# MTBE, Oxygenates, and Motor Gasoline

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## Introduction

The blending of methyl tertiary butyl ether (MTBE) into motor gasoline has increased dramatically since it was first produced 20 years ago. MTBE usage grew in the early 1980's in response to octane demand resulting initially from the phaseout of lead from gasoline and later from rising demand for premium gasoline. The oxygenated gasoline program stimulated an increase in MTBE production between 1990 and 1994. MTBE demand increased from 83,000 in 1990 to 161,000 barrels per day in 1994. The reformulated gasoline (RFG) program provided a further boost to oxygenate blending. The MTBE contained in motor gasoline increased to 269,000 barrels per day by 1997.

Unfortunately, because of leaking underground storage tanks or spills and because MTBE is soluble in water and does not biodegrade easily, there have been increasing detections of MTBE in ground waters and reservoirs.

Because of the occurrence of MTBE in water supplies, the EPA formed the *Blue Ribbon Panel On Oxygenates in Gasoline*. In September 1999, the Panel issued its final report that included the following recommendations on MTBE use:[(1)]

- "Reduce the use of MTBE substantially (with some members supporting its complete phase-out), and action by Congress to clarify federal and state authority to regulate and/or eliminate the use of gasoline additives that threaten drinking water supplies."

- "The current Clean Air Act requirement to require 2 percent oxygen, by weight, in RFG must be removed in order to provide flexibility to blend adequate fuel supplies in a cost-effective manner while quickly reducing usage of MTBE and maintaining air quality benefits."

In December 1999, the California Air Resources Board approved the California Phase 3 gasoline regulation, which prohibits the formulation of gasoline with MTBE after December 31, 2002. Governor Davis has also asked the U.S. EPA to waive the reformulated gasoline oxygen requirement. A decision from the U.S. EPA is pending.

**This Short-Term Energy Outlook (March 2000) assumes no change in the current EPA regulations regarding the blending of MTBE into gasoline or the required properties of reformulated gasoline. Because this short-term forecast extends only through December 2001, no impact from the California ban on MTBE is included.**

The purpose of this analysis is to identify the issues related to the recommendations of the EPA's Blue Ribbon Panel and how they may impact our forecasts.

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## Federal gasoline product quality regulations

As required by the Clean Air Act, the U.S. petroleum refining industry has responded to 5 major new Federal rules on motor gasoline product quality in the last 11 years:

| Environmental Regulations Affecting the Product Quality of U.S. Motor Gasoline | |
|---|---|
| Phase 1 Summer Volatility (RVP) Regulation | June 1989 |
| Phase 2 Summer Volatility (RVP) Regulation | May 1992 |
| Oxygenated Gasoline | November 1992 |
| Reformulated Gasoline Phase 1 | December 1994 |
| Reformulated Gasoline Phase 2 | January 2000 |

Oxygenates were first required in the wintertime ***oxygenated gasoline*** program to reduce exhaust emissions of carbon monoxide (CO) in 39 areas of the country. The oxygenated gasoline program requires oxygen at a minimum level of 2.7 weight percent (equivalent to 15.0 volume percent MTBE or 7.4 volume percent fuel ethanol).

The ***reformulated gasoline*** (RFG) program requires reductions in automobile emissions of ozone-forming volatile organic compounds during the summer high-ozone season, and of toxic air pollutants and nitrogen oxides during the entire year in certain areas of the United States. Reformulated gasoline requires a minimum 2.1 percent oxygen by weight when averaging, which corresponds to approximately 11.7 volume percent MTBE or 5.8 volume percent ethanol. While the sale of Federal reformulated gasoline was mandated for only nine areas in the nation

with the most severe ozone pollution, other areas are allowed to voluntarily join the Federal RFG program.

## What are oxygenates?

Oxygenates are hydrocarbons that contain one or more oxygen atoms. The primary oxygenates are alcohols and ethers, including: fuel ethanol, methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), and tertiary amyl methyl ether (TAME).

