FEATURE

The Future of Biofuels

A Global Perspective

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With near record oil prices, the future of biofuel—made from plant material—is of keen interest worldwide. Global biofuel production has tripled from 4.8 billion gallons in 2000 to about 16.0 billion in 2007, but still accounts for less than 3 percent of the global transportation fuel supply. About 90 percent of production is concentrated in the United States, Brazil, and the European Union (EU). Production could become more dispersed if development programs in other countries, such as Malaysia and China, are successful. The leading raw materials, or feedstocks, for producing biofuels are corn, sugar, and vegetable oils.

While rapid expansion in biofuel production has raised expectations about potential substitutes for oil-based fuels, there have been growing concerns about the impact of rising commodity prices on the global food system. According to the International Monetary Fund, world food prices rose 10 percent in 2006 because of increases in corn, wheat, and soybean prices, primarily from demand-side factors, including rising biofuel demand. The Chinese Government put a moratorium on expanded use of corn for ethanol because of rising feed prices and is promoting other feedstocks that do not compete directly with food crops, such as cassava, sweet sorghum, and jatropha (an oil-bearing plant originally from South America).

Mexico capped tortilla prices in early 2007 to contain food price inflation from higher priced corn imports. Real sugar prices hit a 10-year high in 2006, stressing budgets of low-income people in Brazil and elsewhere. Prices have since declined. The Indonesian Government increased the export duty on crude palm oil, also used in biodiesel production, in mid-2007 to slow the rising cost of domestic cooking oil.

U.S. livestock producers are facing increased costs for corn and other feed, which may translate into higher retail meat prices. And in Japan, historical concerns have been revived about the country's almost complete dependence on imports of feed grain and oilseeds to support its large livestock sector.

The outlook for global biofuels will depend on a number of interrelated factors, including the future price of oil, availability of low-cost feedstocks, sustained commitment to supportive policies by governments, technological breakthroughs that could reduce the cost of second-generation biofuels, and competition from unconventional fossil fuel alternatives.

A New Era of High Oil Prices Attracts Investment in Biofuels

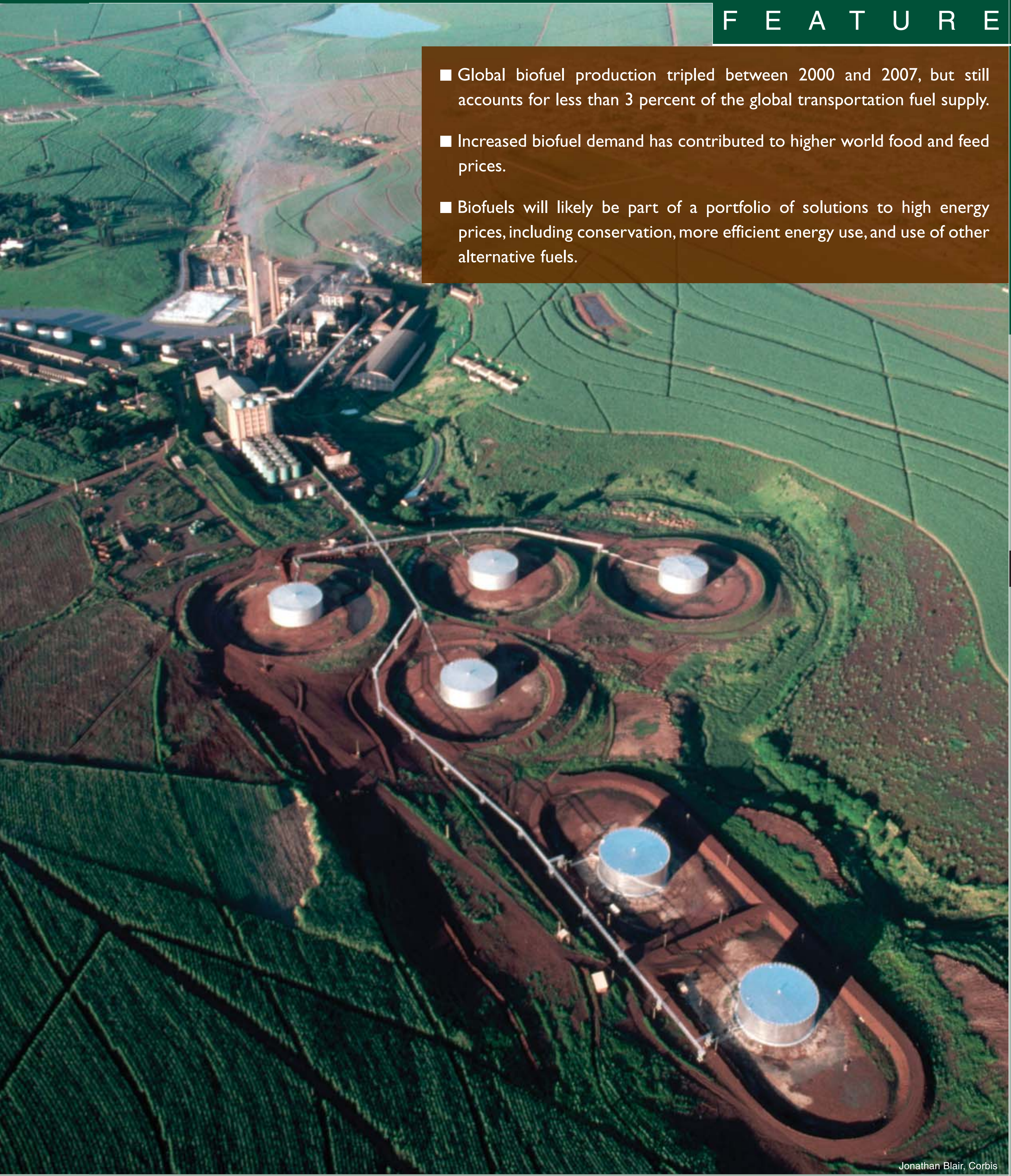
The rise in oil prices is the most important factor boosting the competitiveness of alternative fuels, including biofuels. The unprecedented 6-year rise in oil prices has prolonged opportunities for efficiency gains, stimulated energy conservation, and generated increased supply from traditional and alternative energy sources. While these adjustments may eventually lower oil prices, most forecasts do not show real prices falling below $50 per barrel.

