of the biodiesel feedstock. It is expressed in grams of iodine which react with 100 mg of the respective sample. Iodine number is limited to $\leq$ (gI_2/100g) in EN14214, as discussed in more detail below. Iodine value is important because engine manufacturers have noted that fuels with high iodine numbers tend to form deposits on injector nozzles, piston rings and piston ring grooves when they are heated. *See* Martin Mittelbach, Ph.D. and Claudia Remschmidt, Biodiesel: The Comprehensive Handbook 127-128 (Boersedruck Ges.m.bH, Vienna 2nd Ed. 2005)

Biofuels blending targets were established in Russia in April 2012.

Figure 5: Global Biofuels Mandates



Source: Hart Energy's Global Biofuels Outlook to 2025, September 2012

Tables 3, 4, and 5 provide summaries of higher blend-level mandates.

Table 3: European Biodiesel Mandates

Country	Mandate
Bulgaria	from June 1, 2012 – min 6 vol%
Finland	2011-2014: 6% by energy content 2015: 8% by energy content 2016: 10% by energy content 2017: 12% by energy content 2018: 15% by energy content 2019: 18% by energy content 2020: 20% by energy content
France	2010: 7% by energy content
Germany	2009-2014: 4.4% by energy content
Ireland	2013: 4.8% by energy content 2015: 6.4% by energy content 2018: 8% by energy content
Italy	2014: 5% by energy content
Lithuania	7 vol% (FAME)
Poland	2013: 7.10% by energy content 2014: 7.55% by energy content 2015: 8% by energy content 2016: 8.45% by energy content
Portugal	2010-2014: 6.75 vol%
Romania	2013: 7 vol%
Slovakia	2013: 4% by energy content 2014: 4.5% by energy content 2015: 5.5% by energy content 2016: 5.5% by energy content 2017: 5.8% by energy content 2018: 7.2% by energy content
Slovenia	2010: 5% by energy content
Spain	2013: 7% by energy content
The Netherlands	2013: 5% by energy content 2014: 5.5% by energy content.
United Kingdom	2013-2014: 5.26 vol%

Source: Hart Energy's Global Biofuels Outlook to 2025, September 2012

In Brazil, biodiesel producers and policymakers have expressed strong support for a blend increase above the current B5 mandate but face opposition from automakers and fuel distributors. Argentina increased its blend mandate from B5 to B7 in 2011 and is projected to further increase its blend level to B10 as early as 2013. In Colombia, there have been delays in implementing the B10 mandate originally scheduled for Jan. 1, 2010. Current blend levels range from B2 to B10 in the three main regions of the country. Higher blends are unlikely in the near- to mid-term. In Peru, the B5 mandate is being met on schedule, primarily through imports of B100.

Biodiesel mandates are currently fully in effect in the Philippines, South Korea, Taiwan and Thailand, and partially in effect in Australia, Indonesia and Malaysia. Currently, there are no biofuel mandates in countries including Fiji, New Zealand, Pakistan and Vietnam, although biofuel blends may exist on their markets.

Table 4: Asian Biodiesel Mandates

Country	Mandate
Australia(1)	2010: 2 vol%
India	2017: 2 vol%
Indonesia(2)	2010: 2.5 vol% 2015: 5 vol% 2020: 10 vol% 2025: 20 vol%
Malaysia	2013: 5 vol%
Philippines	2009: 2 vol% 2015: 5 vol% 2020: 10 vol% 2025: 20 vol%
South Korea	2010: 2 vol%
Taiwan	2010: 2 vol%
Thailand	2011: 5 vol%

Source: Hart Energy's Global Biofuels Outlook to 2025, September 2012

(1) Applies to New South Wales only
(2) Applies to state-owned fuel supplies only

Table 5: Latin American Biodiesel Mandates

Country	Mandate
Argentina	2010: 7 vol%
Brazil	2010: 5 vol%
Colombia	2012: 20 vol%
Costa Rica	2008: 5 vol%
Peru	2011: 5 vol%
Uruguay	2012: 5 vol%

Source: Hart Energy Global Biofuels Outlook to 2025, September 2012

E. Production Process, Specifications & Quality Issues

Biodiesel is generally made when fats and oils are chemically reacted with an alcohol, typically methanol, and a catalyst, typically sodium or potassium hydroxide (i.e., lye), to produce an ester, or biodiesel. The approximate percentage proportions of the reaction are shown in Table 6.

