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Impact of the Ethanol Mandate on U.S. Gasoline Supply

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Impact of the Ethanol Mandate on United States Gasoline Supply

Prior to 2003, ethanol usage in gasoline was generally confined to the Upper Midwest states and was encouraged by federal and state tax subsidies. Since 2003, the use of ethanol has significantly accelerated as a result of MTBE bans in California, New York, and Connecticut, and the continuation of the oxygenate requirement for reformulated gasoline (RFG). The Energy Policy Act of 2005 (the "Act") has assured the continued growth of ethanol usage through its renewable fuels standard (RFS) provisions. However, growth of ethanol will be accompanied by a series of problems and complications, many of which are not widely known.

This paper presents an analysis by Baker & O'Brien, Inc. (Baker & O'Brien) of the impact of product specifications, market forces, and fuel production economics on ethanol usage in various United States (U.S.) markets. It also presents a review of current ethanol supply/demand patterns and provides a projection of how these patterns may change due to the Act. Parts of our analysis were conducted using Baker & O'Brien's proprietary *PRISM*™ Refining Industry Analysis system, which includes models of all U.S. refineries and the major elements of the crude and product distribution systems. The *PRISM* database includes process unit capacities, refinery configurations, crude runs, and production profiles, as well as product distribution patterns involving major product pipelines and terminals. The system contains estimates of operating costs, replacement costs, and economic performance on a refinery-by-refinery basis.

Energy Policy Act of 2005 – Ethanol Mandate

The RFS includes targets for annual average usage of renewable fuels, which include ethanol derived from grain, cellulosic ethanol, and biodiesel. The RFS also mandates the production of 0.25 billion gallons per year (BGY) of cellulosic ethanol by 2013. Furthermore, all volumes of cellulosic ethanol used in motor fuel are counted against the mandate at a 2.5 multiplier. For example, if the minimum mandated 0.25 BGY of cellulosic ethanol is blended, that volume would count as a contribution of 0.625 BGY towards the RFS requirement. As a result of this 2.5 multiplier directionally lowering the actual mandated volume, our estimate for the final 2012 RFS target is approximately 7.0 BGY of ethanol. The RFS includes a credit trading system to allow administration of the program for all refiners, blenders, and importers. The mandate requires a minimum of 25 percent (%) of the annual average RFS volume be used in the summer season defined as the six months of April through September.

Year	***Mandated Annual Renewable Usage (Billion Gallons per Year)***
2006	4.0
2007	4.7
2008	5.4
2009	6.1
2010	6.8
2011	7.4
2012	7.5

The RFS average annual average growth rate is 13% for the first five years. With an estimated 2005 ethanol use of 3.9 billion gallons and its currently rapid growth, compliance with the 2006 mandate seems guaranteed. The question remains whether ethanol can maintain this momentum and easily exceed the minimum usage requirement, or whether the growth will slow and just meet the minimum usage. Several factors, such as the final phase out of MTBE, the elimination of the oxygenate requirement for RFG, and future ethanol prices relative to gasoline, will dictate whether ethanol actually continues to achieve greater usage than the mandated minimum.

Ethanol's Political Story

Since 2000, federal and state political support for ethanol, through various tax subsidies and state mandates, has made it the fastest growing gasoline component. Ethanol has enjoyed a federal tax subsidy for its use in gasoline since 1978, which is currently 51 cents per gallon (¢/gal.) of ethanol blended. In addition to the federal subsidy, several states also have tax incentives that favor the use of ethanol as a motor fuel.

In addition to its tax subsidy, in most areas, conventional gasoline (CG) blends with 10% ethanol ("gasohol") receive a 1.0 pound per square inch (psi) waiver in gasoline volatility, commonly measured as the Reid vapor pressure, or RVP. Ethanol blended into RFG does not receive an RVP waiver. However, the Chicago-Milwaukee RFG market does receive an allowance of about 0.3 psi for ethanol blends. These waivers reflect an attempt to compensate for the approximate 1.0 psi RVP increase when ethanol is added to hydrocarbon gasoline.

Minnesota, Arizona, and Hawaii have enacted specific ethanol blending mandates, while many other states have effectively mandated ethanol use through the combination of the RFG oxygenate requirement and a ban on MTBE. The tables below highlight the states that have actual or de facto ethanol mandate.

