January 4, 2007

John Deere bio-fuels white paper

Agriculture, bio-fuels and striving for greater energy independence

A John Deere perspective on the realistic role US agriculture can play in satisfying America's increasing appetite for renewable fuels

By Don Borgman, John Deere Director, Agricultural Industry Relations, North America

Introduction

The purpose of this white paper is to provide historical context on the growth of ethanol and biodiesel – with emphasis on the U.S. energy market – while also providing perspective on the realistic contributions these products and agriculture can make. In addition, this document will also share information designed to clear up misconceptions some might have regarding the energy use and energy efficiency of U.S. agriculture.

In his 2006 State of the Union address, U.S. President George W. Bush made the pronouncement that the United States needs to "move beyond a petroleum-based economy," and then lent his support to the further development of energy from biomass and the increased production of fuels from renewable resources such as corn, soybeans and cellulosic material.

While these statements alone did not accelerate the recent increase in production of bio-based fuels, they certainly cast the spotlight on renewable fuels and the agricultural sector that plays such a vital role in sustaining this burgeoning industry.

Since the energy crisis of the 1970s, the development of energy sources from the agricultural sector has been viewed as a way to expand the domestic energy supply of the United States and help mitigate the nation's growing dependence on imported oil. Including hydropower, renewable energy accounted for six percent[1] of U.S. energy consumption in 2004, with energy from biomass contributing almost half of that total. While wood has provided most of the biomass energy over the years, ethanol – largely produced from corn in the U.S. – has been the fastest growing renewable energy source over the past 10 years. In 2005, the ethanol industry produced 4 billion gallons of ethanol, which is currently blended in 30 percent of the nation's gasoline.

Additionally, biodiesel – a biofuel substitute for petroleum diesel – is just beginning to establish a market in the United States. Biodiesel is most commonly blended with conventional diesel fuel at levels of 20 percent or lower. The majority of the 75 million gallons of biodiesel produced in 2005 came from soybean oil, although it also can be made from other oilseed crops, animal fats, and grease.

Renewable fuels have gained momentum not only in the U.S. but around the world as well. A significantly higher portion of Europe's vehicles are diesel-powered, and as a result, the production of biodiesel derived from rapeseed has expanded rapidly. With the relative cost of diesel fuel significantly higher, the future for renewable biodiesel in Europe is very bright.

In Brazil, a national initiative supporting the development of the renewable fuel business has been underway for several years. While the biodiesel market is still in its early stages, ethanol production has expanded rapidly. In fact, Brazil is a close second to the U.S. in total ethanol production. Because the nation has a total gasoline consumption that is less than 5 percent of what is used in the United States, Brazil's ethanol capacity could fulfill more than 80 percent of its domestic gasoline needs. In other regions of the world, renewable energy research and development is underway, using feedstocks such as Jatropha, castor beans and palm oil.

John Deere has a keen interest in bio-based fuels for a number of reasons:

- It's the right thing to do from a long-term economic standpoint
- It's the right thing to do from an environmental standpoint
- It's the right thing to do from an energy security standpoint
- It's the right thing to do from a rural development standpoint: Customers of John Deere around the globe produce the building blocks for renewable fuels – from sugars to starches to vegetable oils and animal fats.
- Relating specifically to biodiesel, John Deere is a significant manufacturer of diesel engines, so we have a vested interest in a consistent, high quality supply of diesel fuel
- Ethanol and biodiesel plants comprise the only new refinery capacity being added to the U.S. supply chain. Run-ups in gasoline and diesel prices during 2006 were due more to refinery capacity issues than oil availability
- While new oil discoveries are possible – or even likely – the world's supply of crude oil is finite. Developing alternative, renewable energy resources now helps us prepare for the time when limited oil supplies and substantially higher petroleum prices are the norm
- Renewable fuel refinery capacity and local feedstock sourcing contribute to a more stable domestic energy supply for many countries throughout the world

The U.S. Department of Energy forecasts that by 2030, energy consumption in the U.S. will increase by more than 30 percent from current (2006) levels. The growth in energy to meet the transportation sector alone is forecast to increase by more than 40 percent. Therefore, the supply of renewable energy, such as ethanol and biodiesel, must also grow simply to maintain its current share of the overall energy market, and it must grow even faster to make a significant contribution to reduce the nation's reliance on fossil energy resources.

Projections for global energy growth show requirements outside the U.S. increasing at an even faster pace. This places even more pressure on global oil supplies and refinery capacity outside the U.S.

In light of the increasing pressure that is almost certain to be placed on bio-based fuels to help lessen dependence on petroleum, the need to move forward in a reasonable, measured approach has never been greater.

