PIRINC

You may be interested.

PIRINC has prepared the enclosed report, *MTBE, Ethanol - Sorting Through the Oxygenate Issues*.

The past two driving seasons have provided ample evidence of gasoline supply problems, especially with reformulated gasoline. Current initiatives to ban MTBE in a relatively short period of time while maintaining the Federal oxygenate mandate are setting the stage for a massive near-term increase in demand for ethanol. But with MTBE reformulated gasoline used mainly on the coasts and ethanol production almost exclusively in the Midwest, a forced shift to ethanol with its different logistics requirements creates serious new risks of supply disruption.

This report looks briefly at gasoline supply concerns and then attempts to sort through the different arguments---environment, national security, cost, etc.--- made by proponents of various positions on the oxygenate issue. Overall, whatever environmental benefits an oxygenate requirement had in the early 1990s, they have since weakened considerably as a more decisive role is played by improvements in auto emissions technology. Ethanol will continue to be used in growing volumes with or without an oxygenate waiver or further incentives and/or mandates for its use. Long-term, this is an issue with only marginal consequences in terms of benefits or costs. But short-term, failure to be flexible risks creating new vulnerabilities to the country's fuel supplies at a time when, since September 11th, we all have enough to worry about.

If you have any questions or comments, please call John Lichtblau, Larry Goldstein, or Ron Gold.

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MTBE, Ethanol---Sorting Through the Oxygenate Issues

Executive Summary

Typically, movements in gasoline prices reflect changes in crude oil prices and seasonal factors. But over the past two driving seasons supply problems, especially with reformulated gasoline, have had major impacts on prices. Only modest supply shortfalls in an essential product for consumers have caused price spikes, most notably in California and in the Chicago-Milwaukee area. Risks of future supply shortfalls and price spikes are being magnified by current state initiatives to ban MTBE in a relatively short period of time while maintaining the Federal oxygenate mandate for reformulated gasoline. Maintaining the mandate would effectively require an extremely expensive, logistically difficult, rapid switch to ethanol. The issues involved in deciding what to do about MTBE, the oxygenate requirement, and promoting ethanol use are complex as changing technologies challenge the assumptions underpinning the original regulatory justifications. MTBE and ethanol are by far the most widely used oxygenates.[1] Together, they currently make up just under 5% of the gasoline barrel, with MTBE volumes nearly three times those of ethanol.

In recent years, public concern has grown regarding MTBE contamination of water supplies as a result of leaks from gasoline storage tanks and from operation of boats and jet skis. Currently, 12 states have passed legislation that would severely limit, or eliminate entirely, the use of the main oxygenate, MTBE. In California, which last year accounted for about 45% of total national sales of reformulated gasoline, an outright ban is scheduled to take effect at the end of 2002. Other states are considering similar actions. Last year, the EPA issued an Advanced Notice of Proposed Rulemaking asking for comments regarding a Federal phase-out of MTBE. Congress is also considering such a phase-out.

The problem is what to do when MTBE is phased-out, especially if the phase-out is over a relatively short time frame, as is clearly the case in California. California's answer was to request a waiver of the oxygenate requirement, a request the EPA denied in June of this year. Without a waiver, the only way to replace MTBE is with a massive expansion in the use of ethanol, which has long been promoted for reasons other than oxygenate use, including helping domestic agriculture and promoting renewable, domestic source energy. Congress is actively considering the issue of a waiver of the oxygenate requirement, as well as how much (further) to promote and/or require ethanol use in fuel.

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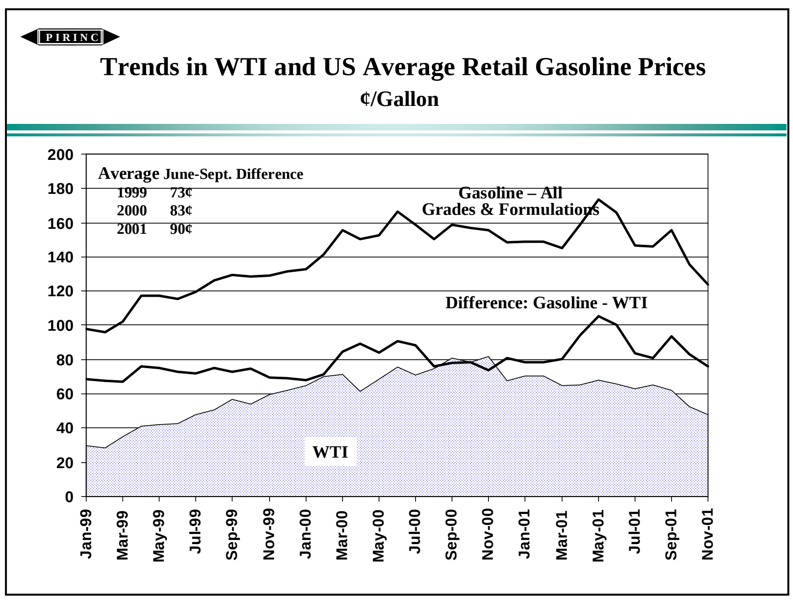
[1] This report focuses on these two oxygenates. There are others approved for blending into gasoline. These are TAME (tertiary amyl methyl ether), ETBE (ethyl tertiary butyl ether), DIPE (di-iso propyl ether) and TBA (tertiary butyl alcohol). However, the first three are ethers, as is MTBE, and raise similar concerns about water contamination. TBA currently is used mainly in the production of MTBE. Volumes of the others are small. The Department of Energy estimated that in 1997, MTBE and ethanol accounted for 95% of oxygenates in gasoline where reformulated or oxygenated gasoline is required. Nearly all of the remainder was TAME. See: Energy Information Administration, <u>Oxygenate Demand in Reformulated and Oxygenated Gasoline Control Areas</u>, URL:ftp://ftp.eia.doe.gov/pub/forecasting/steo/special/rpt/rfg4.xls.

This report looks briefly at gasoline supply concerns and then attempts to sort through the different arguments---environment, national security, cost, etc.--- made by proponents of various positions on the oxygenate issue. Overall, it appears that whatever environmental benefits an oxygenate requirement had in the early 1990s, they have weakened considerably since then as a more decisive role is played by improvements in auto emissions technology. As for ethanol, it will continue to be used in growing volumes with or without an oxygenate waiver or further incentives and/or mandates for its use. Long-term, this appears to be an issue with only marginal consequences in terms of benefits or costs. But short-term, failure to be flexible on this matter risks creating new vulnerabilities to the country's fuel supplies at a time when, since September 11th, we all have enough to worry about.

Gasoline Supply Concerns

In normal circumstances, gasoline prices reflect crude prices, tax, distribution costs and seasonal factors. But over the past two years other supply considerations have had a significant upward impact on prices. The chart below summarizes trends since early 1999 in monthly average crude oil prices, as represented by WTI, and average national retail prices for gasoline, both measured in cents/gallon.