Table 6: Biodiesel Production Input and Output Levels

Process Input Levels		Process Output Levels	
Input	Volume Percentage	Output	Volume Percentage
Oil or Fat	87%	Ester	86%
Alcohol	12%	Alcohol	4%
Catalyst	1%	Fertilizer	1%
		Glycerin	9%

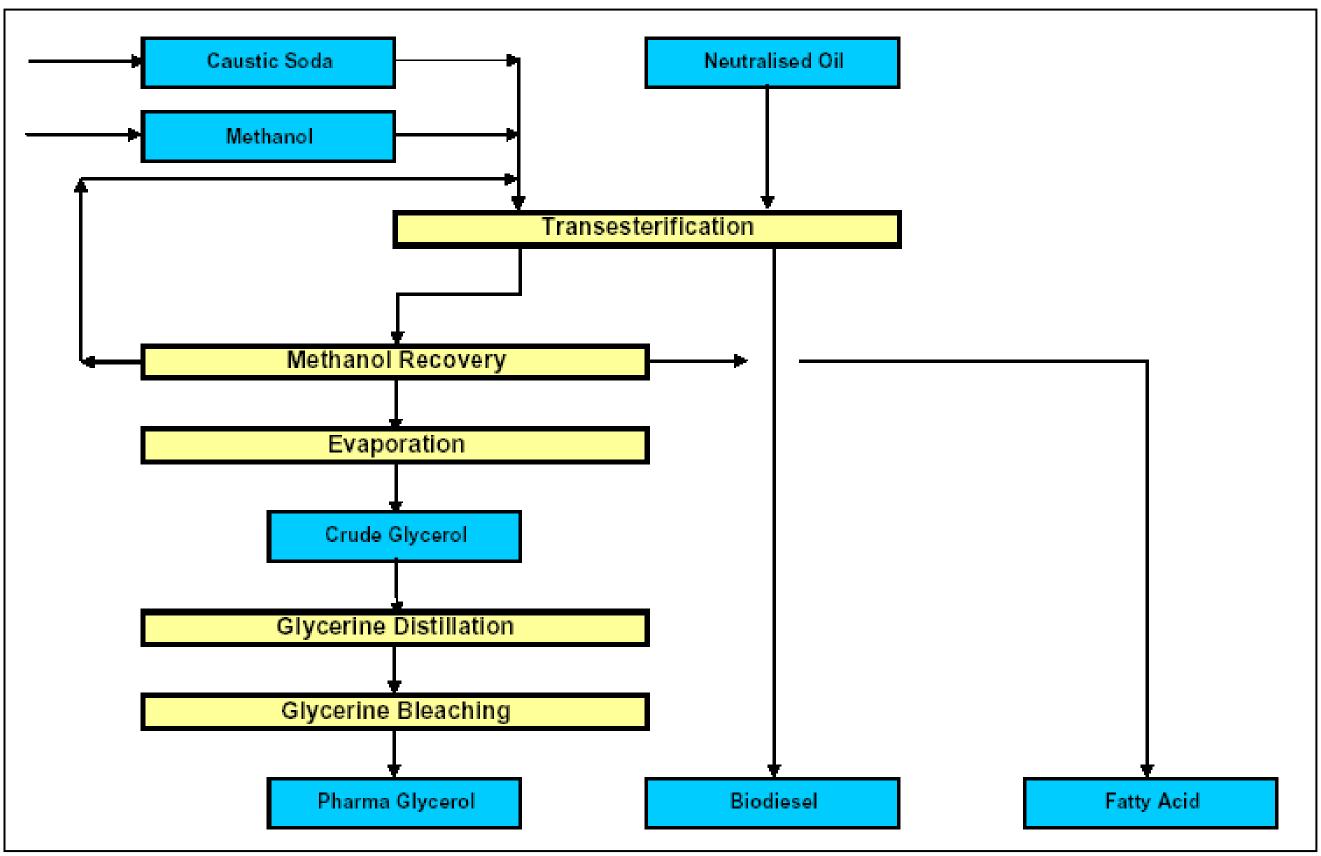
Source: National Biodiesel Board

This production process is generally known as transesterification, and includes the following processes:

- Base-catalyzed transesterification of the oil with methanol.
- Direct acid-catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

The basic production process is summarized in Figure 6.

Figure 6: The Biodiesel Production Process



Source: MAN Ferrostaal

Because biodiesel is less dense than glycerol, it floats on top of the glycerol and may be pumped off, or the glycerol can be drained off the bottom. Residual methanol from this reaction is typically removed after the biodiesel and glycerin have been separated, to prevent the reaction from reversing itself. The methanol is cleaned and recycled back to the beginning of the process. Glycerol (used in pharmaceuticals and cosmetics, among other markets) and fertilizer materials are produced as coproducts.

Biodiesel ***is not*** raw or refined vegetable oils that are unprocessed and those oils should ***not*** be used as biodiesel fuel. According to the National Renewable Energy Laboratory (NREL), raw or unrefined vegetable oils and greases used in CI engines at levels as low as 10% can cause problems including long-term engine deposits, ring sticking and lube oil gelling, which can reduce the engine's useful life.[8] These problems generally stem from these oils' greater thickness, or viscosity, compared to that of typical diesel fuels for which the engines were designed. These problems are avoided through the refinement of these oils in the biodiesel production process.