States With Specific Ethanol Mandates

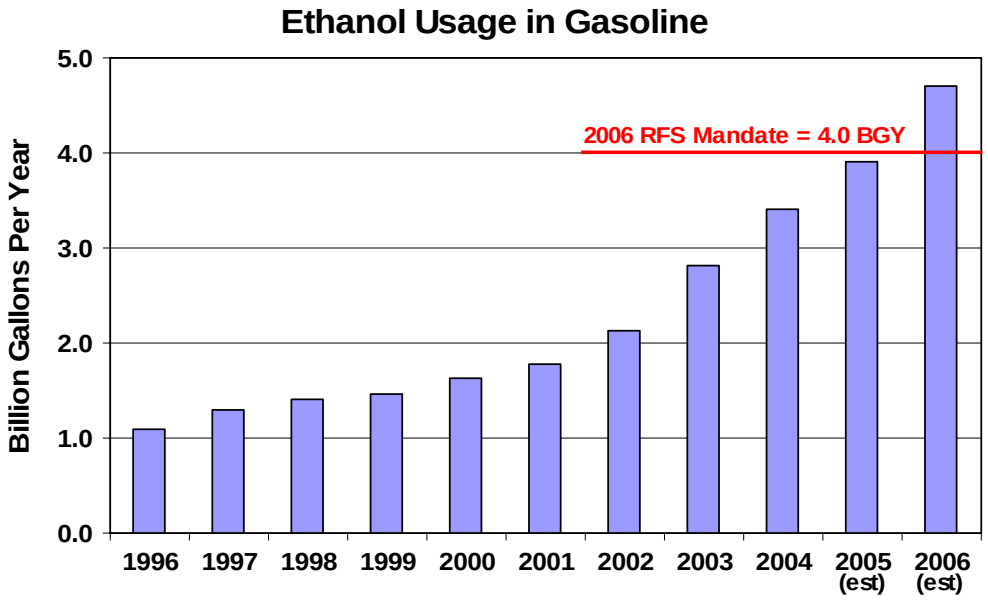
State	*Requirement*	*Effective Date*
Minnesota	All gasoline to include 10% ethanol	Jan-97
Arizona	Phoenix area with 10% ethanol CARB	Jan-04
Hawaii	85% of gasoline to include 10% ethanol	Apr-06
Montana	All non-premium gasoline to include 10% ethanol	2008 or later

RFG States With MTBE Bans

State	*Effective Date*
Illinois	Dec-00
California	Jan-04
Connecticut	Jan-04
New York	Jan-04
Indiana	Jul-04
Wisconsin	Jul-04
Missouri	Jul-05
Kentucky	Jan-06

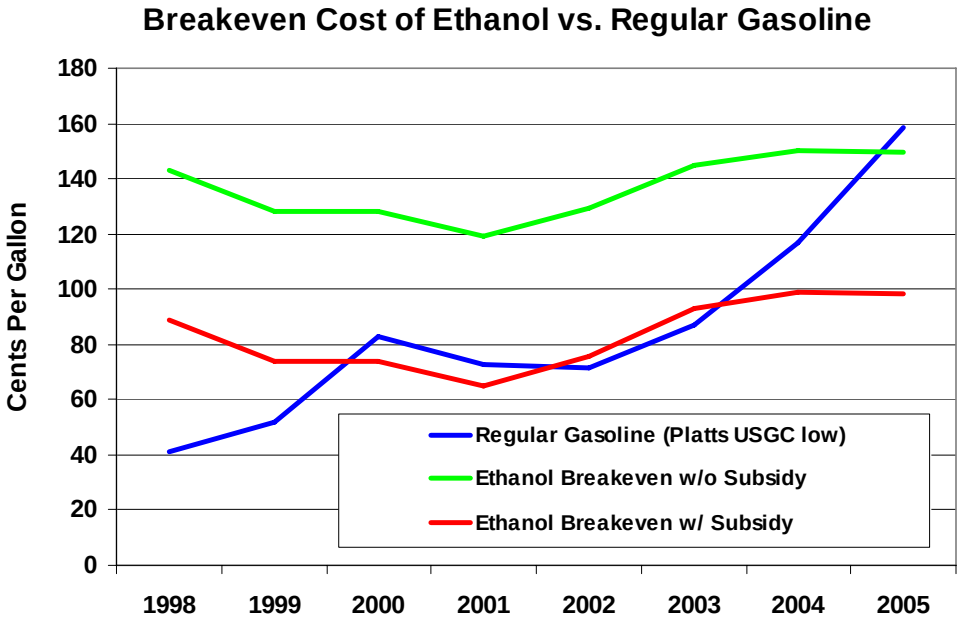
The combination of these incentives and mandates, in addition to market forces, has caused ethanol blending into gasoline to increase from 1.6 BGY in 2000 to our estimate of 3.9 BGY in

