COSTS OF POTENTIAL BAN

OF MTBE IN GASOLINES

Prepared for
Lyondell Chemical Company

Summary Presented to
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INTRODUCTION

objective

Turner, Mason & Company (TM&C) was hired by Lyondell Chemical Company in early February 1999, to independently determine the costs of potential MTBE or oxygenates bans in gasoline in California and in East Coast states. In order to obtain the most accurate long-term costs, we used linear program (LP) refining models to compare several of the most probable MTBE or oxygenates scenarios. These calculated costs increases for reformulated gasoline (RFG) are partly based on our assumptions and premises for this study. The costs results are average costs for these two groups of refineries not the specific cost of individual refineries or companies. Similarly the material balances and processing as well as the gasoline compositions and properties are average results for these two groups of refineries.

oxygenate scenarios

The groups of refineries in California and in the East Coast states were selected for this study because they are the only ones that make most (over 65%) of their finished gasoline as RFG. The following four potential oxygenate scenarios were developed for each of these two group of refineries for the summer of 2005.

! Base with 11.7% MTBE in RFG (statutory minimum oxygen – business as usual);

! Optimum MTBE (eliminate statutory minimum oxygen content in RFG);

- Ethers banned (no MTBE in gasolines).
  - No oxygenates (to avoid potential water contamination);
  - Ethanol @ 6% in RFG (statutory minimum oxygen).

prior work

Prior to starting this study, TM&C had completed independent critiques and peer reviews for the Oxygenated Fuel Association of two recent studies of the costs of ether bans on California Air Resources Board Reformulated Gasoline (CARB) RFG. We critiqued the University of California (UC) Santa Barbara economics report, which was part of the major UC Davis study of an MTBE ban prepared for the California State Government. We also critiqued a MTBE ban study by MathPro for the California Energy Commission (CEC). Earlier studies of RFG costs by TM&C, involving refining industry modeling, were conducted for many clients during the years indicated below:

- National Petroleum Council (NPC) in 1991-93;
- New York State Energy Research and Development Authority in 1994;
- Auto/Oil Air Quality Improvement Research Program (Auto/Oil) in 1990-92
- American Petroleum Institute (API) in 1987, 1989, 1992-93 and 1996;

- Western State Petroleum Association (WSPA) in 1990, 1991, 1994 and 1997; and

- Morgan & Finnegan in 1995-98.

RFG cost studies have also been made for a number of individual oil companies, using our refining LP model.

background of authors

TM&C has been well recognized as having superb refining industry LP modeling expertise and competence. A very experienced team of refining LP model experts were used in this study. This team was headed by Robert E. Cunningham and included Charles L. Miller, George B. Grey and Andres Zapata. Cunningham has over 40 years experience, including 14 with Chevron. Miller has over 25 years experience, including time with Texas City Refining, Hess and Phibro. Grey has over 15 years of experience mostly with Basis/Phibro, Texas City Refining, and Charter. Zapata has over 20 years experience primarily with Coastal and Dow.

scope of report

This report covers the summary results of this study presented to the EPA Blue Ribbon Panel on MTBE in Boston, on March 2, 1999. It includes the detailed results of this long-term costs of MTBE and oxygenates bans study and comparisons of results to those from recent studies by others. Short-term costs and impacts of an MTBE ban and a simple gasoline blending study showing major CARB RFG property impacts of an MTBE ban are included in attached Technical Appendices.

EXECUTIVE SUMMARY

) *Costs of RFG*

- An oxygenates ban would increase pump costs of RFG by about 11.4¢/gallon for CARB RFG in California and by about 7.4¢/gallon for EPA RFG in East Coast states, as shown in Exhibit 1. Due to improved milage, effective consumer added costs would be lower at about 10¢/gallon for CARB RFG and about 5.5¢/gallon for EPA RFG.

- An ether ban with 6% ethanol in RFG would increase state economy costs of RFG by about 7.6¢/gallon for CARB RFG in California and by about 7.9¢/gallon for EPA RFG in East Coast states as shown in Exhibit 1. Due to improved milage, effective consumer added costs would be lower at about 6.9 to 7.1¢/gallon. Increased pump costs would be much lower at about 4.4 to 4.7¢/gallon due to the federal ethanol subsidy. However, this consumer ethanol subsidy is taken directly back out of the state economy by an equivalent reduction in the federal highway trust funds received.

- Use of optimum MTBE would have essentially no impact on pump cost of RFGs. Due to slightly improved milage, effective consumer costs of RFGs would be reduced by about 0.3 to 0.4¢/gallon.

