ECONOMIC AND TECHNICAL EFFECTS OF

A NATIONAL BAN ON MTBE BLENDING

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1. Background

The U.S. Congress continues its consideration of a national Renewable Fuels Standard (RFS), comprising three main elements:

- A national ban on the use of MTBE as a gasoline blendstock;
- Repeal of the oxygen requirement in the federal reformulated gasoline (RFG) program; and
- A national ethanol mandate, with the mandate volume increasing annually until it reaches 5 billion gallons per year (bgy) in 2012.

In connection with the RFS debate, various organizations have published estimates of the economic consequences of a national ethanol mandate. Some of these estimates take a national MTBE ban as a given. That is, they reflect the *assumption* that MTBE would be banned nationally (by either the federal government or state governments), regardless of whether or not Congress established an ethanol mandate. Such estimates understate the true cost of the proposed RFS program, because they ignore the economic consequences of banning MTBE blending. These consequences are significant.

To help shed light on this issue, this paper presents MathPro Inc.'s most recent estimate of the refining cost of a national MTBE ban.

2. Summary of Findings

2.1 Banning MTBE Would Significantly Increase the Cost of CaRFG3 and RFG2

We estimate that, with the federal oxygen requirement in place, the California MTBE ban alone will increase the refining cost of CaRFG3 by about **7½¢/gal**, and a national MTBE ban would increase the average refining cost of CaRFG3 and federal RFG2 by about **6¢/gal**. Repeal of the federal oxygen requirement, which would increase refinery flexibility in RFG production, would reduce the average refining cost of a national MTBE ban to about **2½ ¢/gal**.

Table 1: Estimated National Refining Costs of an MTBE Ban

MTBE Ban Scenario		Estimated Refining Costs	
Area	**Oxygen Required**	**Average Cost (¢/gal)**	**Total Season Cost (MM$/Summer)**
California	Yes	7½	560
Nation-wide	Yes	6	1270
	No	2½	530

These costs are in 2000 dollars. They apply to the total affected volumes of Summer gasoline: CaRFG3 in the California ban scenario; federal RFG2 and CaRFG3 – about 3 million Bbl/day in all – in the national ban scenarios.

The average per-gallon costs are the additional refining costs incurred to produce reformulated gasoline without MTBE; they do not necessarily delineate the corresponding changes in prices paid by consumers. (This subject is discussed further in Section 6.3.)

The *total season costs* are aggregate costs nation-wide, for the Summer gasoline season, summed over all of the regions considered.

2.2 Banning MTBE Would Call for Additional Import and Blendstock Volumes

Banning MTBE would significantly increase the U.S. refining industry's call for imports (of finished gasoline and blendstocks) and for domestic production of blendstocks that are not now in commerce. **Table 2** shows our estimates of the volumes of additional gasoline imports, additional refinery-produced blendstocks, and new iso-octane/iso-octene production required in each of the three scenarios we considered.

Table 2: Estimated Additional Import and Blendstock Volumes With an MTBE Ban

MTBE Ban Scenario		Estimated Volumes (K Bbl/day)		
Area	Oxygen Required	Gasoline Imports	Refinery Blendstocks	Iso-Octane/ Iso-Octene
California	Yes	90	70	7
Nation-wide	Yes	100	50	122
	No	190	80	138

In Table 2, *Gasoline Imports* denotes imports of conventional gasoline in PADDs 1 & 3; *Refinery Blendstocks* denotes the sum of special light (C_7) alkylate, C_6 isomerate, and C_6 isomerate feed produced in PADD 3 refineries and supplied to California refineries; and *Iso-octane/Iso-octene* denotes iso-octane and/or iso-octene produced in U.S. captive (refinery-based) and merchant plants retro-fitted to produce these streams. Iso-octane would be blended in CaRFG3; iso-octene would be blended in federal RFG2 in PADDs 1 and 3.

We estimate that under a national MTBE ban, essentially all U.S. *captive* MTBE capacity and some *merchant* capacity would be retro-fitted to iso-octane/iso-octene production. Some of the iso-octane/iso-octene produced in PADD 3 would go to California; the rest would stay in the region where it was produced (primarily PADD 3).

In all cases, the indicated refinery blendstock volume includes 25 K Bbl/day of special light alkylate (the assumed maximum volume that PADD 3 could deliver).

3. MTBE IS A PRIME BLENDSTOCK FOR REFORMULATED GASOLINE

As these results indicate, eliminating MTBE from the U.S. gasoline pool would have important technical and economic consequences throughout the U.S. refining sector. This is a consequence of MTBE's blending properties, which make MTBE an almost perfect blendstock for reformulated gasoline. It has unusually high octane (about 110 (R + M)/2). Its RVP is marginal (about 8.5 psi), but its other blending properties relevant to RFG production are outstanding: oxygen content, low sulfur, no aromatics, no benzene, no olefins, low T_{50}, and low T_{90}. Consequently, with the advent of the federal and California RFG programs, U.S. refiners made capital investments shaping their refineries both to produce MTBE and to use it in RFG production.

