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**BIODIESEL: PRESENT AND FUTURE
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NATIONAL BIODIESEL BOARD

The National Biodiesel Board (NBB) is a trade association based in Jefferson City, Missouri, dedicated to creating a market for biodiesel. NBB serves as the product development team for biodiesel in the U.S., coordinating the research, regulatory, and market development programs needed to commercialize biodiesel. Full-time soybean farmers volunteer their time to guide the board's investment in biodiesel research and market creation efforts. The NBB is largely funded through soybean checkoff dollars. The member base of the organization also includes non-voting associate members, including fuel marketers and related feedstock producing and marketing associations. Federal government agency representatives periodically attend NBB's meetings to gain insight on the effort, to coordinate their role in biodiesel commercialization.

NBB's research is focused on the fuel, its characteristics, and economics and engine testing for emissions and non-emissions work. NBB's market development program is focused on federal and state regulatory work and market development through the education of the industry and end users.

Introduction

The name "biodiesel" was introduced in the United States in 1992 by the National Soy Diesel Development Board (now the National Biodiesel Board), which has pioneered the commercialization of biodiesel in the U.S.

Chemically, biodiesel is referred to as the mono-alkyl esters of long-chain fatty acids derived from renewable lipid sources.

Biodiesel is the name for a variety of ester-based oxygenated fuels from renewable biological sources. It can be used in compression-ignition (diesel) engines with little or no modifications. Pure biodiesel is biodegradable, nontoxic and essentially free of sulfur and aromatics.

Biodiesel is a methyl or ethyl ester of mainly vegetable oils. Since soybean oil is the dominant oil produced in the U.S., the development effort has focused around it as a feedstock for biodiesel. Biodiesel readily blends with diesel fuel in any percent. The blend level is a function of economics, the desired emissions profile, material compatibility, and combustion characteristics. The focus at the moment is on a 20 vol.% blend of biodiesel in petrodiesel.

Methyl or ethyl esters can be produced from vegetable and tree oils, animal fats, and/or used oils and fats. These oils are blended with an alcohol (usually methanol, although ethanol can be used as well) and a catalyst such as sodium hydroxide. The resulting chemical reaction (which occurs at moderate temperatures and pressures) produces an ester and glycerine. Glycerine is a valuable material used extensively in the manufacture of soaps and other consumer products.

Biodiesel's performance is similar to diesel. While biodiesel has slightly less energy per gallon than number 2 diesel, it has slightly more energy than number 1 diesel. Tests have shown its performance when used in vehicles to be virtually the same as diesel.

Advantages

Biodiesel has a number of advantages when compared with both petroleum diesel and other alternative fuels. It needs to be emphasized, however, that the goal of the biodiesel industry is not to replace petrodiesel or to supplant the invaluable role of other alternative fuels. Each of these fuels has a place in the development of a balanced energy industry. The compression-ignition engine has certain advantages over spark-ignition engines and the role of biodiesel is to contribute to the longevity and cleanliness of diesel engines.

Markets are being developed based on the end users desire to purchase a more costly, premium fuel in either neat, 100% form, or blended with diesel. Consumers have shown that they are willing to purchase biodiesel based upon several factors:

First, biodiesel is produced domestically, which helps reduce the United States' dependence on imported petroleum.

Second, the development of the biodiesel industry would strengthen the domestic, and particularly the rural, agricultural economy.

Third, it is a renewable fuel that can be made from agricultural crops and/or other feedstocks that are considered waste, such as cooking oil and trap grease. This helps conserve resources and makes the best possible use of materials which may be perceived as having little or negative value.

Fourth, the U.S. agricultural sector has, for many years, produced a surplus of soybean oil, and the implementation of the GATT agreement and, to some extent, NAFTA, will affect the U.S. market for this commodity. Use of surplus soybean oil to produce energy domestically and renewably will benefit everyone.

Fifth, the production of soy-based biodiesel has a positive energy balance (as much as 3:1), due to the high energy value of ester-based feedstocks, the low-energy requirements of the conversion process, and the nitrogen-fixing characteristic of soybeans, which reduces the need for fertilizer.