- An oxygenates ban would cause the incremental costs to produce CARB RFG to increase by about 36¢/gallon compared to the average cost increase of 11.4¢/gallon as illustrated in Exhibit 2. Removing the last fourth of the MTBE is very costly and difficult as also shown in Exhibit 2.

) investments required

- ! An oxygenates ban would require huge added refining investment of about $5.6 billion in California and about $1.8 billion in East Coast states. Total added refining investments in the U.S. were estimated at $9.9 billion as shown in Exhibit 3.

- ! This California delta investment would be about 150% of the CARB RFG added investment made in 1993-96 and would approach the fair market values of the existing California refineries. This added investment hurdle would probably cause several marginal refineries to shutdown permanently and thereby increase CARB RFG import requirements. The CARB RFG investment hurdle reduced the number of operating California conversion refineries by 30%, from 1993 to 1996.

- ! An ether ban with 6% ethanol in RFG would require added refining investments of about $2.5 billion in California and about $1.2 billion in East Coast states. Total delta refining investments in the U.S. were estimated at about $5.7 billion as illustrated on Exhibit 3.

- ! Required added ethanol investment to supply 6% ethanol in all RFGs would be about $2.9 billion in California, $1.8 billion in East Coast states and about $7.2 billion in the entire U.S.

- Optimum MTBE usage in RFG would require very small added refining investments of only about $0.1 billion each in California and in East Coast states.

comparisons to other studies

- Our) CARB RFG costs are almost triple those calculated by MathPro in their 1998 study for CEC. Comparisons are shown in Exhibit 4 with valid adjustments to the MathPro CARB RFG added cost results to increase them to close to our results.

- Our added refining investments required for California with either an oxygenates ban or an ether ban were about five times those determined by MathPro for CEC. Ours were so much larger due to MathPro's invalid additional free capacity assumptions and extensive LP model over-optimization.

other impacts

- In the cases with 6% ethanol in RFG, the distillation index increased significantly, by about 104 numbers for EPA RFG and by about 55 numbers for CARB RFG. In the no-oxygenates cases, the driveability index increased by about 37 numbers for EPA RFG.

- Use of 6% ethanol in RFG would require modifications of most terminals for ethanol blending into RBOB. Delivery of this ethanol would substantially increase train traffic and demand for rail tank cars.

! A nationwide ether ban would either waste or require other uses for most U.S. MTBE production facilities in which about $12 billion was invested.

ANALYTICAL APPROACH

aggregated LP models

We used Turner Mason Modeling System (TMMS) refining LP Models to represent aggregated groups of refineries in California and in the East Coast states. Aggregate modeling enables us to determine U.S. refining industry capability and costs without revealing any specific refinery's confidential data. These TMMS aggregate conversion refinery models were developed and extensively calibrated during several prior studies which are listed in the introduction section above. TMMS Models had been modified to include many commercial gasoline production and modification processes as well as gasoline fractionation into narrow cuts to control, as independently as possible, all of the RFG properties limited by EPA and CARB regulations. These regulated properties include aromatics, olefins, benzene, oxygen, sulfur, RVP, T50, T90, E200 and E300, in addition, to many other ASTM gasoline limits. To allow maximum refining flexibility while meeting required reduced gasoline combustion and evaporation emissions, the CARB predictive model and the EPA complex model have been included as linearized equations relating emissions to these properties. The TMMS LP models and these enhancements have been extensively reviewed by industry task forces in prior studies for API, Auto/Oil, WSPA and NPC.

model regions and oxygenate scenarios

We created LP models for the summer of 2005 for California and for the East Coast states -– Petroleum Allocation of Demand District I (PADD I). These are the only two U.S. refining regions with over 65% RFG in their total finished gasoline production. Hence, they would be most affected by a potential ether ban. Because of their high percent of RFG production, these two regions would also be least likely to over-optimize the impacts of RFG oxygenate changes. In addition to our base scenario (business as usual with 11.7% MTBE in RFGs) for 2005 summer, we ran alternate cases (oxygenate scenarios) for 2005 summer to study potential MTBE and oxygenate policy changes as follows:

- Optimum MTBE usage (eliminate statutory minimum oxygen in RFGs);

- MTBE and oxygenates bans (with no oxygenates) and

- MTBE and ether bans with 6% ethanol in RFGs (statutory minimum oxygen).

