



## IMPACT OF ETHANOL ON WORLD OIL DEMAND AND PRICES

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Biofuels expand the supply of motor fuel and reduce pressure on world crude oil supplies needed to refine gasoline. In a market environment of increasing demand for fuel led in large part by significant economic growth and development of the transportation sectors in China and India, and constrained global production, this means that a relatively small shortfall in supply can translate into a significantly larger short-term increase in price. This paper examines the impact of the production of 485 million barrels (20.4 billion gallons) of ethanol globally on the demand for crude oil needed to refine the gasoline displaced by ethanol use. When adjusted for energy content, 485 million barrels of ethanol are the equivalent of 320 million barrels of gasoline. If ethanol were not available for use, the world's refiners would need an additional 1.9 million barrels of crude oil per day (700 million barrels), or 2.2 percent of current world production. Given the inelastic demand for crude oil, a shortfall of this small magnitude would likely result in a short-term price increase of 27.5 percent. Using current prices as a guide (West Texas Intermediate crude of \$130 per barrel for the week ending May 23, 2008), without ethanol to expand the available fuel supply crude oil prices would be \$35.70 per barrel higher than they are currently! Looked at another way, world ethanol production is keeping crude oil prices 27.5 percent *lower* than would otherwise be the case.

World ethanol production reached 16.9 billion gallons in 2007 and is projected to total nearly 20.4 billion gallons this year.<sup>1</sup> This represents a near doubling of ethanol production in just five years. As shown in Table 1, 12 countries reported annual production in excess of 100 million gallons with the two largest producers – the U.S. and Brazil -- accounting for nearly 78 percent of global ethanol production. The growth in global ethanol production has been the result of increased interest in biofuels as a result of sharply rising oil and gasoline prices. The market for ethanol in the U.S. has benefitted from the decision of refiners to voluntarily remove MTBE from the market and from the Renewable Fuels Standard provisions of the 2005 and 2007 federal energy bills. Global ethanol production is expected to continue expanding as world crude oil prices increase to new record levels and remain high. In the U.S., the Energy Independence and Security Act of 2007 requires that 36 billion gallons of renewable fuels, largely ethanol, be used in the nation's motor fuel supply by 2022. According to the Renewable Fuels Association, the U.S. ethanol industry has current capacity to produce more than 8.5 billion gallons of ethanol and

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<sup>1</sup> F.O. Lichts World Ethanol & Biofuels Report. Vol. 6, No. 17. May 8, 2008

an additional 5.1 billions of new capacity are under construction and will come on-line within the next several years.<sup>2</sup>

Table 1  
World Ethanol Production  
(Million Gallons)

|              | 2004     | 2005     | 2006     | 2007     | 2008     | 2008 Share | Cumulative Share |
|--------------|----------|----------|----------|----------|----------|------------|------------------|
| U.S.         | 3,403.9  | 3,905.1  | 4,857.2  | 6,487.7  | 8,926.0  | 43.8%      | 43.8%            |
| Brazil       | 3,874.0  | 4,244.9  | 4,710.4  | 5,958.1  | 6,895.6  | 33.9%      | 77.7%            |
| China        | 924.7    | 924.7    | 937.9    | 990.8    | 1,017.2  | 5.0%       | 82.7%            |
| India        | 325.5    | 290.6    | 435.9    | 647.3    | 607.7    | 3.0%       | 85.7%            |
| France       | 219.3    | 240.4    | 237.8    | 303.8    | 396.3    | 1.9%       | 87.6%            |
| Canada       | 60.8     | 67.4     | 150.3    | 184.9    | 264.2    | 1.3%       | 88.9%            |
| Germany      | 60.8     | 92.5     | 199.5    | 184.9    | 216.6    | 1.1%       | 90.0%            |
| Thailand     | 65.2     | 81.6     | 101.2    | 104.5    | 149.3    | 0.7%       | 90.7%            |
| Russia       | 196.7    | 189.2    | 146.5    | 147.2    | 148.7    | 0.7%       | 91.4%            |
| Spain        | 88.3     | 100.2    | 115.6    | 112.2    | 132.1    | 0.6%       | 92.1%            |
| South Africa | 101.8    | 106.8    | 108.1    | 106.7    | 107.8    | 0.5%       | 92.6%            |
| U.K.         | 75.3     | 76.6     | 74.0     | 86.4     | 105.7    | 0.5%       | 93.1%            |
| All Others   | 1,350.1  | 1,392.2  | 1,515.5  | 1,627.5  | 1,401.5  | 6.9%       | 100.0%           |
| WORLD        | 10,746.4 | 11,712.2 | 13,589.8 | 16,942.1 | 20,368.7 | 100.0%     |                  |

