



This ethanol plant in Carrollton, Mo., in the west-central part of the state, began production in May. The plant, owned by Show-Me Ethanol LLC, was built at a cost of more than \$80 million. Capacity is 55 million gallons a year.



# Ethanol

## Economic Gain or Drain?

*By Joshua A. Byrge and Kevin L. Kliesen*

Shucking the  
hype yields a  
kernel of truth  
—oil will still  
dominate

In 2005 and 2007, two pieces of energy-related legislation with potentially far-reaching consequences became law. A key feature of these bills was a federal mandate to substantially increase the production of ethanol over the next two decades. These bills were aimed at reducing U.S. dependence on foreign-produced petroleum and at addressing global climate change.

Even before the federal mandate, ethanol production had been increasing rapidly since 2000. Some of this can be traced to the sharp rise in crude oil prices, which is a derivative of the rapid growth in developing nations like China. At the same time, food prices have begun to rise sharply, which is sometimes attributed to higher prices for corn, the primary ingredient in ethanol.

What are the costs and benefits of the ethanol boom, and is increased production of ethanol the primary cause of rising food prices?

### **The Drivers of the Ethanol Boom**

According to the Renewable Fuels Association (RFA), ethanol production has increased by an average of almost 22 percent per year

from 2000 through 2007, as seen in the figure on Page 8. Over this period, the number of ethanol plants more than doubled, to 134. By January 2008, industry capacity stood at 7.9 billion gallons per year. According to the RFA, when all current building projects are completed, total capacity will exceed 13 billion gallons per year.

The surge in ethanol production can be attributed mainly to three factors: higher crude oil prices; federal production mandates and tax incentives given to ethanol producers; and the use of ethanol as a fuel oxygenate to replace methyl tertiary butyl ether (MTBE), which was phased out in 2006.<sup>1</sup>

#### *1. Higher oil prices*

From 2001 to 2007, the spot price of a barrel of West Texas Intermediate (WTI) crude oil rose from an average of about \$26 per barrel to a little more than \$72 per barrel. (See the figure.) Thus far in 2008, WTI prices have risen further, topping \$135 in May.

Unlike past oil-price shocks that were supply-driven (for example, the OPEC oil



embargo), this increase in crude oil prices mostly reflects increased demand, particularly from China and India. Of the 10.6 percent growth in world oil consumption from 2000 through 2006, China accounted for just over three percentage points—more than double the U.S. contribution.

A rise in oil prices naturally leads to an increase in motor fuel prices. Since early 2006, average U.S. motor gasoline prices have increased to nearly \$4 per gallon from \$2.25, while retail diesel prices have risen to about \$4.50 per gallon from about \$2.50 per gallon.

Higher oil prices elicit numerous responses from consumers and firms. In the short run, with few alternatives, demand for gasoline tends to be relatively unaffected. Over time, though, higher oil prices spur an increase in demand for alternative fuels and a decline in the quantity of oil demanded.

In the United States, the search for alternative fuels has chiefly focused on ethanol, which can be mixed with gasoline and

comes from plant material that is domestically grown, it is hoped that this mandate will, in the long run, reduce U.S. dependency on crude oil—a significant portion of which comes from regions with an unusually high level of political instability.

Originally, the Energy Policy Act of 2005 required that 5.4 billion gallons of biofuels be blended with gasoline in 2008. This amount would then increase to 7.5 billion gallons in 2012. The Energy Independence and Security Act of 2007 (EISA) increased the target for 2008 to 9 billion gallons and extended the mandate through 2022, when 36 billion gallons of biofuel are to be blended.

To achieve this policy goal, Congress has provided numerous incentives for domestic ethanol producers over time, such as subsidies and import tariffs. The Energy Tax Act of 1978 created the first ethanol subsidy by exempting motor gasoline containing ethanol from the gasoline excise tax. As the sidebar on the next page shows, the combination of rising crude oil prices and a government subsidy, much like today, created a boomlet in ethanol production.

The American Job Creation Act of 2004 replaced this exemption with a tax credit for gasoline blenders.<sup>2</sup> This credit is currently 51 cents per gallon. To protect domestic ethanol producers and to generate tax revenue to offset some of the cost of the ethanol tax credits, the U.S. imposes an import tax of 54 cents per gallon on ethanol imported for fuel.<sup>3</sup> All else equal, this tariff raises the price of ethanol to U.S. consumers.

Unlike gasoline or crude oil, there are no existing interstate ethanol pipelines; thus, ethanol is transported by truck or rail, which is why most ethanol plants are located in the Midwest. To spur development of the infrastructure necessary to increase ethanol-based fuel use, Congress is making money available to explore the feasibility of building an ethanol-dedicated pipeline.