flexibility

These cases had the flexibility in the LP models to allow them to efficiently meet the stringent conditions to be evaluated. Flexibility included allowing new investment for added processing capacity and allowing export of lower quality regular gasoline, as well as any unusable gasoline blendstocks. We also allowed ethylene recovery from the FCC process gas and ethylene alkylate production to provide a high octane, low T50, low RVP gasoline component, to substitute for some of the banned MTBE. We fixed most raw material and major product volumes to simplify the analysis of the case study costs. A few swing crudes, No. 6 fuel and C_4

and lighter products were allowed to vary. This approach assured reasonable LP model solutions that are supportable and practical and dependent on only a few crude and product prices.

analysis of results

We compared the results of each of the alternate cases related to oxygenate policy changes to the base case in each of the two refining regions. We reported the solutions for the base case, and we calculated the incremental RFG costs and investment changes from these solutions for each of the three alternate cases (oxygenate scenarios) in each refining area. The results are shown in the attached tables.

adjustments

We adjusted the unit costs and investment changes for other costs which could not be included in the LP models – such as enhanced debutanizers to reduce the RVP of gasoline components, FCC ethylene recovery, and in-line motor gasoline blenders. We adjusted the refining margins from the atypically high 1997 summer level (assumed) to the more typical 1998 summer level, based on the Gulf Coast crack spread (3:2:1) for West Texas Intermediate (WTI) crude. This crack spread shifted from $3.83/barrel in the summer of 1997 to $2.88/barrel in the summer of 1998, which is typical of the summer average during the past five years. We also reduced the 1997 price of high sulfur #6 fuel oil (bunker fuel) by $0.80/barrel to make it more typical of its price relative to crudes over the past 5 years. Added RFG costs were adjusted for mileage changes due to oxygenate policy changes.

tabular reporting

For each scenario, we listed the average refinery results for material balance, process unit rates and added process unit capacitities on the attached tables. We also tabulated detailed gasoline properties and gasoline compositions by types of gasoline and for the entire gasoline pool for each alternate case. Limiting gasoline properties and calculated emissions levels were also indicated in the attached tables.

optimized costs

The LP model technique systematically finds the least cost or highest margin solution to any given case description. Although there are hundreds of feasible solutions with the large number of independent variables that can be changed, the LP model finds the one mathematically optimal solution. The benefits of comparing results from an ether ban case LP solution against a base case LP solution is that both are optimized for their respective situations; therefore, the difference in margin is the least costs for the ether ban changes. This technique is much better than comparing results of simulation cases, because it offers a consistent approach to these costs and is not an arbitrary comparison of selected feasible solutions. This approach avoids significant under or over-optimization of the alternative oxygenate scenarios and their economic impacts.

ASSUMPTIONS

general

We used most of the assumptions and premises which were used in the August 1993 NPC study, “U.S. Petroleum Refining Meeting Requirements for Cleaner Fuels and Refineries”. These assumptions and premises are detailed in the TM&C Tables A in Volume 5, Refining Capability Appendix. These NPC study assumptions were updated to reflect the recent 2005 supply and demand outlook based on 1997 actual data and the most recent consensus projections made in 1997-98. We assumed fixed finished gasoline imports at the base case level, thereby requiring added crude runs and refining capacity to replace finished gasoline at lower oxygenate usage levels. Crudes and products pricing and process investments were updated to the summer of 1997 levels. Product qualities and emissions were updated to reflect 1997 actual data from surveys made in 1996-98 as well as EPA regulatory requirements taking effect in 2000 and an anticipated EPA requirement of 30 parts per million (ppm) maximum sulfur in all domestic finished gasolines beginning in 2004.

supply and demand

We updated supply and demand for refining input and products plus crude production and imports to 1997 actual using the Department of Energy (DOE) 1997 *Petroleum Supply Annual (PSA)*, plus requested DOE data for California refineries. We also used 1997 California Department of Conservation crude production data by field. These 1997 actual data were then projected to 2005 using the DOE EIA *Annual Energy Outlook*, 1998 for domestic crude production.

We update the major products supply and demand to 2005 using the CEC forecast for California and the Survey of Forecasters, Fall 1998 *Oil & Gas Journal* Energy Database consensus for the U.S. prorated for PADD I. We updated product qualities and grade splits using 1996-97 summer data from the API/National Petrochemical and Refiners Association (NPRA) and CEC surveys.

emissions

We used the CARB Predictive Model to determine CARB RFG emissions. We limited the CARB RFG emissions to the 1997 summer weighted average based on the CEC survey. For emission calculations for EPA RFG and conventional gasoline anti-dumping limits, we used the EPA Phase II Complex Model. We used required reductions from statutory for EPA RFG target emission limits and we used the weighted average of 1990 refinery baselines for the emission limits for conventional gasoline. We used typical refining industry compliance margins of 1.0% lower than these EPA emissions limits. We reduced the maximum average sulfur specification in all domestic gasolines to 30 parts per million (ppm) in anticipation of planned EPA regulations beginning in 2004.