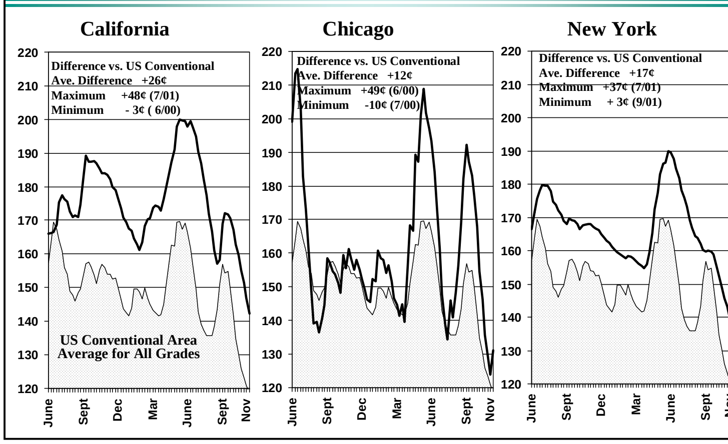


Throughout 1999, retail gasoline prices moved about in line with rising crude oil prices. In 2000, however, the rise in gasoline prices outpaced crude prices. In 2001, gasoline prices stayed relatively high through the summer even as crude prices were declining. Focusing on the peak, June-September driving season, the average difference between retail gasoline and crude prices in 1999 was 73 cents/gallon, close to the 1990-98 average of 75 cents. In 2000 the difference was 83 cents/gallon, up 10 cents/gallon from the year earlier. This year the difference was higher still, 90 cents/gallon.

Some of the causes of the rising price differentials apply to all grades and formulations of gasoline, in particular, low gasoline stocks early in the driving season as strong winter demand for distillate in 2000 and especially in 2001 delayed the normal seasonal refinery shift to higher gasoline production and limited summer peak refining capacity. But overall price differentials were also pushed up by specific problems impacting reformulated gasoline including: (1) in 2000, problems of meeting the more stringent, Phase 2 requirements, especially for ethanol blended reformulated gasoline used in the mid-west, (2) periodic production problems for

California's unique reformulated gasoline blend, normally in precarious supply/demand balance, and (3) spill-over effects of natural gas price surges on MTBE supply and prices.[2] The chart below focuses on the behavior of retail gasoline prices as published weekly by the Department of Energy in three reformulated areas, California, Chicago, and (reformulated areas within) New York. These are compared with national average retail prices for conventional area gasoline.

Trends in Selected Reformulated Area Retail Gasoline Prices June 2000 – November 2001, All Grades, ¢/Gallon



In California, where reformulated gasoline is used throughout the year, differentials versus US conventional area gasoline since early June 2000 have averaged 26 cents/gallon. But differentials have ranged from a high of 48 cents/gallon reached in July of this year to –3 cents/gallon in early June of 2000. MTBE is the oxygenate used in the state's reformulated gasoline. The geographic distribution of MTBE and ethanol use is discussed in detail later in the report.

In Chicago and New York, reformulated gasoline is subject to EPA seasonal use regulations. These require only reformulated gasoline to be sold at retail outlets and to wholesale purchasers in reformulated areas from June 1 through September 15, the "high" ozone season. Terminals serving these areas are required to have only reformulated supplies on hand as of May 1. Chicago reformulated gasoline uses ethanol as its oxygenate while New York uses MTBE. Price volatility in Chicago has been even more dramatic than in California. The average difference between Chicago retail prices and US conventional area prices is relatively narrow, 12 cents/gallon. But there have been temporary price spikes pushing the differential far above the average, with the maximum 49 cents/gallon shown for early June 2000, when supply problems for new, Phase 2, ethanol-based reformulated were at their most severe. On the other hand, there are times when prices in Chicago are about in line with the national average or below it, as was the case in late July 2000 when they were about 10 cents/gallon below the national average.

Price volatility, and the price peaks were more subdued in New York. While problems with MTBE supply this year pushed up reformulated prices in New York as well as elsewhere, the differential versus US conventional area prices never reached the maximum levels seen in California and Chicago. New York is less vulnerable to local production problems since its reformulated blend is not unique and the state is easily supplied by pipeline as well as domestic

[2] These issues are discussed in detail in earlier PIRINC reports, especially, It's All Connected: Natural Gas, Electricity, Heating Oil And Gasoline, July 2001 and Gasoline 101: A Politically Explosive Topic, June 2000. As discussed in detail in the latter report, gasoline is a virtual necessity and in the short run has almost no substitutes. In economic terms, the product is price inelastic, i.e., small supply shortfalls require disproportionate price changes to adjust demand.

and international marine transport. However, these advantages would be severely compromised if the state were forced to switch in a relatively short period of time to ethanol. New York plans to eliminate MTBE by January 1, 2004 and, without a change in the Federal oxygenate requirement, could face exactly this situation.

The Role of Regulation and Incentives

MTBE and ethanol use predate the 1990 Clean Air Act Amendments. Both are not only oxygenates but octane boosters as well, with octane ratings of 110 and 115 respectively, an important consideration with the phase-out of the traditional octane-booster, lead, that began in the late 1970s. In the 1990s, limits on another class of octane-boosters, aromatics, in reformulated gasoline added to their usefulness for this purpose. Ethanol use has been encouraged by tax incentives. Beginning in 1979, the Federal government has provided a partial exemption from the gasoline tax for "gasohol.[3]" Currently, gasohol with a 10% by volume ethanol blend receives a reduction in the Federal gasoline tax of 5.3 cents/gallon, which translates into a 53 cents/gallon ($22.26/barrel) tax benefit for ethanol. The tax advantage is given in the form of a 53 cent/gallon credit for ethanol blended into the qualifying product. To insure the benefit goes to domestic producers, an equivalent, virtually prohibitive, tariff is imposed on ethanol imports. MTBE imports are generally subject to a 5.5% ad valorem tariff, which given the average Gulf Coast price for MTBE so far this year, would amount to about 6 cents/gallon, far lower than the 53 cent/gallon tariff on ethanol.[4] Last year, the tax exemption cost the Federal Highway Trust Fund about $800 million in lost gasoline tax revenue, a cost that grows with rising ethanol use.