1. Quality Specifications

Specifications for biodiesel have been implemented in several countries around the world, most notably in the U.S., through what was formerly known as the American Society of Testing and Materials (ASTM International), and in Europe through the European Committee for Standardization (CEN). The relevant committees of these groups that oversee fuel specification development, including standards for biodiesel, are comprised of automobile and engine manufacturers, refining companies, biofuel producers, government entities and other fuel users who agree by consensus on specifications to help ensure good quality fuels for safe and satisfactory operation of vehicles and engines.

In the U.S., the ASTM specification for biodiesel is ASTM D 6751; in the EU, it is EN 14214. The ASTM specification defines biodiesel as a fuel comprised of mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats. Raw vegetable oils and animal fats that have not been processed do not meet biodiesel specifications. Moreover, the ASTM specification is for biodiesel as a blendstock for blending into diesel, and is not meant to be a specification for B100 as a stand-alone fuel. Note that ASTM standards are not laws in and of themselves; however, many states adopt ASTM standards and transpose them into law. In Europe, EN 14214 establishes specifications for fatty acid methyl esters for diesel engines. In contrast to ASTM D 6751, B100 that meets this standard could be used unblended in a diesel engine (if the engine has been adapted to operate on B100) or blended with diesel fuel to produce a blend in accordance with EN 590, the European diesel fuel specification. Blends up to 7% of fatty acid methyl ester (FAME) are allowed in diesel fuel defined by EN 590, though the blend level should be indicated at the point of sale, according to the EU's FQD. EN 14214 is more restrictive and applies only to mono-alkyl esters made with methanol, FAME. The minimum ester content is specified at 96.5%. The addition of components that are not FAME – other than additives – is not allowed. Table 7 summarizes diesel and biodiesel specifications for both the U.S. and EU.

[8] National Renewable Energy Laboratory, *2006 Biodiesel Handling & Use Guidelines*, DOE/GO-102006-2288 (Mar. 2006) *available at* http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/39451.pdf.

Table 7: Quality Specifications for Diesel and Biodiesel in the U.S. and EU

Property	UNITED STATES				EUROPEAN UNION			
	ASTM D975-12 Diesel		ASTM D6751-12 Biodiesel		EN 590:2009(2) Diesel		EN 14214:2008 Biodiesel	
	Spec	Test Method	Spec	Test Method	Spec	Test Method	Spec	Test Method
Flash point, min	52°C	D93	93°C (2)/130°C(2)	D93	55°C	EN 22719	101°C	prEN ISO 3679
Water & sediment, max	0.05% vol	D2709	0.05% vol	D2709				
Water, max	-		-		0.02vol%	EN ISO 12937	500 mg/kg(8)	EN ISO 12937
Total contamination, max			-		24 ppm	EN 12662	24 mg/kg	EN 12662
Distillation temperature (% vol recovered)	90%: 2D <288°C 2D 282-338°C	D86	90%: <360°C	D1160	65%: >250°C 85%: <350°C	EN ISO 3405		
Kinematic viscosity	1D 1.3-2.4 mm²/s 2D 1.9-4.1 mm²/s	D445	1.9-6.0 mm²/s	D445	2.0-4.5 mm²/s	EN ISO 3104	3.5-5.0 mm²/s	EN ISO 3104
Density @ 15°C, min-max	-		-		820-845 kg/m³	EN ISO 3675 EN ISO 12185	860-900 kg/m³	EN ISO 3675 EN ISO 12185
Ester content			-		< 7% FAME	EN 14078	>96.5%	EN 14103
Ash, max	0.01% wt	D482	-		0.01% wt	EN ISO 6245		
Sulfated Ash, max			0.020% wt	D874			0.02% wt	ISO 3987
Sulfur, max (by weight)	15 ppm	D5453 D2622	15 ppm(1)	D5453	10 ppm	EN ISO 14596 EN ISO 8754 EN ISO 24269	10 mg/kg	prEN ISO 20846 prEN ISO 20884
Copper strip corrosion	No 3	D130	< No 3(3)	D130	class 1	EN ISO 2160	class 1 (9)	EN ISO 2160
Cetane number, min	40	D613	47	D613	51 (temperate) / 47-49 (arctic & severe winter) (5)	EN ISO 5165	51.0	EN ISO 5165
Cetane index, min	40(1)				46 (temperate) / 43-46 (arctic & severe winter) (5)	EN ISO 4264		
One of: - cetane index - aromaticity	> 40 < 35% vol	D976 D1319						
PAH, max					11% wt	IP 391 EN 12916		