Ethanol-based fuels

Ethanol is a clean-burning, high-octane fuel that is produced from renewable resources. At its most basic, ethanol is grain alcohol, produced from crops such as corn. Domestically produced ethanol helps reduce America's dependence upon foreign sources of energy.

Pure, 100 percent ethanol is not used as a motor fuel in the U.S.; instead, a percentage of ethanol is combined with unleaded gasoline. Any amount of ethanol can be combined with gasoline, but the most common blends are:

E10 – 10 percent ethanol and 90 percent unleaded gasoline

E10 is approved for use in any make or model of vehicle sold in the U.S. Many automakers recommend its use because of its high performance, clean-burning characteristics. In 2005, 30 percent of America's gasoline was blended with ethanol, most in this 10% variety. Ethanol is also used as an octane-enhancer, replacing methyl tertiary butyl ether (MTBE). In Brazil, ethanol is most commonly available in the E20 to E25 range, or as E100.

E85 – 85 percent ethanol and 15 percent unleaded gasoline

E85 is an alternative fuel for use in flexible fuel vehicles (FFVs) in the U.S. There are currently more than 5 million FFVs on America's roads today, and automakers are rolling out more each year. In conjunction with more flexible fuel vehicles, more E85 pumps are being installed across the country. When E85 is not available, these FFVs can operate on straight gasoline or any ethanol blend up to 85%.

Ethanol can be produced from a variety of feedstocks such as sugar cane, sugar beets, grain sorghum, switchgrass, barley and corn, among others. In Brazil, sugar is the major feedstock used to derive ethanol. In the United States, the majority of ethanol currently produced is derived from corn. In fact, about 14 percent of the U.S. corn crop was used for ethanol in 2005/06[2] and the United States Department of Agriculture (USDA) projects 20 percent of domestic corn production will be converted into ethanol in 2006/07.

Current production and market potential

A combination of factors – from the phase out of the oxygenate MTBE to rising petroleum costs to the drive to reduce our nation’s dependence on foreign oil – has fueled rapid expansion of the domestic ethanol industry in recent years.

In 2000 there were 54 ethanol facilities in the U.S. with a production capacity of 1.75 billion gallons per year. In 2006 more than 100 plants were in operation with a combined annual capacity of 4.5 billion gallons. An additional 40 ethanol facilities are currently

under construction or expansion bringing production capacity to more than 7 billion gallons by 2008.

According to US Department of Energy (DOE) data, the U.S. consumes 140 billion gallons of gasoline per year. While ethanol at its current production level accounts for only about 3 percent of domestic gasoline consumption, two significant factors should help sustain continued near-term growth for the industry.

First, the Energy Policy Act of 2005 (EPACT), requires U.S. fuel production to include a minimum amount of renewable fuel each year, starting at 4 billion gallons in 2006 and reaching 7.5 billion gallons by 2012. Second, because MTBE has been found to be a drinking water contaminant, its use as an oxygenate in gasoline is being phased out. Refiners have been and will continue to replace MTBE with ethanol

Future outlook

The future for ethanol looks bright well beyond the near term. This is due in no small part to rising crude oil prices and tightening oil supplies and, of course, to the lack of new petroleum refinery capacity being constructed in the U.S. and in Europe. World oil prices have increased sharply since 1999, when the annual average nominal price of West Texas Intermediate (WTI) oil jumped from $19.25 per barrel in ’99 to $30.29 in 2000. From 2000 to 2003, the average WTI price ranged from $26 to $31 per barrel. Starting in 2004, the WTI prices surged upward from $41 per barrel to over $56 per barrel in 2005. Short-term projections from the US Department of Energy, Energy Information Administration (EIA) indicate the average WTI price for a barrel of crude oil will continue at current levels through at least 2007. And, for practical purposes, ethanol and biodiesel plants are the only new refinery capacity the U.S. has added in the past 25 years.

Higher crude oil prices have translated into higher wholesale and retail prices for gasoline as well as diesel fuel. EIA estimates the average wholesale price for gasoline increased from $1.28 per gallon in 2004 to $2.04 per gallon in 2006.

Under EIA’s long-term forecast, world oil supplies are expected to remain tight as demand for oil stays strong, keeping pressure on oil prices through 2030. If future oil prices reflect EIA projections, demand for ethanol-based fuels will continue to grow.