Source: F.O. Licht; EIA

The 20.4 billion gallons of ethanol production expands the quantity of gasoline available to consumers around the world. Since ethanol has a lower energy content than gasoline, there is not a one-to-one substitution of ethanol for gasoline. The btu content of ethanol is about two-thirds that of gasoline (76,330 btu/gal for ethanol compared to 116,090 for gasoline).<sup>3</sup> Reflecting this, if ethanol were not available, the world's oil refiners would have to "find" an additional 13.4 billion gallons (320 million barrels) of gasoline to make up the shortfall. Considering that a 42 gallon barrel of crude oil typically produces about 19.2 gallons of finished gasoline, an additional 1.9 million barrels of crude oil per day, or 2.2 percent of current world supply, would be required to produce the 13.4 billion gallons of gasoline needed to make up for the lost volume of ethanol.<sup>4</sup>

<sup>2</sup> <http://www.ethanolrfa.org/industry/locations/>

<sup>3</sup> Low heating (LHV) from USDOE EERE Alternative Fuels & Advanced Vehicles Data Center. <http://www.eere.energy.gov/afdc/fuels/properties.html>

<sup>4</sup> Source for refinery yield (2007) is EIA Petroleum Supply Annual, Vol 1, Table 21.

Both the demand for and supply of crude oil are very inelastic in the short-run. That is, it takes relatively large movements in price to effect a small change in demand. Similarly, producers typically are unable to increase supply dramatically in the short-term. Consequently, even a small (2.2 percent) shortfall in the supply of crude oil to produce additional gasoline is expected to have a large impact on prices. As indicated earlier, given the inelastic demand for crude oil a shortfall of this small magnitude would likely result in a short-term price increase of 27.5 percent. Using current West Texas Intermediate crude prices of \$130 per barrel as a base, this would add \$35.70 per barrel to crude oil prices.<sup>5</sup>

This estimate was arrived at by applying a price flexibility coefficient to the change in crude oil supply that would result from removing the gasoline equivalent of 16.4 billion gallons of ethanol production from the world market to estimate the expected short-term price impact. This price impact was then applied to the average price of West Texas Intermediate crude oil for the week ending May 23, 2008.

Price flexibility is the percentage change in the price of a commodity associated with a one percent change in quantity, keeping all other factors constant.<sup>6</sup> The concept of price flexibility is particularly useful in a situation where supply is inelastic, that is, current production cannot be easily changed. Given current world production and inventories and refinery capacities the world oil markets fit this description. The price flexibility coefficient is the reciprocal of the price elasticity of the commodity in question. If demand for the product is inelastic (an absolute value of less than one) the value of the price flexibility coefficient will be greater than one meaning that prices are flexible.

Empirical studies of crude oil demand have shown that the demand for gasoline is inelastic particularly in the short run. This means that relatively large changes in price result in correspondingly small changes in demand. Two recent studies estimate the short-term and long-term price elasticities for crude oil using relatively recent data. In a 2003 paper published in the *OPEC Review*, Cooper used annual data for the period 1971 to 2000 to calculate short and long-term price elasticities for crude oil in 23 countries and estimated a short-run elasticity of -0.061 for the U.S. and a long-run elasticity of -0.453.<sup>7</sup> In a more recent IMF Working Paper, Krichene used data for the period 1974 through 2004 to calculate a short-run price elasticity of -0.08 and long-run elasticity of -0.26. Aside from the differences in time period, Krichene's analysis takes into account the effect of the nominal effective exchange rate of the U.S. dollar on crude oil prices and demand.<sup>8</sup>

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<sup>5</sup> EIA Petroleum Navigator. Daily spot market prices. [http://tonto.eia.doe.gov/dnav/pet/pet\\_pri\\_spt\\_s1\\_d.htm](http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm)

<sup>6</sup> For a discussion of the price flexibility concept see chapter 3 of *Agricultural Product Prices* by William G. Tomek and Kenneth L. Robinson. Fourth Edition, 2003. Cornell University Press.