Property	UNITED STATES				EUROPEAN UNION			
	ASTM D975-12 Diesel		ASTM D6751-12 Biodiesel		EN 590:2009(2) Diesel		EN 14214:2008 Biodiesel	
	Spec	Test Method	Spec	Test Method	Spec	Test Method	Spec	Test Method
Operability, one of: - cloud point - LTFT/CFPP	Regional requirements	D2500 D4539 D6371						
Cloud point, °C, max			report	D2500	-10 to -34 (6)	EN 23015		
CFPP			-		+5 (class A temperate) to -44 (class 4 arctic and severe winter) (5)	EN 116	Location & season dependent	EN 116
Carbon residue10%, wt%, max	1D: 0.15% wt 2D: 0.35% wt	D524	0.050% wt	D4530	0.30% wt(7)	EN ISO 10370	0.30% wt	EN ISO 10370
Acid number, max			0.50 mg KOH/g	D664			0.50 mg KOH/g	EN 14104
Oxidation stability @ 110°C			3 hrs	EN 14112	< 25 g/m³	EN ISO 12205	6.0 hrs	EN 14112
Iodine value			-				< 120	EN 14111
Methanol, vol%, max			0.2(2)				< 0.20% wt	EN 14110
Linolenic acid methyl ester			-				< 12.0% wt	EN 14103
Polyunsaturated methyl esters			-				< 1% wt	No method specified
Monoglycerides, diglycerides & triglycerides			-				MG <0.8% wt DG <0.2% wt TG <0.2% wt	EN 14105
Group I metals (Na + K)			5 ppm max	UOP 391			< 5.0 mg/kg	EN 14108 EN 14109
Group II metals (Ca + Mg)			5 ppm max	UOP 389			< 5.0 mg/kg	EN 14538
Free glycerol, max			0.020% wt	D6584			0.02% wt	EN 14105 EN 14106
Total glycerol, max			0.240% wt	D6584			-	EN 14105
Phosphorous, max			10ppm	D4951			4 ppm	EN 14107
Lubricity, HFRR wear scar diam @ 60 °C , micron, max	< 520 µm	D6079	-		< 460 µm	ISO 12156-1		

Notes:
(1) Either the specification for minimum cetane index or that for maximum total aromatics must be met.
(2) If methanol content is above this maximum level, this specification may still be met if the flash point meets a minimum of 130° Celsius.
(3) The Copper Strip Corrosion Test is conducted for 3 hrs at 50° Celsius.
(4) FAME shall comply with EN 14214.
(5) Depends on climate rating.
(6) Only applicable to countries with arctic or severe weather conditions.
(7) The limiting value for the carbon residue is based on product prior to addition of ignition improver, if used.
(8) Water content must not exceed 500 mg/kg.
(9) Measured at 50° Celsius.

Source: Hart Energy's International Fuel Quality Center, citing specifications from the ASTM and CEN.

Table 8 explains the purpose and importance of the ASTM specifications in D 6751.

Table 8: ASTM Specifications and Their Importance

Property & Units	Purpose	Importance
Flash point	Fire safety	B100 flash point is typically higher than diesel to ensure that excess methanol has been removed. It is required to be at least 93° Celsius (200° Fahrenheit) to ensure it is classified as nonhazardous under the National Fire Protection Association (NFPA) code.
Water and sediment	Prevent corrosion and proliferation of organisms	Set at the same level as for conventional diesel fuel. Excess water can lead to corrosion and provides an environment for the proliferation of microorganisms. Oxidation can increase sediment levels; thus, this test can be used with tests for acid number and viscosity to determine whether fuels have oxidized too much during storage.
Kinematic viscosity	Satisfactory fuel combustion	A minimum viscosity is required for some engines because of the potential for power loss caused by injection pump and injector leakage. This is not an issue for B100, and the minimum is set at the same level as for petroleum diesel. The maximum viscosity is limited by the design of engine fuel injection systems. Higher viscosity fuels can cause poor fuel combustion that leads to deposit formation as well as higher in-cylinder penetration of the fuel spray, which can result in elevated engine oil dilution with fuel. The maximum allowable viscosity in ASTM D975 for No. 2 diesel is 4.1 mm^2/s at 104° Fahrenheit (40° Celsius). ASTM D6751 allows for slightly higher viscosity than D975, primarily because that is where the normal viscosity of B100 lies. Biodiesel blends of 20 vol% or lower should have a viscosity within the range allowed by D975.
Sulfated ash	Injector and fuel system performance	Prevent injector deposits or fuel system fouling
Sulfur	Protect exhaust catalyst systems	Biodiesel generally contains less than 15ppm sulfur, which is the required limit for proper functioning of diesel particle filters. NREL recommends ASTM D 5453 as the most appropriate test method for accurate results.
Copper strip corrosion	Indicates difficulties with bronze and copper vehicle components	Same as for conventional diesel. Generally not an issue for biodiesel.
Cetane number	Higher cetane numbers help ensure good cold start properties and minimize the formation of white smoke.	Conventional diesel must have a minimum cetane of 40; 47 was chosen by ASTM because this is the level identified by the National Conference of Weights and Measures as premium diesel and also because 47 is the lowest level found in biodiesel produced and used in the U.S.