In addition to Federal tax benefits, ethanol also benefits from tax advantages in place in 12 states as of 1999. Five states, Alaska, Connecticut, Idaho, Iowa and South Dakota offer full or partial exemptions from their gasoline taxes. Hawaii, Illinois and New Mexico offer relief from sales tax. Three states, Minnesota, Montana, North Dakota, and South Dakota offer tax credits ranging from 15 cents to 40 cents/gallon of ethanol, provided the ethanol is domestically produced. Ohio offers a 10 cent/gallon refund to dealers for each gallon of qualified gasohol.[5]

Oxygenates first became a subject of regulatory action with the Clean Air Act Amendments of 1977. Among other provisions, the act prohibited the introduction or increase in additives that were not "substantially similar" to those used in gasoline used to certify 1975 or later model year vehicles. The EPA could grant waivers for additives that don't cause or contribute to failure of emissions control devices. Ethanol received such a waiver for up to 10% by volume (3.5%

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[3] Gasahol was initially defined for tax purposes as a blend of gasoline and at least 10% by volume alcohol other than alcohol derived from fossil fuel. In 1993, the definition was broadened and the tax advantage expanded on roughly a pro-rata basis to include blends with 7.7%-10% alcohol, and 5.7%-7.7% alcohol. The 7.7%-10%% blend would provide the minimum 2.7% oxygenate requirement by volume for winter oxygenated gasoline while the 5.7%-7.7% blend meets the Federal minimum oxygenate requirement for reformulated gasoline.

[4] There are limited tariff-free allowances for ethanol from the Caribbean Basin. MTBE imports from Canada are exempt from the tariff under NAFTA.

[5] State data are taken from the Federal Highway Administration, Highway Statistics 1999, Table MF-121T.

oxygen by weight) in 1978. In 1981, MTBE received a waiver for up to 11% by volume (2% oxygen by weight), subsequently raised to 15% (2.7% oxygen by weight) in 1988.

The Clean Air Act Amendments of 1990 introduced two formal oxygenate requirements for gasoline. The first to be implemented was a winter oxygenate requirement, effective in 1992, to reduce carbon monoxide emissions in specific "nonattainment areas," i.e., areas of the country classified by the EPA as not attaining the National Air Quality Standard for this pollutant. The second was a minimum oxygenate requirement for reformulated gasoline, required, as of 1995, to be sold from June 1 through September 15 in the nine areas classified by the EPA as "extreme" or "severe" ozone nonattainment areas with provisions for opt-in by other, less severe, nonattainment areas. The winter fuels minimum requirement was set at 2.7% oxygen by weight (7.7% ethanol or 15% MTBE by volume) while RFG requires a minimum average of 2.1% oxygen by weight.[6] While they established minimum oxygenate requirements, maximum requirements, under the "substantially similar" rules continue in effect.

Initially, the winter fuels program was the more important in terms of volume. But its importance has diminished while the role of reformulated gasoline has grown substantially. As shown in the table on the right, in 1994, winter oxygenated gasoline accounted for 9% of total annual refiner sales (to end-users and resellers). In 2000, its share had fallen to 3%. Sales of reformulated, on the other hand, have grown from 2% in 1994 to nearly one-third of the gasoline market in 2000. The spread of advances in automobile pollution control technology, in particular fuel injection and three-way catalysts, since the beginning of the program has reduced the role of oxygenates in controlling CO emissions. Significant gains are achieved only with the diminishing number of older technology vehicles on the road---and those newer vehicles with faulty emissions controls. Currently, about 31 million people live in CO nonattainment areas, of which nearly 18 million, (13 in the Los Angeles South Coast Air Basin) live in "serious" nonattainment areas.

Share of Refiner Gasoline Sales

	1994	2000
Oxygenated Gasoline	**9%**	**3%**
Reformulated Gasoline	**2%**	**32%**

Population in nonattainment areas 8/2001
CO 30.5 million
Of which 17.6 in "serious" (13 in Los Angeles Basin)

Ozone 104.9 million
Of which 29.0 in "serious
42.1 in "severe"
13.0 in "extreme" (Los Angeles Basin)

A far larger number of people, 105 million, live in ozone nonattainment areas. Moreover, a total of 84 million live in areas classified as either "serious" (29 million), "severe" (42 million) or "extreme" (13 million in the Los Angeles Basin). Those areas in the latter two categories are required to use reformulated gasoline.[7]

[6] Under an EPA waiver, the California winter oxygenate program calls for a minimum of 1.8% and a maximum by weight of 2.2% as opposed to 2.7% to 3.5% for other states.
[7] About 25 million people live in previously classified nonattainment areas for CO while about 35 million live in previously classified ozone nonattainment areas.

Regulatory Adjustments for Ethanol

Adjustments to regulations have also been made to avoid penalizing ethanol. In 1992, as a means of reducing evaporative emissions of VOCs, the EPA implemented an RVP limit of 9.0 psi on sales of all gasoline during the high ozone season in the cooler northern states and a more stringent 7.8 psi for warmer southern states.[8] Ethanol has a much higher RVP than MTBE, 18 versus 8, and to avoid discouraging ethanol use, a 1 psi waiver was granted for ethanol-blended conventional---but not reformulated---gasoline.

Reformulated gasoline has its own RVP limits tied to performance requirements as determined by model results relative to a 1990 baseline gasoline formulation. The effective RVP limits under Phase I (1995-99) were about 8.0 in the northern states and about 7.1 in the southern states. Under Phase II, which began last year, the effective RVP limit dropped to 6.7.9 The blendstock (RBOB) for ethanol-based reformulated gasoline is more severe than for comparable MTBE-based gasoline to compensate for the higher RVP of the ethanol component. The move to an even lower RVP limit under phase II led to new difficulties in producing the ethanol blendstock and temporary supply shortages and price spikes for the only section of the country relying on ethanol-based reformulated gasoline, the Chicago-Milwaukee area. In June of this year, the EPA finalized a rule designed to ease supply problems by effectively allowing an increase in the RVP of about 0.3 psi for reformulated gasoline with 3.5% weight oxygen from ethanol (10% by volume). The change was justified on the basis of offsetting reductions in emissions from carbon monoxide, an ozone precursor, as well as a pollutant in its own right.

In June, 1994, the EPA issued a final regulation incorporating a “Renewable Oxygenate Standard” that would require 15% of the oxygenates used in reformulated gasoline in 1995 to come from renewable sources, rising to 30% in 1996 and thereafter. This direct intervention in favor of ethanol-based oxygenates was challenged in court, where a stay was granted. In early 1996, the US Court of Appeals reversed the regulation.[10] The issue of direct intervention is back as part of the debate over waiving the oxygenate requirement for reformulated gasoline. In its recently released White Paper on “Boutique Fuels” the EPA notes the support for ethanol as a means of enhancing agricultural markets and energy security and goes on to state:

[8] VOCs, or volatile organic compounds include all hydrocarbon emissions. RVP, or Reid Vapor Pressure (per square inch or psi) is a measure of a fuel's volatility; the higher the RVP the faster a fuel evaporates.

[9] California introduced RFG in 1992 with initially a lower RVP limit than the Federal standard. Phase I California RFG, in effect from 1992 through 1995, had an RVP limit of 7.8. Phase II RFG, in effect from 1996 through 2002, has a limit of 7.0. The same limit applies to Phase III California RFG, which begins in 2003.

