Ethanol produced from corn through wet or dry milling makes up the bulk of U.S. biofuels production. Next-generation biofuels production processes are using feedstocks other than corn or other grains that fit into the traditional corn-dominated process. Of the current 13.5 billion gallons of annual ethanol production capacity in the U.S., less than four-tenths of a percent utilize next-generation biofuels feedstocks. This is after including 35 million gallons of capacity that is planned for cellulosic ethanol—not expected to be completed until 2012. Biodiesel production from soybean oil, animal grease or other sources is much lower as a whole than the production of ethanol.

The Energy Independence and Security Act (EISA) of 2007 mandates the blending of 36 billion gallons of renewable fuels per year by 2022 in the U.S. While EISA allows for corn ethanol to meet 15 billion of that target, 21 billion gallons from advanced renewable fuels (non-corn ethanol) are legislated. In conjunction with increased demand for biofuels from European Union legislated requirements, the global outlook for biofuels is strong.

Corn is currently the dominant biofuels feedstock and will likely remain so in the future even with every intention of commercializing alternatives. We will see significant corn production channeled through ethanol refineries as long as market conditions and regulatory structures allow corn ethanol to be priced competitively with next-generation renewable fuels.

**CORN-BASED ETHANOL DOMINATES PATHWAY TO BIOFUELS MARKET**

Ethanol production grew slowly in the 1980s, but ethanol’s rise began with the Clear Air Act Amendments of 1990. The legislation required the year-round use of reformulated gasoline (RFG) in cities with the worst smog problems. One of the requirements of RFG was a 2% oxygen additive (oxygenate), which was met primarily with the petroleum industry using methyl tertiary butyl ether (MTBE) or ethanol in gasoline. Midwest refineries utilized ethanol to meet the oxygenate requirement, while MTBE was the preferred alternative outside the Midwest. However, from the late 1990s into the early 2000s, several states banned MTBE, a known carcinogen, when it was found in groundwater. This set the stage for increased ethanol consumption as refineries replaced MTBE with ethanol.
The move to ethanol was accelerated by the Energy Policy Act of 2005, which required U.S. transportation fuels to include a minimum level of renewable fuels. The Renewable Fuel Standard (RFS) required 4 billion gallons of renewable fuels in 2006 and will increase to 7.5 billion gallons by 2012. Another important change was that the 2005 Act removed the limited liability associated with groundwater contamination and related forms of pollution. Thus, refiners associated with MTBE fearing prosecution quickly moved to replace MTBE with ethanol. The surge in demand for ethanol caused shortages, and ethanol prices soared to a peak near $4 per gallon in mid-2006. The high ethanol prices and extremely favorable production margins sparked a huge expansion in corn-based ethanol capacity.

Energy policy impacted ethanol even further with the Energy Independence and Security Act (EISA) of 2007. EISA established a new, higher RFS often referred to as RFS2. The RFS2 standard calls for total renewable fuels “sold or introduced into commerce in the United States” to reach 36 billion gallons by 2022. Within this standard, ethanol derived from corn is to reach 15 billion gallons in 2015. RFS2 essentially doubled the previous corn-based ethanol mandate of 7.5 billion gallons for 2012. The remainder of the RFS2 standard is to consist of “advanced biofuel” with specific volumes designated for cellulosic biofuels and biomass-based diesel.

ETHANOL CAPACITY AND PRODUCTION

Ethanol production capacity has tripled in the U.S. since 2006. In May 2010, there were 201 ethanol refineries in the U.S. with nameplate capacity of 13.5 billion gallons per year. Most of the plants currently in operation utilize corn as the feedstock. There are about 700,000 gallons of idle capacity and 1.2 billion gallons of capacity under construction (Source: Renewable Fuels Association, 2010). Idle capacity has been an issue since the corn price spike in 2008. Negative processing margins due to rising input costs followed by weaker ethanol prices led to financial stress for the industry. The idle capacity is slowly coming back, but with processing margins near breakeven, the incentive to restart plants is limited. Within the next year or two, plants under construction should be completed. Once these plants are on line, capacity will total 14.7 billion gallons. Therefore, it doesn’t appear that plant capacity will be a limiting factor in reaching the 15-billion-gallon corn-based ethanol portion of the RFS2.