Sixth, biodiesel blends are competitive with other alternative fuels on a life-cycle cost basis, because of its lower associated infrastructure costs (no extensive engine or refueling modifications needed), the positive energy balance discussed above, and the efficiency of the fuel on a per-Btu basis. Used in conjunction with the compression-ignition engine, which is much more efficient than spark-ignition engines, biodiesel compares quite favorably with CNG, ethanol and methanol, the other leading alternative fuels in the marketplace today.

Seventh, it is considered readily biodegradable and non-toxic. Continued testing indicates that biodiesel degrades as fast as and is as safe as sugar in the environment, and when blended with diesel accelerates the diesel's degradation in the environment. These characteristics may prove valuable in certain markets.

Eighth, biodiesel and biodiesel blends significantly reduce harmful tail pipe emissions as documented in tests using U.S. EPA protocols.

Ninth, The emissions smell better and appear to help reduce nausea in those breathing the fumes.

Tenth, biodiesel fuel and biodiesel/petrodiesel fuel blends smell better than conventional diesel. A value to those who work in close proximity to the fuel.

Challenges

As a new fuel in the highly competitive marketplace, biodiesel has performed admirably. Consumer recognition, scientific expertise, and technical development within the industry have grown by leaps and bounds over the last four years, with more progress clearly visible. Demonstrations of biodiesel have taken place in more than 40 states, with millions of miles logged and still counting. The fuel has been used in a wide variety of engines and conditions, and the results of these demonstrations have been overwhelmingly positive.

Despite this remarkable progress, biodiesel is not exactly a household word, and the fuel is not in wide commercial use. The challenges that the industry faces -- to increase awareness of potential consumers of biodiesel, finalize the best combination of chemical and mechanical

additives to optimize the emissions benefits of biodiesel, continue to meet U.S. EPA and U.S. DOE regulations, and, of utmost importance, make sure it is available and price competitive in the market place with other alternative fuels and technologies. Biodiesel is registered with the U.S. EPA as both a fuel and a fuel additive.

The compression-ignition (diesel) engine normally has a higher oxides of nitrogen (NOx) emissions profile compared to engines fueled with other products and, for reasons that are not entirely understood, in certain engines use of biodiesel tends to slightly increase those emissions of oxides of nitrogen. Since NOx is an ozone precursor, there is some concern about this issue. However, this problem is not insurmountable and a number of techniques are being developed to ensure that NOx emissions with biodiesel will be lower than for diesel fuel. Recent research suggests that biodiesel used in new engines developed to meet 1998 emission standards will not increase NOx emissions.

Other hurdles presently facing biodiesel are the cost of biodiesel and its availability and the need to gain alternative fuel status for biodiesel blended with petrodiesel.

Since most biodiesel is currently made solely from soybean oil, a commodity whose price can fluctuate based on the success of the soybean production, and since the marketing of the fuel is presently limited to several companies, the price of the fuel is a temporary barrier to its successful commercialization. Efforts are underway to address this dilemma from several angles. First, NBB continues to work with DOE and EPA policy makers to inform them of the emissions benefits and efficiency of biodiesel at lower blend levels, and to coordinate our efforts with DOE and EPA.

Biodiesel plants are under development across the U.S. When they are completed and on-line, it will increase the current supply in the United States. In addition, some of these new plants intend to blend soybean oil feedstock with lower-cost alternatives -- waste grease and used cooking oil mentioned earlier. These plants may also produce other higher value ester products to market other environmentally safer products. These factors, combined with increased competition and free-market forces, will begin to make the cost of biodiesel competitive and more readily available in various niche markets.

Markets

An initial regulatory opportunity for biodiesel has been created by the EPA's Urban Bus Rebuild/Retrofit Program for 1993, which is part of the Clean Air Act Amendments of 1990 (CAAA). It targets earlier model year buses used in cities with a population of 750,000 or more. If biodiesel receives certification as part of a "rebuild package" under this program as a means of meeting the program's goal of reducing particulate (PM) emissions, it can be sold to urban bus fleets participating in the program.