Absent a waiver of the federal oxygen requirement for RFG, an MTBE ban would force refiners to replace MTBE with ethanol. Ethanol is a less attractive blendstock, because of its high blending RVP and its affinity for water. Under normal market conditions, ethanol-blended RFG is more costly to produce and deliver to the pump than MTBE-blended RFG. U.S. refiners would have to invest additional capital to re-shape their refineries and adopt new operating methods and trading patterns to replace MTBE and accommodate ethanol.

4. SCENARIOS ANALYZED

To delineate the costs of a national MTBE ban, we analyzed a Reference case and three MTBE ban scenarios, identified in **Table 3** below.

Table 3: Scenarios Analyzed

Descriptors	Scenarios		
	1	2	3
➢ MTBE Ban			
California	X	X	X
Nation-wide		X	X
➢ Oxygen Requirement			
Yes	X	X	
No (i.e., requirement repealed)			X

The Reference case incorporates the federal Tier 2 sulfur standard for gasoline, the federal Mobile Source Air Toxics (MSAT) program (which prevents "back-sliding" in toxic emissions of a refinery's gasoline out-turn, relative to the refinery's 1998-2000 baseline), but no restrictions on MTBE usage.

The MTBE Ban scenarios also incorporate the federal Tier 2 sulfur standard for gasoline and the MSAT program. In addition, the first MTBE Ban scenario denotes the California ban, scheduled to take effect in January 2004. The other two denote a national MTBE ban, with and without repeal of the federal oxygen requirement for RFG.

> The MTBE Ban scenarios involve no increase in overall toxics emissions – *with respect to the Reference case* – as a consequence of a state or national ban on MTBE blending, after giving effect to (1) the toxics emissions benefits of the federal Tier 2 gasoline sulfur standard and (2) ethanol's toxics emissions performance, which is inferior to that of MTBE in EPA's Complex Model for certifying federal RFG.

5. Key Elements of the Analysis

The scenarios incorporated the federal RFG2 program and the California CaRFG3 program. All applied to the long term – the time period in which (1) the refining industry and its blendstock suppliers would have completed their investments to deal with an MTBE ban and (2) the federal Tier 2 gasoline sulfur standard (30 ppm average) would be in full effect.

We analyzed the Reference case and the three MTBE Ban scenarios by modeling

- Refining operations in three regions
  - PADDs 1 & 3 (combined)
  - PADD 2
  - California

- The inter-regional flows of key gasoline blendstocks, including ethanol and various streams produced by refineries and retro-fitted merchant MTBE plants.

We modeled refining operations for the *Summer* season (only), using three corresponding regional refinery LP models.

We estimated a long-term supply function for fuel ethanol, expressed in terms of volumes supplied to areas outside the Midwest (excluding the volumes required for the Winter oxygenated gasoline program in PADDs 4 and 5). The supply function covers a range of ethanol volumes, corresponding to *total* ethanol production of 100 K Bbl/day to 240 K Bbl/day. The lower volume is approximately the volume of ethanol production in 2000 (before ethanol production capacity began to expand in anticipation of an RFS). The higher volume is approximately the required ethanol supply in the event of an MTBE ban with no oxygen waiver and with continuation of (1) existing state programs for ethanol blending, (2) current use of ethanol in RFG2 and gasohol in the Midwest, and (3) the Winter oxygenated gasoline program for CO control.

The estimated ethanol prices incorporate (1) the refining values of ethanol in gasohol and RFG2[1]; (2) a per-gallon capital charge for investments in new capacity, reflecting a 10% return on investment; (3) a charge for re-commissioning shut-in ethanol capacity; (4) the statutory phase-down in the blender's tax credit from \$0.54/gal to \$0.51/gal (in nominal dollars), from 2001 to 2005; and (5) the effects of increased ethanol production on the prices of ethanol plant feed (corn) and by-products.

We embedded in the PADDs 1 & 3 regional refining model an implicit long-term supply function for iso-octane and iso-octene production from existing MTBE units retro-fitted for the purpose. We developed the iso-octane/iso-octene supply function using information from public sources and confidential information provided by two leading MTBE technology providers.

In each scenario, we assumed that refiners in PADDs 1 & 3 could import additional volumes of conventional gasoline – up to 100 K Bbl/day at a price equal to the marginal cost of gasoline production in PADDs 1 & 3 in the Reference case and then additional volumes at a higher price (marginal cost plus 2¢/gal).

6. Interpreting the Results of the Analysis

6.1 Implications of Key Assumptions and Premises

The estimated refining costs shown in Table 2 reflect certain key assumptions and premises.