The 1977 Clean Air Act amendments set requirements for "substantially similar gasoline," which requires that oxygenates be approved by the U.S. EPA before they are allowed to be used in gasoline. In 1981 the EPA allowed the blending of MTBE up to 11 volume percent, and extended the limit to 15 volume percent in 1988.

Oxygenates are added to motor vehicle fuels to make them burn more cleanly, thereby reducing toxic tailpipe pollution, particularly carbon monoxide. Oxygenates are favored not only for their vehicle emission benefits but also their blending properties in motor gasoline (e.g., octane).

**Table 1. Typical Properties of Oxygenates**

| | Ethanol | MTBE | ETBE | TAME |
|---|---|---|---|---|
| Chemical formula | $CH_3CH_2OH$ | $CH_3OC(CH_3)_3$ | $CH_3CH_2OC(CH_3)_3$ | $(CH)_3CCH_2OCH_3$ |
| Oxygen content, percent by weight | 34.73 | 18.15 | 15.66 | 15.66 |
| Octane, (R+M)/2 | 115 | 110 | 111 | 105 |
| Blending vapor pressure, RVP | 18 | 8 | 4 | 1.5 |

Source: National Petroleum Council, *U.S. Petroleum Refining: Meeting Requirements for Cleaner Fuels and Refineries* (Washington, DC, August 1993) Appendix L.

## Who gets gasoline with oxygenates?

Reformulated gasoline makes up about one-third of all gasoline sold in the United States. Oxygenated gasoline makes up about 5 percent of the gasoline sold during the winter months (November through February) and averages about 1.3 percent over the full year.[(2)]