As part of the EISA, biofuels must meet new greenhouse gas emission thresholds based on a lifecycle assessment using the petroleum fuels they replace as the baseline. The assessment was conducted by the Environmental Protection Agency (EPA). For corn-based ethanol, the threshold is a 20% reduction in greenhouse gas emissions. Corn ethanol plants under construction before December 19, 2007, were grandfathered in and are qualified to produce ethanol under EISA without needing to meet the greenhouse gas reductions. However, ethanol plants that commenced construction after that date must meet the 20% reduction in greenhouse gas emissions. Under the EPA’s methodology, most corn–ethanol production processes will meet the 20% threshold and won’t be a significant constraint to industry expansion.

DISTILLERS GRAIN PRODUCTION AND USE RISE DRAMATICALLY

The dry mill process produces approximately 2.8 gallons of ethanol and 17 to 18 pounds of distillers grain from a bushel of corn. Because the starch is removed for ethanol production, the remaining distillers grain contains approximately three times the amount of protein, fiber, and fat as raw corn. Distillers grain is classified as a mid-protein feed, but is most often fed as an energy source in dairy and beef cattle rations. Industry estimates suggest that 75% to 80% of the distillers grain produced is fed to beef and dairy cattle. This is because ruminants are better able to utilize the high fiber levels in distillers grain than swine or poultry. Corn wet mill plants can also produce ethanol and co-product feeds including corn gluten feed and gluten meal, but since most of the increase in ethanol production is from dry mill plants, our focus is on their various co-product feeds (loosely described as distillers grains).

Fermentation from dry mills produces ethanol, carbon dioxide and residual grain. The mixture is distilled to remove ethanol and centrifuged to remove liquid. The liquid is called “thin stillage” and can be condensed to yield condensed distillers solubles (CDS). The remaining solid is wet distillers grain (WDG) and can be sold directly as livestock feed or dehydrated to produce dried distillers grain (DDG). CDS can be added to distillers grain to produce distillers grain with solubles.

**Corn and Alternative Biofuels Feedstock Sources**

- The move to ethanol was accelerated by the Energy Policy Act of 2005, which required U.S. transportation fuels to include a minimum level of renewable fuels. The Renewable Fuel Standard (RFS) required 4 billion gallons of renewable fuels in 2006 and will increase to 7.5 billion gallons by 2012. Another important change was that the 2005 Act removed the limited liability associated with groundwater contamination and related forms of pollution. Thus, refiners associated with MTBE fearing prosecution quickly moved to replace MTBE with ethanol. The surge in demand for ethanol caused shortages, and ethanol prices soared to a peak near $4 per gallon in mid-2006. The high ethanol prices and extremely favorable production margins sparked a huge expansion in corn-based ethanol capacity.

- Energy policy impacted ethanol even further with the Energy Independence and Security Act (EISA) of 2007. EISA established a new, higher RFS often referred to as RFS2. The RFS2 standard calls for total renewable fuels “sold or introduced into commerce in the United States” to reach 36 billion gallons by 2022. Within this standard, ethanol derived from corn is to reach 15 billion gallons in 2015. RFS2 essentially doubled the previous corn-based ethanol mandate of 7.5 billion gallons for 2012. The remainder of the RFS2 standard is to consist of “advanced biofuel” with specific volumes designated for cellulosic biofuels and biomass-based diesel.

- **ETHANOL CAPACITY AND PRODUCTION**

  - Ethanol production capacity has tripled in the U.S. since 2006. In May 2010, there were 201 ethanol refineries in the U.S. with nameplate capacity of 13.5 billion gallons per year. Most of the plants currently in operation utilize corn as the feedstock. There are about 700,000 gallons of idle capacity and 1.2 billion gallons of capacity under construction (Source: Renewable Fuels Association, 2010). Idle capacity has been an issue since the corn price spike in 2008. Negative processing margins due to rising input costs followed by weaker ethanol prices led to financial stress for the industry. The idle capacity is slowly coming back, but with processing margins near breakeven, the incentive to restart plants is limited. Within the next year or two, plants under construction should be completed. Once these plants are on line, capacity will total 14.7 billion gallons. Therefore, it doesn’t appear that plant capacity will be a limiting factor in reaching the 15-billion-gallon corn-based ethanol portion of the RFS2.