Another drawback is that most vehicles can only accommodate fuel that is at most 10 percent ethanol. Hence, Congress has enacted tax incentives to increase the availability of flex-fuel vehicles, such as those that burn E85 (85 percent ethanol). Also, Congress is considering a mandate for ethanol distribution at gas stations in regions where flex-fuel vehicles are common.

## What Makes Ethanol Economically Viable?

In a 2003 study, Vernon Eidman and Douglas Tiffany found that the three most important factors in determining the profitability of an average U.S. fuel-ethanol plant were the price of ethanol, the plant's primary source of revenue; the price of corn, representing roughly 40 percent of the plant's input cost; and the plant's conversion factor, the pure ethanol yield per bushel of corn.

Eidman and Tiffany's model shows that ethanol plants were not profitable in 2000, when corn prices averaged about \$1.90 per bushel and oil prices averaged about \$30 per barrel.<sup>8</sup> In April 2008, however, with corn prices at about \$5.50 per bushel, ethanol would have been profitable to produce as long as the price of crude oil was at least \$96 per barrel. That month, the spot price of WTI was \$112.57 per barrel.<sup>9</sup>

burned in automobile engines. These fuels include E85, which is a blend of 85 percent ethanol and 15 percent gasoline, and biodiesel, which is produced mainly from soybean oil. But since alternative fuels are more expensive to produce than gasoline or diesel, ethanol's economic viability depends importantly on the price of corn and the price of crude oil, as seen in the sidebar above.

### 2. Government support for ethanol production

Since 2005, Congress has begun requiring that an increasing portion of U.S. motor fuel come from ethanol. Because ethanol





## The 1980s Ethanol Boom and Bust

The 1970s were a period of sharply rising crude oil prices, much like the past few years. In 1978, to spur development of alternative fuels, a 40-cent-per-gallon ethanol subsidy was enacted for producers.

In 1980, according to the Energy Information Administration, there were fewer than 10 ethanol production facilities in operation in the U.S., producing a total of about 50 million gallons.<sup>10</sup> In the same year, the Energy Security Act made insured loans available to small ethanol producers. Congress also enacted an import tax on foreign-produced ethanol. Finally, in 1983

and 1984, the ethanol subsidy was increased to 50 and then 60 cents per gallon, respectively. Meanwhile, oil prices, which had risen from about \$12 per barrel in early 1976, peaked at about \$40 per barrel in mid-1980 and then began to steadily decline.

In 1983, the number of ethanol plants peaked at 163. By August 1986, crude oil prices averaged less than \$12 per barrel and fewer than half of the domestic ethanol producers were still in business. A similar development might occur today if the surge in oil prices is not sustainable.

### 3. Ethanol as a fuel additive

In 1995, the federal government mandated the use of reformulated gasoline to help reduce smog in the cities experiencing the worst air pollution. To accomplish this, refineries primarily used MTBE as an additive. Four years later, 30 percent of the nation's gasoline was reformulated.

Over time, though, MTBE was found to be a groundwater pollutant. Beginning in 2006, as a consequence of the 2005 Energy Policy Act, refiners switched to ethanol as a gasoline additive. (In effect, the 2005 act did not provide liability protection against MTBE-related lawsuits.)

As MTBE was phased out, the demand for ethanol rose significantly. As a result, ethanol prices rose from an average of \$2 per gallon in December 2005 to nearly \$4.25 per gallon in mid-June 2006. As the supplies of ethanol increased, prices fell to an average of about \$1.90 per gallon in September 2006.

### Higher Food Prices and Ethanol

Ethanol produced in the U.S. is derived mostly from corn. Hence, the primary consequence of an increase in the demand for ethanol as a gasoline fuel additive is an increase in the demand for corn. With the federal government mandating a five-fold increase in ethanol production by 2022, it seems inevitable that an increasing share of the nation's corn crop will be devoted to ethanol production. The prospect of higher corn prices—and the prices of other commodities, as more acres are devoted to corn production—has raised the specter of a food-fuel debate in some quarters.

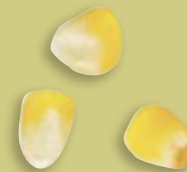
According to the U.S. Department of

Agriculture (USDA), the percentage of the domestic corn supply used to produce ethanol has increased from less than 5 percent in 2000 to 22 percent last year. The USDA's latest long-term projections indicate that nearly 5 billion bushels of corn, or about 31 percent of total projected supply, will be used to produce ethanol in 2017. At the same time, the USDA projects that the price of corn in nominal terms will fluctuate between \$3.50 per bushel and \$3.80 per bushel. Although this is considerably less than prices seen currently, it represents a substantial step-up from the roughly \$2.25 per bushel average price seen from 2000 to 2006.