With corn as the feedstock, U.S. ethanol production will exceed 4.5 billion gallons in 2006. Some experts maintain the industry holds the potential to expand to 16 billion gallons by 2015 based on reasonable predictions for:

- Growth in corn yields (bushels per acre)
- Growth in ethanol yield (gallons per bushel)
- The probable expansion of corn acres

Meeting the long-term expansion potential of 60 to 80 billion gallons by 2030 may require the production of ethanol from cellulosic material such as crop and forest residues and dedicated energy crops. However, some believe the development of new generations of hybrid seed corn and improved production techniques could increase the U.S. corn crop to 25 billion bushels and beyond, lessening the need for development of cellulosic

sources. One thing, however, is certain: no matter the feedstock, deriving energy from renewable resources is positive for the environment, rural economies, and energy security for nations around the globe.

John Deere perspective on ethanol-based fuels
John Deere has been and will continue to be a champion for policy that enhances energy independence, strengthens national security and promotes rural development. As such, the company supports incentives that ensure ongoing research and development and create a positive environment for long term investment in renewable energy distribution and production infrastructure. In addition, the company supports research efforts and technology improvements that aid the efficient, expanded production of ethanol from corn and other viable feedstocks

John Deere also has been an active supporter of the "25 by '25" initiative of the Ag Energy Working Group that advocates "Agriculture will provide 25 percent of the total energy consumed in the United States by 2025 while continuing to produce abundant, safe and affordable food and fiber."

John Deere's manufacture of gasoline-powered equipment is limited to smaller units, such as handheld and ride-on grounds care and golf course equipment. The technology required to make these smaller, less expensive engines compatible with high ethanol blends like E85 is cost-prohibitive at this time. Therefore, John Deere approves the use of 10 percent ethanol (E10) blend for the company's gasoline-powered products.

Biodiesel

In a speech delivered in 1912, Rudolf Diesel, the German inventor of the diesel engine, stated: "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." Despite Rudolf Diesel's vision from nearly a century ago, biodiesel is still the relative new kid on the biofuels block, having gained significant momentum only since the start of the new millennium.

Biodiesel – produced from domestic, renewable resources such as soybeans – is a clean-burning alternative to petroleum-based diesel fuel. Pure biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. At lower blend levels, 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 made through a process called transesterification whereby the glycerin is separated from the fat or vegetable oil. The process leaves behind two products – methyl esters (the chemical name for biodiesel) and glycerin (a byproduct usually sold for use in soaps and other products).

It is important to note that biodiesel is not the same thing as raw vegetable oil. Fuel-grade biodiesel must be produced to strict industry specifications (ASTM D6751) in order to ensure proper performance. Biodiesel that meets ASTM D6751 and is legally registered with the Environmental Protection Agency is a legal motor fuel approved for sale and distribution. Raw vegetable oil cannot meet biodiesel fuel specifications, is not registered with EPA and is not a legal motor fuel.

Biodiesel refers to the pure alternative fuel before blending with petroleum-based diesel fuel. Biodiesel blends are denoted as "BXX" with "XX" representing the percentage of biodiesel contained in the blend (B5, for instance, is 5 percent biodiesel and 95 percent petroleum diesel). Biodiesel is most commonly blended with petroleum-based diesel fuel at levels of 20 percent or less. The majority of the 75 million gallons of biodiesel produced in 2005 came from soybean oil, although it can also be made from other oilseed crops, animal fats, waste oil and grease.

Current production and market potential

Compared to ethanol, which has been in the marketplace since the 1970s, biodiesel is still in its relative infancy. Biodiesel currently represents the proverbial drop in the bucket of total U.S. diesel fuel consumption: The 75 *million* gallons out of a total diesel fuel consumption of 58 *billion* gallons in 2005 equates to B.13 (less than two-tenths of one percent).

The industry is currently experiencing a tremendous growth spurt. Government incentives, recent increases in oil prices, and the lack of refinery capacity have made biodiesel blends more cost-competitive, thus attracting investment in biodiesel production facilities. In 2000 there were fewer than 10 biodiesel plants in the U.S. That number had increased to 65 in 2006, providing the industry with a production capacity of 395 million gallons. Another 58 plants are currently under construction or in the process of expanding, adding another 318 million gallons of capacity upon completion. While ethanol production increased 120 percent between 2001 and 2005, biodiesel production increased nine-fold over the same period.

Future outlook

The future for biodiesel looks bright, both near term and long term. As with ethanol, the Energy Policy Act will encourage near-term growth for biodiesel, and is a major reason capacity is projected to reach 1.7 billion gallons by mid-2008. Over the long term, the same projections relating to crude oil prices and tightening supplies outlined in the previous section on ethanol-based fuels also should contribute to the growth of biodiesel.