  - As part of the EISA, biofuels must meet new greenhouse gas emission thresholds based on a lifecycle assessment using the petroleum fuels they replace as the baseline. The assessment was conducted by the Environmental Protection Agency (EPA). For corn-based ethanol, the threshold is a 20% reduction in greenhouse gas emissions. Corn ethanol plants under construction before December 19, 2007, were grandfathered in and are qualified to produce ethanol under EISA without needing to meet the greenhouse gas reductions. However, ethanol plants that commenced construction after that date must meet the 20% reduction in greenhouse gas emissions. Under the EPA’s methodology, most corn–ethanol production processes will meet the 20% threshold and won’t be a significant constraint to industry expansion.

- **DISTILLERS GRAIN PRODUCTION AND USE RISE DRAMATICALLY**

  - The dry mill process produces approximately 2.8 gallons of ethanol and 17 to 18 pounds of distillers grain from a bushel of corn. Because the starch is removed for ethanol production, the remaining distillers grain contains approximately three times the amount of protein, fiber, and fat as raw corn. Distillers grain is classified as a mid-protein feed, but is most often fed as an energy source in dairy and beef cattle rations. Industry estimates suggest that 75% to 80% of the distillers grain produced is fed to beef and dairy cattle. This is because ruminants are better able to utilize the high fiber levels in distillers grain than swine or poultry. Corn wet mill plants can also produce ethanol and co-product feeds including corn gluten feed and gluten meal, but since most of the increase in ethanol production is from dry mill plants, our focus is on their various co-product feeds (loosely described as distillers grains).
High-protein DDG is produced through a fractionation technology. In this process, bran and germ are removed from the corn, resulting in endosperm that is used for ethanol production. The co-product that results is high-protein DDG, which contains between 41% to 45% crude protein. It contains more protein but less fat and fiber than conventional DDG, allowing for higher inclusion rates in feed rations. Recent research from the University of Illinois found that high-protein distillers grain could replace 100% of the soybean meal in a finishing pig’s diet. This is without any negative effects on performance or carcass characteristics as long as the diet is fortified with lysine, threonine and tryptophan.

A 2006 USDA study indicated that 36% of beef feeding operations and 38% of dairy cattle operations were using co-products. Only 12% of hog operations were using co-products. However, 30% to 35% of those who were not using co-products were considering them. The most common reasons for not using co-products were availability, infrastructure and handling, with nearly 50% of respondents citing these issues. If transportation and storage issues can be resolved it would imply a larger domestic market for distillers grain. The industry is also working to reduce the variability in the feed’s nutrient content from plant to plant and even from batch to batch from a single plant.

As ethanol production increases, the additional supply of distillers grain must be utilized domestically or exported. Figure 5 depicts the steep increase in distillers grain production over the past 12 years. Production has soared from less than 3 million metric tons (mmt) in the late 1990s to 30.5 mmt in 2009/10, a ten-fold increase. Distillers grain production is forecast to reach 37 mmt by 2014/15. With more raw corn used for ethanol production, more distillers grain is available to replace raw corn in feed rations.

Corn feed use has decreased sharply over the past few years with corn delivered to ethanol plants and distillers grain production being offered into the market for feed. Since 2004/05, aggregate livestock numbers have increased 2%, but raw corn feed use is down 14% (850 million bushels). There are no statistics on feed consumption directly, but the implied decline in raw feed use is relatively close to the equivalent amount of distillers grain production in the U.S. net of exports. This strongly suggests that distillers grain is increasingly replacing raw corn in feed rations. With additional growth in distillers grain production over the next few years in conjunction with rising renewable fuel mandates, distillers grain use will hold raw corn feed and residual use in check.

Distillers grain exports are increasing steadily, climbing from about 0.7 mmt 10 years ago, to an estimated 6 mmt in 2009/10. Distillers grain exports are expected to climb to nearly 10 million metric tons within the next four to five years. Exports become more important sources of demand as adoption rates increase and inclusion levels in domestic feed rations near their upper limits.