capacities

We updated refinery unit capacities to operating capacities available or under construction on January 1, 1999. We used the most recent DOE reported operating capacities for January 1, 1997 listed in the DOE PSA for 1996. These were updated to January 1, 1999 based on the unit capacity differences between the *Oil & Gas Journal* surveys for 1-1-99 and for 1-1-97. We also added the capacity under construction based on published information in the *Oil & Gas Journal* and *Hydrocarbon Processing*.

economics

We assumed a capital charge based on a 15% return on investment in the LP cases and in the reported results. We updated our investment cost to mid-1997 dollars based on the ratio of the applicable Nelson Inflation Indexes. We updated raw material and product pricing to the summer 1997 average. We assumed ethanol would be made available from domestic supply from added capacity. We assumed the continued federal ethanol tax subsidy of 54¢/gallon in calculating increased gasoline pump costs. In the overall state economy, this ethanol subsidy is fully offset by a reduced federal gasoline tax rebate of highway trust funds to each state, based entirely on the federal ethanol subsidy utilized within each state.

RESULTS

Base Cases

The 2005 summer base cases with 11.7% MTBE in RFGs provide good starting points for the analysis of costs and refining changes for potential ether or oxygenate regulation changes in this study. In Tables A2 and B2 attached, 1997 summer actual material balances have been shown for comparison to the 2005 summer base case material balances. The 2005 summer base cases, with much lower sulfur (30 ppm) in gasolines, have higher demands and higher crude imports, more refining capacity (especially more desulfurization on the East Coast) with higher unit utilizations than in 1997. The base cases required additional facilities to process more crude to meet increased demands for gasolines and middle distillates based on the consensus forecasts. This study did not attempt to ascertain the requirements or costs of gasoline desulfurization, as no higher sulfur gasoline cases were developed. The EPA RFG was limited by sulfur, benzene, RVP, oxygenate and octane, plus VOC emissions. CARB 2 RFG was limited by NOx and toxics emissions plus the same limitations as the EPA RFG. Conventional gasolines were limited by RVP, sulfur and octane, as well as toxics emissions.

optimum MTBE cases

The results of optimum MTBE cases are similar in PADD I and in California. MTBE usage would drop to about 85-88% of the base case level. There is essentially no impact on the cost per gallon of RFG at the pump due to using the optimum MTBE level. Calculated RFG pump costs changes are only 0.0-0.1¢/gallon. Optimum (lower) MTBE usage would slightly improve mileage and thereby create effective consumer costs savings of about 0.3-0.4¢/gallon. Optimum MTBE usage cannot occur without eliminating the federal minimum oxygen requirement of 2.1 weight % in RFG. CARB RFG changes would require congressional approval of the pending Bilbray/Feinstein amendments to the Federal Clean Air Act Amendments. EPA RFG changes would require passage of similar RFG legislation to eliminate the minimum oxygen limit, nationwide.

If the federal minimum oxygenate requirement were eliminated, the ether content would be reduced in EPA RFG from about 12% to about 7-9%. Usage in CARB RFG would drop from about 12% to about 10%. MTBE usage would be increased in conventional gasoline from 0 up to about 2-5%. Optimum MTBE usage would have little impact on gasoline emissions except for an increase in the amount of gasoline that is toxics limited. It would also cause a slight increase in crude runs to replace the purchased petrochemical MTBE.

oxygenates ban cases

costs

Banning oxygenates from gasolines would create the need for huge refining investments, especially in California, assuming no increased finished gasoline or alkylate imports. Our modeling results showed required increased investments in the refining industry of about $5.6 billion in California and about $1.8 billion in PADD I. We estimated the refining investments required in the rest of the U.S. at about $2.5 billion for a total of about $9.9 billion in the U.S. The calculated refining investments required in California are about 150% of the refining investments made in 1993-95 to upgrade most of the conventional gasoline to CARB RFG. Such large investment requirements would undoubtedly cause several marginal California refineries to shut down as five others did in 1992-95, due to the CARB RFG investments hurdle. The increase in CARB RFG unit costs from an oxygenate ban are also quite high. We calculated added pump costs of 11.4¢/gallon for CARB RFG in California and 7.4¢/gallon for EPA RFG in PADD I. The effective costs to the consumer would be slightly lower at about 10¢/gallon for CARB RFG in California and about 5.5¢/gallon for EPA RFG in PADD I, due to increased mileage credits of about 1.4 and 1.9¢/gallon, respectively. Most (about 85%) of these increased RFG unit costs are due to capital charges for the refining investments.