[10] US Court of Appeals D.C. Circuit, No. 94-1502, API and NPRA vs. EPA, February 16, 1996. The EPA had justified its regulation on several grounds: (1) conservation of fossil fuels, (2) global warming concerns, and (3) the need to encourage conversion of ethanol to ETBE which has a much lower RVP (4 versus 18) and/or to compensate for the more severe ethanol blending requirement. The court ruled that the EPA had overstepped its authority by deviating from the sole purpose of reducing air pollution, in the case of RFG, reducing emissions of VOCs and Toxics. Classified toxic air pollutants related to gasoline include benzene, polycyclic organic matter (POM), acetaldehyde, formaldehyde, and 1,3-butadiene. They comprise about 4% of total VOC emissions, with benzene accounting for about 70% of the 4%.

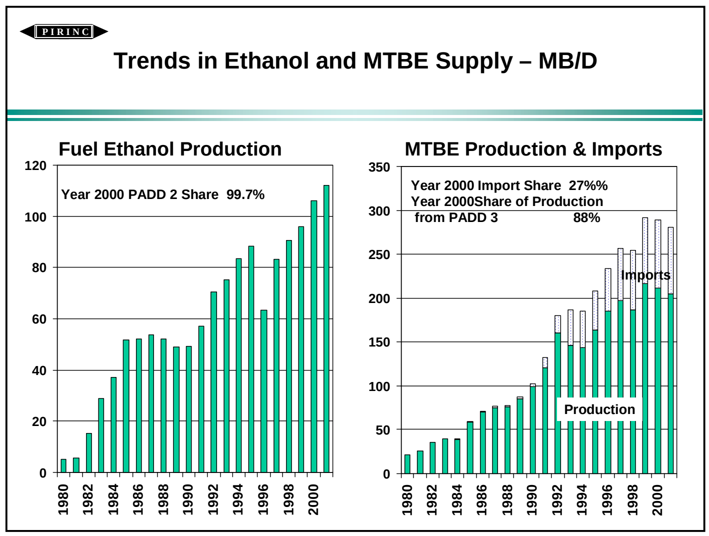
> Consequently, it is our belief that any change to the CAA oxygen requirement in RFG, including the mandate's role in cleaner fuels, should be carefully studied and, if adopted, should be coupled with an alternative requirement of a national renewable fuel program.[11]

The EPA White Paper points out that the current oxygenate mandate for reformulated gasoline has contributed to the spread of "boutique" gasolines by encouraging states not required to use reformulated gasoline to specify presumably lower-cost, low RVP fuels without an oxygenate requirement instead of opting in to the RFG program. States promoting ethanol can take advantage of the 1 psi RVP waiver in their fuel specifications by remaining outside the RFG program.

Trends in Ethanol and MTBE Volumes

The favorable regulatory environment plus, in the case of ethanol, tax incentives has led to a surge in volumes for both oxygenates over the years, with the biggest volumetric gains coming in the 1990s. The chart below summarizes trends in volumes for both since 1980.

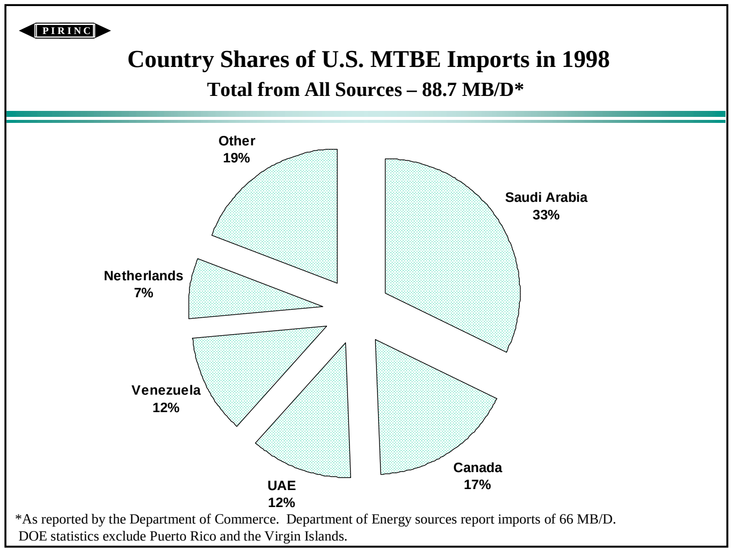
The left panel shows trends in fuel ethanol production, which in 1980 amounted to only about 5 MB/D. By 1990, ethanol volume had risen to about 50 MB/D and has since more than doubled to about 115 MB/D this year. With high tariffs holding imports to de minimus levels, fuel ethanol production is about the same as total consumption for gasoline blending purposes. About 90% of the feedstock for US ethanol production comes from corn. Virtually all production is in PADD 2, the Midwestern states.



The right panel shows trends in MTBE production and, in this case, imports since imports account for a significant share, over 25%, of total supply. Production plus imports have risen from about 20 MB/D in 1980 to about 100 MB/D in 1990 and nearly tripled to about 290 MB/D by 1999. Although volumes of MTBE, including imports, are running at nearly 3 times the volume of ethanol, differences are less in terms of oxygen supplied. Ethanol has higher oxygen content than MTBE for the same volume, about 35% by weight for ethanol versus 18% for MTBE. Thus, while MTBE supplies in volumetric terms are about triple those of ethanol, MTBE supplies about double the amount of oxygen from ethanol. There is another consideration in

[11] EPA Office of Transportation and Air Quality, Staff White Paper: Study of Unique Gasoline Fuel Blends (Boutique Fuels), Effects on Fuel Supply and Distribution and Potential Improvements, October 24, 2001, p.20.

comparing volumes, energy content. Ethanol has an energy content of 76 thousand BTU/gallon while MTBE has an energy content of 93.5. Both are less than the average for conventional gasoline of about 115 thousand BTU/gallon. Blending either into gasoline means some marginal loss in overall fuel economy in terms of miles per gallon. The loss is slightly larger for ethanol than for an MTBE blend.[12]



Until the 1990s, domestic production accounted for nearly all of the country's supply of MTBE. Production then, as now, is concentrated in PADD 3, the Gulf Coast. Last year this area accounted for 88% of total production. Since 1990 imports have risen from less than 5 MB/D to about 75 in 1999-2001. The chart on the right shows the distribution of MTBE imports in 1998 by country of origin.[13] About one-third came from Saudi Arabia with another 17% from Canada. Venezuela and the UAE each accounted for 12% and the Netherlands 7%. All other sources accounted for 19% with France, Malaysia, Korea, and Brazil the largest components of that group. The volumes of the largest single source, Saudi Arabia, amounted to about 10% of US consumption.