2005, an impressive 20% average annual growth rate over the last five years. We expect that ethanol usage will reach about 4.7 BGY for 2006, which is one year ahead of the RFS mandated schedule.

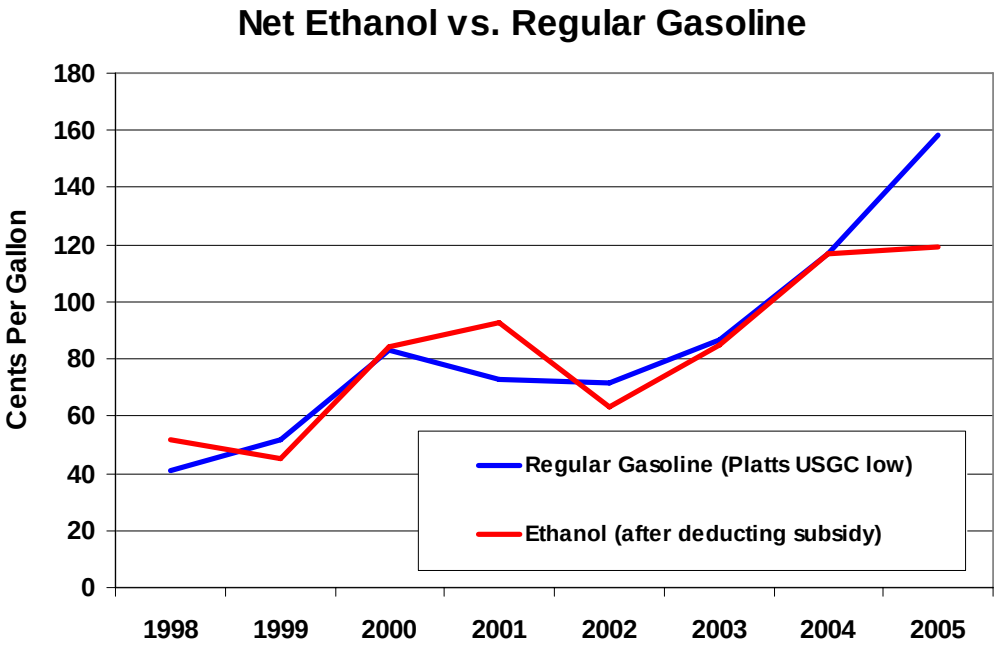


Near Term Ethanol Supply and Demand

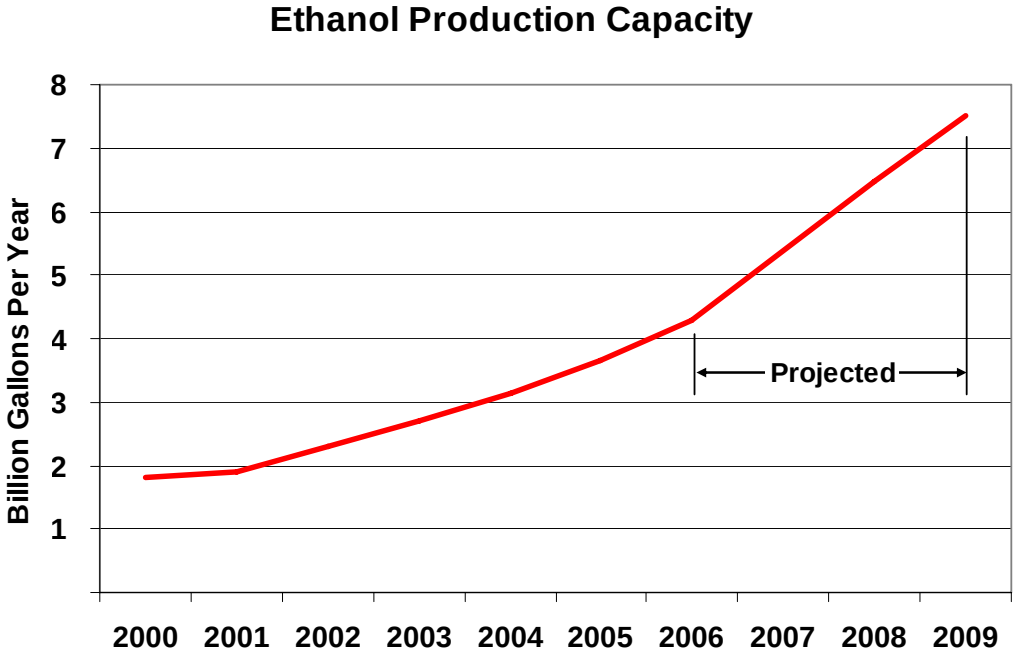
The economics of ethanol production at the end of 2005 were very favorable based on low corn prices and relatively high gasoline prices. The breakeven cost to produce ethanol using the more common dry mill process can be calculated by adding the costs for corn, operating cost, capital recovery, and deducting the value of corn by-products. The graph below shows how the breakeven production cost for ethanol has remained relatively flat over the last several years, while the average wholesale gasoline spot price has increased significantly. Because the value of ethanol will tend to track regular gasoline price, the graph indicates that the federal subsidy has become less of a requirement to make ethanol a competitive gasoline component.



The spot ethanol price at the end of 2005 rebounded from earlier in the year and was slightly above parity with gasoline after deducting the 51¢/gal. federal subsidy. The graph below shows that through 2004 the price of ethanol after deducting the subsidy normally tracked with regular gasoline price. Ethanol spot prices were lower relative to gasoline for the first half of 2005.

