Appendix: Refining Economics of Reducing Ethanol with Rising Ethanol Prices

Introduction

As a result of the Renewable Fuel Standard (RFS), industry made the necessary investments to blend ethanol into gasoline, and most gasoline today contains 10-percent ethanol (by volume). With the drought this past growing season, the price of corn, the major feedstock for fuel ethanol, increased, and thus the price of ethanol increased. The Environmental Protection Agency (EPA) was asked to consider waiving the RFS, with the underlying assumption being that fuel demand for ethanol would decline, thus lowering both corn demand and the price of corn.

The price of ethanol relative to gasoline is a key measure of when refiners might find it economic to back ethanol out of gasoline, should such a waiver be issued, and setting aside the hurdles and economics of transporting and storing additional gasoline "types".[2] As a result, DOE's Office of Policy and International Affairs sponsored an analysis to explore the economics of reducing ethanol use at a refinery as the cost of ethanol rises relative to gasoline.

Many refiners have changed their operations to make use of ethanol's high octane. They produce a sub-octane blending component that, when blended with 10-percent ethanol, produces a finished gasoline with the appropriate octane and other driveability and emission properties. For these refiners, there is a cost to change back to producing a gasoline without ethanol. It was assumed that reformulated gasoline (RFG) would continue to be produced with ethanol, as it is easier and less expensive to remove ethanol from conventional gasoline.

The study focused on Gulf Coast refineries[3]. Gulf Coast refineries represent about half of U.S. refinery capacity, and they produce mainly conventional gasoline, which represented almost 83% of the gasoline and blending component output in 2012. These refiners supply the Gulf Coast area as well as East Coast and Midwest consumers with gasoline, and thus represent a large potential for ethanol reduction.

[2] We recognize that the distribution system is where the largest challenge may lie in changing the level of ethanol content in gasoline, but we also need to understand the costs at the refining level.
[3] Gulf Coast for this memo is Petroleum Administration for Defense District (PADD) 3.

Analysis

The purpose of the study was to obtain a rough estimate of the level of cost changes refiners might see when reducing ethanol, which could then be used to explore relative ethanol price levels necessary to provide incentives to reduce ethanol volumes. A representative Gulf Coast refinery was analyzed using a detailed refinery linear programming model (LP) developed by Jacobs Consultancy for the Department of Energy (DOE). The representative refinery runs a moderately heavy, high sulfur crude mix, and is equipped with fluid catalytic cracking (FCC), alkylation, coking, reforming, and full desulfurization units to accommodate the streams produced from the crude oil feed.

Ethanol has a very high octane number, which adds to its value as a gasoline blend stock; however, it has a high vapor pressure and lower energy content than most other gasoline blend components. These properties impact how and at what cost refineries are impacted with reduction in ethanol use.

The analysis examined the economics when refineries switch a portion of their production from conventional gasoline blend stock for oxygenate blending (CBOB), which is a sub-octane blend that will only meet all finished gasoline quality requirements when ethanol is added at the terminal in the sales region, to finished conventional gasoline that will meet quality specifications without ethanol being added.

Crude oil was priced at $107 per barrel, gasoline was $123 per barrel, and ultra-low sulfur diesel (ULSD) $128 per barrel, with typical summer/winter variations. Ethanol was priced equal to gasoline to isolate the added refinery variable cost resulting when ethanol volume is reduced.

The base LP model run made 100% CBOB, meaning 10% ethanol would be added to every gallon of CBOB produced at the refinery. Then ethanol use was progressively reduced in subsequent cases. Three reduction cases were explored: 1) CBOB production at 67% of total gasoline and 33% conventional, 2) 33% CBOB and 67% conventional, and 3) 100% conventional with no ethanol use.

When the high-octane ethanol volume is reduced, the refinery compensates by finding more octane in other streams, primarily in reformate. Reformate is the gasoline blending component made in the reformer where molecules in the low-octane naphtha feed are reformed into higher-octane aromatic molecules. The refiner can increase the aromatic content of the product, increasing the product octane, but in doing so the volume of reformate product decreases, and the volumes of light lower-priced refinery gases increase. The result is an increase in operating costs and a decrease on refinery margins both as operating costs increase and volumes of higher margin product decline. But if a refinery must pay a higher price for ethanol, it may be more economical to reduce ethanol and increase reformate octane (with its associated loss of volume for the gasoline pool).

Table 1 summarizes the economics for this Gulf Coast refiner. The table shows that as the refiner reduces ethanol use, the compensating cost increases from 1.1 cents per gallon at the 33% conventional gasoline level to 3.7 cents per gallon when all the ethanol is removed.

The model runs kept ethanol priced equal to gasoline, but we can calculate a break-even price, above which it is more economic for the refiner to reduce ethanol volumes and alternatively produce more octane within the refinery. As the table shows for the 33% conventional case with its 33% reduction in ethanol use, if ethanol prices rose 26.4 cents per gallon above the price of gasoline, then ethanol volume reduction becomes attractive. The table shows the increasing variable margin penalty and the increase in ethanol prices required to make ethanol reduction economic.

Table 1. Summary Economic Results for Three Ethanol Reduction Cases

	Base	Ethanol Reduction		
		Moderate	Large	Full
Percent CBOB	100	67	33	0
Percent Conventional (No Ethanol)	0	33	67	100
Average Percent Ethanol in Gasoline Pool	10	7	3	0
Added Variable Cost/Gallon of Gasoline (cpg)		1.1	2.4	3.7
Breakeven Ethanol Price Increase (cpg)		26.4	29.8	32.8
Ethanol/Gasoline Price Ratio		1.09	1.10	1.11

Note: cpg – cents per gallon

Additional model runs were made for a Gulf Coast refinery making 20% RFG and the balance CBOB in the base case. The results showed only a small change compared to the table above. Based on conversations with several refiners, it seems likely many would experience results similar to those shown in the table. Some, however, will have more challenging economics for ethanol reduction. For example, refiners with poor gasoline octane pools and those who bring in large volumes of low-octane blending material such as “pentanes plus” streams would see less attractive economics.

Conclusion

Our assessment based on analysis at the refinery level only is that, if the distribution system were able to handle variations on ethanol blends and if there was a waiver of the RFS program beyond one year, substantial ethanol could potentially be removed from U.S. refineries (mainly Gulf Coast). For reductions in ethanol blending to be profitable to refiners, however, the price of ethanol would have to increase significantly; more than 26 cents per gallon of ethanol to incentivize an ethanol reduction of 33% and increasing ethanol costs to further reduced ethanol blending.