Mexico is the number one destination for distillers grain exports. Exports to Mexico of this ethanol co-product totaled 1.4 mmt in 2008/09, a five-fold increase from three years earlier. Canada has traditionally been the second largest importer of distillers grain from the U.S., at 0.7 mmt last season. This represents a 600% increase from 2005/06. However, China’s imports of distillers grain have surged over the past six months. At the current pace, China will eclipse Canada and become the second largest importer at 1.5 mmt and will even rival Mexico as the largest destination. Mexico and Canada accounted for 42% of total distillers grain exports in 2008/09. Based on Doane’s 2010 forecast, Mexico and Canada, along with China, will make up over 50% of total exports. Several Asian destinations have also emerged as important markets for distillers grain exports.

With further increases in distillers grain production expected, the DDG/corn price ratio is likely to remain under pressure as distillers grain must compete aggressively with corn and other feeds for inclusion in feed rations.
Corn for ethanol has essentially accounted for all the growth in corn demand over the past 10 years. In fact, corn use for purposes other than for ethanol has declined slightly since 1999/2000. Corn use for both feed and export did increase through the mid-2000s, but has since eased and totals nearly 8.6 billion bushels, down from 8.95 billion in 1999/2000. In contrast, corn for ethanol has soared to 3.8 billion bushels this year, driving total corn demand in the U.S. to 13 billion bushels in 2009/10.

U.S. CORN ACREAGE REACHES 60-YEAR HIGH

One of the most significant impacts of the ethanol boom has been a sharp increase in the level of corn plantings. To determine the impact that ethanol has had on corn acreage, we compared corn supply and demand using a much lower ethanol production growth rate since 2004/05 with the actual corn demand. The lower growth rate was based on USDA’s February 2005 Baseline Projection (USDA-OCE, 2008). The 2005 baseline was done prior to the implementation of renewable fuel mandates. We also adjusted corn feed and residual use to reflect lower co-product feed availability, resulting in higher raw corn feed and residual use.

Using the lower corn for ethanol growth rate, only about 75 million acres of corn were needed to meet 2010 demand. That compares to expected 2010 plantings of 89.90 million acres. This 2010 analysis suggests corn acreage would be 14-15 million acres higher if not for the sharp increase in corn for ethanol production. Rather than acreage increasing by 7-10 million acres from nearly 81 million acres in 2004, corn acreage needed to meet demand would have declined by about 6 million acres as rising yields offset the growth in consumption.

Year-to-year yield gains have increased over the past 10 years compared to the prior 10, 20 or 50 years. Since 2000, yields have increased by about 2.9 bushels per acre per year compared to 2.1 bushels per acre per year during the 1990s, compared to the 50-year trend increase at 1.9 bushels per acre. Boosting the trend yield by 1 bushel per acre from 1.9 to 2.9 doesn’t seem too dramatic, but over 10 years it adds 10 bushels to the trend yield or about 800 million bushels to production, tempering the need for additional acreage. The higher trend yield has reduced the need for additional acreage to meet ethanol demand by about five million acres. In other words, rather than expectations for corn plantings nearing 90 million acres in 2010, plantings would need to be closer to 95 million acres to meet growing ethanol demand if not for the higher trend yield over the past 10 years.

The forecast for the next five years assumes yield growth of 2.5 bushels per acre per year, the middle ground between the slower growth rate of the past 50 years and the faster yield increases of the past 10 years.
Corn and Alternative Biofuels Feedstock Sources

CORN PRICES MOVE TO NEW, HIGHER PLATEAU

The expansion of corn-based ethanol production has had a profound impact on corn prices. As the price chart illustrates, corn prices ranged from $1.75 per bushel to $2.50 per bushel from 2000 through 2004, with prices briefly climbing to near the $3 mark in 2004. From 2005 to the present, prices have ranged from $3 to $5 per bushel.

In the five years prior to the ethanol boom, corn prices at the farm level averaged $2.12 per bushel. Since 2005/06, corn prices have averaged $3.38 per bushel, an increase of $1.26 per bushel. Corn disappearance for purposes other than for ethanol has made the largest contribution and likely accounts for much of the increase in prices over the past four to five years.