Consumption Patterns for Ethanol and MTBE

Although ethanol and MTBE are octane boosters, it is clear that Federal requirements for oxygenated gasoline are the key drivers for their use, especially for MTBE. The table below shows details for 1997 by PADD of ethanol and MTBE use in oxygenated gasoline control areas, i.e., areas required to use oxygenated or reformulated gasoline and in "opt-in" areas and total amount used.[14]

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[12] The Chevron Technical Bulletin, Oxygenated Gasolines and Fuel Economy, reported test results for gasoline with 10% ethanol and for gasoline with 15% MTBE. The ethanol blend had an average energy content 3.4% below conventional gasoline and an average fuel economy of 2.6% less. For the MTBE blend, energy content was 2.2% below conventional gasoline and fuel economy 2.4% below. The Technical Bulletin may be found at: http://www.chevron.com/prodserv/fuels/bulletin/oxy-fuel/.

[13] Source: Table 3-6 of the U.S. International Trade Commission Investigation No. 332-404, Methyl Tertiary-Butyl Ether (MTBE): Conditions Affecting the Domestic Industry, September, 1999.

[14] Data for oxygenated gasoline in these areas are taken from the Energy Information Administration study cited earlier, Oxygenate Demand in Reformulated and Oxygenated Gasoline Control Areas.

In that year, about 45 MB/D of ethanol and 260 MB/D of MTBE were used in the control areas. About 70% or 31.5 MB/D of the total control area ethanol is used in PADD 2, where production of ethanol is concentrated.[15] Very little MTBE, only 4.2 MB/D, is used in this region, mainly for reformulated gasoline in the Cincinnati/Louisville area. Smaller volumes of ethanol were used in PADD 5, 7.3 MB/D, mainly in the Phoenix area, and in PADD 4, 2.5 MB/D, mainly in the Denver area. The geographic distribution of MTBE use is very different with coastal areas predominating. About half of control area MTBE use is in PADD 1, the east coast while PADD 5 in the west accounts for nearly 40%. Virtually all the PADD 5 control area MTBE use is in California. Nearly all the remaining MTBE is used in PADD 3, the gulf coast region.

Ethanol and MTBE in Control Area Oxygenated Gasoline*
For Year 1997, MB/D

	Ethanol	MTBE	
US Total	45.3	255.8	
PADD 1	2.3	127.6	
PADD 2	31.5	4.2	2.9 of MTBE in Cincinnati/Louisville
PADD 3	1.7	25.8	
PADD 4	2.5	0.3	1.8 of ethanol in Denver, CO
PADD 5	7.3	97.8	4 of ethanol in Phoenix, AZ
California	-	96.2	
Total Uses in Gasoline: All Areas, All Gasoline			
US Total	86.7	268.9	
Control Area Oxygenate Use			
As % of Total Use	52%	95%	

*Includes Reformulated, Oxygenated, and Oxygenated Reformulated gasoline in areas required under Federal Regulations to use such fuels and in "Opt-In" areas using such fuels.

In the case of MTBE, its uses in control area oxygenated gasoline account for about 95% of its total 1997 volume of 269 MB/D. While MTBE has useful properties as an octane booster, such an extremely high percentage suggests its use is driven primarily, indeed almost entirely, by regulation regarding oxygenates. The figure is much lower for ethanol, 52% of the total 87 MB/D of ethanol used in gasoline. The lower figure indicates the importance of other factors besides Federal oxygenate requirements in determining ethanol use in gasoline. These include the Federal tax preference for "gasohol" and various state measures to encourage its use.

Distribution of US Ethanol Use in "Gasohol"

The next chart considers the geographic distribution of all ethanol used in Federally defined gasohol and compares this distribution with its use in oxygenate control areas.

According to statistics for 2000 recently released by the Federal Highway Administration, a total of 96 MB/D of ethanol was used in gasoline meeting the Federally defined definitions of gasohol, which, at a minimum, require at least 5.7% alcohol content by volume. Nearly 75% of the ethanol used in gasohol was used in PADD 2 where 30% of all gasoline was classified as gasohol. The 70 MB/D of ethanol so used was more than double the amount (in 1997) used in control area oxygenated gasoline within the same region. Small amounts of ethanol were used for gasohol in all the other PADDs. Within PADD 5, a modest amount of ethanol, 4 MB/D, was used in California, although none (in 1997) appeared to be used in reformulated gasoline.

[15] Of the 31.5 MB/D total, 21.7 is used for blending reformulated gasoline in the metropolitan Chicago and Milwaukee areas. Another 7.5 MB/D is used for oxygenated gasoline in the Minneapolis-St. Paul area.

For the country as a whole, gasohol amounted to about 12% of the total gasoline pool in 2000 with the ethanol content of gasohol itself amounting to about 1% (as opposed to about 3% for MTBE). Ethanol use in gasohol last year was up by 12 MB/D or 14% from 1999, a gain encouraged by the favorable price trends for ethanol versus MTBE that are discussed in the next section of the report. The US Department of Energy reports total fuel ethanol production at about 106 MB/D for 2000, with PADD 2 accounting for nearly all of it. The region also accounts for 97% of total ethanol nameplate capacity as of mid-2001.

Distribution of US Ethanol Use in "Gasohol"*
For Year 2000, MB/D

	2000 Use in Gasohol	Control Area (1997) Oxygenate	Gasohol as % of Total 2000 Gasoline
US Total	96	45	12%
PADD 1	7	2	2%
PADD 2	70	32	30%
PADD 3	5	2	4%
PADD 4	4	2.5	17%
Colorado	3.5	2	31%
PADD 5	9	7	9%
California	4	-	7%

% Change in Ethanol Use in Gasohol from 1999 +12 MB/D or +14%
US 2000 Fuel Ethanol Production 106 MB/D. PADD 2 Share 99.7%.
US mid-2001 Ethanol Nameplate Capacity 144 MB/D. PADD 2 Share 97%.

*Prior to the Energy Policy Act of 1992 (EPACT) gasohol was defined as a blend of gasoline and at least 10% fuel alcohol by volume. EPACT created two additional categories, 7.7% gasohol (7.7%-10%) and 5.7% gasohol (5.7%-7.7%). The 7.7% gasohol is generally used to meet requirements for winter oxygenated gasoline. The 5.7% category meets the Federal 2% by weight minimum oxygenate requirement for reformulated gasoline.

The Department of Energy production figure for 2000 is higher by about 10 MB/D than the figure from FHWA statistics for use in gasohol for the same year. The difference may reflect in large part differences in timing and basis of data collection but possibly also use of ethanol as an octane booster apart from its use in Federally defined, and tax-favored, gasohol.[16]

The differences in geographic distribution between the use of MTBE and the use of ethanol create serious problems in any attempt to replace MTBE with ethanol in a relatively short period of time. Apart from the issue of how rapidly supplies of fuel ethanol could rise (with the near-certainty that political considerations would strictly limit imports) to replace current oxygen supplied from MTBE, there is the further concern about how, and at what cost, to move substantial increases in volumes of ethanol from the Midwest to the east and west coasts.[17] Because of ethanol's affinity for water, ethanol blends of gasoline cannot be transported by pipelines (which sometimes contain water), as is the case with MTBE. Ethanol would have to be transported by rail and/or marine transport to the coasts for blending close to the final customers, mainly at terminals. Marine transport would involve Jones Act ships.