Much of the marketing efforts to date have focused on mass transit authorities and other public entities exempt from the taxes imposed on retail diesel fuel. While this situation lowers the cost of petrodiesel for these transit authorities, it also makes the use of B20 more affordable. In addition, mass transit authorities in many urban areas are obligated to meet the requirements of the Clean Air Act Amendments and related regulations issued by EPA and state governments;

and biodiesel compares favorably with the alternatives available to them. Since biodiesel requires no major engine modifications or refueling infrastructure changes, initial costs are much lower and the transition to this alternative much easier. This obligation of mass transit to meet clean air requirements provides an opportunity for biodiesel to develop a specialty market.

Completed certification testing under the EPA Urban Bus Rebuild/Retrofit Program should provide mass transit operators with a fully viable course of action to comply with the mandate for cleaner air and allow the fuel market to sell biodiesel to them.

A second regulatory market opportunity has been created by the Energy Policy Act of 1992, which is intended to displace imported petroleum products. This law encourages and mandates the purchase of alternatively-fueled vehicles. Federal and state fleets, and alternative fuel providers are affected. NBB is working with the affected fleets, the DOE and vehicle manufacturers to develop this market.

Neat biodiesel is considered an alternative fuel by DOE; however, action is underway to gain DOE's support that a 20% blend of biodiesel with diesel is acceptable as a separate and distinct alternative fuel under the provisions of the Energy Policy Act of 1992. Such a determination will add to the attractiveness of biodiesel in the regulated fleets market.

Marine Market

One of the most promising new markets for biodiesel appears to be the marine market. As a biodegradable, non-toxic fuel, biodiesel can help prevent damage to marine environments such as wetlands, marshes, rivers, and oceans. In addition, it has been shown that methyl esters similar to biodiesel can be used to clean up oil spills, further proving its ability to be an environmentally safer fuel for this market.

One of the most successful marine demonstrations, the around the world voyage of the *Sunrider*, a biodiesel-fueled, customized, 24-foot Zodiac Hurricane Boat with a standard 180-horsepower MerCruiser diesel stern drive engine and a 27horsepower Yanmar diesel outboard auxiliary engine was completed in 1994.

- *Sunrider*, captained by Bryan Peterson, covered 40,000 miles and visited 40 countries to publicize biodiesel and renewable energy.
- On the voyage, *Sunrider* successfully used 100% biodiesel (methyl soyate) for two years, two months and six days with no modifications needed to either engine.
- While the voyage was not without incident, Captain Peterson encountered everything from hurricanes to pirates on his trip; no engine performance problems related to the fuel were reported.

Interest in marine applications of biodiesel is growing. EPA has released draft regulations for control of marine engine emissions and a number of individuals and organizations have expressed an interest in using biodiesel to meet these regulations, prevent pollution, and help protect the oceans and marine life from damage caused by petroleum use. This market may be a "neat" fuel or blended fuel market. Those most interested in purchasing biodiesel in this market at this time are recreational boaters and commercial charter operators. They appear to be willing to buy biodiesel or biodiesel blends based upon its positive impact on the environment, better

emissions and biodegradability, lack of toxicity, and the better smell of the fuel and the engine emissions.

Other marine demonstrations are and will continue in the future. The NBB is currently assisting in the test marketing of biodiesel in the marine market through commercial outlets in the Florida Keys.

Underground Mines and Confined Areas

Underground mines also provide a potential market for biodiesel as the industry looks for technologies capable of reducing harmful emissions in confined spaces. Competing against and complementing technologies to clean the air in mines will be the subject of continued research.

There are other potential reduced emission markets, especially in confined areas and environmentally-sensitive areas. In South Dakota, a contractor excavating a new basement under an existing building used 100% biodiesel to power his skid loader because it enabled him to operate his equipment during the day, not at night when the building was empty. He had been forced to move to a night-time schedule because of building employee complaints and the risk of contamination to highly sensitive computer equipment from diesel particulate matter emissions. For the contractor, the higher price of the biodiesel was more than offset by the emissions reductions allowing him to work during regular work hours.

