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MTBE facts and alternatives

MTBE background

Methyl tertiary-butyl ether, more commonly referred to as MTBE is a chemical compound that is manufactured by reacting methanol and isobutylene. It has been in use since 1979 mostly to replace lead as an octane enhancer; however, it's most popular use most recently has been as an oxygenate, to fulfill the requirements of the Clean Air Act. An oxygenate helps gasoline burn more completely and helps cut down on toxic emissions, such as ozone and carbon monoxide[1]. It also dilutes and or replaces other toxic chemicals that are used in the production of gasoline, such as benzene and sulfur. In 2000 approximately 9.1 billion kilograms of MTBE were produced.[2]

In 1990 the Clean Air Act Amendments stated that areas that have a high level of air pollution must use re-formulated gasoline (RFG). RFG is specially formulated to have fewer polluting compounds than conventional gasoline. One of the primary methods of pollution reduction in alliance with the RFG program is the use of oxygenates. RFG is currently used in 17 states and the District of Columbia. Approximately 30 percent of the fuel used in the United States is re-formulated and 87 percent of that uses MTBE as it's primary oxygenate. The Clean Air Act does not specifically require MTBE, but it is the most popular fuel oxygenate because refiners find it the most economical, as well as the easiest to blend during the refining process (most notably vs. ethanol).[3]

MTBE has consistently been a hot topic in the petroleum and agricultural industry. Areas and corporations that are responsible for refinement and production of fuel oil have often produced the most outspoken proponents of MTBE. However in areas that rely largely on the Agricultural industry Ethanol is often championed due to the fact that it is derived from corn.

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[1] EPA, Remediation of MTBE contaminated soil and groundwater http://www.epa.gov/swerust1/mtbe/mtbefs2.pdf visited on 02/25/2004
[2] United States Geological Survey,The Gasoline Oxygenate Bibliography http://sd.water.usgs.gov/nawqa/vocns/mtbe/bib/ visited on 02/09/2004
[3] EPA, MTBE in gasoline http://www.epa.gov/mtbe/gas.htm visited on 02/25/2004

MTBE is not considered a human carcinogen by any of the leading authorities, (OSHA, IARC). According to the Material Safety Data Sheet[4] as prepared by the Hess Corporation which is one of the primary manufacturers of MTBE in the U.S.[5]

The major argument against MTBE is that it pollutes water supplies. According to The United States Geological Survey, "Routine monitoring of ambient ground water by the U.S. Geological Survey's (USGS's) National Water-Quality Assessment (NAWQA) Program between 1993-1998 documented the frequent occurrence of MTBE, typically at low levels, in shallow urban ground water."[6] Although it is clear that MTBE shows up in water-quality assessment it is unclear what the presence of MTBE means. In 1998 the MTBE Blue Ribbon Panel was developed by a Clean Air Act advisory panel in response to a request from the EPA. Their sole purpose was to investigate MTBE and it's effects on humans and the environment. The Blue Ribbon panel concluded that, "MTBE detections have primarily caused consumer odor and taste concerns, and that in some instances MTBE has been found in drinking water supplies at levels above USEPA's drinking water advisory of 20 to 40 parts per billion which is based on taste and odor thresholds."[7] Despite these recommendations the EPA has set no formal national standards for MTBE, although some states have. The suggested limit of 20 to 40 ppb is just a generalized guideline which states may adopt, or base their guidelines on.

The primary concern with MTBE is that it can pollute and travel through the ground much more easily than other chemicals. MTBE is highly soluble in water and therefore can transfer readily to groundwater because it does not "cling" well to soil, it can migrate faster and farther through the ground than other gasoline components and therefore often contaminates public water systems and private drinking wells.[8] MTBE does not degrade easily and can be costly and difficult to remove from groundwater. However it has been shown to evaporate relatively quickly from surface waters (lakes and reservoirs).[9]

Most MTBE contamination comes from underground storage tanks (UST's) and pipelines. Although there are extensive regulations and codes of federal regulation (CFR) it is commonly known that it is impossible to avoid leaks. The EPA is in charge of all UST regulation, codes and enforcement. Through upgraded standards and enforcement they hope to cut down on leaks, spills and overflows that are contributing to groundwater contamination.[10] All pipeline codes