**Figure 1. Reformulated and Oxygenated Gasoline Demand by PADD, 1997**
(thousands of barrels per calendar day)

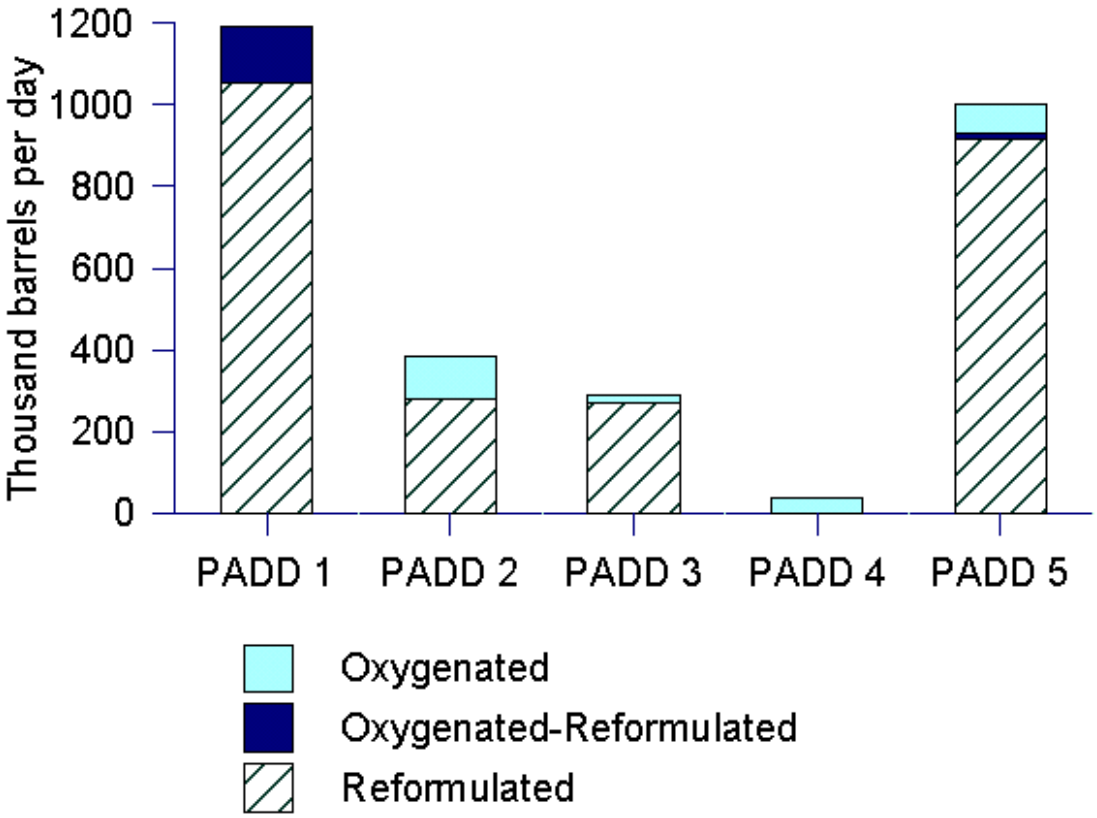


**Table 2. Reformulated and Oxygenated Gasoline Demand by PADD, 1997**
(thousands of barrels per calendar day)

| PADD Region | Reformulated Gasoline | Oxygenated-Reformulated Gasoline | Oxygenated Gasoline |
|---|---|---|---|
| PADD 1 - East Coast | 1,052 | 138 | 0 |
| PADD 2 - Midwest | 282 | 0 | 105 |
| PADD 3 - Gulf Coast | 270 | 0 | 19 |
| PADD 4 - Rocky Mountain | 0 | 0 | 36 |
| PADD 5 - West Coast | 915 | 13 | 73 |
| ***Subtotal U.S.*** | **2,522** | **151** | **233** |

**Sources:** Control area gasoline demand calculated from control area population as share of State population and 1997 State gasoline demand from Federal Highway Administration, "Monthly Gasoline Reported by States," *Highway Statistics 1997*, FHWA-PL-98-020 (Washington, DC, Nov. 1, 1998), Table MF-33GA.

For additional information refer to:

**Environmental Protection Agency**

- Oxygenated gasoline program areas
- Reformulated gasoline program areas

**Energy Information Administration**

- Oxygenated gasoline program areas
- Reformulated gasoline program areas
- Oxygenated and Reformulated Gasoline Sales by State:
  - *Petroleum Marketing Monthly* Table 48
  - *Petroleum Marketing Annual* Table 48

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# Which areas get MTBE?

While EIA reports monthly data on production, imports, and stocks of individual oxygenates, there is no comparable data on the disposition of oxygenates. However, an oxygenate demand balance can be derived from EPA estimates of the oxygenate content in reformulated and oxygenated gasoline by control area. MTBE is the dominant blendstock in reformulated gasoline, and ethanol is generally the oxygenate of choice in oxygenated gasoline. Almost all MTBE supply is used for reformulated and oxygenated gasoline blending, while only about one-half of the total ethanol supply is. Demand for ethanol in gasohol blending and MTBE as a motor gasoline octane blendstock make up the balance of the oxygenate demands.

[Click here for estimated oxygenate demands by control area in an Excel .XLS file]

**Table 3. Oxygenate Demand in Reformulated and Oxygenated Gasoline Control Areas, 1997**

(thousands of barrels per calendar day)

| Region | Estimated Oxygenate Volume in Control Area Gasoline | | |
|---|---|---|---|
| | MTBE | ETBE or TAME | Ethanol |
| **Reformulated Gasoline** | | | |
| PADD 1 - East Coast | 110.8 | 8.7 | 0.7 |
| PADD 2 - Midwest | 4.2 | 0.0 | 22.4 |
| PADD 3 - Gulf Coast | 25.8 | 3.0 | 1.0 |
| PADD 4 - Rocky Mountain | 0.0 | 0.0 | 0.0 |
| PADD 5 - West Coast | 97.2 | 3.3 | 1.0 |
| ***Subtotal U.S.*** | **238.1** | **15.0** | **24.2** |
| **Oxygenated-Reformulated Gasoline** | | | |
| PADD 1 - East Coast | 17.8 | 0.0 | 1.6 |
| PADD 5 - West Coast | 0.1 | 0.0 | 1.2 |
| ***Subtotal U.S.*** | **17.9** | **0.0** | **2.8** |