Engine Testing (Emissions)

Use of biodiesel or biodiesel blends reduces the harmful emissions from diesel engines at various rates dependent upon the amount of biodiesel used and the type of engine it is used in. Data developed in the United States demonstrates differences in emissions between engines: two-stroke cycle, four-stroke cycle, mechanically controlled, electronically controlled, direct-injected and indirect-injected. Generally, the newer and cleaner the engine, the higher the environmental benefits of biodiesel. The newer four-stroke cycle engines are not demonstrating the NO_x increase expected in older two-stroke cycle engines (in some engines, NO_x is actually reduced). Biodiesel (B20) tends to significantly reduce the carbon fraction of the particulate matter (PM) while retaining the soluble organic fraction (SOF). The newer, "drier" diesel engines have such an inherently low SOF fraction that the reduction in the carbon fraction of the PM shows up dramatically when B20 is used.

Biodiesel may complement emissions reduction equipment. An oxidizing exhaust catalyst is very effective in reducing the SOF fraction of PM but does not work well in reducing the carbon fraction. If the carbon fraction of PM is reduced and SOF fraction is increased by using biodiesel, the overall efficiency of the exhaust catalyst will be enhanced.

Fortunately, much of the testing already completed, or to be completed, under the Urban Bus Retrofit Rebuild Program, will also be applicable to meeting EPA's substantially similar or waiver requirements under the Clean Air Act Amendments of 1990. Meeting these requirements will ensure that biodiesel will continue to be fully acceptable in the diesel marketplace.

Engine Testing (Non-Emissions)

NBB is continually working with diesel engine manufacturers to ensure that engine parts and fueling systems are compatible for long-term use with biodiesel and biodiesel/diesel blends. This process is ongoing and expanding as customers contact engine manufacturers for biodiesel warranted engines.

Fuel Standards

As part of the effort to ensure that biodiesel is acceptable to the marketplace, NBB has worked in cooperation with standard-setting organizations such as the American Society for Testing and Materials (ASTM), National Council on Weights and Measures (NCWM), American Society of Agricultural Engineers (ASAE), etc., to develop a comprehensive U.S. biodiesel fuel standard. In addition, this U.S. standard is being developed to conform to the extent possible to the European standards. A recent meeting in Vienna, Austria was held to begin the development of a world standard.

While there has not been a quality problem using the current interim standard, the development of an ASTM standard will help to provide both engine manufacturers and fuel users with the continued assurances they need to warrant the use of biodiesel in their engines and to rely on biodiesel as a fuel. An ASTM subcommittee for biodiesel is actively working on the formal standard.

Conclusions

- Under current conditions, biodiesel can legally be sold into the diesel marketplace.
- Biodiesel currently competes in the alternative fuels market and against clean engines emissions technology and does not nor is not intended to compete directly with diesel fuel in the near term.
- Approval of biodiesel emissions reduction package by EPA under the CAAA program will provide marketing opportunities to Urban Bus fleets.
- The regulated fleet market, mandated by the Energy Policy Act of 1992, will continue to be pursued.
- The new opportunities in the marine markets will continue to be developed.
- The mining market will be pursued performing the emissions and other research as required prior to sales.
- Off-road vehicles/equipment may also provide a significant potential market for the future.
- Other markets will be assessed before being developed; as the effort continues.

The biodiesel industry will continue to work as closely as possible with oil refiners and engine manufacturers to ensure that diesel fuel continues to be a viable fuel in a marketplace that is increasingly impacted by environmental requirements.

Keeping diesel in the marketplace is important in terms of efficiency of refinery operations and fuel economy. Keeping biodiesel in the marketplace is important in terms of reduced dependence on imported oil, revitalization of the rural economy, and allowing fleet operators who have diesel engines to continue to be in their fleets for decades into the future.

Biodiesel has a few economic and regulatory hurdles that must be overcome, but there is reason to believe that this will happen. It has already happened in Europe. Any work or biodiesel market

development programs for a specific country or region needs to be developed on the market drivers for that country, based upon the characteristics of biodiesel and rationale used to approach end user needs based upon those characteristics.

NBB will continue to coordinate the overall product development effort in the U.S. with interested parties through its Strategic Business Plan and Marketing Plan. The main goal is to get industry to invest in the production and marketing of biodiesel. That goal is slowly being accomplished for the benefit of all involved including the founders of the current effort, the soybean producers.

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