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[4] A material safety data sheet is required for any substance that meets the requirements of the Chemical Hazard Inventory, the chemical must be shown to pose a physical or health hazard in at least one study. MSDS sheets are compiled by the companies that are responsible for their manufacture, and must be approved by OSHA in accordance with the Hazard Communication Standard. From Hazard Communication Standard http://www.ilpi.com/msds/osha/1910_1200.html#1910.1200 visited 03/10/2004. (and) Understanding MSDS http://www.nmsu.edu/~safety/programs/chem_safety/hazcom_MSDS-info.htm visited on 02/28/2004

[5] Hess, Material Safety Data Sheet MTBEhttp://www.hess.com/about/msds/MTBE_9922_clr.pdf visited on 2/25/2004

[6] Untied States Geological Survey, The Gasoline Oxygenate Bibliography http://sd.water.usgs.gov/nawqa/vocns/mtbe/bib/ visited on 02/09/2004

[7] EPA, Recommendations and Actions http://www.epa.gov/mtbe/action.htm visited on 02/25/2004

[8] EPA, Movement and Disposition of MTBE in the Environment http://www.epa.gov/mtbe/water.htm#concerns visited on 02/25/2004

[9] Material Safety Data Sheet MTBEhttp://www.hess.com/about/msds/MTBE_9922_clr.pdf visited on 02/25/2004

[10] EPA, Underground storage tanks http://www.epa.gov/mtbe/storage.htm visited on 02/09/2004

and enforcement is handled by the Department of Transportation, although pipelines and transportation play a much smaller role in MTBE spills than does that from UST's.

The methods used to clean up a site that has been contaminated with MTBE's can fluctuate widely due to MTBE's varying characteristics in different mediums. According to the EPA, "when soil is contaminated with MTBE, treatment may be even easier than for other gasoline compounds since pure MTBE has a high vapor pressure and does not sorb ("stick") easily to organic carbon in soil. When MTBE is dissolved in water, MTBE treatment may be more difficult and time consuming than for other gasoline compounds."[11] Cleaning MTBE from water can be a more costly and involved process due to MTBE's high water solubility and natural degradation. It must however be emphasized that only water that would be used from drinking is usually cleaned, because cleaning can be much more expensive and difficult than treatment and remediation.

States' Experiences

Eighteen states—Arizona, California, Colorado, Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Michigan, Minnesota, Nebraska, New Hampshire, New York, Ohio, South Dakota and Washington—have enacted laws to either phase out MTBE or opt out of the federal RFG program as of June 2002. Other state legislative activities include: laws to direct state agencies to study MTBE contamination of water supplies and its health effects.(See Figure 1)

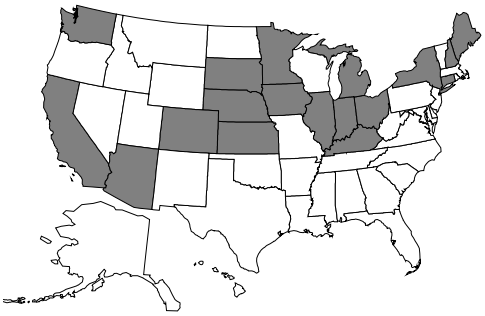

Figure 1: States with MTBE bans (shaded gray)[12]

The Energy Information Administration (EIA) addresses preparations for the Connecticut and New York bans on MTBE potential problems in a report. The limited ability of the east coast refineries to increase production could make adjustments to the MTBE ban problematic. Producing a new type of gasoline such as RBOB (reformulated gasoline blend-stock for oxygenate blending) will require a change in production. The net result is that refiners adding

[11] EPA, MTBE clean up and treatment, http://www.epa.gov/mtbe/clean.htm visited on 02/25/2004
[12] National Conference of State Legislatures, MTBE, http://www.ncsl.org/statefed/mtbeIB.htm visited on 02/23/2004

RBOB to their product slate will not be as capable of increasing the production and output to meet demands of the market.[13]