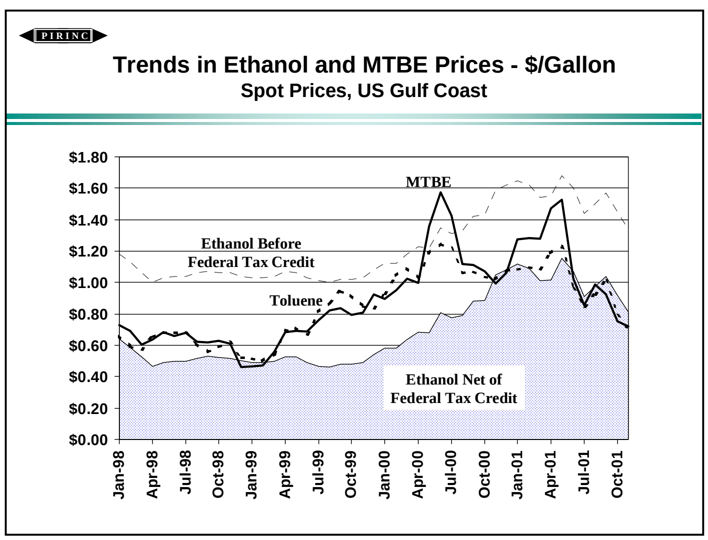
[16] Federal Highway Administration statistics regarding "gasohol" consumption are based on Federal and State tax data. Department of Energy statistics regarding ethanol (and MTBE) production are based on monthly surveys via form **EIA-819M, Monthly Oxygenate Telephone Report,** of 94 "oxygenate producers, petroleum and petroleum product distributors, petroleum and petroleum product processors (includes refiners and blenders), petroleum and petroleum product storers." There are no readily available statistics regarding another potential source of the discrepancy, ethanol exports.

[17] Since a gallon of ethanol has about twice the amount of oxygen by weight as does a gallon of MTBE, the volume of fuel ethanol production would have to double rather than triple to replace the oxygen lost by a phase-out of MTBE. However, this replacement alone would leave the gasoline pool with less energy value and less octane. Additional volumes of petroleum-based additives such as toluene and/or alkylates would be required to make up the difference.

In its report on MTBE cited earlier, the International Trade Commission noted that most MTBE imports from the Arabian Gulf went to the west coast where Jones Act shipping costs made it most difficult for US gulf coast producers to compete. Freight costs of shipping MTBE from the gulf coast in early 1999 were estimated at 7.5 cents/gallon to the west coast and 3.5 cents/gallon to the east coast. Of course proposals to promote ethanol use have domestic producers in mind, not foreign suppliers. Without access to imports however, an early phase-out of MTBE without an easing of the oxygenate requirement means the west coast would face not simply normal costs of Jones Act shipping, but the costs of bidding away available shipping (and rail) capacity from other uses. While shipping costs to the east coast appear low, currently pipelines are by far the more important means of moving the relevant products from the gulf to the east coast. In 2000, gulf coast refiners supplied nearly 30% of the reformulated gasoline used in PADD 1. Of the volume of reformulated gasoline moved to PADD 1, 95% moved by pipeline. A forced shift to mid-west based ethanol for reformulated gasoline used on the east coast would thus require a radical change in distribution infrastructure with a high potential for disruption if not implemented over an extended period of time.

Price Trends for Ethanol and MTBE

While the short-term forcing ethanol on the east and west coasts is a recipe for supply disruption, within and around its own backyard, when current tax incentives are allowed for, ethanol can be very competitive against the alternatives. The chart below shows monthly trends since early 1998 in gulf coast spot prices for ethanol and MTBE. For comparative purposes, the chart also shows prices for the octane booster, toluene. Toluene has a somewhat higher octane rating and a much lower RVP (1.0 to 1.5) than either ethanol or MTBE. It is among the alternatives proposed as a potential replacement for MTBE in California reformulated gasoline.[18] Toluene is a toxic contaminant of drinking water with an EPA Maximum Contaminant Level (MCL) standard of 1 part per million. No MCL standard (as yet) has been set for MTBE although the EPA is studying the issue. Breathing air with high levels of toluene can have toxic effects, most clearly on the nervous system. However, the mean concentration of toluene in the air in California is estimated at 0.0085 mg/m3 far below the EPA Reference



[18] See: Keller, AA, LF Fernandez, S Hitz, H Kun, A Peterson, B Smith, M Yoshioka. 1998. An Integral Cost-Benefit Analysis of Gasoline Formulations Meeting California Phase II Reformulated Gasoline Requirements. UC TSR&TP Report to the Governor of California and Cost/Benefit Analysis of the Health and Environmental Issues of Oxygenated and Non-Oxygenated Gasoline Formulations, a presentation by AA Keller to the Workshop on the Increased Use of Ethanol and Alkylates in Automotive Fuels in California, April, 2001 The presentation may be accessed at http://www-erd.llnl.gov/ethanol/proceed/fuelc_b.pdf.

Concentration level for toluene of 0.4 mg/m3, at or below which "inhalation over a lifetime would not likely result in the occurrence of chronic, noncancer effects."[19]

Net of the Federal tax credit, the spot price of gulf coast ethanol has generally been cheaper than MTBE. Most, but not all of the difference is the result of the tax credit. However, when demand is high and oil prices are at very high levels, as they were over the summer of 2000, or when natural gas prices are at extraordinary levels, as they were early this year, MTBE prices approach or even exceed the pre-tax credit prices for ethanol. In the most recent months, with the driving season over, natural gas prices depressed, and oil prices down, MTBE prices have fallen marginally below the ethanol price net of the tax credit. Prices for toluene have generally tracked MTBE prices, although they have not shown the same price spikes as MTBE over the past two years. The favorable price of ethanol net of the Federal tax credit relative to MTBE (and toluene) over much of 2000 was supportive of the high growth in use of fuel ethanol shown for last year in the previous section of the report

Why Insist on Ethanol

In considering the oxygenate issue in general, and ethanol in particular, it should be kept in mind that the latest evidence on environmental effects does not provide compelling support for any particular mandates. With respect to reformulated gasoline, which can be made without oxygenates, the report released last year of the National Research Council concluded, "The use of commonly available oxygenates in RFG has little impact on improving ozone air quality and has some disadvantages."[20] The report noted that the most significant advantage of oxygenates in RFG was the displacement of some toxics. But not all toxics are displaced. With MTBE blends, emissions of formaldehyde might be increased. While formaldehyde emissions might not increase with ethanol blends, emissions of another toxic, acetaldehyde, are increased. The reactivity of exhaust emissions appear to be lower, although not by a statistically significant difference, from ethanol as opposed to MTBE blended RFG, due to lower carbon monoxide emissions. On the other hand, evaporative emissions (both in mass and in terms of reactivity) were significantly higher for ethanol-based reformulated gasoline. On a combined basis, the report finds---"a net increase in overall reactivity of motor-vehicle emissions (exhaust plus evaporative) would result from the use of ethanol-blended RFG (with an elevated RVP) instead of MTBE-blended RFG."