<sup>7</sup> Cooper, John C.B. "Price elasticity of demand for crude oil: estimates for 23 countries". *OPEC Review*. March 2003.

<sup>8</sup> [Krichene](#), Nouredine. "A Simultaneous Equations Model for World Crude Oil and Natural Gas Markets". International Monetary Fund. IMF Working Paper WP/05/32. Washington, DC. February 2005.

We adopted the Krichene’s short-run price elasticity estimate of -0.08 to calculate the price flexibility used in our analysis. Since the price flexibility coefficient is the reciprocal of the price elasticity, the calculated value is  $1/-0.08 = -12.5$ . This suggests that a one percent shortfall in crude oil supply would result in a 12.5 percent short-term increase in crude oil prices.<sup>9</sup>

The short-term change in crude oil prices was estimated by multiplying this price flexibility coefficient by the shortfall in world crude oil supply that would result from removing 20.4 billion gallons of ethanol from the world motor fuel supply. As shown in Table 2, according to the EIA, projects world crude oil supply to total 31.8 billion barrels in 2008. This will produce 14.5 billion barrels (610 billion gallons) of gasoline.<sup>10</sup> Global production of ethanol in 2008 is estimated at 20.4 billion gallons. Adjusted for energy content of ethanol this equates to 320 million barrels (13.4 billion gallons) of gasoline equivalent. In the short-run this translates into a shortfall of nearly 700 million barrels of crude oil, or 2.2 percent of supply.

Table 2  
Impact of Removing Ethanol on World Oil Supply: 2008

|                         | Mil bbl | Mil Gal   |
|-------------------------|---------|-----------|
| Crude oil supply        | 31,834  | 1,337,037 |
| Finished motor gasoline | 14,516  | 609,689   |
| Ethanol Production      | 485     | 20,369    |
| EtOH Gas Equiv          | 320     | 13,393    |
| Gasoline w/ethanol      | 14,835  | 623,081   |
| Crude to make gasoline  | 32,533  | 1,366,406 |
| Crude shortfall         | -699.3  | -29,370   |
| % Shortfall             | -2.2%   | -2.2%     |

Multiplying the shortfall in crude oil supply by the estimated price flexibility (-2.2% X -12.5) suggests that crude oil prices would increase 27.5 percent in the short-term. Using the spot market price of West Texas Intermediate crude oil (\$130/bbl) as the base, a 27.5 percent increase translates to a price of \$165.70 per barrel, or a difference of \$35.70 per barrel.

It is important to note that the long-run price elasticity of crude oil is larger (-0.26) as producers respond to higher prices and increase supply. As a result the price flexibility is smaller meaning

<sup>9</sup> In the context of this analysis short-run is defined as up to one year. In this period consumers are relatively unable to make significant changes to consumption patterns and suppliers are unlikely to significantly increase production. Over the long-run the demand for oil is more elastic (meaning the absolute value of the price elasticity is closer to one) and the price flexibility is smaller. Krichene estimates a short run price elasticity for crude oil of -0.08 and a long-run elasticity of -0.26.

<sup>10</sup> EIA Petroleum Supply Annual. [http://tonto.eia.gov/dnav/pet/pet\\_pnp\\_pct\\_nus\\_pct\\_a.htm](http://tonto.eia.gov/dnav/pet/pet_pnp_pct_nus_pct_a.htm)



that the long-run increase in price resulting from the 2.2 percent shortfall in crude oil would be only \$10.98 per barrel.