| | | | |
|---|---|---|---|
| **Oxygenated Gasoline** | | | |
| PADD 1 - East Coast | 0.0 | 0.0 | 0.0 |
| PADD 2 - Midwest | 0.0 | 0.0 | 9.0 |
| PADD 3 - Gulf Coast | 0.0 | 0.0 | 1.7 |
| PADD 4 - Rocky Mountain | 0.3 | 1.1 | 2.5 |
| PADD 5 - West Coast | 0.5 | 0.0 | 5.1 |
| ***Subtotal U.S.*** | **0.8** | **1.1** | **18.3** |
| **Average 1997 Oxygenate Demand for RFG and Oxygenated Gasoline Blending** | **257** | **16** | **45** |
| **Imputed Oxygenate Demand for Conventional Gasoline (e.g., octane and gasohol)** | **12** | **n.a.** | **37** |
| **Total 1997 Oxygenate Supply** | **269** | **n.a.** | **82** |

n.a. - not available
**Notes:** Total oxygenate supply includes domestic production, net imports, and stock change. Imports of RFG (161,000 barrels per day) assumed to contain 11.2 percent MTBE by volume.

**Sources:** Oxygenate content in RFG control area gasoline: Environmental Protection Agency, 1997 RFG Surveys Oxygenate Information. Oxygenate market shares in oxygenated gasoline control areas: Environmental Protection Agency, State Winter Oxygenated Fuel Programs, February 1, 1999. Control area gasoline demand calculated from control area population as share of State population and 1997 State gasoline demand from Federal Highway Administration, "Monthly Gasoline Reported by States," *Highway Statistics 1997*, FHWA-PL-98-020 (Washington, DC, Nov. 1, 998), Table MF-33GA. Oxygenate supply: Energy Information Administration, *Petroleum Supply Annual 1997, Volume 1*, DOE/EIA-0340(97)/1 (Washington, DC, June 1998), Tables 3, 20, 27, 30; and *EIA-819M Monthly Oxygenate Telephone Report*.

## How much has been invested in MTBE production capacity?

Although we do not have an estimate of the total investment in MTBE production plants over the last 20 years, we can estimate the current replacement cost of existing MTBE capacity. If only MTBE use is banned, capacity can be converted to the production of ETBE. If all ether use is banned, the conversion of existing MTBE production equipment to alternative uses may be very limited.

There are three types of MTBE production plants:

- **Refinery/Petrochemical plants**: Isobutylene, produced as a byproduct in refinery catalytic crackers and in petrochemical ethylene plants, is reacted with methanol to produce MTBE. These are the smallest and the least expensive MTBE plants to build at $6,000 to $10,000 per daily barrel of capacity.[(3)] The typical 2,500 barrel per day captive plant would cost $15 million to $25 million to build. It would cost a total of $0.6 billion to $1.0 billion to replace the existing 102,000 barrels per day of captive MTBE plant capacity.

- **Merchant plants:** Merchant plants isomerize normal butane to isobutane, then dehydrogenate isobutane to isobutylene, and then combine the isobutylene with methanol to produce MTBE. The merchant plants are the most expensive to build at $20,000 to $28,000 per daily barrel of capacity.[(3)] The typical 12,000 barrel per day merchant plant would cost $240 million to $336 million to build. It would cost a total of $1.7 billion to $2.4 billion to replace the existing 87,000 barrels per day of merchant MTBE plant capacity.
- **TBA plants:** Tertiary butyl alcohol (TBA) is a byproduct of the propylene oxide production process. TBA is reacted with methanol to produce MTBE. We don't have an estimate of the capital cost of TBA conversion plants. For this analysis we assume the capital replacement cost of the existing TBA-MTBE capacity is equivalent to that of refinery/petrochemical plants. It would then cost $260 million to $430 million to replace the existing 43,000 barrels per day of TBA-MTBE capacity.

