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Betting on **biofuels**

The industry is still in its infancy but evolving rapidly. Companies that hope to compete must devise their entry strategy now.

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Billions of dollars, euros, pounds, and reais are pouring into biofuels. High fuel prices and generous regulatory support have given the industry healthy margins and relatively short investment payback times. Meanwhile, the triumphs of the first movers and dreams of future growth are enticing companies in industries from petroleum and agribusiness to biotechnology, chemicals, engineering, and financial services. And of course, the allure of a greener future has raised the expectations of investors and bystanders who hope that biofuels will help meet the world's energy needs while lowering greenhouse gas emissions.

Can biofuels deliver? The answer appears contingent on fuel prices as well as three other variables that directly influence the profitability and environmental impact of biofuels: the cost and availability of feedstock, government regulation, and conversion technologies. All are in flux, so an investment today is a bet on how these interrelated factors will evolve. Feedstock costs vary tremendously by region and could change significantly in the years ahead. Governments may alter the industry's ground rules to match changing priorities in climate change, energy security, and economic development. The energy, cost, and carbon efficiency of various biofuels are already quite different,[1] and new conversion technologies

[1] Corn ethanol, for instance, generates only 30 percent more energy than is required to make it, whereas sugarcane ethanol generates 8.3 times more energy, according to the International Energy Agency.

Article at a glance

The emerging biofuel industry is attractive to many companies but full of uncertainty.

Major factors affecting the industry's profitability—feedstock costs, regulation, and technologies—are in flux.

Despite these uncertainties, waiting to enter might be costly because resources are in short supply.

Companies that decide to enter now will have to mitigate risk by hedging their bets and building relationships that could help reduce uncertainty and volatility.

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could make them even more so—at different rates in different regions. Decisions about where to produce and distribute biofuels could have dramatic implications for the feasibility of the business.

Amid all this uncertainty, why enter now? In many commodity industries, the winners are the latest entrants, at the bottom of the cost curve—wielding the newest, most efficient technologies. But waiting may be a costly strategy in the nascent biofuel industry because land and other essential resources are at a premium.

Biofuel players should consider different ways to mitigate the risks, but every strategy will require trade-offs. Betting on a number of geographies and technologies will make things more complex, for example, but helps balance risk. Vertical integration, though both complex and costly, may be essential in helping to establish this young industry. Companies that want to play should try to get a head start on the difficult task of reducing the seemingly infinite number of options to a feasible set of solutions.

A world of uncertainty

Not long ago, the biofuel industry was relatively straightforward. Producers mostly used mature technologies and local feedstock to supply domestic markets with a single biofuel: bioethanol from cornstarch (in the United States) and sugarcane (in Brazil) or biodiesel from rapeseed oil (in Europe). Now, as global demand increases, companies are beginning to produce and sell biofuels in a number of geographies—and that's when things start to get tricky.

In many industries, the factors affecting returns vary geographically, and companies combine locations accordingly. With biofuels, these factors are particularly dynamic, often interconnected, and mostly uncertain. Two of them—feedstock costs and government regulation—are critical to any geographic strategy today, and conversion technologies will increasingly affect production costs as next-generation processes become

commercialized. (Capital expenditures vary tremendously across regions, but no more so in biofuels than in any other industry.)

Feedstock costs and consequences

Feedstock accounts for 50 to 80 percent of biofuel production costs, so its price has a huge effect on the producers' returns. In the United States, for example, every dollar increase in the price of a bushel of corn raises the production cost of bioethanol by $0.35 a gallon and reduces the producer's operating margin by 20 percent.[2] Many different forms of biomass can be used as feedstock, and costs vary hugely by region. Fermentable sugars from Brazil's sugarcane, for example, are less than half as expensive as those from European sugar beets. Government subsidies and alternative uses of feedstocks also affect feedstock costs.

In many regions, rising demand threatens both the cost and availability of feedstock. From 2003 to 2006, the percentage of the total US corn harvest used to produce biofuels rose to 16 percent, from 12 percent. But now that the federal government has adopted a goal of 35 billion gallons of alternative fuels a year by 2017, the use of domestic corn-based bioethanol to meet even half of this target would require 40 percent of that year's expected harvest. Not surprisingly, the cost of corn has soared: average wholesale prices rose from $1.90 a bushel in 2005 to $2.41 in 2006, and corn has regularly surpassed $4 a bushel on the spot market since late 2006.