The continued expansion of the biodiesel market is dependent upon the development of production and distribution systems that are intensely focused on consistent, high quality supplies of biodiesel.

There are three broad-category challenges that need to be successfully addressed in order to realize the full promise the product holds.

Quality: Quality issues in the early days of Gasohol – more than 25 years ago – soured a significant portion of the population on the product. In fact, the most recent survey results indicate 19 percent of Americans don't want to use ethanol today due to concerns over fuel-system or engine problems. It took more than two decades and significant upgrades in quality and industry standards – not to mention a name change from Gasohol to Ethanol – before the industry was able to overcome these negative consumer perceptions. It is essential that the biodiesel industry avoid these problems and learn the lessons from the early days of ethanol.

In an effort to increase biodiesel production and acceptance, the industry has moved very rapidly, and the risk of quality issues and negative public perception is high. A number of companies and organizations attempting to show their support of agriculture have advocated blends as high as B20. Unfortunately, when operators use blend rates higher than B5, they run a greater risk of experiencing difficulties such as:

- Water in the fuel due to storage problems
- Foreign material plugging filters due to the solvent characteristics of biodiesel that "clean up" storage and fuel systems
- Fuel system seal and gasket failure
- Fuel gelling in cold weather
- Crankcase dilution
- Injection pump failure due to water ingestion
- Power loss and, in some instances, power growth detrimental to long engine life

This is not to imply that an operator will experience any or all of these problems, but their risk of occurrence increases as the level of biodiesel blend increases. Recent findings of quality problems with biodiesel blends in many regions of the country underscore the immediate need for intense industry focus on quality improvement.

Supply: The availability of adequate feedstocks is another significant factor that affects the near-term viability of B20 as an industry-wide standard. Remember, current biodiesel production equates to an industry-wide blend rate of B.13 (less than two-tenths of one percent). A B2 blend is an attainable goal, as it would require 1.1 billion gallons of pure biodiesel. Still, that would consume all the soybean oil from 18 million acres, or about one-fourth of current U.S. soybean production. Even meeting the supply needs of B5 would prove to be an aggressive goal as it would require 2.9 billion gallons of pure biodiesel, or the oil from 46 million acres of soybeans.

Distribution: While the industry has made significant headway in expanding production facilities for biodiesel, the distribution channels are still limited due to an extremely tight product supply. A distribution infrastructure needs to be developed that helps facilitate the growth of the biodiesel industry. As with any industry, it is difficult to develop all needed elements at once. But, until adequate supplies of high-quality biodiesel are available, it is difficult to attract investment in broad scale distribution. And until distribution outlets are available, it's difficult to justify broad-scale investment in higher production. That's why public policy incentives and broader industry efforts are needed to develop the distribution infrastructure more rapidly.

John Deere perspective on biodiesel

At John Deere, we were an early champion for biodiesel and we continue to be a strong advocate for its use. John Deere approved B5 biodiesel blend for general use in December 2001. Then in March 2005 the company initiated U.S. factory fill of self-propelled equipment with B2 biodiesel blend.

John Deere has supported and promoted B2 as a logical first step in biodiesel growth. At a 2 percent level, most negative impacts that come from biodiesel that does not meet specifications are mitigated and engine and fuel system performance are usually not compromised. B2 blends for the U.S. would consume somewhat more than a billion gallons of biodiesel annually, so even at the B2 level, there are still significant growth opportunities for the industry.

John Deere believes focusing the industry at the B2 level will give farmers, refiners, distributors, retailers, and engine builders the time needed to address issues that will help ensure positive use experiences for consumers. With quality standards and enforcement practices in place, the biodiesel industry will be on a sound footing to grow biodiesel usage to higher blend levels.

Additionally, John Deere supports these actions relating to biodiesel:

- Public policy that encourages simultaneous development of biodiesel plants *and* distribution networks
- Public policy that encourages long-term development of additional feedstock sources
- Public policy that recognizes the need for standards, quality control, inspection, and strict enforcement
- The development of and adherence to biodiesel blend specifications
- Production facility and distribution channel adherence to quality standards (BQ9000)

In summary, there's an old saying that "If you want things to go faster, sometimes you have to slow down." It is John Deere's belief that the industry benefits far more if *everyone* has a good experience with B2 or B5 instead of *most* people having a good experience with B20. Agriculture, the environment and John Deere benefit significantly if biodiesel use expands. But to make certain biodiesel gains the consumer confidence required to achieve broad, long-term use, it is essential that quality, supply and distribution issues take priority over short-term growth.