The total cost of replacing the existing MTBE production capacity would range from about $2.6 billion to $3.8 billion.

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## What does new Ethanol capacity cost?

There are two types of ethanol production processes: wet milling and dry milling. The capital cost for building a new wet mill plant is about $2.00 per annual gallon, and $1.50 per annual gallon for a dry mill plant.[(3)] If all ethers were banned and the reformulated gasoline minimum oxygen requirement maintained, new ethanol plant capacity would be required to replace the ethers. If we assume that all ethanol would go to oxygenated or reformulated gasoline and none into conventional gasohol, an investment of about $2 billion in new ethanol plant capacity would be required.

**Table 4. Estimated New Ethanol Capacity Required** based on 1997 volumes
(barrels per calendar day)

| | |
|---|---|
| Ethers (MTBE, ETBE, and TAME) blended into oxygenated and reformulated gasoline | 285,000 |
| Ethanol required to substitute for ethers (at contained oxygen equivalency of 1/2 gal ethanol = 1 gal ether) | 142,000 |
| Less ethanol blended into gasohol available for reformulated gasoline market | - 37,000 |
| Less existing unused ethanol production capacity | - 15,000 |
| Net new ethanol capacity required | 91,000 |

Notes: For total ether volume and ethanol blended into gasohol (conventional gasoline) refer to Table 3. Existing unused capacity based on 1999 average ethanol production of 95,000 barrels per day with production capacity of about 110,000 barrels per day.[(4)]

Cost of building new ethanol (dry milling) capacity:

| | |
|---|---|
| $ 1.50 per annual gallon | (e.g., 10 million gallon per year plant = $15 million) |
| = $63 per annual barrel | (e.g., 238,000 barrel per year plant = $15 million) |
| = $22,995 per barrel per calendar day | (e.g., 652 barrel per calendar day plant = $15 million) |
| x 91,000 barrels per calendar day | |
| = ***$2.1 billion*** | |

There would also be additional capital costs for the distribution infrastructure to transport and blend ethanol into gasoline. In just California the capital cost for ethanol distribution infrastructure was estimated to total $60 million.[(3)]

Other considerations:

- The Reid vapor pressure of ethanol in gasoline blending is 18 psi versus an MTBE Reid vapor pressure of 8 psi. During the summer months all butanes will already be removed from gasoline to achieve 7.0 psi RVP in reformulated gasoline. Replacing MTBE with ethanol would require removal of pentanes from gasoline pool. The distribution infrastructure and markets for pentanes do not currently exist for the volumes potentially displaced from the gasoline pool.
- There would be a net loss of gasoline supply volume with replacement of 285,000 barrels per day of ethers with 106,000 barrels per day of ethanol and additional loss of pentanes due to vapor pressure control. Some MTBE feedstock (i.e., isobutylene) may be used to produce alkylate (a gasoline blend component with very favorable blending qualities).
- Although the octane of ethanol is slightly higher than MTBE, there will still be a significant loss of gasoline pool octane because of the smaller blending volumes. The traditional source of octane, aromatics, cannot be returned to the gasoline pool because of emissions restrictions on toxic air pollutants and nitrogen oxides under the reformulated gasoline regulations. Clean sources of octane, such as alkylate, are scarce.
- Methanol plant capacity must also be shut down. 0.34 barrels of methanol is required to produce 1 barrel of MTBE. Methanex, the world's largest producer of methanol has filed a $1 billion claim for compensation under NAFTA against the U.S. government over California's MTBE ban. NAFTA allows companies to seek compensation for damages from changes in government regulations.
- Butane supply will increase. Merchant MTBE plants produce their isobutylene feedstock from normal butane. 1 barrel of normal butane is required to produce 1 barrel of MTBE.

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## What would an MTBE ban cost?