There is a potential for two price increases over time. The first of the two cost increases is potential for price volatility during transitions to MTBE and the second is changes to long-term price. The experiences of California and the Chicago-Milwaukee area when making changes to new fuel indicate the Northeast may see increased volatility as New York and Connecticut switch from MTBE the ethanol. The first is upon implementation of ban on January 1, 2004 and the second that will occur when the Northeast moves from winter-grade gasoline to the harder to produce summer grade gas. EIA expects to see fewer suppliers that are able to produce summer-grade RBOB than winter grade, causing more price volatility due to the lack of supply.[14]

Currently, EIA cannot account for approximately 20 to 30 percent of the supply of RBOB required by New York and Connecticut for the summer of 2004 . This could delay resolution of any supply problems long enough for prices to surge. After transitions are complete, the long-term equilibrium price during the summer months might be in the range of 5 cents per gallon higher than MTBE blended RFG (reformulated gasoline). However, this estimate is highly uncertain. The issues rising from the need to segregate MTBE and ethanol-blended gasoline would have been avoided had Northeast RFG consuming states banned MTBE at one time. But other much more severe supply problems could have occurred had the entire Northeast banned MTBE at once. Each transition would require storage and delivery changes, and supply sources could continue to shift, potentially leaving the region in a continuous state of transition for years, with associated price volatility.[15]

Connecticut enacted the MTBE ban because of increasing ground water contamination. On July 1, 2000, section 22a-450a of the Connecticut General Statutes was enacted, effectively banning the sale and use of MTBE as an additive to gasoline in the state as of Oct. 1, 2003 and requiring that the Department of Environmental Protection (DEP) implement the ban. The DEP has undertaken the steps to implement the ban. The DEP policy is Outreach and Education. The DEP has sent several notices to suppliers and retail distributors of gasoline apprising them of the legislative changes. In addition, the DEP has and will continue to partner with other organizations to provide outreach and assistance to gasoline retailers, fuel suppliers, state agencies, and municipalities.[16]

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[13] United States Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf visited on 02/23/2004

[14] United States Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf visited on 02/23/2004

[15] United States Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf visited on 02/23/2004

[16] Connecticut Department of Environmental Protection, Connecticut Activities Regarding MTBE, http://dep.state.ct.us/air2/mtbe/ctactivities.htm visited on 02/23/2004

The DEP expects infrastructure investments to allow for the receipt and storage of ethanol to occur. Retail Gasoline Stations over the next several months will also take steps to prepare for the transition to an ethanol-based gasoline. These steps will likely include flushing or cleaning underground storage tanks, installing filters and addressing gasoline-labeling requirements. Initial concerns voiced to the Department include a shortage of the necessary dispenser filters used to remove impurities from the ethanol-based gasoline blend. Ethanol Availability remains a variable dependent on several factors including adequate production and transportation logistics. Ethanol will be transported separately than RBOB into Connecticut and will be mixed at supply terminals. Ethanol will be produced in the Midwest and transported to Connecticut by truck and by barge.[17]

MTBE Alternatives

Ethanol has been proposed to replace MBTE as one of the primary alternative oxygenates in RFG. Ethanol is produced by fermentation by fungi and other microorganisms, and is found at low levels in the blood and breath of persons who do not drink alcohol.
Ethanol (ethyl alcohol) is a clear, colorless liquid with a characteristic, agreeable odor. In dilute aqueous solution, it has a somewhat sweet flavor, but in more concentrated solutions has a burning taste and a strong affinity to water.[18] Ethanol is made like most other alcohol; cornmeal is mixed with water and enzyme alpha-amylase, heated, cooled and the second enzyme gluco-amylase is added to convert the liquefied starch to sugars. Then yeast is added to ferment the sugars to ethanol and carbon dioxide, and finally distilled, dehydrated, and denatured.[19] Because ethanol is corn-based, it is almost solely produced in the Mid-Western U.S.