Property & Units	Purpose	Importance
Cloud point	Good performance in cold temperatures	Cloud point is the most commonly used measure of low-temperature operability. Fuels are generally expected to operate at temperatures as low as their cloud point. The B100 cloud point is typically higher than the cloud point of conventional diesel. Cloud point must be reported to indicate biodiesel's effect on the final blend cloud point.
Carbon residue	Engine performance	Indicates tendency of deposits to form on the engine. For conventional diesel fuel, the carbon residue is measured on the 10% distillation residue. Because B100 boils entirely at the high end of the diesel fuel range and in a very narrow temperature range, it is difficult to leave only a 10% residual when distilling biodiesel. So, biodiesel carbon residue specifies that the entire biodiesel sample be used rather than the 10% distilled residue.
Acid number	Ensuring engine deposits do not form	An indicator of free fatty acids (FFAs); acid numbers higher than 0.50 have been found to cause fuel system deposits and reduced life for fuel pumps and filters.
Free/total glycerin	Storage tank, fuel system, engine, and filter performance	Biodiesels that exceed these limits can cause storage tank, fuel system, engine fouling and filter plugging.
Phosphorus content	Prevent damage of catalytic converters	Phosphorus content is limited to 10 ppm maximum in biodiesel to prevent damaging catalytic converters. Some vegetable oils do contain 10 ppm or higher phosphorus; biodiesel in the U.S. typically has low phosphorus, around 1 ppm.
Distillation temperature	Fuel quality	Incorporated to ensure that fuels have not been contaminated with high boiling materials such as used motor oil.
Calcium and magnesium; sodium and potassium	Emission control	These metals can cause deposits to form, catalyze undesired side reactions, and poison emission control equipment. The Group I and II metals are limited as the combination of metals in each category, Na+K and Ca+Mg. For each combination, the limit is 5 ppm.
Alcohol	Safety	Residual methanol in biodiesel is a safety issue, because even very small amounts reduce the flash point; can affect fuel pumps, seals and elastomers; and can result in poor combustion properties. The intent of the alcohol control requirement is to limit methanol to less than 0.2 wt%. This can be accomplished by meeting a higher flash point requirement of 130° Celsius (266° Fahrenheit); or by measuring methanol content by gas chromatography.
Oxidation stability	Storage performance	Biodiesel can oxidize during storage and handling, leading to the formation of peroxides, acids, gums, and deposits. The minimum oxidation stability requirement is intended to ensure the storage stability of B100 and biodiesel blends.
Cold soak filterability	Fuel performance	Needed, along with cloud point, to predict low-temperature operability.

Source: Hart Energy's Global Biofuels Center, NREL, Biodiesel Handling and Use Guide, Fourth Edition 2009.

The Truck and Engine Manufacturers Association (EMA) released test specifications for biodiesel blends of up to 20 vol% (B20) in May 2006. These specifications are not an approved national standard. They outline minimum requirements for fuel properties of biodiesel blends at the point of delivery of the fuel to the end-user. They are primarily designed for evaluating the performance of various blends of biodiesel fuels in compression ignition engines. These specifications are for blends which use biodiesel fuel, meeting either the ASTM 6751 or EN 14214 standards, with D1 or D2 or a D1/D2 petroleum diesel fuel blend, meeting ASTM D975 standard.

Other countries that have adopted B100 and biodiesel blend specifications include Brazil, Canada, China, Czech Republic, France, Japan, New Zealand, Poland, South Africa, South Korea and Vietnam.

2. Biodiesel Quality

Biodiesel quality has improved tremendously over the past few years, though it remains a concern for engine and automobile manufacturers. The NBB established its BQ-9000 program in 2001 to improve fuel quality assurance and noted in 2011 that biodiesel fuel from BQ-9000 companies made up 81% of biodiesel produced in the U.S.[9] Moreover, according to NBB, as of December 2012 every state except Alaska had adopted the ASTM D 6751 specification as part of its fuel quality regulations.