The primary policy options to reduce the use of MTBE in gasoline blending are the elimination of the minimum oxygen requirement in reformulated gasoline and a ban on the use of MTBE and

possibly other ethers. Cost estimates have focused on the following four policy combinations, in order of increasing expense:

- No MTBE ban. Eliminate the minimum oxygen requirement in reformulated gasoline.
- Ban use of MTBE or all ethers in all gasoline. Eliminate the minimum oxygen requirement in reformulated gasoline.
- Ban use of MTBE in all gasoline. Retain minimum oxygen requirement in reformulated gasoline.
- Ban use of all ethers (MTBE, ETBE, and TAME) in all gasoline. Retain minimum oxygen requirement in RFG.

The cost estimates cover either California only or the entire U.S. The wider the MTBE ban the higher the cost should be. The estimated costs are typically average rather than marginal costs. Costs of an MTBE ban will be higher for some refiners and regions and lower for others. It should also be noted that the published cost estimates do not reflect the cost of operating under the EPA's new sulfur reduction requirements (Tier 2 gasoline) that begin in 2004.

The price of ethanol in most studies is assumed to be the market price, which includes the 54 cents per gallon Federal excise tax exemption. The addition of 100,000 barrels per day of ethanol to the gasoline pool would reduce Federal excise tax revenues by about $800 million per year.[(5)]

- **No MTBE ban. Eliminate the minimum oxygen requirement in reformulated gasoline.**

  Eliminating the minimum oxygenate requirement in reformulated gasoline without restricting the use of MTBE or other oxygenates should reduce the cost of producing gasoline because of the increased flexibility allowed refiners.

  Key considerations for this option are:

  - Eliminating the minimum oxygen requirement would likely require Congressional action to amend the Clean Air Act.
  - No assurance it would reduce blending of MTBE rather than ethanol in certain areas of the country, particularly during the summer months.
  - MTBE may be diverted to conventional gasoline to free up high octane gasoline blendstocks (e.g., alkylate) for reformulated gasoline.

  Estimated average costs of the minimum oxygenate requirement:

  - California Energy Commission:[(6)] If Federal legislation were to eliminate the minimum oxygen requirement for California only, the average cost of California reformulated gasoline would be *reduced* by 0.2 cents per gallon in the intermediate term (3 years) and by 0.3 cents per gallon in the long term (6 years). MTBE use California in the long-term would be reduced by 13 percent.

- U.S. Dept. of Energy:[(1)] Eliminating the minimum oxygenate requirement would *reduce* the average cost of producing reformulated gasoline in PADD 1 (East Coast) by 0.3 cents per gallon.

- **Ban use of MTBE or all ethers in all gasoline. Eliminate the minimum oxygen requirement in reformulated gasoline.**

  Key considerations for this option are:

  - Eliminating the minimum oxygen requirement would likely require Congressional action to amend the Clean Air Act.
  - Banning MTBE could be left up to the States by letting them follow the California model.
  - With a ban on MTBE only, some existing MTBE capacity may be converted to ETBE production. This may require an increase in the supply of ethanol, which is a feedstock in the production of ETBE.
  - A ban on all ethers would significantly reduce the octane available for the gasoline blending pool. The traditional source of octane, aromatics, cannot be returned to the gasoline pool because of emissions restrictions on toxic air pollutants and nitrogen oxides under the reformulated gasoline regulations. Clean sources of octane, such as alkylate, are scarce.

  Estimated average costs of an MTBE or ether ban:

  - Energy Information Administration:[(7)] Restricting MTBE blending to 3 percent by volume of the total gasoline pool (equivalent to the 1993 blending level) would increase the national average reformulated gasoline price by about 2.8 cents per gallon. Investment of $2.43 billion would be required and imports of gasoline and blending components would increase by about 135,000 barrels per day. These results reference a base case that includes the California MTBE ban.
  - Chevron/Tosco MathPro Analysis:[(1)] California-only ether ban with no oxygenate requirement increases the price of California reformulated gasoline by 2.7 cents per gallon in the intermediate term (3 years) and by 1.2 cents per gallon in the long term (6 years).
  - U.S. Dept. of Energy:[(1)] Banning all ethers and eliminating the oxygenate requirement would increase the average cost of producing reformulated gasoline in PADD 1 (East Coast) by 1.9 cents per gallon in the long term (at least 4 years with investment allowed).