The energy efficiency of modern production agriculture

A misconception that has been promoted by a handful of influencers is that there is a lack of energy efficiency in the agricultural industry. In reality, energy use by agriculture peaked nearly 30 years ago, in 1978[3]. One frequently quoted study on the net energy impact of ethanol uses 30-year-old data that grossly overstate the amount of energy used to move corn from the field to the gasoline pump.

Energy efficiency on the farm has improved for a number of reasons. Rapidly rising energy prices caused by oil price shocks in the early 1980s forced farmers to become more efficient. Since 1978, total energy use by the agricultural sector has fallen. And even though energy use has decreased, agricultural output has increased since the 1970s. One measure of energy efficiency, the ratio of energy use to agricultural output, has fallen by almost 50 percent since 1978.

Significant changes in production practices have made a major contribution. For instance, no-till systems are currently used on about 62 million acres of cropland. Assuming an average savings of 3.5 gallons per acre in diesel fuel, this amounts to a savings of 217 million gallons of diesel fuel per year, with a cost savings to farmers of roughly $500 million per year. These efficiencies keep farmers competitive, but they also ensure an even more positive energy balance from the production of ethanol and biodiesel. The less energy used to produce renewable fuel feedstocks, like corn and soybeans, the greater the energy gain from biofuels.

Equally as important as the adoption of more-efficient production practices is the introduction and adoption of significant new production technologies. The use of Digital Global Positioning-based guidance systems such as our John Deere GreenStar AutoTrac, has greatly reduced overlap in field operations and helped farmers become more efficient and productive than ever before. Future applications of these and other John Deere technologies will serve to reduce input costs and raise farm productivity – all critical factors in making renewable fuels even more abundant and cost-effective.

Equipment technologies have made tremendous strides as well. The John Deere 8000 THIRTY Series tractors, first available to farmers at the beginning of 2006, were proven by the independent Nebraska Tractor Test Laboratory to be the most fuel-efficient tractor that facility had ever tested.

Conclusion

From the growth of feedstocks used to generate biofuels to the ever-increasing productivity and efficiency of its production practices, the agricultural industry has made an important contribution toward our national goal of increased energy independence. This contribution is certain to increase in the decades to come.

John Deere's 170-year commitment to leadership and advocacy on behalf of agriculture has helped put us at the forefront of the biofuels revolution. We were the first equipment manufacturer to approve B5 biodiesel blend for general use and to start using biodiesel as a factory fill at the end of the assembly line. Since then, others have promoted the rapid adoption of even higher blends. We believe, however, that until quality methods and standards are in place, promoting the B2 blend level is the best way to increase long term customer acceptance and expanded use of biodiesel. We urge the industry to adopt a careful, analytical and measured approach. We believe this would help biodiesel achieve sustainable, long-term success while avoiding some of the issues that ethanol encountered in its early days.

Moving forward, John Deere remains committed to an ongoing search for new ideas and the adoption of innovative solutions that ultimately result in the steadily expanded use of bio-based fuel products. As the ethanol industry matures, the promise of greater energy security, positive environmental impacts, and improved economic health in rural America are proving to be attainable realities. We believe that with the right focus on product quality, supply and distribution, biodiesel can add significantly to these same outcomes. John Deere's belief in and commitment to biodiesel is so strong, in fact, that we are investing millions of dollars in research and development. Our efforts are designed to result in future technologies and additives that will enable blends substantially higher than B2 or B5 to provide performance very similar to petroleum diesel fuels.

Finally, just as it has since our founder started the company 170 years ago, John Deere will continue to explore new ideas and develop new technologies to keep farmers around the world at the forefront of productivity and efficiency.

About the author:

Don Borgman has worked for John Deere in a variety of sales, marketing and product support capacities in his 33 years with the Moline, Illinois-based farm equipment manufacturer. In his current role of Director of Agricultural Industry Relations for North America, he is responsible for fostering industry contacts and relationships, overseeing joint projects with industry partners, and helping lead John Deere's renewable energy efforts. Borgman was raised on a corn and soybean farm in west-central Missouri that has been in his family for more than 130 years, and that he owns and operates today. Serving on the board of directors of a Missouri-based biodiesel plant and his ownership in various other biodiesel and ethanol facilities has provided Borgman with valuable firsthand insight into the biofuels industry. He also has been active in both the National Corn Growers Association (NCGA) and the American Soybean Association (ASA). Borgman holds degrees in agricultural economics and agricultural journalism from the University of Missouri.

Sources:

[1]Source: U.S. Department of Energy, Energy Information Administration (EIA)

[2]United States Department of Agriculture – Energy and Agriculture, August 2006

[3]United States Department of Agriculture – Energy and Agriculture, August 2006