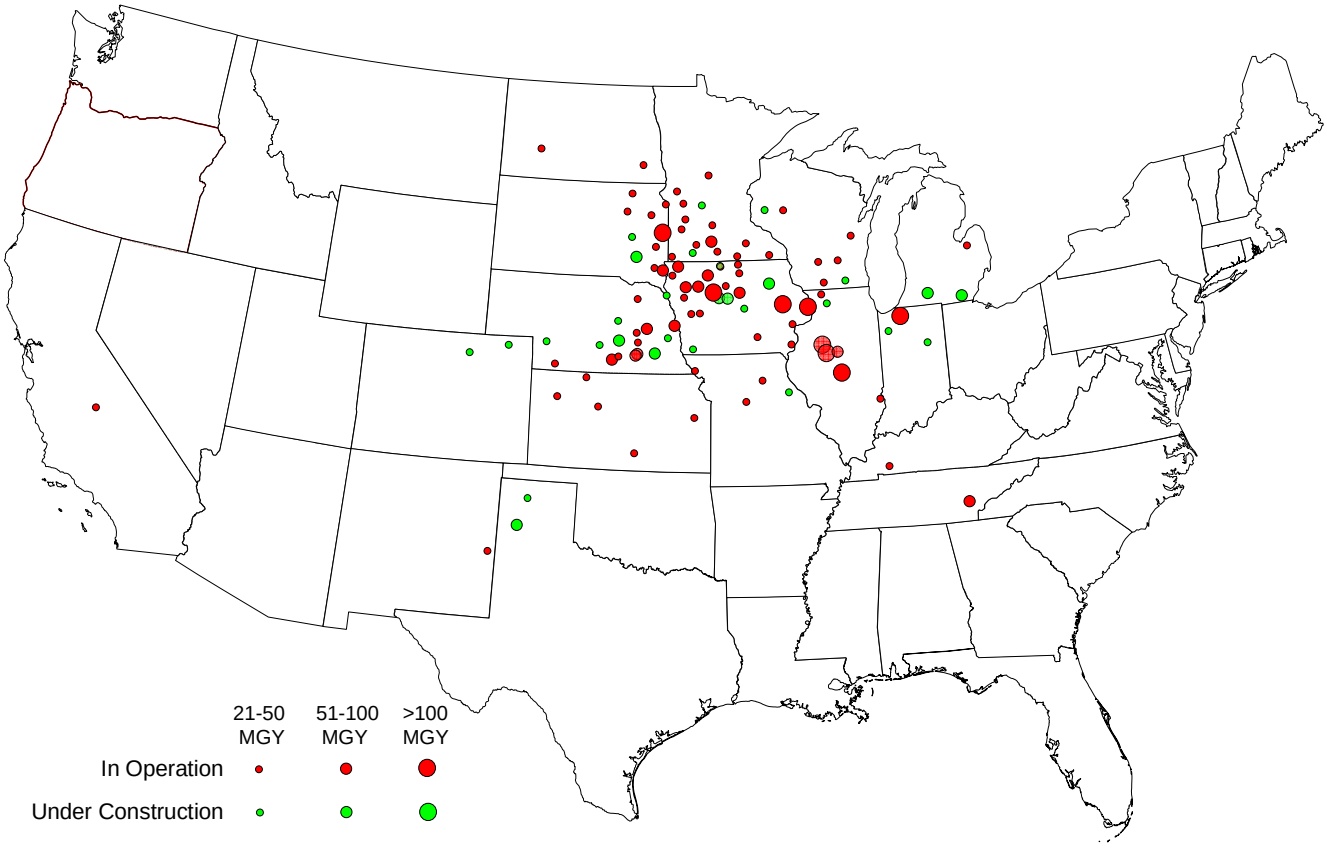


The strong ethanol margins in late 2005 indicated that most ethanol plants were being operated at full capacity, and that economics generally supported the continued construction of new plants. The graph below shows how the ethanol production capacity has rapidly increased and is estimated to be up to about 6.0 BGY by 2007. At this growth rate, the ethanol industry capacity will reach 7.5 BGY in 2009.