The increased percentage of the corn crop used in ethanol production, according to the USDA, largely comes at the expense of corn used for livestock purposes (feed) and, perhaps more important, buffer stocks (inventory). In addition, the increased acreage devoted to corn reduces the area devoted to other important crops, like wheat and soybeans. All else equal, this means higher prices for those crops also.

For farmers, higher crop prices eventually lead to higher land prices, which has already occurred. At the same time, higher crop prices increase the cost of producing beef, poultry and chicken.

Critics of the U.S. ethanol mandate argue that this increase in commodity prices has led to increased food prices worldwide. In the U.S., the Consumer Price Index for food and beverages increased by more than 4.5 percent last year, following an average increase of 2.5 percent from 2000 to 2006. This trend has continued into this year. Researchers, such as C. Ford Runge and



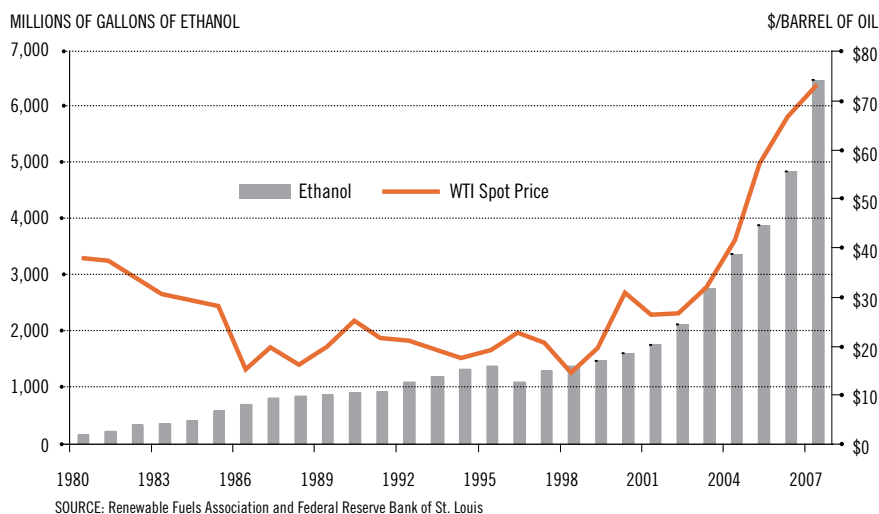
Benjamin Senauer, professors of economics at the University of Minnesota, argue that increased biofuel production will lead to even more significant price increases for consumers in poor and less-developed nations, where food expenditures are a larger portion of consumer incomes. These concerns were also recently noted by officials from the United Nations and the International Monetary Fund.

However, in the U.S. the percentage of the corn crop used to produce food for humans is projected by the USDA to decline only from 9.6 percent of total supply in 2007 to 9.4 percent of total supply in 2017. In effect, to compensate for the increased ethanol production, the USDA assumes that (1) corn yields will continue to increase and (2) that

the 1980s, and then has averaged about 20 percent since the 1990s.<sup>4</sup>

According to a study published recently by Texas A&M University, the approximate doubling of corn prices from 2004 (\$2.06 per bushel) to 2007 (\$4 per bushel) raised the farm cost of high fructose corn syrup in a 12-pack of soda from 11.5 cents to 22.2 cents. Similarly, when wheat prices rose from \$3.40 per bushel in 2004 to \$6.65 per bushel in 2007, the farm cost (wheat) in a loaf of bread rose from 5 cents to 9 cents. Thus, all else equal, if the price of bread in 2004 averaged \$2 per loaf, then its price would have been \$2.04 per loaf in 2007, an increase of 2 percent. However, the price of bread rose by 15.6 percent over this period. This suggests that some other factors have been more important in raising the price of bread and other commodities. One important factor has probably been higher energy prices.

## U.S. ETHANOL PRODUCTION AND CRUDE OIL PRICES



### Weighing the Benefits

Greater use of ethanol would make a dent in the demand for oil, albeit a pretty small dent. (Using all corn grown in the U.S. to produce ethanol would replace only 12 percent of the gasoline used for transportation in the U.S.<sup>5</sup>) Moreover, many experts contend that burning ethanol will lower greenhouse-gas emissions.