Other unintended consequences of greater demand could bring a consumer backlash like the one that broke out in Mexico when tortilla prices skyrocketed because of bioethanol-related corn shortages. Environmental concerns were also raised after last autumn's burning of Indonesian forestland to make space for palm oil crops that were linked to increasing demand for biodiesel. The environmental impact of other aspects of biofuel production, including the widespread cultivation of fast-growing jatropha (a plant that produces a toxic vegetable oil), are unknown.

Government regulations

Whether through subsidies, import tariffs, or research grants, government regulation has helped drive both demand and profitability in the industry. Because the energy policies of most nations are still evolving, regulation is perhaps the greatest uncertainty of all. Lower subsidies, for example, could diminish profits. A production cost of about $2.90 a gallon and

[2] This analysis assumes that crude oil costs $40 a barrel.

a government subsidy of $1.81 a gallon helped German producers to earn $0.42 for every gallon of biodiesel in 2006. The role of taxpayer money in creating new millionaires hardly went unnoticed, and the government decided to eliminate these subsidies, gradually, by 2012, replacing them with a mandated blend rate (the percentage of conventional fuel that blenders must replace with biofuel). Blend rates guarantee producers a certain level of sales, but the elimination of subsidies and the fact that supply will likely exceed mandated demand in the short term should depress margins. In such a market, companies generate attractive returns only when the cost curve is steep and lower-cost producers operate under the price umbrella established by marginal, high-cost producers. Since vegetable oil, itself a globally traded commodity, accounts for 80 percent of the production cost of biodiesel, the biodiesel cost curve isn't steep. Analogies with industries that have similar cost structures suggest that biodiesel margins could fall by 80 percent from 2006 levels.

The impact of mandated blend rates is also unclear. US regulators could set any ethanol blend rate from 10 percent (the maximum suitable for current vehicles) to 85 percent (the maximum suitable for most flex-fuel vehicles).[3] Minnesota, for example, has mandated a 20 percent ethanol blend rate to take effect in 2013. What's more, mandated blend rates below 85 percent could be met either with the uniform blending of biofuels at the mandated rate or with a disproportionately high share of high-biofuel blends. All of these regimes would increase overall demand, but they could have vastly different effects on bioethanol companies and on other businesses, particularly car manufacturers. For now, car companies can keep selling vehicles with current engine designs, but some already plan to offer more flex-fuel vehicles, which use high-concentration biofuels, conventional fuels, or a mix of the two. Of course, the way carmakers deal with these issues will influence their other product-development decisions, especially for different low-carbon approaches, such as hybrid or hydrogen-fuel-cell cars.

Other policies are also in flux. With some exceptions,[4] current biofuel regulations in the European Union and the United States protect domestic producers, but these policies—especially import tariffs—may change. Regulators increasingly recognize that current trade policy, which taxes imports of ethanol but not of petroleum, may not serve the goal of energy

[3] Maximum ethanol blend rates also vary geographically. Current regulations in Europe allow up to only 5 percent ethanol in gasoline blends, whereas in Brazil the government encourages higher ethanol blend rates and flex-fuel vehicles already account for 85 percent of new-car sales.

[4] The Caribbean Basin Initiative, for example, allows Caribbean producers to avoid tariffs on up to 7 percent of total US biofuel consumption. The proposed free-trade agreements between the United States and Latin American nations such as Peru provide for the duty-free import of sugar. Likewise, the European Union's "Everything but Arms" agreement provides for duty-free imports of all products (other than armaments) from developing countries.

security. As evidence amasses confirming sugarcane ethanol's importance for reducing carbon emissions,[5] regulators may ease restrictions on its importation.

The impact of new conversion technologies

New conversion technologies are going to cut overall production costs. Regional variations will either validate geographic strategies for biofuels—or turn them on their heads.

Take, for example, bioethanol, produced when microorganisms such as yeast ferment sugars into ethanol. Next-generation technology will allow producers to use the sugars that make up cellulose (the main structural component of plants). Cellulose is found in all manner of vegetation, so cheap feedstocks—such as corn stover, sugarcane stalks (bagasse), and high-yield "energy crops" like switchgrass, energy cane (a relative of sugar cane), and wood—will become important feedstocks. The technology involves "pretreating" feedstocks physically or chemically and then using enzymes to digest the cellulosic components to release the fermentable sugars. For every step, competing technologies are under development.[6] Each could lead to different production processes, biorefinery designs, and costs.