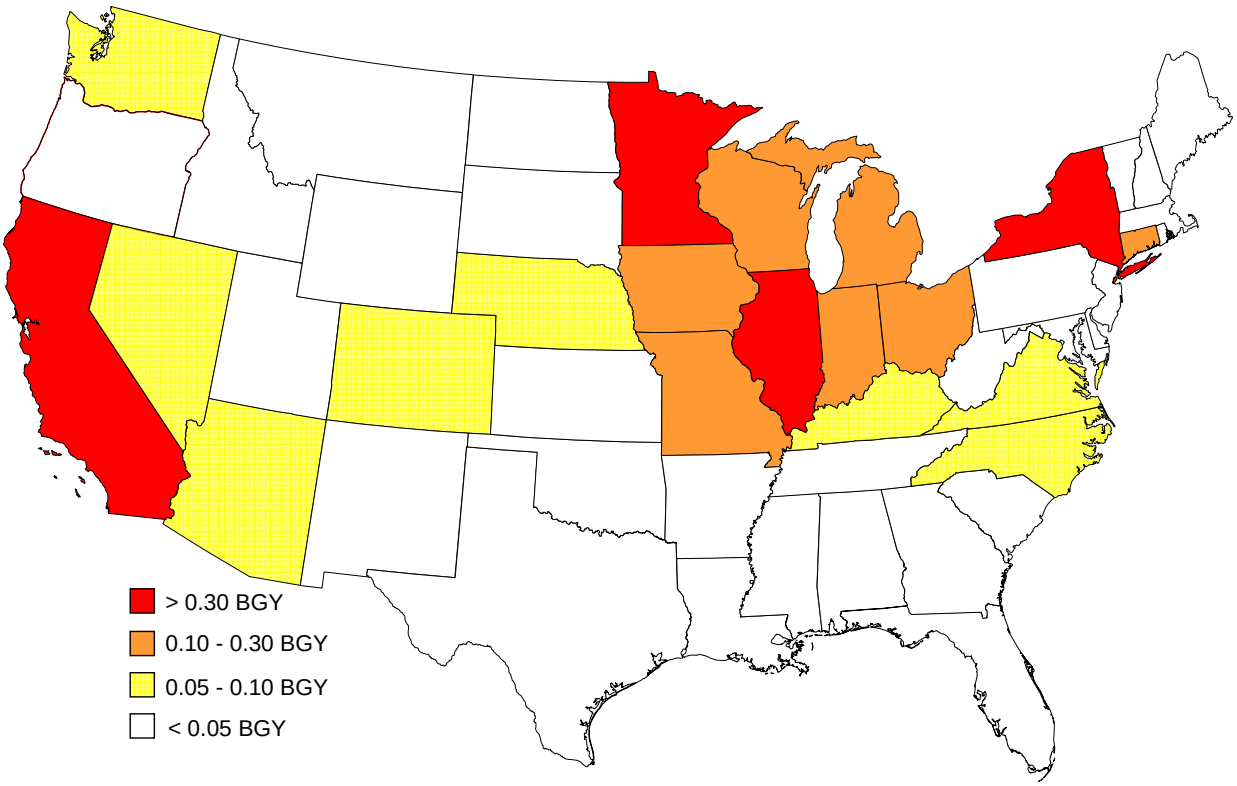


We expect that ethanol production capacity will likely continue to remain concentrated in the Midwest, although new plants are being constructed in other areas such as Texas and Colorado. Almost all new plants are dry mill design and are typically sized at between 40 and 100 million gallons per year (MGY). The location of major ethanol plants with a capacity of more than 20 MGY, both operating and under construction, are shown in the map below.

Location of U.S. Ethanol Plants



Ethanol consumption increased significantly starting in 2003, in response to the MTBE bans in California, New York, and Connecticut. The distance between the Midwest production sites and the growth markets of consumption on the coasts will put a strain on rail transportation to the new ethanol markets. Estimated regional consumption of ethanol for 2005 is shown in the map on the following page.



Short Term Consequences of the Act

The Act removes the requirement to include oxygenates in RFG after May 5, 2006. While the Act does not actually ban MTBE usage, it is possible that many refiners and blenders will interpret this legislation and the lack of a liability shield as a de facto MTBE ban.

It has been reported in *Platts Oilgram News* that Colonial pipeline will prohibit gasoline containing MTBE starting in April 2006. This implies that much of the MTBE-based RFG previously supplied from PADD 3 to the Northeast corridor, from Virginia to New York, will likely be replaced with ethanol-based RFG. This will put significant pressure on this market to procure adequate supplies of ethanol and reformulated blendstock for oxygenate blending (RBOB) for the 2006 summer season. It is unclear whether marketers in these areas have sufficient time to prepare for this conversion, and how the increased demand for ethanol will affect prices for ethanol and RFG. It is also unclear whether the refiners currently producing RFG with MTBE will be capable of producing the volumes of lower RVP RBOB that will be required this summer. As a result of these supply issues, our expectation is that New England markets that are currently supplied with MTBE-based RFG from foreign imports will continue to be supplied in this manner through 2006. We have assumed that these markets will switch to ethanol–based RFG by 2008.