Previous periods of high oil prices were short. Prices tended to rise very sharply, usually induced by military conflict, peaked in a matter of weeks or months, and then declined sharply. Following these price spikes, the rapid decline in petroleum prices made it difficult to sustain alternative fuel programs and reduced incentives for consumers to curb their use of petroleum products.

Unlike previous high-price periods, the current oil market is driven by strong demand-side factors. These factors include robust economic growth and rising oil demand from rapidly growing middle-income economies, where consumers are demanding a higher standard of living and exhibiting big appetites for energy. Almost two-thirds of recent global growth in oil demand has come from China and other middle-income economies.

Profitability of Biofuels Depends on the Availability of Low-Cost Feedstocks

Feedstock costs are the most significant cost of biofuel production, ranging from 37 percent for sugarcane-based ethanol in Brazil in 2003-04 to 40-50 percent for corn-based ethanol in the United States. Sugar beets represented 34 percent of the cost of sugar-



- Global biofuel production tripled between 2000 and 2007, but still accounts for less than 3 percent of the global transportation fuel supply.
- Increased biofuel demand has contributed to higher world food and feed prices.
- Biofuels will likely be part of a portfolio of solutions to high energy prices, including conservation, more efficient energy use, and use of other alternative fuels.

Jonathan Blair, Corbis

based ethanol production in the EU. With rising commodity prices, these cost shares are even higher now. Another major cost component is energy, which may account for as much as 20 percent of biofuel operating costs in some countries.

The ratio of crude oil prices to feedstock prices offers a simple indicator of the competitiveness of biofuel made from various feedstocks. The ratio of crude oil to corn prices, for example, rose sharply after 2004 as oil and ethanol prices increased and corn prices were stable. But the ratio dropped sharply after September 2006, making biofuels less cost competitive. Biodiesel producers in Europe and Southeast Asia also faced declining competitiveness as soy and palm oil prices rose in 2006-07. World sugar prices, on the other hand, declined by 50 percent from 10-year highs in 2006, boosting relative prospects in Brazil's ethanol sector.

The sale or productive use of byproducts also contributes to a biofuel plant's profitability. Dried distillers' grain (DDG), a byproduct of corn ethanol production, can be used as a protein-rich livestock feed additive. Sales of DDG can add as much as 10-15 percent to ethanol producers' incomes. Carbon dioxide, usually released into the atmosphere, is captured by some ethanol plants and sold for use in the food and beverage sector. Bagasse, the fibrous material left over from pressing sugarcane, can be burned to provide heat for distillation and electricity to power machinery or sold to local utilities. Glycerin, a byproduct of biodiesel production, has a wide number of pharmaceutical, food-processing, and feed applications.