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When this "lignocellulosic" technology becomes commercially viable—as early as 2010, by some estimates—the savings in costs and carbon emissions will vary by feedstock. Since feedstocks vary by region, their costs could change a region's attractiveness to producers. Consider these examples:

- Today biofuel production in China is uncompetitive, because feedstock costs are relatively high. Cellulosic technology, however, could lower production costs to as little as $0.60 a gallon, from about $1.80, making Chinese bioethanol one of the world's cheapest biofuels.

- In the United States and Brazil cellulosic ethanol production costs won't be much lower than today's corn- and sugarcane-based ethanol

[5] Per-Anders Enkvist, Tomas Nauclér, and Jerker Rosander, "A cost curve for greenhouse gas reduction," *The McKinsey Quarterly*, 2007 Number 1, pp. 34–45.

[6] Enzymes, for example, can be made separately and added exogenously to the pretreated biomass, expressed directly in a genetically modified feedstock plant, or produced by the fermentation organisms.

costs. Facilities processing cellulosic material thus will likely supplement rather than replace older ones, though cellulosic technology would have a significantly better energy balance when compared with the corn ethanol currently produced in the United States.

- In Europe cellulosic technology could lower production costs enough to threaten companies producing beet (or wheat) ethanol with current methods.

Governments can help to advance technologies, but not without risk. In 2006 the government of Spain allocated $29 million to finance a joint Spanish-Argentine biodiesel research project. Likewise, the US Department of Energy recently announced $385 million in grants to six different cellulosic ethanol research projects. Technology could make it practical to use biobutanol, a molecule that outperforms ethanol as a premium gasoline replacement. Biodiesel, though far from cost competitive with regular diesel today, could in time be produced from jatropha, which provides a low-cost vegetable oil and can be cultivated on marginal land. Biomass-to-liquid (BTL) technology, a gasification process long used to convert coal into fuels, could eventually make it possible to produce high-quality synthetic diesel and gasoline. Most of these new technologies have yet to prove that they can be cost competitive. However, farsighted governments should avoid policies that favor today's technologies at the expense of tomorrow's.

Placing the right bets to manage risk

Companies that enter the market now can mitigate uncertainty by hedging their bets and forming relationships that may help them reduce volatility and influence regulation.

The argument against waiting

Understandably, some companies will wait for technology to advance and the regulatory landscape to evolve before entering. After all, in commodity industries, early entrants often lose out to latecomers using larger-scale, more modern technologies. Such leapfrogging has occurred time and again—for example, in the steel industry.[7]

Nonetheless, in any complex industry, early entrants can gain a valuable lead in understanding its technologies, operations, and economics, as well as through influencing local regulation. When companies face high levels of uncertainty in variables they can influence, taking steps to shape

[7] Andrew Carnegie, August Thyssen, and Alfried Krupp used large, integrated works to eclipse British steelmakers in the late 19th century. Kawasaki Steel and Nippon overtook US steelmakers following World War II. More recently, South Korea's Pohang Iron and Steel became a formidable competitor, with efficient, low-cost steelworks.

Modeling supply and demand in the biofuel industry

McKinsey recently brought a fact-based perspective to the future of the global biofuel industry. After interviewing more than 80 current and potential industry participants and leading academics, we created a database on the availability and cost of feedstocks, as well as a bioethanol supply-demand model that incorporates the impact of crude oil prices, government regulation, and new technologies.

We make three important assumptions: only land that does not have to be deforested will be available for feedstock production, cellulosic technology and high-density ranching practices will be used extensively, and agricultural products will be devoted to biofuels only after demand for food and animal feed is met. Our model suggests that there is sufficient land to cultivate almost four billion tons (that is, one thousand million tons) of feedstock a year—in theory, enough to produce bioethanol providing more than 50 percent of total transportation fuels by 2020.

The availability of feedstock is critical, but the economic viability of bioethanol also depends on its cost effectiveness vis-à-vis gasoline. The higher the price of crude oil, the wider the gap between gasoline prices and bioethanol production costs. Crude oil at $40 a barrel (our base-case scenario) would provide for the economical production of 70 billion gallons of bioethanol a year by 2020—about seven times current production and 10 percent of the total demand for transportation fuel. At up to $50 a barrel, bioethanol could replace as much as 30 percent of all transportation fuel economically (exhibit). At $70 to $80 a barrel, the replacement of up to 50 percent of all transportation fuel would in theory be economically viable, and the availability of feedstock would limit the industry's further growth. Subsidies, which were not considered in this model, could also trigger higher penetration rates.