These potential benefits must be weighed against the potential costs of ethanol production noted above. But there might be other costs. For example, one study, co-authored by Princeton University lecturer Timothy Searchinger, claims that when the environmental effects of land clearing for ethanol source crops are taken into account, ethanol actually produces more carbon emissions than standard gasoline. Moreover, ethanol faces other environmental barriers, such as water and fertilizer intensity. One cost rarely discussed is the opportunity cost of scarce resources devoted to producing more corn.

For these and other reasons, Congress has begun to promote cellulosic ethanol, which could produce 250 percent more ethanol per acre than corn.<sup>6</sup> Of the 36 billion gallons of biofuels required by 2022—and nearly all of this is expected to be ethanol rather than biodiesel—16 billion must be from cellulose. One key source of cellulose is switchgrass, which is considerably cheaper to produce. However, as a recent academic study found,

there will be no major drought. The latter assumption might be crucial, given the projected decline in buffer stocks over time. Without adequate inventories (or imports), a major drought would probably cause a sharp increase in corn prices.

Another important, but often ignored, reason why higher raw commodity prices cannot fully explain the rise in food prices is that the commodity component of the consumer's food bill is relatively small. Over time, the farmers' average share of total consumer expenditures for domestically produced food has dropped measurably. This share averaged about 33 percent during the 1960s and 1970s, fell modestly to 26 percent during



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In McLean, Ill., farmer Mike Olson checks his crop as he augurs corn from a storage bin into a truck for delivery to a grain elevator. Olson said at that time (April 2007) that he planned to increase his corn planting to take advantage of rising prices for corn.

the infrastructure to support ethanol from switchgrass is “virtually nonexistent,” and the U.S. Department of Energy’s National Renewable Energy Laboratory has probably underestimated the costs of producing cellulosic ethanol by as much as 37 to 191 percent.<sup>7</sup>

Obviously, significant improvement in technology will be necessary to bring this form of ethanol to market. Moreover, if the 2022 mandate is met, the combination of corn and cellulosic ethanol produced in that year will be “energetically” equivalent to roughly 21 billion gallons of gasoline (15 percent of the gasoline used for transportation in 2005). In short, crude oil will remain the dominant source of motor fuels production.

Furthermore, the long-term benefit from ethanol production depends on its viability when compared to conventional fuels. A repeat of the 1980s’ decline in oil prices would most probably lead to a considerable departure of economic resources from ethanol production. This development could create pressure to extend or increase the federal tax credit and the import tax. Hence, meeting the federal mandates set by EISA might require even larger subsidies and government outlays than are currently anticipated.

One way to partly meet the federal mandate would be to remove the federal import

tax. This would allow imports of ethanol from Brazil, which is the world’s second-largest ethanol producer. According to a recent report by the Congressional Research Service, Brazilian ethanol enjoys a significant cost advantage relative to U.S.-produced ethanol. Moreover, since Brazilian ethanol is made from sugar cane, allowing increased imports from Brazil would lessen the potential supply pressures on U.S. feed grain production noted above. <sup>8</sup>

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## ENDNOTES

- <sup>1</sup> See the 2008 Economic Report of the President.
- <sup>2</sup> See Lazzari (2005).
- <sup>3</sup> See chapters 99 and 22 of the Harmonized Tariff Schedule of the United States (2008 Rev.1) at [www.usitc.gov/tata/hts/index.htm](http://www.usitc.gov/tata/hts/index.htm).
- <sup>4</sup> See [www.ers.usda.gov/data/FarmToConsumer/marketingbill.htm](http://www.ers.usda.gov/data/FarmToConsumer/marketingbill.htm)
- <sup>5</sup> See Hill, et al. (2006).
- <sup>6</sup> Currently, ethanol yield per acre of corn is 400 gallons while cellulose is expected to produce 1,000 gallons per acre or more. See Coyle (2007).
- <sup>7</sup> See Epplin et al. (2007).
- <sup>8</sup> See Doering, Hurt and Tyner (2006) for assumptions used in the Eidman/Tiffany model and to relate ethanol price with crude oil price. Here, we assume a production capacity of 40 million gallons per year and zero additive-premium value of ethanol.
- <sup>9</sup> These issues will be discussed at a conference co-sponsored by the St. Louis Fed at Washington University in St. Louis on Nov. 14, 2008. See inside back cover.
- <sup>10</sup> For more on the history of ethanol production and legislation, see [www.eia.doe.gov/kids/history/timelines/ethanol.html](http://www.eia.doe.gov/kids/history/timelines/ethanol.html).

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