Once refiners and marketers make the investments required to produce and sell RBOB and ethanol blended RFG, they may find it difficult to later justify changing the supply to non-oxygenated RFG. Removing ethanol from the gasoline pool would require the refiner to make up for the lost octane, which may require further investment. Unless ethanol costs become high relative to gasoline, those investments may not be justified. For this reason, we expect that ethanol blended RFG will be the normal domestic supply for the East Coast market.

Potential Response of Refiners to the Ethanol Mandate

Our *PRISM* database includes estimates of gasoline production by grade and formulation for every refinery in the U.S. The *PRISM* refinery simulator includes the EPA Complex Model and the California Air Resources Board (CARB) Phase 3 Predictive Model. Using the *PRISM* system, we evaluated the ability of individual refineries to produce increased volumes of both RBOB and conventional blendstock for oxygenate blending (CBOB) based on the following assumptions about ethanol consumption:

- Year-round use in all RFG areas except Texas
- Year-round use in California
- Used in all winter oxygenated fuel program (OFP) areas
- Complete MTBE phase-out by 2008
- Use in Midwestern conventional gasohol markets that allow the 1 psi RVP waiver, as needed, to meet the RFS targets

The main focus of this paper is to estimate how the ethanol mandate will affect refinery gasoline supplies. Although E-85 (a mixture of 85% ethanol and 15% gasoline blendstock) has the potential to consume large quantities of ethanol, we feel that the sales volume will not become significant until after 2012. E-85 sales currently account for only about 0.3% of total ethanol usage and its growth is limited by infrastructure and other issues.