Government Support Is Used To Reduce Volatility

Strong long-term government intervention is a feature in the two top biofuel-producing countries—the United States and Brazil (see box, "Lessons From Brazil")—as well as the EU, China, and other countries. Governments justify support in the name of achieving broad societal goals: to diversify energy sources, to enhance energy security, and to meet environmental and rural development objectives. Governments tend to introduce support to help fledgling biofuel ventures overcome cost and scale disadvantages and weather the inherent volatility in profits.

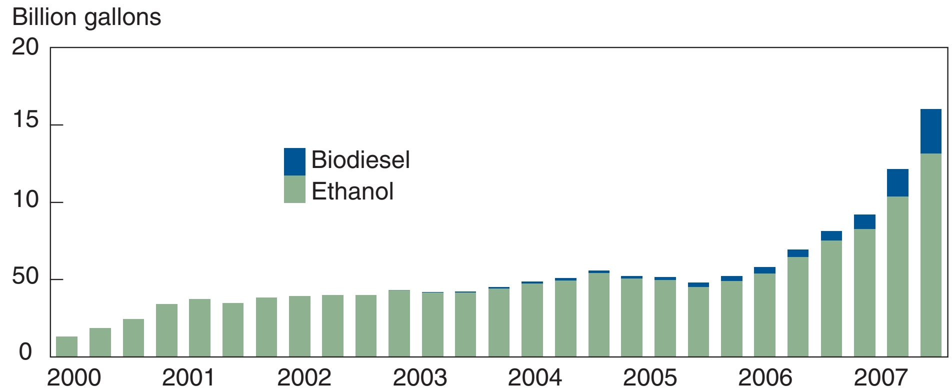
Governments have introduced a variety of policy tools that reduce risk and uncertainty in response to investor and producer concerns about the double-edged uncertainty of volatile feedstock and energy input prices and biofuel output prices. The most common tool is a requirement to blend biofuel with its fossil fuel counterpart to provide a guaranteed market for biofuels. The nature of this requirement varies around the world in the extent to which it is mandatory, the phase-in period, the volume or blend percentage mandated, and whether a nationwide or regional strategy is used.

Countries also rely on subsidies, tax credits, and preferential taxes to overcome the higher cost of biofuel production relative to gasoline and diesel and to encourage consumers to buy biofuel-containing gasoline or diesel. Europe offers an 18.7-euro per acre energy premium for production of biofuel feedstocks. India's Government offers sugar mills interested in setting up ethanol production facilities subsidized loans for 40 percent of project costs. Brazil encourages consumption by imposing a lower sales tax for hydrous ethanol (containing water) and E25 (25 percent ethanol) than for gasoline.

The United States provides a $.51 per gallon tax refund for blenders of ethanol and $1.00 per gallon for biodiesel from vegetable oils and animal fat ($.50 for recycled cooking oil or animal fat). Some States also provide support, and other Federal incentives are provided for smaller biofuel plants.

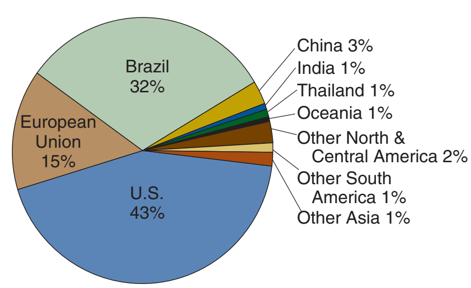
Import restrictions are also used to promote the emerging biofuel industry. Effective tariffs range from 9 percent in Canada (for ethanol imports from Brazil, 0 tariff for renewable fuels from the U.S.) to about 45 percent for undenatured and 24 percent for denatured ethanol in the EU. Import duties and tariffs are waived by the EU for many developing countries (not

Global biofuel production tripled between 2000 and 2007



Source: International Energy Agency; FO Licht.

About 90 percent of global biofuel production is concentrated in U.S., Brazil, and Europe, 2007



Source: FO Licht, includes only ethanol for fuel.

William Coyle, ERS/USDA

including Brazil). The U.S. tariff on ethanol is currently about 25 percent when the 2.5-percent tariff is combined with the $.54 per gallon duty.