The percent stocks-to-use (ending stocks as a percent of annual use) is commonly used as an indicator of surplus or shortfall. Stocks-to-use below 10% is considered tight or only a marginal supply, while 20% or higher is considered adequate or a surplus. For the first half of the current decade, percent stocks-to-use averaged 15.2%. Including Doane’s estimate for 2009/10, the percent stocks-to-use for the second half of the decade will average 13.2%. Expectations for stocks-to-use below 10% are forecasted into early years of the next decade due to tight supplies.

Nonetheless, corn prices are sharply higher. Clearly the difficulty is finding the money. Under pay-as-you-go rules, Congress must find offsets by taking the money from other programs to pay for tax credits, and that has been the main problem with renewing the tax credit for biodiesel. Still, with all of the benefits associated with the ethanol industry, Congress is expected to find a way to extend both the tax credit and the import tariff.

Corn prices are forecasted to gradually increase during the next five years with the season average price reaching nearly $4 by 2012/13.

Economic theory also tells us that as additional uses for corn are found without ready substitutes, the price elasticity of demand for corn should decrease with corn demand becoming more inelastic. The theory holds that the quantity of corn demand is now somewhat less responsive to changes in price than it was five years ago, before the ethanol boom. Generally, this is positive for prices. It should be noted that while corn prices have grown, the additional revenues have been capitalized into costs to farmers in the form of higher land rents and other input prices.

CHALLENGES FACING THE BIOFUEL INDUSTRY (INCENTIVE SUPPORT)

A bill to extend the 45-cent-per-gallon Volumetric Ethanol Excise Tax Credit (VEETC) has been introduced by Senators Conrad and Grassley. The bill would also extend the 54-cent-per-gallon tariff on imported ethanol through the end of 2015. Congressional action is needed or the tax credit and the tariff will expire at the end of 2010. A similar biodiesel tax credit was allowed to expire at the end of 2009, and production of biodiesel has plunged. Most members of Congress favor the ethanol support programs, but the difficulty is finding the money. Under pay-as-you-go rules, Congress must find offsets by taking the money from other programs to pay for tax credits, and that has been the main problem with renewing the tax credit for biodiesel. Still, with all of the benefits associated with the ethanol industry, Congress is expected to find a way to extend both the tax credit and the import tariff.

A recent study by the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri indicated that if the tax credit and import tariffs are not extended at the end of 2010, corn use for ethanol would decline by about 500 million bushels per year from the baseline forecast (Meyer and Thompson, 2010).

Another important policy decision being considered is the ethanol blend rate in gasoline. The U.S. Environmental Protection Agency (EPA) has approved a waiver to the Clean Air Act that allows higher levels of ethanol to be blended into gasoline. The EPA has approved the ethanol blend rate to 15%, up from the current rate of 10%. The agency was initially expected to announce a decision in December 2009, but oil companies, automakers and fuel sellers largely opposed the move and the EPA opted to delay an announcement on the basis that results of long-term tests wouldn’t be available until mid-2010.

A waiver of E15 raises logistical concerns. Many automobiles still require E10 to fuel their small engines. Retailers could offer both E10 and E15. However, increased costs associated with this solution will be a significant hurdle to increased ethanol consumption. Another obstacle is that some states have gasoline regulations that limit the blend rate. It’s also likely that any waiver will prompt litigation on several fronts, thereby delaying implementation.
What is clear is that without higher ethanol blend rates, ethanol production is approaching the “blend wall.” Ethanol production is expected to reach 12.6 billion gallons this year, well above the 12.0 billion gallon RFS mandate. Motor fuel consumption in 2010 as forecast by the Energy Information Administration is 138 billion gallons. Adjust gasoline for ethanol’s inclusion, and the calculation indicates that ethanol makes up nearly 10% of U.S. gasoline consumption.

These are aggregate totals which include all ethanol products. Recent data also suggest that more than 80% of U.S. gasoline production is currently being blended with ethanol. With ethanol blending exemptions for small refineries totaling nearly 15 billion gallons per year, ethanol is approaching full market potential, or in industry terms, the “blend wall.”

The blend wall is also a barrier to meeting the RFS2 mandates. Barring an unexpected surge in E85 demand, it appears that the ethanol blend rate will remain below 10% for the remainder of the year. These mandates will continue to represent a large portion of the increase in corn demand and account for more than one third of total use. Per-acre-yield gains will help meet increased demand, but additional acreage will likely be needed, too. Corn prices are expected to trend higher as stock levels are gradually reduced. However, ethanol does face some challenges. Policies regarding ethanol’s tax exemption and blend rate are important in determining future ethanol growth and, in turn, corn demand.