The NRC report presented an extensive discussion of findings from the laboratory study conducted by the Auto/Oil Air Quality Improvement Research Program of 1989-95. The NRC noted in particular that:

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[19] See the EPA Hazard Summary for toluene available at: http://www.epa.gov/ttn/uatw/hlthef/toluene.html. Toluene has not been found to be carcinogenic.

[20] National Research Council, Ozone-Forming Potential of Reformulated Gasoline, National Academy Press, Washington, D.C., 2000. The quote, and subsequent discussion of the report are taken from pp. 6-10. The report was prepared by an NRC Committee on Ozone-Forming Potential of Reformulated Gasoline in response to a request by the Environmental Protection Agency.

The most dramatic effects on ozone-precursor exhaust emissions seen in the various gasoline compositional matrices studied were those due to lowering the fuel's RVP and the amount of sulfur-containing compounds.

Only slight reductions, less than 10%, in the CO and VOC emissions can be ascribed to the addition of either MTBE or ethanol.[21]

Although the report did not consider reductions in CO emissions from the addition of oxygenates significant enough to impact their comparisons between RFG blends, it can still be a factor in assessing winter oxygenate issues. This report, as do previous reports, points to evidence of significant reductions in winter CO emissions. However, the gains are most important for the high-emitting, older technology vehicles and those with defective emissions control systems. Over time, the number of old technology vehicles is declining but is still a long way from zero. In 1999, about 40% of cars on the road were over 9 years old and accounted for about 30% of miles driven. Based on estimated survival rates for 1990 cars, about 75% to 80% are still on the road.[22] While ethanol has some marginal advantages over MTBE in terms of CO reduction, it should be kept in mind that this is a market already dominated by ethanol. In the Energy Information Administration study cited earlier, about 90% of the 1997 oxygenate volume in winter oxygenated gasoline was ethanol, with about half of the volume used in Minnesota.

CO emissions are being impacted by other regulations besides oxygenates. Federal Tier 2 regulations require a reduction in average sulfur levels from about 300 ppm today to 30 (about the current average for California RFG) by 2004. Federal CO emissions standards for cars have been set at 3.4 grams/mile (for 50 thousand miles) since 1981 but the standards for light trucks were not brought down to that level until 1994. From 1981 to 1983, the standard for light trucks was 18 grams/mile and from 1984 to 1993 10. The tightening of these standards and turnover of the fastest growing segment of the light duty vehicle fleet are helping curb CO emissions. In any case, as noted earlier, winter oxygenated gasoline has become a very minor fraction of the gasoline pool as former nonattainment areas have been able to reach and maintain attainment status without it.

While there appear to be no environmental imperatives to support expanded ethanol use, there remain two other objectives often cited in favor of ethanol, support for domestic agriculture and energy security.

It is of course true that expanding use of ethanol helps domestic agriculture, assuming that via tariffs and/or other measures, ethanol imports are kept to minimal levels. But gains are likely to be very modest, especially in relation to costs. In January 2000, the Department of Agriculture released a study prepared in response to a request from Senator Tom Harkin of Iowa on the

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[21] From Chapter 6, p. 169 of the NRC Report.

[22] Figures taken from tables in chapters 4 and 6 of the Department of Energy, Center for Transportation Analysis, Transportation Energy Data Book: Edition 21.

economic impact of replacing MTBE in reformulated gasoline with ethanol.[23] The study assumed a complete phase-out of MTBE by 2005 with all the lost oxygenate replaced by domestic ethanol, primarily from corn. The study estimated that ethanol production would rise by about 100 MB/D and that some ethanol would be bid away from non-RFG markets. The balance of the gasoline pool loss was assumed to be made up by alkylates. The study estimated the shift to ethanol would raise net farm income by about $1.6 billion and total jobs from increased ethanol production and distribution (but with no allowance for job losses from elimination of MTBE production and distribution) by about 13 thousand. The study also projects a small net increase in agricultural exports, about $250 million, although such an estimate assumes the higher costs of farm products can be passed on to foreign markets. These gains do not come cheap. Assuming the 2005 51 cent/gallon tax exemption rate under current law, the increased use of ethanol by 100 MB/D costs about $750 million in lost Federal revenues, nearly a 50 cent loss for every dollar of net farm income gained and about $57,000 per year lost for every estimated job created.

Most of the Agriculture Department's projected gains in farm income are due to higher corn prices as a result of about a 550 million bushel increase in demand by 2005. The increase in demand amounts to about 5-6% of the current corn crop, and would about double the amount of corn currently used in fuel ethanol production. The price rise resulting from the higher demand reaches 19 cents/bushel in 2004-5 and then eases back to a 16-cents/bushel gain later in the decade. The projected price increases are about in line with the estimates of 4 cents per 100 million of additional bushels of corn devoted to ethanol under relaxed supply conditions cited in a recent Congressional Research Service study of the issue.[24] Such figures imply that the current program itself has raised incomes of corn producers, and costs to consumers, by about $2.5 billion. Of course, the Federal government has a decades-long commitment to assist farmers in times of oversupply and depressed prices and at such times, the current ethanol program is more an alternative means of assistance rather than an incremental one. On the other hand, when markets are tight, the price impact of the ethanol program would be greater. This becomes a more critical issue the greater the amount of any ethanol mandate. In this regard, both the corn price and production level have shown significant variability. Between 1990 and 2000, corn production has averaged 8.8 billion bushels, and ranged from a low of 6.3 billion bushels in 1993 to a high of 10.1 billion in 1994. Prices have averaged $2.32/bushel over the same period with range of from $1.82 in 1999 to a high of $3.24/bushel in 1995. Last year, production was nearly 10 billion bushels and the average price was $1.85.

Regarding energy security, ethanol from agricultural products has been viewed as a secure supply of renewable, domestic source energy (although this is subject to qualification given variability in corn production and prices noted above). Here, however, there is the issue of just how "renewable" a source is ethanol when due allowance is made for the fossil fuel inputs that

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[23] Department of Agriculture, Office of Energy Policy and New Uses, Economic Analysis of Replacing MTBE with Ethanol in the United States, January 2000. The study accompanied a transmittal letter from the Secretary of Agriculture to Senator Harkin.