Brazil is the only country promoting biofuel use beyond minimal blending levels by allowing consumers to choose it as a fuel substitute. The Brazilian Government has promoted the availability of ethanol at almost every gasoline station and the manufacture of flexible fuel cars (capable of using pure gasoline, E25, or pure hydrous alcohol). Proposed U.S. legislation would also provide incentives for expanding E85 distribution and the manufacture of more E85-capable vehicles.

While biofuels share similar attributes with oil-based fuel, they are not perfect substitutes. Biofuels can be used in existing gasoline and diesel engines in blends of up to 10 percent in the case of ethanol and 20 percent for biodiesel with little or no engine modification. This compatibility contrasts with hydrogen fuel cell technology, which would require a radically different distribution system.

However, ethanol has only two-thirds the energy content of gasoline, and biodiesel has 90 percent that of diesel. Thus, a car will get fewer miles per gallon the greater the biofuel blend. Shipping ethanol is more expensive; it cannot be transported by low-cost pipelines because of potential contamination from ethanol's tendency to absorb water and to dissolve impurities on the inside surfaces of multiproduct pipelines. Dedicated pipelines for ethanol are being considered in Brazil and the United States and may become economical with expanded production.

Looking to the Future: The Potential of Second-Generation Biofuels

Many uncertainties remain for the future of biofuels, including competition from unconventional fossil fuel alternatives and concerns about environmental tradeoffs. Perhaps the biggest uncertainty is the extent to which the land intensity of current biofuel production can be reduced. The amount of biofuel that can be produced from an acre of land varies from 100 gallons per acre for EU rapeseed to 400 gallons per acre for U.S. corn and 660 gallons per acre for Brazilian sugarcane.

Cellulosic ethanol could raise per acre ethanol yields to more than 1,000 gallons, significantly reducing land requirements. Cellulosic ethanol is made by breaking down the tough cellular material that gives plants rigidity and structure and converting the resulting sugar into ethanol. Cellulose is the world's most widely available biological material, present in such low-value materials as wood chips and wood waste, fast-growing grasses, crop residues like corn stover, and municipal waste.

U.S. cellulosic fuel production costs are now estimated at more than $2.50 per gallon, compared with $1.65 per gallon for corn ethanol. Venture capital and government subsidies are supporting companies interested in making cellulosic ethanol commercially viable, primarily in the United States, but also in several other countries, including Canada, Brazil, China, Japan, and Spain.

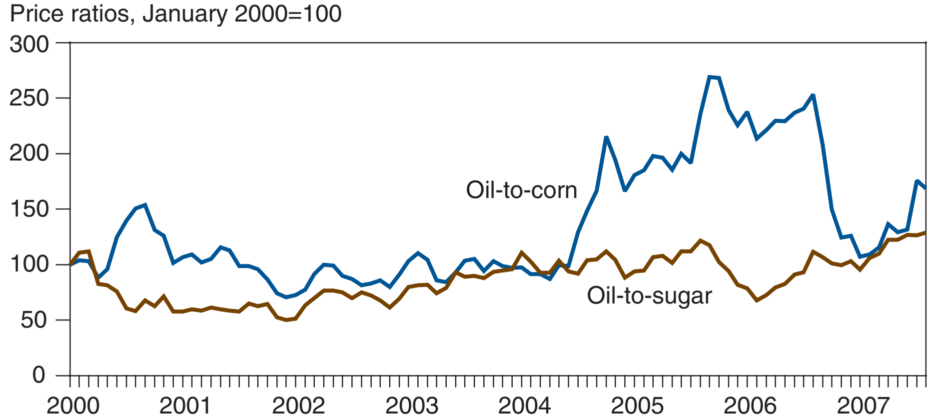
In the meantime, other costs of cellulosic ethanol production need to be fully assessed, such as the impacts of harvesting grasses, trees, and crop residues on the erodibility and fertility of land resources. There are also questions regarding the upstream logistical and environmental costs of harvesting, transporting, and storing large volumes of bulky feedstock used in processing.