The results of our analysis are clear. Refiners that are currently making RFG with MTBE will probably require capital investments, whether they decide to produce non-oxygenated RFG or RBOB. Non-oxygenated RFG may be economical for those refiners who can compensate for the loss of octane by removing MTBE without using ethanol. For example, refiners with light naphtha isomerization capacity will have a greater ability to produce non-oxygenated RFG, due to the advantageous RFG blending properties of isomerate. The growth of non-oxygenated RFG will depend on many factors including ethanol price and overcoming the “boutique” nature of this fuel as it is introduced into the domestic pipeline systems.

The two tables on the following page show estimates of regional refiner production of base gasoline for ethanol blending including RBOB, CBOB, and California Air Resources Board blendstock for oxygenate blending (CARBOB) for 2004 and a projection for 2012. Our analysis indicates that PADD 1, 2, and 3 refiners will more than double their production of blendstocks for ethanol. PADD 2 refiners are expected to contribute the largest volume increase of these blendstocks, as a result of the regional synergies of ethanol production. We estimate that the overall production of CBOB and RBOB will almost triple over the eight-year period.

Estimated 2004 Refiner Production of Blendstocks for Ethanol Blending

(Thousands of Barrels Per Day)

	Petroleum Adminstration for Defense District					
	1	***2***	***3***	***4***	***5***	***TOTAL US***
CBOB	56	499	7	24	17	603
RBOB	144	237	122	--	--	502
CARBOB	--	--	--	--	952	952
Total BOBs	200	735	129	24	970	2,058
BOB as % of Total Gasoline Production	24%	39%	3%	8%	70%	25%

Estimated 2012 Refiner Production of Blendstocks for Ethanol Blending

(Thousands of Barrels Per Day)

	Petroleum Adminstration for Defense District					
	1	***2***	***3***	***4***	***5***	***TOTAL US***
CBOB	56	1,526	112	27	24	1,745
RBOB	480	327	665	--	--	1,472
CARBOB	--	--	--	--	1,098	1,098
Total BOBs	536	1,853	777	27	1,122	4,314
BOB as % of Total Gasoline Production	64%	89%	18%	9%	74%	48%

Impact of Ethanol Blending on Gasoline Supplies

In aggregate and on an individual refinery basis, blending ethanol into RFG forces higher RVP blendstocks such as normal butane or pentanes out of the gasoline pool and into other markets. We estimate the butane/pentane volume loss in RFG to be approximately 0.40 gallons for each one gallon of ethanol added to the RFG pool. Stating it another way, because of volatility limits on RFG, the addition of one gallon of ethanol to the RFG pool only increases the size of that pool by 0.60 gallons. The butane/pentane forced out of the RFG pool does have value in the fuel and petrochemical feedstock market, but does not contribute to the supply of gasoline.

Ethanol's energy content is only about two-thirds that of ordinary gasoline, which means that ethanol yields about 70% of the miles per gallon (mpg) of gasoline. Therefore, motorists using RFG blended with 10% ethanol will get about 3% fewer mpg. Combining the butane/pentane effect with the mpg effect, we conclude that adding one gallon of ethanol to the RFG pool increases the "effective supply" of RFG by 0.42 gallons (.60 x .70).

The situation for ethanol blending into conventional gasoline (CG) is better than with RFG as a result of the 1 psi RVP waiver. The 1 psi waiver is sufficient, in most cases, to allow ethanol blending with no volatility changes to the base stock. The environmental impact of the 1 psi waiver is outside the scope of this paper. From a fuel supply perspective, the addition of one gallon of ethanol to the CG pool increases the effective supply of CG by 0.70 gallons.

Clearly, the ethanol mandate will have an impact on the gasoline supply and will drive investments in the refining industry. We expect that the impending removal of MTBE from the gasoline pool will create an intense short term demand for ethanol as it replaces MTBE in RFG. Over the long run, it remains to be seen if ethanol will remain in summer grade RFG or be replaced by non-oxygenated RFG. We project that the incremental volume of ethanol required by the mandate will be ultimately used close to the Upper Midwest where it is produced.