ASTM continues to refine its biodiesel specifications and released an update to D 6751 in December 2012. The specification was updated with an optional biodiesel grade, which had been under discussion and review. The new optional grade, called No. 1-B, has a monoglyceride limit and a lower cold soak filterability time. The monoglyceride limit is more stringent than the limit in the current biodiesel standard under Europe's CEN (EN 14214:2008). Producers may find it difficult to produce a biodiesel meeting the No. 1-B grade using feedstocks like palm oil, coconut oil and animal fat. The grade No. 1-B is described as a special purpose biodiesel blendstock intended for use in middle distillate fuel applications that can be sensitive to the presence of partially reacted glycerides, including those applications requiring good low-temperature operability.

In addition, the California Air Resources Board (ARB) released on Oct. 4, 2011 its Guidance on Biodiesel Use covering biodiesel fuel characteristics and biodiesel blends that supersedes previous guidance.[10]

F. Warranty Issues

The Worldwide Fuel Charter (WWFC) is prepared and supported by the Alliance of Automobile Manufacturers (AAM), European Automobile Manufacturers Association (ACEA), the Engine Manufacturers Association (EMA) and Japanese Automobile Manufacturers Association (JAMA).[11] The WWFC is a statement by the world's auto industry on the quality of fuels needed to ensure optimal operation of the different types of vehicles they manufacture and that are in use around the world. Recommended specifications are provided for four different categories of gasoline and diesel fuels.

The 4th Edition of the WWFC, released in September 2006, allows the addition of biodiesel at up to 5 vol% in diesel fuel Categories 1-3[12], and thus guarantees vehicles using biodiesel at these blends with the following caveat: for biodiesel, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where biodiesel is used, it is recommended that fueling pumps be marked accordingly.

For Category 4 fuels, the WWFC calls for biodiesel to be non-detectable (i.e., at or below detection limit of the test method used, which is specified as EN 14078). This means that automakers would reserve the right *not* to repair a vehicle under warranty if the origin of the problem was perceived to be poor or inappropriate fuel quality.

A proposed 5th Edition of the WWFC has been released and will be finalized in 2013.

[9] *See* National Biodiesel Board, *Quality Assurance*, available at http://www.nbb.org/results/project-showcase/quality-assurance

[10] *See* California Air Resources Board, *Biodiesel and Renewable Diesel, Biodiesel Regulatory Guidance*, Oct. 4, 2011 available at http://www.arb.ca.gov/fuels/diesel/altdiesel/biodiesel.htm

[11] Alliance of Automobile Manufacturers, et al., 4th edition Worldwide Fuel Charter (Sept. 2006) available at www.autoalliance.org/index.cfm?objectid=385A3AF0-B982-11E1-9E4C000C296BA163

[12] Categories 1-3 refer to the categories of fuels quality that have been established by the WWFC for both diesel and gasoline. There are actually four categories of fuels described briefly here: Category 1: Markets with no or first level of emission control; based primarily on fundamental vehicle/engine performance and protection of emission control systems; Category 2: Markets with stringent requirements for emission control or other market demands; Category 3: Markets with advanced requirements for emission control or other market demands; Category 4: Markets with further advanced requirements for emission control to enable sophisticated NO_X and particulate matter aftertreatment technologies. For more information, refer to the Worldwide Fuel Charter.

Generally, biodiesel is believed to enhance the lubricity of conventional diesel fuel and reduce exhaust emissions of particulate matter, or PM. At the same time, engine and auto manufacturers have concerns about introducing biodiesel into the marketplace, especially at higher levels, because:

- Biodiesel may be less stable than conventional diesel fuel, so precautions are needed to avoid problems linked to the presence of oxidation products in the fuel. Some fuel injection equipment data suggest that such problems may be exacerbated when biodiesel is blended with ultra-low sulfur diesel fuels.
- Biodiesel may negatively impact natural and nitrile rubber seals in fuel systems. Also, metals such as brass, bronze, copper, lead and zinc may oxidize from contact with biodiesel, thereby creating sediments. Transitioning from conventional diesel fuel to biodiesel blends may lead to an especially large increase in sediments that may plug fuel filters. Thus, fuel system parts must be chosen for their compatibility with biodiesel.
- Neat (100%) biodiesel fuel and high concentration biodiesel blends have demonstrated an increase in NO_X exhaust emission levels. However, a study released by NREL in late 2006 evaluated the effect of the biodiesel blend B20 on NO_X, finding that the impact on NO_X emissions varied depending on the engine/vehicle technology and the drive cycle, ranging from 5.8% to 6.2%. The report concluded that while individual engines might show an increase or decrease in NO_X, on average there is no net effect. Nevertheless, this issue continues to be investigated by the automobile industry, engine manufacturers, biodiesel producers, the federal government and others.
- Biodiesel fuel that comes into contact with the vehicle's shell may dissolve the paint coatings used to protect external surfaces.