[24] Congressional Research Service Issue Brief RL30369: Fuel Ethanol: Background and Public Policy Issues, March 22, 2000.

go into the chemicals, fuels, and electricity used in production and transport of feedstock crops, especially corn, and in the distillation process. Early estimates indicated that more fossil fuel energy was used directly and indirectly in producing ethanol than it contained, suggesting that in terms of net energy value, it was not renewable at all. More recent studies have pointed to improved trends in corn production per pound of fertilizer used, efficiency gains in the production of fertilizers, and improved energy efficiencies in the distillation process. A Department of Agriculture study published in 1995 estimated a ratio of energy output to energy input of just over 1:1 when no credits were allowed for co-products such as corn oil and feeds. With such credits, the estimated ratio rose to 1.24:1. The study also notes that liquid fuels account for a fraction of total fossil fuel inputs, about 15%, with natural gas (as the prime chemical feedstock) accounting for another 15% and coal, presumably through coal-based electricity, the remainder.[25] Greater efficiencies will come with the growth of alcohol from cellulose.[26]

Ethanol thus appears to be "renewable" on a net energy basis and on a net basis a substitute for imported oil. However, the extent of the substitution should be kept in proportion. The prime feedstock for MTBE is natural gas, not oil so that elimination of domestically produced MTBE, two-thirds of total MTBE, has a marginal impact on oil imports. Moreover, any increased use of other octane boosters derived from oil such as alkylates and toluene raises imports. The elimination of foreign source MTBE would, of course, count as a reduction in oil imports. Based on the Department of Agriculture estimates, an increase in ethanol production of 100 MB/D would itself require an increase in oil inputs of about 15 MB/D. If the increased ethanol substituted barrel for barrel for imported MTBE in reformulated gasoline---and no other effects were considered---net oil imports would be reduced by less than 1% of current year net imports. However, other effects must be considered. Since a given volume of ethanol contains less energy than the same volume of MTBE, the switch by itself reduces the energy content of each gallon of gasoline affected by about 2.4%. The result is a debit of up to 2%for average fuel economy for vehicles using the fuel and therefore a compensating increase in gasoline consumption of about 20 MB/D.[27] The net reduction in oil imports, after allowing for the impact on fuel economy, and ignoring the impact of greater use of oil-based octane boosters, thus falls to well under 1% of current year net oil imports.

A further complication is that the switch from MTBE to ethanol in reformulated gasoline means refiners must produce far more of the severe reformulated blendstock (as is used in Chicago)

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[25] U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 721,Estimating the Net Energy Balance of Corn Ethanol by Hosein Shapouri, James A. Duffield, and Michael S. Graboski.

[26] For a discussion of current and prospective efficiencies see, Fuel-Cycle Energy and Emissions Impacts of Fuel Ethanol, by Michael Wang, Argonne National Laboratory presented at the NRC Review of the DOE Biofuels Program, December 17,k 1998. The presentation may be accessed at: http://www.transporation.anl.gov/ttrdc/publications/papers/wang/sld001.html.

[27] The switch of an equal volume of ethanol for an equal volume of MTBE would raise oxygenate levels in the gasoline. A higher oxygenate level improves engine efficiency in older vehicles with carburetors but not in newer vehicles. To allow for this factor, an overall fuel economy debit of less than the 2.4% loss of btu's is used.

required in order for ethanol-based reformulated gasoline to meet effective RVP limits.[28] Eliminating the oxygenate requirement for reformulated gasoline and substituting a modest renewable fuels mandate for the gasoline pool as a whole would, within limits, avoid this complication. The EPA Staff White Paper indicates that about 49% of US summer gasoline was 9.0 RVP conventional gasoline (and presumably eligible for the 1.0 ethanol waiver) while FHWA statistics indicate that, as of last year, about 12% of US gasoline qualified as "gasohol." There would thus appear room for significant expansion of ethanol use within the 9.0 RVP conventional gasoline pool where blending problems would be minimal. However, this pool is going to shrink. In February of this year, the Supreme Court upheld the EPA's more stringent 8-hour ozone standard. The new standard will expand significantly the number of nonattainment areas, although the EPA as yet has made no formal designations, and therefore the number of areas that will have to take actions, including adoption of low RVP fuel, to reduce ozone concentrations. The EPA as yet has made no formal designations of nonattainment areas under the new rule. But data for 1997-1999 show a total of nearly 650 counties potentially in violation of the new standard, up from nearly 400 counties fully or partially included in nonattainment areas under the old standard.[29]

Conclusions

Over the past two driving seasons, price spikes have provided ample evidence of gasoline supply problems, especially with reformulated gasoline. Current initiatives to ban MTBE in a relatively short period of time while maintaining the Federal oxygenate mandate are setting the stage for a massive near-term increase in demand for ethanol. But with MTBE reformulated gasoline used mainly on the coasts and ethanol production almost exclusively in the Midwest, a forced shift to ethanol with its different logistics requirements creates serious new risks of supply disruption and price spikes--- unless the time-frame for an MTBE phase-out is far more gradual than currently contemplated.

While supply risks associated with maintaining the oxygenate mandate for reformulated gasoline are clear, the case for oxygenate requirements of any kind, but especially for reformulated gasoline, has been growing weaker with the improvements in emissions control technology and enabling fuel specifications. This process, already advanced in California, is continuing at the national level with tier 2 Federal emissions and fuel specification regulations. As the EPA has acknowledged, the oxygenate requirements in their present form have also contributed to the problem of "boutique" fuels.

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[28] Achieving a low RVP gasoline while accommodating high RVP ethanol requires removing certain high volatility hydrocarbons, especially pentanes, from the blendstock. These in turn must be disposed of ---potentially via use in petrochemicals, exports, gasoline not subject to low RVP limits, or combusted for heat or power. Effectively, more hydrocarbons are required to make the ethane-based low RVP gasoline. If the (lower value) uses of the discarded pentanes fully displace other oil inputs, there is no net increase in oil import requirements. If not, the process would involve a further marginal reduction in potential oil imports saved by using ethanol.

[29] The counties potentially impacted by the new standard that were not covered by the old standard include metropolitan areas such as Memphis, Tampa-St. Petersburg, Indianapolis and Tulsa.

There appear to be no compelling environmental advantages to ethanol. While increased use would be beneficial to the agricultural sector and could have a marginal impact on oil imports, the gains are small and the costs high. Nonetheless, this sector has not been the first, nor will it be the last to receive government support, although mandates for use are another matter. With its current tax advantages, ethanol is very competitive within its current market areas and is likely to grow in volume even without a mandate. If a mandate is politically inevitable, it should not be tied to reformulated gasoline. If linked to the gasoline pool as a whole with trading possibilities as per the recent EPA Staff White Paper, and if volume requirements moved up gradually, ethanol use could expand in its most logistically efficient manner, thereby minimizing risks of supply disruption. If a mandate is to be considered, the role of the current Federal tax advantage should be revisited since, with a mandate, the market for ethanol is essentially assured.