- **Ban use of MTBE in all gasoline. Retain minimum oxygen requirement in reformulated gasoline.**

  Key considerations for this option are:

  - Congressional action likely not required.
  - Oxygenate credit trading and/or regional averaging option could be implemented.
  - Banning MTBE could be left up to the States by letting them follow the California model.

    - Some existing MTBE capacity may be converted to ETBE production. This may require an increase in the supply of ethanol, which is a feedstock in the production of ETBE.

  Estimated average costs of an MTBE ban:

    - California Energy Commission:[(6)] With a California-only MTBE ban the average cost of California reformulated gasoline would increase by 0.2 cents per gallon in the intermediate term (3 years) and decrease by 0.3 cents per gallon in the long term (6 years).

- **Ban use of all ethers (MTBE, ETBE, and TAME) in all gasoline. Retain minimum oxygen requirement in RFG.**

  Estimated average costs of an ether ban:

    - California Energy Commission:[(6)] With a California-only ether ban the average cost of California reformulated gasoline would increase by 6.7 cents per gallon in the intermediate term (3 years) and increase by 2.5 cents per gallon in the long term (6 years).
    - Chevron/Tosco MathPro Analysis:[(1)] California-only ether ban increases the price of California reformulated gasoline by 6.1 cents per gallon in the intermediate term (3 years) and by 1.9 cents per gallon in the long term (6 years).
    - U.S. Dept. of Energy:[(1)] EPA ban of ethers would increase the average cost of producing reformulated gasoline in PADD 1 (East Cost) by 6.0 cents per gallon in the near term (less than 2 years with no investment) and by 2.4 to 3.9 cents per gallon in the long term (at least 4 years with investment allowed).
    - Turner, Mason & Company:[(8)] EPA ban of ethers would increase the average cost of California reformulated gasoline by 4.5 cents per gallon and increase the cost of PADD 1 reformulated gasoline by 4.8 cents per gallon.

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# On-line information resources

Energy Information Administration, U.S. Dept. of Energy

- Data:
    - MTBE and Ethanol monthly production data by PADD, EIA-819M Monthly Oxygenate Telephone Report.
    - MTBE and Ethanol inventories by PADD, Petroleum Supply Monthly Table 51.
    - Reformulated and Oxygenated gasoline production by States, Petroleum Marketing Monthly Table 48.
- Analysis Reports:
    - Annual Energy Outlook 2000: California Ban of MTBE, December 17, 1999.
    - Price and Demand Outlook for Phase 2 Reformulated Gasoline, August 6, 1999.
    - Areas Participating in the Oxygenated Gasoline Program, July 1999.

    - Areas Participating in the Reformulated Gasoline Program, June 1999.
    - Environmental Regulations and Changes in Petroleum Refining Operations, June 1998.
    - Oxygenate Supply/Demand Balances in the Short-Term Integrated Forecasting Model, March 1998.
    - The Impact of Environmental Compliance Costs on U.S. Refining Profitability, November 3, 1997.

Environmental Protection Agency

- Blue Ribbon Panel on Oxygenates in Gasoline
- Index of MTBE information

International Trade Commission

- Methyl tertiary-Butyl Ether (MTBE): Conditions Affecting the Domestic Industry

House Science Subcommittee on Energy and Environment

- 1999 Hearings on Reformulated and Low-Sulfur Gasoline

California Energy Commission

- Energy Commission MTBE study documents
- Staff Report: Supply and Cost Alternatives to MTBE in Gasoline, February 1999 (PDF file).
- Commission Findings: Timetable for the Phaseout of MTBE From California's Gasoline Supply, June 1999 (PDF file).