Competitive Fossil Fuel Alternatives

High oil prices have drawn attention not only to biofuels, but to a range of other liquid fuel alternatives. Large investments are being made in developing more difficult-to-access conventional oil resources located in remote areas or deeper waters, unconventional sources, such as oil sands and heavy crude oil, and the conversion of coal to oil. While world oil production is expected to increase 30 percent by 2030, production from unconventional fossil fuels will increase even faster, according to the U.S. Department of Energy. Global biofuel production is projected to more than double. Many of the fossil fuel alternatives have lower costs of production than biofuels. Canada's oil sands, for example, can produce

Corn ethanol profits were more subdued in 2007

Price ratios, January 2000=100



Source: USDA, Economic Research Service and Federal Reserve Bank of St. Louis.

oil for $30 per barrel. Current production is more than 1 million barrels per day, with some forecasting production rising to more than 3.5 million barrels per day by 2030.

Another alternative is converting coal to oil, which is of particular interest to economies with abundant coal resources, such as China and the United States. Oil prices of $40 per barrel may be sufficient to make this process profitable despite high investment costs.

What Are the Environmental Tradeoffs?

A key interest in developing or expanding biofuel production and use is the environmental benefits, including the potential to reduce emissions, such as greenhouse gases (GHG). An estimated 25 percent of manmade global carbon dioxide (CO_2) emissions, a leading GHG, comes from road transport. Global road transport has grown rapidly over the past 40 years and is projected to continue to increase, especially in middle-income countries experiencing rapid economic growth, middle-class expansion, and urbanization.

Both biofuels and gasoline give off CO_2 when burned. Biofuels are theoretically carbon neutral, releasing CO_2 recently absorbed from the atmosphere by the crops used to produce them. Gasoline and other fossil fuels add to the CO_2 supply in the atmosphere by giving off CO_2 absorbed and trapped in plant material millions of years ago.

The advantage of biofuels is less clear in a "life-cycle" analysis that examines not just combustion, but the production and processing of the feedstock into fuel. Most studies indicate that the net energy balance of biofuels is positive (energy output is greater than energy input), but estimates vary widely. Net balances are small for corn ethanol and more significant for biodiesel from soybeans and ethanol from sugarcane and from cellulose. The biofuel with the highest net energy balance reduces GHG the most when compared with that for gasoline.

Biofuel blending targets, selected countries

Country	Feedstocks		2007 production forecast (million gals.)		Blending targets
	Ethanol	Biodiesel	Ethanol	Biodiesel	
Brazil	sugarcane, soybeans, palm oil	castor seed	4,966.5	64.1	25 percent blending ratio of ethanol with gasoline (E25) in 2007; 2 percent blend of biodiesel with diesel (B2) in early 2008, 5 percent by 2013.
Canada	corn, wheat, straw	animal fat, vegetable oils	264.2	25.4	5 percent ethanol content in gasoline by 2010; 2 percent biodiesel in diesel by 2012.
China	corn, wheat, cassava, sweet sorghum	used and imported vegetable oils, jatropha	422.7	29.9	Five provinces use 10 percent ethanol blend with gasoline; five more provinces targeted for expanded use.
EU	wheat, other grains, sugar beets, wine, alcohol	rapeseed, sunflower, soybeans	608.4	1,731.9	5.75 percent biofuel share of transportation fuel by 2010, 10 percent by 2020.
India	molasses, sugarcane	jatropha, imported palm oil	105.7	12.0	10 percent blending of ethanol in gasoline by late 2008, 5 percent biodiesel blend by 2012.
Indonesia	sugarcane, cassava	palm oil, jatropha	--	107.7	10 percent biofuel by 2010.
Malaysia	none	palm oil	--	86.8	5 percent biodiesel blend used in public vehicles; government plans to mandate B5 in diesel-consuming vehicles and in industry in the near future.
Thailand	molasses, cassava, sugarcane	palm oil, used vegetable oil	79.3	68.8	Plans call for E10 consumption to double by 2011 through use of price incentives; palm oil production will be increased to replace 10 percent of total diesel demand by 2012.
United States	primarily corn	soybeans, other oilseeds, animal fats, recycled fats and oil	6,498.7	444.5	Use of 7.5 billion gallons of biofuels by 2012; proposals to raise renewable fuel standard to 36 billion gallons (mostly from corn and cellulose) by 2022.

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Sources: FO Licht; USDA.

Another important environmental consideration is the potential land requirements if biofuels become a more mainstream fuel. According to the University of Minnesota, devoting all U.S. corn and soybean acreage to ethanol and biodiesel production would offset only 12 percent and 6 percent of gasoline and diesel consumption for transportation fuel, respectively, and even less if adjustments were made for the fossil fuel requirements for producing the biofuel.