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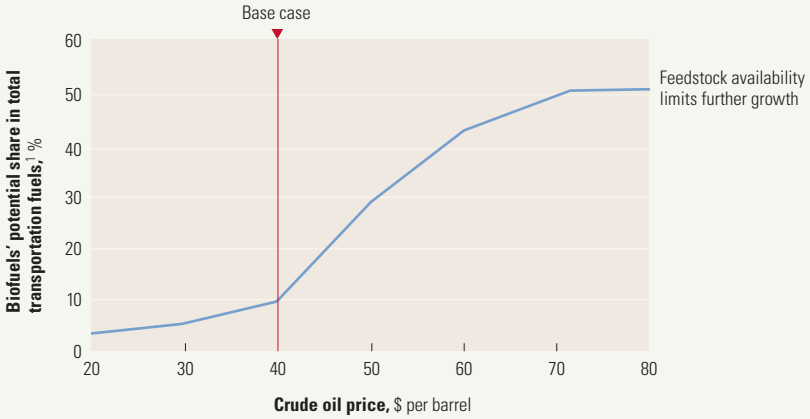
EXHIBIT

The economic viability of biofuels

Impact of crude oil prices on economic-replacement potential of biofuels



[1] Based on transportation fuel outlook for 2020.

Source: Expert interviews; Food and Agricultural Policy Research Institute (FAPRI), United States; UN Food and Agriculture Organization (FAO); McKinsey analysis

outcomes can make sense.[8] Some companies and investors will enter now to capitalize on today's high prices, but market conditions could easily change before new factories begin operation. Prices of biofuels, unlike those of pure commodities, are greatly influenced by the cost of competing products, such as gasoline and diesel fuel (see sidebar, "Modeling supply and demand in the biofuel industry").

For companies with long-term aspirations in biofuels, the strongest argument against waiting is that certain vital resources are in short supply. Biofuel companies will need partners, for instance, and the best may soon be taken. Similarly, the cultivation of feedstocks, like many agricultural undertakings, is most efficient on large expanses of land. Even in the absence of deforestation, hundreds of thousands of hectares for growing feedstock are available, but large swaths in the choicest areas are not. Land in Brazil's highly developed São Paulo region, for example, is expensive, in part because it is close to urban demand centers. More land is available in the country's untapped, relatively inexpensive northeast and interior, but building an infrastructure to reach it would be pricey.

How to play now

The way companies determine their strategy will depend on the subsector of biofuels where they play. Three distinct segments have emerged.

- Asset owners (including agribusinesses, petroleum companies, chemical companies, plant operators, and small farmers) are heavily invested in producing and marketing biofuels. They grapple with uncertainties in the long-term attractiveness of geographies, as well as with technological change.

- Product and service providers (including seed companies, engineering and equipment companies, and biotechnology firms developing enzymes and fermentation organisms) tailor their technologies and processes to the needs of the biofuel industry. Their strategies are mostly not specific to geography, and they face technological and commercial risk.

- Market participants (including gasoline blenders, farmers, agricultural-equipment companies, suppliers of inputs such as fertilizers, and logistics providers) benefit when the growth of the biofuel industry increases demand in their core businesses.

All of these players, whatever their subsector, need to make smart bets in a few key areas:

[8] Hugh Courtney, "Making the most of uncertainty," *The McKinsey Quarterly*, 2001 Number 4, pp. 38–47.

Betting on geographies and technologies. Asset owners and, to a lesser degree, market participants have increasingly entered the international biofuel trade, mixing and matching geographies for production and distribution to balance risk and investment. In the United States, for example, demand is all but guaranteed thanks to the world's most ambitious biofuel targets, a well-developed infrastructure, and generous subsidies, but feedstock constraints could continue to put most of the profits in the pockets of farmers or landowners. Undeveloped tropical regions in Africa, Asia, and Central America—especially those that have free-trade agreements with the European Union or the United States—seem appealing, but they pose political and economic risks of their own and require significant investments in infrastructure.

Companies can mitigate some geographic risk (and reduce payback periods) if they acquire producers operating under known conditions. By acquiring older ethanol plants and introducing modern management practices, Cosan, for example, improves its plants' operating performance and recovers its acquisition premiums. Many smaller, undermanaged plants in Brazil and the United States could also flourish under new owners—either large multinational industrials or private-equity firms.