Renewable Fuels Association

- USDA, Economic Analysis of Replacing MTBE with Ethanol in the United States
- Downstream Alternatives Inc., Comment on RFG/MTBE Issues and Options in the Northeast, May 11, 1999 (PDF file)
- Downstream Alternatives Inc., The Use of Ethanol in California Clean Burning Gasoline, February 5, 1999 (PDF file)

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## Endnotes

1. EPA Blue Ribbon Panel, *Achieving Clean Air and Clean Water: The Report of the Blue Ribbon Panel on Oxygenates in Gasoline* (Washington, DC, September 15, 1999).

2. The oxygenated gasoline market share has been higher in previous years but because of improved air quality a number of areas no longer require oxygenated gasoline.

3. California Energy Commission, *Supply and Cost Alternatives to MTBE in Gasoline*, P300-98-013 (Sacramento, CA, February 1999). Wet mill plant capital cost from California Energy Commission. Dry mill plant capital cost from Renewable Fuels Association. The $1.50 per annual gallon dry mill plant cost estimated by the Renewable Fuels Association is lower than the $2.50 per annual gallon cost reported by the California Energy Commission.

4. Ethanol production from Energy Information Administration, EIA-819M Monthly Oxygenate Telephone Report. Capacity from Renewable Fuels Association, *The Ethanol Industry Outlook - 1999 and Beyond* (Washington, DC, February 1999) and California Energy Commission, *Staff Report: Supply and Cost Alternatives to MTBE in Gasoline*, Appendix B, P300-98-013 (Sacramento, CA, February 1999).

5. The Federal excise tax exemption is currently $0.54 per gallon and it is scheduled to drop to $0.53 on January 1, 2001, $0.52 on January 1, 2003, $0.51 on January 1, 2005., and expire on December 31, 2006. The loss of excise tax revenue may be offset by reduced farm program spending on marketing assistance loans. The U.S. Department of Agriculture estimates that a complete phaseout of MTBE would increase the average corn price by about $0.14 per bushel. Where loan deficiency payments are being made, each $0.10 per bushel increase in corn prices could lower farm program payments by about $1 billion per year. However, the USDA also reports that under the FY2000 President's Budget baseline, farm crop prices are expected to strengthen from current levels, which results in increased ethanol use having little or no impact on the forecast cost of farm price and income support programs. U.S. Department of Agriculture, *Economic Analysis of Replacing MTBE with Ethanol in the United States* (Washington, DC).

6. Assumes that refiners continue to use the "averaging" option. Cost estimates for operating under the "flat limit" are generally lower. But the risk of producing off-spec material under the flat limit and reprocessing costs are not included and may be significant. California Energy Commission, *Supply and Cost Alternatives to MTBE in Gasoline*, P300-98-013 (Sacramento, CA, February 1999).

7. Energy Information Administration, *Annual Energy Outlook 2000, Appendix F* (Washington, DC, December 17, 1999).

8. Includes 3 cent per gallon Federal excise tax credit for 6 volume percent ethanol. Robert E. Cunningham, Turner, Mason & Company, *Costs of Potential Ban of MTBE in Gasolines*, presented to EPA Blue Ribbon Panel to Review the Use of Oxygenates in Gasoline, March 2, 1999.

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## Summary of Revisions to this Analysis

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Revisions March 6, 2000:

- What does new ethanol capacity cost:
  - Revised Table 4 to include credit for unused ethanol production capacity.
  - Revised estimated cost of new ethanol capacity to reflect construction of dry milling capacity at a lower capital cost.
- Added new endnote number 5, qualifying the potential loss in Federal excise tax revenue.
- Corrected reference to "Chevron/Texaco" study of the cost of an MTBE ban to "Chevron/Tosco MathPro".
- Added Renewable Fuels Association to On-line information resources.

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