In Europe, some manufacturers have sanctioned the use of certain vehicles with B100 or B30 fuels, but the majority of vehicles are only approved for use with EN590 diesel, which by definition currently contains a maximum of 7 vol% biodiesel. Automakers have raised concerns over the suggested increase in the blend limit to 10 vol% owing to concerns over compatibility of such a fuel with the existing fleet and the potential for increased emissions. In the U.S., the position taken by most automakers is that biodiesel blends up to 5 vol% (and in some cases up to 20 vol%) are acceptable as long as they meet the requirements of ASTM D 6751.

Moreover, the American Trucking Association, which represents the nation's trucking industry, has also approved the use of B5. Many in the industry are concerned about blends higher than 5 vol% because of quality and stability (discussed above) and want a B20 ASTM standard. Of course, manufacturers warrant their products against defects associated with materials and workmanship and the use of biodiesel in and of itself does not void the warranty – this is prohibited by a federal law known as the Magnuson-Moss Warranty Act. Automakers and engine manufacturers' positions on the use of biodiesel can be found on the National Biodiesel Board's Web site.

G. Resources

The Methanol Institute, working with industry leaders, technology partners and customers, has created a Methanol Safe Handling Manual to address both common and technical questions related to methanol handling, storage and transport. The manual can be found on the Methanol Institute's Web site.

The National Renewable Energy Laboratory has also produced a Biodiesel Handling and Use Guide which can be found on the National Biodiesel Board's Web site.

H. A Final Word: Should You Make Your Own Biodiesel?

You certainly can make your own biodiesel – many people have for years – and now some companies offer "kits" or at-home production units to make biodiesel. The question is, should you? Following are a few points to consider:

- **In no way** should you be making your own biodiesel unless you receive proper training and instruction from a **professional** on how to store, transport and use biodiesel, methanol and other components of biodiesel (e.g., lye).
- Be wary of claims from Internet sites and Web blogs about how "easy" it is to make your own biodiesel, and be especially aware of Web "recipes" for biodiesel. Moreover, some Internet companies will sell biodiesel kits, but do not offer any information on obtaining feedstock supplies of vegetable oils, methanol and lye and how to handle them safely. Before purchasing a biodiesel kit, make sure you have secured access to the necessary feedstock chemicals from a reputable supplier.
- Only purchase materials from reputable suppliers. Methanol is sold in quantities ranging from 55-gallon drums to deliveries of thousands of gallons in trucks, railcars and barges. Many distributors will not ship methanol to a residential or farm address, and some require minimum orders of US$300 or more. The purchase price for methanol will vary considerably depending on the delivered quantity, location and frequency of delivery. For more information on how to purchase methanol, please contact the Methanol Institute at http://www.methanol.org/Contact-Us.aspx.
- Be sure that the quality of your biodiesel meets specifications. Many biodiesel producers have in-house labs or take other measures to ensure that the quality of the biodiesel they produce meets ASTM standards for optimal performance of diesel engines and vehicles.
- Know how you will store the biodiesel. Storage is another quality-related issue because biodiesel should be stored for six months or less to ensure it does not become contaminated.
- Know the amount of biodiesel that you will actually use? If you use a small amount of biodiesel, it may be more cost-effective to simply purchase your biodiesel from a reputable producer or retail distributor. To find a biodiesel supplier in your area, contact the National Biodiesel Board.
- Many people want to make their own biodiesel to partake in fiscal incentives at the state and federal levels. However, these incentives are generally geared toward larger biodiesel producers, and petroleum refiners and distributors that blend biodiesel.
- At what percentage will you use the biodiesel? Remember, most engine and vehicle manufacturers warrant their vehicles for use of up to B5. The use of high-level blends (B20+) and pure biodiesel, B100, should probably be avoided.
- Home producers should contact their local fire department to ensure compliance with local requirements for storing hazardous and flammable chemicals.

I. Internet Sources to Consult for More Information

Following is a list of sources to consult for more information on biodiesel and methanol, but note that this list is not exhaustive:

1. Alliance of Automobile Manufacturers, et al., Worldwide Fuel Charter (4th Edition and proposed 5th Edition, 2006 and 2013, respectively), http://www.autoalliance.org/fuelcharter
2. Biofuels Association of Australia (BAA), http://www.biofuelsassociation.com.au/
3. Canadian Renewable Fuels Association, http://www.greenfuels.org/en.aspx
4. Centre for Jatropha Promotion (India), http://www.jatrophaworld.org/
5. Truck and Engine Manufacturers Association (EMA), http://www.truckandenginemanufacturers.org/
6. European Biodiesel Board, http://www.ebb-eu.org/
7. European Commission Renewable Energy, Biofuels and other renewable energy in the transport sector, http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