Ethanol is thought to be a viable replacement for currently used MTBE to meet the RFG standard for oxygen content while supplying the needed octane without adding toxic components.[20]
Ethanol has good octane characteristics and is relatively clean compared to many gasoline components, but it creates higher toxics emissions than MTBE.[21]
Ethanol, the second most commonly used gasoline oxygenate, had an average increase in production of 10 percent from 1984 to 2000, with about 4.9 billion kilograms produced in 2000.[22]

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[17] Connecticut Department of Environmental Protection, Connecticut Activities Regarding MTBE, http://dep.state.ct.us/air2/mtbe/ctactivities.htm visited on 02/23/2004
[18] Univ. of WI,Chemical of the Week, http://scifun.chem.wisc.edu/chemweek/ETHANOL/ethanol.html Visited on 2/18/2004
[19] American Coalition for Ethanol, http://www.ethanol.org Visited on 02/25/2004
[20] Office of Oil and Gas Energy Information Administration U.S. Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans October 2003, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf Visited on 02/23/2004
[21] Office of Oil and Gas Energy Information Administration U.S. Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans October 2003, http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf Visited on 02/23/2004
[22] U.S. Department of the Interior, U.S. Geological Survey, The Gasoline Oxygenate Bibliography (September 2001), http://sd.water.usgs.gov/nawqa/vocns/mtbe/bib/ Visited on 02/25/2004

The proposed use of ethanol as a replacement oxygenate for MTBE would require a massive change in the distribution system of oxygenates. The central problem that arises concerns the method of storage and distribution of ethanol. Water is present in most of the gasoline storage and distribution chain. Petroleum does not mix with water, so water accumulates separately at the bottom of petroleum tanks and does not get into engine fuel lines. However, unlike petroleum, ethanol has a strong affinity to water. If ethanol-blended gasoline comes in contact with water, the ethanol is pulled into the water, resulting in gasoline that is not useable.[23] This calls for installation of completely separate pipelines, used specifically for ethanol and the result is a reduction in supply system flexibility.

Ethanol blends have already been used to increase octane and improve the emissions quality of gasoline. All automobile manufacturers that do business in the United States approve the use of 10 percent ethanol/gasoline blends. In some areas, ethanol is blended with gasoline to form an E10 blend (10% ethanol and 90% gasoline), but it can be used in higher concentrations such as E85 or in its pure form.[24] A problem with this is that there are only certain vehicles, called flexible fuel vehicles (FFVs) that have only one fueling system, confining owners and producers to ethanol production and consumption. Seasonal gas shifts can also be problematic due to differences in production methods. Winter-grade gasoline is easier to produce than summer-grade gasoline.

The Governor of California assigned the Office of Environmental Health Hazard Assessment (OEHHA)[25] to research the effects ethanol by conducting an "environmental fate and transport analysis of ethanol in air, surface water, and ground water," as well as "an analysis of the health risks of ethanol in gasoline, the products of incomplete combustion of ethanol in gasoline, and any resulting secondary transformation products."[26] According to this evidence from the study, there is no evidence that ethanol is carcinogenic via the inhalation route. The OEHHA ran an assessment of risk characterization, focusing on the effects of inhalation and the cancerous and non-cancerous effects of the additional oxygenate replacements. Possible replacements include Acetaldehyde, Benzene, Butadiene, Formaldehyde, and Peroxyacetyl-Nitrate (PAN).

Prepared by Jared Bombaci, Dave Vega, and Stephanie Nemore under the supervision of Professor Anthony Gierzynski for Senator Matt Dunne on March 22, 2004.

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[23] Office of Oil and Gas Energy Information Administration U.S. Department of Energy, Preparations for Meeting New York and Connecticut MTBE Bans October 2003 http://www.eia.doe.gov/pub/oil_gas/petroleum/analysis_publications/mtbebans/mtbebans.pdf Visited on 02/23/2004

[24] Alternative Fuels Data Center, Ethanol Market, http://www.afdc.doe.gov/altfuel/eth_market.html Visited on 03/08/2004

[25] California Environmental Protection Agency, Potential Health Risks of Ethanol in Gasoline, Office of Environmental Health Hazard, http://www.oehha.ca.gov/air/pdf/etohR3.pdf Visited on 02/18/2004

[26] California Environmental Protection Agency, Potential Health Risks of Ethanol in Gasoline, Office of Environmental Health Hazard, http://www.oehha.ca.gov/air/pdf/etohR3.pdf Visited on 02/18/2004