Use of so much land to meet a relatively small share of transportation fuel demand is improbable. The resource commitment to meet domestic fuel demand would be less in a lower income economy. Expanding feedstock production, however, that encroaches on fragile rainforest areas and wildlife habitats is still a concern in countries like Indonesia, Malaysia, and Brazil.

Future Role of Biofuels Depends on Profitability and New Technologies

Technological advances and efficiency gains—higher biomass yields per acre and more gallons of biofuel per ton of biomass—could steadily reduce the economic cost and environmental impacts of biofuel production. Biofuel production will likely be most profitable and environmentally benign in tropical areas where growing seasons are longer, per acre biofuel yields are higher, and fuel and other input costs are lower. For example, Brazil uses bagasse, which is a byproduct from sugar production, to power ethanol distilleries, whereas the United States uses natural gas or coal.

The future of global biofuels will depend on their profitability, which depends on a number of interrelated factors. Key to this will be high oil prices: 6 years of steadily rising oil prices have provided economic support for alternative fuels, unlike previous periods when oil prices spiked and then fell rapidly, undercutting the profitability of nascent alternative fuel programs. On the other hand, the sector's profitability has been negatively affected by rising feedstock prices (corn and vegetable oil, not sugar), which account for a very large share of biofuel cost of production. For this commodity-dependent industry, government support to reduce profit uncertainty has been a common theme in the U.S., Brazil, and the EU, where biofuel production has been most significant.

Biofuels will most likely be part of a portfolio of solutions to high oil prices, including conservation and the use of other alternative fuels. The role of biofuels in global fuel supplies is likely to remain modest because of its land intensity. In the U.S., replacing all current gasoline consumption with ethanol would require more land in corn production than is presently in all agricultural production. Technology will be central to boosting the role of biofuels. If the energy of widely available, cellulose materials could be economically harnessed around the world, biofuel yields per acre could more than double, reducing land requirements significantly. W

Lessons From Brazil

Brazil has the world's second largest ethanol program and is capitalizing on plentiful soybean supplies to expand into biodiesel. More than half of the nation's sugarcane crop is processed into ethanol, which now accounts for about 20 percent of the country's fuel supply.

Initiated in the 1970s after the OPEC oil embargo, Brazil's policy program was designed to promote the nation's energy independence and to create an alternative and value-added market for sugar producers. The government has spent billions to support sugarcane producers, develop distilleries, build up a distribution infrastructure, and promote production of pure-ethanol-burning and, later, flex-fuel vehicles (able to run on gasoline, ethanol-gasoline blends, or pure hydrous ethanol). Advocates contend that, while the costs were high, the program saved far more in foreign exchange from reduced petroleum imports.

In the mid- to late 1990s, Brazil eliminated direct subsidies and price setting for ethanol. It pursued a less intrusive approach with two main elements—a blending requirement (now about 25 percent) and tax incentives favoring ethanol use and the purchase of ethanol-using or flex-fuel vehicles. Today, more than 80 percent of Brazil's newly produced automobiles have flexible fuel capability, up from 30 percent in 2004. With ethanol widely available at almost all of Brazil's 32,000 gas stations, Brazilian consumers currently choose primarily between 100-percent hydrous ethanol and a 25-percent ethanol-gasoline blend on the basis of relative prices.

Approximately 20 percent of current fuel use (alcohol, gasoline, and diesel) in Brazil is ethanol, but it may be difficult to raise the share as Brazil's fuel demand grows. Brazil is a middle-income economy with per capita energy consumption only 15 percent that of the United States and Canada. Current ethanol production levels in Brazil are not much higher than they were in the late 1990s. Production of domestic off- and on-shore petroleum resources has grown more rapidly than ethanol and accounts for a larger share of expanding fuel use than does ethanol in the last decade.

This article is drawn from . . .

Ethanol Expansion in the United States: How Will the Agricultural Sector Adjust? by Paul C. Westcott, FDS-07D-01, USDA, Economic Research Service, May 2007, available at: www.ers.usda.gov/publications/fds/2007/05may/fds07d01/

Pacific Food System Outlook 2006-07: The Future Role of Biofuels, Pacific Economic Cooperation Council, November 2006, available at: www.pecc.org/food/pfso-singapore2006/PECC_Annual_06_07.pdf

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