8. European Commission, Agriculture and Rural Development, Agriculture and Bioenergy http://ec.europa.eu/agriculture/bioenergy/index_en.htm
9. The European Federation of Vegetable Oils Producers (FEDIOL), http://www.fediol.be/
10. 2005 European Barometer of Renewable Energies, 5th Report, Eurobserv'er, http://www.energies-renouvelables.org/
11. Malaysian Palm Oil Board (MPOB), http://www.mpob.gov.my/
12. Methanol Institute, Biodiesel: A Growing Market for Methanol available at http://www.methanol.org/Methanol-Basics/Resources/Biodiesel.aspx
13. Methanol Institute, Health and Safety and Emergency Response available at http://www.methanol.org/Health-And-Safety/Safe-Handling/Methanol-Safe-Handling-Manual.aspx
14. National Biodiesel Board, http://www.biodiesel.org
15. National Biodiesel Accreditation Program, BQ-9000, http://www.bq-9000.org/
16. National Renewable Energy Laboratory, Biodiesel Publications, http://www.nrel.gov/vehiclesandfuels/npbf/pubs_biodiesel.html
17. Department of Alternative Energy Development and Efficiency (DEDE) (Thailand), http://www.dede.go.th/dede/
18. U.S. Department of Energy, Energy Efficiency & Renewable Energy, Alternative Fuels Data Center, FAQs http://www.afdc.energy.gov/
19. U.S. Department of Agriculture, http://www.usda.gov
20. U.S. Environmental Protection Agency, Renewable Fuel Standard, http://www.epa.gov/otaq/renewablefuels/index.htm
21. Ministry of New and Renewable Energy (MNRE) (India), http://www.mnre.gov.in/
22. Planning Commission (India), http://planningcommission.nic.in/

J. Biodiesel Unit Conversions

Table 9 provides a simple way to convert biodiesel from different units. In the U.S., biodiesel is typically expressed in gallons, while in Europe and other parts of the world, biodiesel is expressed in tons and/or cubic meters.

Table 9: Biodiesel Unit Conversions

Metric Tons	m^3	U.S. Liquid Gallons (in millions)
1,000	1,136	0.30
880	1,000	0.26
3,333	3,788	1.00

Source: Global Biofuels Center, 2006.

For a biodiesel with a density of 880 kg/m^3 (the mid-point of the European EN14214 specification) the table illustrates equivalent quantities of biodiesel expressed in terms of both mass and volume.

K. More on the Methanol Institute

The Methanol Institute (MI) serves as the global trade association for one of the world's most vibrant and innovative industries. Founded in 1989 to lobby the U.S. Congress in support of methanol fuel markets, MI now serves its members in every corner of the globe from our offices in Singapore, Washington, D.C., and Brussels.

The global methanol industry impacts our daily lives in countless ways. Methanol is an essential chemical building block for numerous products, and in an era focused on alternative energy, it is an emerging energy resource. Each day, roughly 70,000 metric tons of methanol (23 million gallons or 87 million liters) is shipped from one continent to another, enough product to fill 777 rail cars. Today, our membership includes the world's leading methanol producers, technology companies, distributors, terminal operators and shippers.

The methanol industry's leading companies have joined to support MI as the most effective way to interact with governments, NGOs and potential new customers throughout the global marketplace. MI collaborates with each of our member companies to create solutions for the global industry, and to ensure that already vibrant markets for methanol and its numerous derivatives continue to thrive.

Most importantly, the leading executives of MI's member companies provide their vision and insight to help drive the future of the methanol industry. The Methanol Institute provides the platform for our members' voices to resonate throughout the global marketplace and in the halls of government around the globe.

As the global trade association for the methanol industry, the mission of the Methanol Institute is to serve and provide cost-effective value to its membership by:

- Promoting the growth of the global methanol industry as an essential chemical commodity and emerging source of clean energy;
- Providing product leadership to ensure the proper and safe handling of methanol across the global distribution chain;
- Ensuring that the best available science is made available to regulatory and public policy debates which impact the industry; and
- Serving as the voice of the global methanol industry to promote the image of methanol, the Methanol Institute and its member companies.

Read more about the Methanol Institute at http://www.methanol.org/ or contact the Methanol Institute at:

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L. More on Hart Energy's Global Biofuels Center

The **Global Biofuels Center** highlights and gathers all available information on biofuels globally for our members to enable them to make sound decisions based on industrywide information, experience and analysis. We assemble relevant information from the global biofuels market into a single, easily accessible destination for stakeholders and decisionmakers around the world. GBC does not advocate any position for our members; rather, we serve as an information resource, networker and facilitator. Our members-only site houses biofuels-related intelligence, data and analyses focusing on production capacities, production/consumption, feedstocks; tax incentives and fiscal policy. specifications, and legislative and regulatory policy for 70 countries around the world.

Read more about the **Global Biofuels Center** at http://www.globalbiofuelscenter.org or contact Tammy Klein, Senior Vice President, Hart Energy at +1.239.970.2231.

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