- We assumed that the refining industry would have a sufficiently long lead-time (3-4 years) to implement an MTBE ban or phase-out without incurring costs for expedited implementation. Adequate lead-time would permit completion of refinery upgrades in normal maintenance and unit turn-around cycles and without costs such as additional unit downtime, additional labor usage, and accelerated permitting.

- Similarly, we assumed that the ethanol industry would have sufficient lead-time to build and commission the additional production capacity that a national MTBE ban or phase-out would require, without incurring costs for expedited project implementation.

- The analysis did not include the economics associated with meeting gasoline demand growth in the period preceding an MTBE ban. The estimated refining costs reflect solely the cost of replacing MTBE volume and MTBE's contributions to gasoline pool quality.

1 These refining values are the minimum prices that ethanol users outside of the Midwest would have to pay to bid away ethanol from its current applications.

- The Reference case, which established baseline costs for the analysis, included the federal Tier 2 sulfur standard for gasoline (to take effect in 2005). Hence, the MTBE Ban scenarios in this analysis represent the refining industry's having first invested in gasoline sulfur control (Reference case) *and then* investing to produce gasoline without MTBE. A different assumption – that the timing of an MTBE ban would allow refiners to invest simultaneously in gasoline sulfur control and MTBE replacement – might lead to investment costs and resulting capital charges different than those presented in this report.

- The analysis addressed only the Summer gasoline season. The Winter season costs are likely to be substantially lower than Summer costs (on a per gallon basis); but they are still significant and the Winter season is longer than the Summer in most regions. In general, an overall accounting of the total cost to the nation of an MTBE ban must include both Summer and Winter season costs.

- We assumed that finished gasoline and/or gasoline blendstocks could be imported in the desired volumes and at prices close to their marginal production costs in the importing regions. Higher import prices would tend to increase the total cost of an MTBE ban.

6.2 Additional Economic Effects of an MTBE Ban

By design, the study focused on estimating the refining costs of producing RFG under an MTBE ban in the Summer season. It did not address other economic effects of an MTBE ban, including costs and income transfers associated with additional production and consumption of ethanol. For example, the estimated total refining costs shown in Table 2 do <u>not</u> include two cost elements associated with additional ethanol supply volumes that would be called out by an MTBE ban:

- The amount of the federal tax subsidy for ethanol on additional Summer production

- The increased cost of ethanol blended into *Winter* oxygenated gasoline in PADDs 4 and 5 (arising from the increase in the market-clearing price of ethanol)

Together, these two elements would add about **$500 MM/year** to the cost of gasoline production under a national MTBE ban, with the oxygen requirement in place, and about **$20 MM/year** with repeal of the oxygen requirement.

Similarly, the analysis did not address the economic effects of the additional corn production needed to support new ethanol production. This additional production would tend to raise the price of corn in all of its markets.

6.3 Refining Costs vs. Market Prices

The economic results shown in Table 2 are estimates of the total and average per-gallon refining cost (in the Summer season) of a California or national MTBE ban, under various policy scenarios. Per gallon *costs* do not necessarily translate into corresponding changes in *prices* that consumers would pay for gasoline under the various scenarios.

> For each region considered, the estimated total seasonal costs of an MTBE ban are the additional costs that the regional refining industry would incur in meeting projected demands for refined products, through internal production and importation of refined products and blendstocks. The corresponding average per-gallon costs are simply total seasonal costs divided by the total volume of (MTBE-free) RFG produced.

The estimated total and average per-gallon costs reflect the additional economic resources expended in the refining sector (and in the acquisition of imports) to produce reformulated gasoline without MTBE. These costs are appropriate measures of the overall economic impact of an MTBE ban – but they do not directly determine market prices.

Market prices are influenced less by *average* costs of supply than by *marginal* costs of supply. In general, the *marginal* cost, associated with the "last gallon" supplied, is greater than the *average* cost of the total volume supplied.

Changes in the marginal cost of supply caused by an MTBE ban would be a key determinant of subsequent changes in the market prices of gasoline (and other refined products). In the long-term after an MTBE ban were instituted, the marginal supply of RFG would be either imported gasoline or domestic production from new refining capacity. In the former case, the marginal cost of gasoline would be the CIF (delivered) price of imported gasoline. In the latter case, the marginal cost of gasoline would be the marginal cost of domestic production, including return on investment – so long as the refining sector had not created excess gasoline-making capacity by "over-investing". If it had over-invested in new capacity (as it often does), only part of the marginal cost of production – direct costs, but not return on investment – would be embodied in the market price of gasoline.

These considerations all apply to *steady-state* market conditions in an average Summer season. That is, they do not address cost and price transients that might occur in periods of temporary market disruption, caused by short-term (say) supply interruptions, refinery outages, capacity shortfalls, inventory shortages, or the exercise of market power by various participants.