**LEGISLATED DEMAND (DOMESTIC AND INTERNATIONAL)**

The impact of RFS2 on corn-based ethanol and other fuels is significant. Biodiesel benefitted from the incentives afforded by federal funding authorities as well. The subsequent lapse of incentives for biodiesel has demonstrated that a mandate itself does not necessarily support a fledgling industry. While the regulatory requirement for biodiesel will need to increase to at least 12% to meet the RFS2 mandates through 2015.

The April 23, 2009, directive also states that the “demonstration and commercialization phase” must be supported. This is a key consideration, as the fledgling industries that are expected to grow need to be given sufficient support to develop into reliable sources of energy.

The EU’s plan for biofuels is based on a broad-based environmental and economic concept. Comparatively, the U.S. model was developed with the mindset of an economic/crop use framework with environmental and energy self-reliance as supporting factors. Arguably, if the EU is to meet its goal for transportation energy (as well as a 20% share of overall energy use from renewable sources), the U.S. market for agricultural products will likely be supported greatly with global stocks being used to produce high volumes of energy.

The acceptance of imported fuels and feedstocks, with continued support of government funds and mandates, will help the EU to reach a targeted renewable fuels standard, while strengthening the market for U.S. agricultural products.

**SUMMARY THROUGH 2010**

The incredible growth in ethanol production has had a huge impact on the corn market, particularly over the past five years. The growth rate will slow over the next five years, but increased ethanol production will continue to represent a large portion of the increase in corn demand and account for more than one third of total use. Per-acre-yield gains will help meet increased demand, but additional acreage will likely be needed, too. Corn prices are expected to trend higher as stock levels are gradually reduced. However, ethanol does face some challenges. Policies regarding ethanol’s tax exemption and blend rate are important in determining future ethanol growth and, in turn, corn demand.

**THE OUTLOOK FOR BIOFUELS BEYOND 2010**

The incredible growth in ethanol production has had a huge impact on the corn market, particularly over the past five years. The growth rate will slow over the next five years, but increased ethanol production will continue to represent a large portion of the increase in corn demand and account for more than one third of total use. Per-acre-yield gains will help meet increased demand, but additional acreage will likely be needed, too. Corn prices are expected to trend higher as stock levels are gradually reduced. However, ethanol does face some challenges. Policies regarding ethanol’s tax exemption and blend rate are important in determining future ethanol growth and, in turn, corn demand.

**THE POLITICS OF BIOFUELS: JUST WORDS, OR IMPORTANT CONSIDERATIONS?**

A common theme in any biofuels discussion on future capacity is to look at the political winds, where there is a strong basis for this mindset. Markets might grow without external pressure for renewable fuels as consumers seek alternatives to petroleum-based fuels. However, the tremendous growth in corn-based ethanol seen in the U.S. was linked closely with subsidies, market protection and mandates that originated with political clout. The intense focus and corresponding growth in next-generation biofuels will likely be associated with legislative and regulatory considerations that seek a social benefit that might otherwise not be valued in the marketplace. Indeed, the influence of government policies should be a part of any outlook for biofuels or viable feedstocks that are considered for the energy harvest.
Corn and Alternative Biofuels Feedstock Sources

Farmers, farm organizations and agribusinesses across the U.S. pooled their support for the development of corn ethanol. Resistance in the fuel markets due to technical difficulties and economic impacts were eventually overcome. But broad support from a political base was utilized because these groups had a desire for market expansion of a crop that was already prevalent. Who grows algae? Who will benefit from an expansion of this potential feedstock?

A public sector investment for a product that utilizes a feedstock not harvested commercially on a broad basis may be required. Cellulosic ethanol from feedstocks such as wood, straw, grasses and specialty crops has been proposed. The flagship cellulosic plant for Verenium in Jennings, Louisiana has been a testing ground for enzymes to more readily access the energy contained in plant materials. The Jennings plant has also been a study in sugar cane bagasse as a feedstock. The annual capacity of 1.5 million gallons in this plant is a pilot-scale operation. Verenium has been awarded DOE grants for examining cellulosic potential. However, investment from the oil industry, with BP funding certain projects, may be a stronger sign that future market penetration may occur.