To deal with technological risk, asset owners should invest in a number of options. BP, for example, founded the Energy Biosciences Institute (EBI), in California, which hosts leading industry research groups and gave it $500 million in sponsorship funds. In return, the company gains early knowledge of—and the right of first refusal for—much of the intellectual property developed there. Shell, by contrast, has invested in companies researching both lignocellulosic and gasification processes (including BTL) for biomass conversion. While BP's approach gives it broader exposure to breakthroughs in fundamental science and technology, Shell's offers a more intimate relationship with companies closer to the commercial application of technologies.

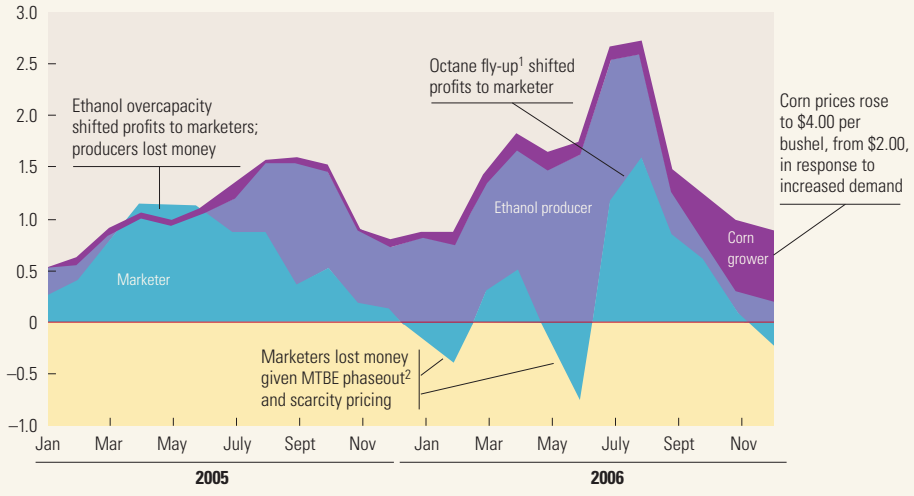
For product and service providers, mitigating technological risk means commercializing intellectual property. They can partner with major (future) asset owners for access to a sizable captive market (as DuPont did in a joint venture with BP to develop biobutanol) or collaborate with other product and service providers. One biotechnology company, Novozymes, is working with Broin, a leading engineering firm that will use the Novozymes enzymes technology in every new ethanol plant it constructs.

Building relationships. The establishment of young industries often calls for coordinated efforts all along the value chain. Building a biofuel industry

EXHIBIT

High volatility

Profit margin captured by value chain player, $ per gallon



[1]Sudden price increase.
[2]MTBE = Methyl tert-butyl ether, chemical compound used as antiknocking additive in gasoline; phaseout enacted in response to risk of MTBE contamination of ground water.

Source: Bloomberg; Platts; McKinsey analysis

in a new geography, for example, requires the simultaneous application of skills in agronomics, feedstock and fuel procurement, storage, distribution, refinery operations, commodities trading, and the influencing of local regulation. No asset owner can claim all these skills, so most companies would benefit from true or virtual integration (for example, through partnerships) along the value chain.

Even in more developed markets, integrating along the value chain can diminish risk and volatility. In the United States from January 2005 to November 2006, for example, changes in some state regulations of fuel—the shift from MTBE (methyl tert-butyl ether) to ethanol as an antiknocking additive—and the increase in prices of gasoline and gasoline components created substantial fluctuations in the demand for and price of corn ethanol. Simultaneously, a shortage of corn and the resulting high prices triggered large swings in the allocation of profits between farmers and asset owners (exhibit). Integrating the cultivation and production of feedstocks removes the latter source of uncertainty.

Biofuel companies must also build relationships with the government agencies that regulate biofuels and the nongovernmental organizations that influ-

ence public opinion. Proponents of biofuels can identify potential areas of cooperation and conflict by analyzing these players' concerns (including consumer advocacy, environmental protection, and fair trade) as well as the economic interests of groups such as farmers, petroleum companies, auto manufacturers, and food companies.[9]

Biofuels have a tremendous potential to give the world efficient and sustainable energy, but much about the industry remains uncertain. Those who enter it today must bet carefully on geographies and technologies and establish the right relationships at critical points along the value chain. Q

[9] Scott C. Beardsley, Denis Bugrov, and Luis Enriquez, "The role of regulation in strategy," *The McKinsey Quarterly*, 2005 Number 4, pp. 92–102.

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