**NEXT-GENERATION BIOFUELS: MEETING NEEDS VS. REPLACING CORN**

The commercialization of alternative fuels has not occurred to the levels necessary to meet U.S. mandates. Indeed, only now is research being initiated to explore how to harvest feedstocks on a pilot-project basis. Transformation to a commercial scale can be much more difficult when a laboratory is replaced by a refinery. When corn prices increased dramatically for ethanol plants, lack of profitability resulted in shuttered plants. If plants are not able to cover variable costs, economic theory says they will shut down. While some ethanol plants may have covered their initial capital expenditures during their first few operating years, that does not guarantee they will remain viable.

Ethanol production was at 175 million gallons in 1980 and rose to 9 billion gallons in 2008. By consistently applying the highest year-over-year growth rate recorded during this period for ethanol capacity to non-corn biofuels production capacity (after the 35 million gallons under construction is included), we could achieve 20.23 billion gallons in 2022. This is slightly short of the legislated mandates for next-generation renewable fuels.

POET, a leader in corn ethanol production, has plans for a 25-million-gallon-per-year (mgy) cellulosic ethanol plant that would use corn cobs as feedstock. The intention is to use this plant (known as Project LIBERTY) to demonstrate the commercial scalability of next generation biofuels. This would be the first large-scale cellulosic plant. While the stated goal is to "make" cellulosic ethanol economically feasible, that will require a number of conditions that are not in POET’s control. This includes the need for a DOE loan guarantee to begin construction of the LIBERTY facility. The increase from 20,000 gallons per year in POET’s pilot plant to 25 mgy will be challenging as well.

**CHAMPIONS FOR GROWTH**

Ethanol expansion during the past few decades has benefited from the coordinated efforts of engineering firms and ethanol pioneers who were marketing, developing and building substantial capital from outside investors - often farmers. The technology and processes for ethanol plants could be replicated readily. That expansion plan is not feasible at this time for commercial next-generation biofuels plants.

POET plans to leverage its cellulosic ethanol system to produce 3.5 billion gallons by 2022. This includes adopting the technology in its existing corn ethanol plants through licensing to other producers, and transferring the technology to process other feedstock materials. As an early adopter, POET could receive a significant economic return, but it also runs a large risk. Uncertainty in the regulatory environment, competition from cleaner or lower-cost fuel sources, increased or unexpected costs for feedstock acquisition and even the expansion of the technology itself from pilot to commercial scale pose significant risks.

Environmental issues will need to be addressed with the potential harvesting of crop residues and grasses as biofuel feedstocks. The volume of residue left after harvest can impact soil erosion and the level of fertilization needed to replenish harvested soil nutrients. Further analysis of the total carbon lifecycle for biomass fuel production of various types will need to be addressed. Transportation of materials with lower density can mean that each load contains less energy to harvest, or that more energy is required to prepare and transport the material to a central biofuels plant.

Initial steps are being taken for the first generation of cellulosic ethanol production (sometimes referred to as second-generation biofuels). However, fledgling industries often take a long time to develop larger commercial operations - much less become profitable.

The development of commercial operations that can be replicated will have the potential to drive growth in next-generation biofuels further and faster than we’ve seen with corn ethanol. This would be necessary to meet existing mandates for advanced biofuels.

**SUMMARY**

Corn ethanol is likely to remain a large source of demand for the U.S. corn crop into the foreseeable future. If the baseline is to include current mandates and trade policies, corn will have a place at the biofuels table for some time. The replacement of corn ethanol with next-generation biofuels is not likely in the next decade given the existing infrastructure and political landscape. Dramatic changes in the commercialization of next-generation fuels will be necessary as existing policies remain status quo. Even with this potential commercialization of alternatives, corn ethanol production would need to be priced higher than market ready alternatives that meet renewable fuel requirements to slow growth in the demand of corn for fuels - much less to diminish existing demand for corn. Sunk costs in existing plants means corn ethanol producers only need to cover variable costs to continue operation.
Corn and Alternative Biofuels Feedstock Sources

Environmental regulations impacting farms and the production of corn could result in higher overall commodity prices - but these issues will impact the broader economy as well as biofuels. Energy legislation could increase the cost of producing corn, but it may also increase the demand for corn ethanol. It is the structure of these policies that will determine the economic impacts.

International biofuels policies, such as the mandates in Europe for renewable fuels, will likely provide support for U.S. crop demand. This could increase competition for domestic production. Industry expectations are that continued increases in crop yields can meet anticipated needs. These expectations will continue to be a reason why alternatives are sought for corn ethanol.

Corn should maintain its role as a major energy crop into the foreseeable future. Alternative biofuels are simply not available on a commercial basis at this time due to trade policies.

KEY INDICATORS TO WATCH

Legislative and Regulatory Issues

Look for potential changes that may impact biofuels as a whole and individual types of fuel and feedstocks. Waivers from mandates are as likely as incentives for specific fuels if commercialization does not keep pace with legislative targets. The political battleground that will erupt should technology arise for an even lower-emission fuel source could also impact renewable fuels negatively.

Trade

If imports of cane-based ethanol from sources such as Brazil are allowed with lower barriers (tariffs, etc.), the competitiveness of corn ethanol will come into greater scrutiny. The carbon impact of cane biofuels will be an interesting question as well. Potentially lower carbon expression with cane ethanol may be challenged with the global impact of acreage shifts.

Non-Biofuel Technology Shocks

Hydrogen cells and other factors could result in cleaner fuel technologies than combustion engines powered by renewable biofuels. Social and environmental aspects of fuels are broadly based and consider more than agriculture. If lower cost and emissions are possible with systems outside of those using existing crops, markets for biofuels could dissipate quickly.

Biofuels Transformation Technology

Advances in biofuels transformation technology with enzymes and other processes may also spur growth in next-generation fuels. These would be unlikely to replace corn unless they’re at a lower cost.

Feedstock Technology

Biotenology may allow for increased energy to be obtained from existing corn acres. The social and regulatory acceptance of industrial biotechnology with food-and feed-based products can be a difficult road to travel. However, this could renew the call for an advanced corn ethanol as a new and larger champion for the environment and energy security.

Commercialization Rates

When next-generation biofuels are rolled out beyond the laboratories and into the pumps, there will be more than a blip on the media scene. When the technologies are in place, there will be a ramp-up for commercial application. The first commercial advanced biofuels plant is likely years away for second-generation biofuels, with additional years for any expansion or replication.

Biomass Crops

Switchgrass, elephant grass, specialty biomass have limited current marketability beyond research and pilot-scale biofuels plants. Broad acceptance of these crops for a biofuels production process is limited by the demonstration that these processes are economically and environmentally viable. Pilot-scale biofuels plants that utilize these crops for a single purpose will demand limited volumes.

As pilot-scale plants are replaced with commercial-volume plants, there will be a need for additional acres for feedstock purposes, with overall volume dependent on the size and number of plants that are "online." The ability of producers to focus on these crops will likely be limited to a large degree by their proximity to biofuels plants utilizing alternative feedstocks. Limiting production and market risks with coordination through contracting and general relationships management practices will be likely when these crops are demanded for commercial biofuels production. An open market is unlikely.

Petroleum Prices

Are biofuels an additive or a substitute for petroleum-based fuels? This is a question that will drive a lot of economic arguments. As an additive that is mandated, biofuels can derive a potential premium. As a substitute, they will be somewhat more limited to the market price of gasoline. High sustained petroleum prices will encourage research, investment and utilization of biofuels.

The Economy

The ability of the U.S. to sustain incentive payments in several areas is in question. Balancing the economy’s need for fuels with the delicate economic position of the biofuels industry - especially next-generation biofuels - is critical.
This white paper was published for PNC Bank by Doane Advisory Services.

This material is intended to provide readers with useful information. It does not constitute the provision by PNC of legal, tax, accounting or investment advice to any person or a recommendation to buy or sell any security or adopt any investment strategy. PNC is not responsible for the accuracy of the information contained in this material. The views expressed by the authors are not necessarily the views of PNC. Any law, regulation or other information discussed should be independently reviewed in its entirety before it is relied on in any particular situation.