material balances

In PADD I, average material balance changes per refinery due to replacing about 7 MBPD of MTBE would be about 20 MBPD increase in crude run and about 13 MBPD increase in No. 6 fuel. In California, crude would increase by about 37 MBPD per refinery to replace about 9 MBPD of MTBE and create about 4 MBPD of lower quality regular gasoline for export. Due to the need to upgrade more heavy gasoline without making more middle distillates, there was a significant hydrocracker yield shift in California from a high level of hydrocracked kerosene jet production in the base case to all hydrocracked gasoline production, along with a significant hydrocracker feed shift to more 300-430EF FCC gasoline. With more middle distillate and gas oil feeding the FCC, the No. 6 fuel yield increase was very high at about 17 MBPD from the additional crude run due to the ether ban.

processing

Increased processing per refinery in PADD I amounted to about 20 MBPD of crude plus about 5 MBPD each of reforming, isomerization, FCC, alkylation, and aromatics extraction. Added hydro-desulfurization was about 7 MBPD and added gasoline component fractionation was about 10 MBPD. Added processing per refinery in California was much more extensive with about 37 MBPD crude, about 24 MBPD cat-reforming, about 7 MBPD each of FCC and benzene saturation, and about 3 MBPD each of isomerization and diesel saturation. Total hydro-desulfurization increased by about 32 MBPD and gasoline component fractionation increased by about 45 MBPD.

RFG composition

The effects of an oxygenate ban on composition of RFG is very extensive. For CARB RFG, the percent FCC gasoline dropped by 17%, reformate increased by 7% and saturates increased by 9%. Biggest changes in reformate were a decrease of 12% of whole reformate and an increase of 15% in heartcut reformate. Biggest changes in saturates were the reduction of 12% MTBE and an increase in light raffinate plus light reformate of 13%. Alkylate and isomerate increased by about 5% each. In PADD I, the EPA RFG composition changes were significant although not as extensive as for the CARB RFG in California. In the saturates category, MTBE decreased by 12%

while alkylate increased by 10% and light raffinate increased by 4%.

ethanol substitution cases

costs

While the total investment with ethanol substitution for MTBE is greater than for an oxygenate ban, most of the ethanol substitution investment would be made by ethanol producers instead of refiners. To create the ethanol to substitute for MTBE, we calculate additional ethanol plant investments required of about $1.8 billion for PADD I, about $2.9 billion for California, and about $7.2 billion for the total U.S. Refining industry investments would be about $1.2 billion for PADD I, about $2.5 billion for California, and about $5.7 billion for the U.S. as shown in Tables A-6 and B-6. Increased costs for RFG made with ethanol would be about 4.4 to 4.7¢/gallon at the pump. Most of these unit costs at the pump are due to capital charges for refining and terminal upgrades. For the total impact on the state or regional economy, these increased pump costs would have to be increased by the 3.2¢/gallon federal tax rebate loss by the state(s) of federal highway funds directly due to the federal ethanol subsidy. Consumers costs would be effectively decreased by about 0.5-1.0¢/gallon due to improved mileage from the lower oxygenate content.

material balance and processing

Material balance changes, per refinery, include about 16-17 MBPD of crude to replace the 3-4 MBPD of lost oxygenate and to provide about 5 MBPD of low quality export gasoline in California. No. 6 fuel oil yields from the incremental crude continue to be high. Increased refinery process capacity in

California, includes about 18 MBPD of crude, about 10 MBPD of reforming capacity as well as about 4 MBPD each of benzene saturation, alkylation and isomerization. Added HDS capacity is about 7 MBPD and increased gasoline component fractionation capability is about 10 MBPD. Added capability per refinery is less for PADD I with the need for about 17 MBPD of crude, about 5 MBPD of isom, and about 7 MBPD of HDS along with about 8 MBPD of gasoline component fractionation.

RFG properties and compositions

The most extensive impact on gasoline properties is an increase in distillation index in PADD I EPA RFG of about 100 numbers and in California CARB RFG of about 55 numbers. The most extensive gasoline composition changes occur for CARB RFG with a 7% decrease in FCC components and 8% increase in reformate. For EPA RFG in PADD I the changes were less extensive with a 5% increase in reformate and a 5% decrease in saturates.

incremental costs

The incremental costs of banning oxygenates in CARB RFG are much higher than the average costs. This is shown graphically in Exhibit 2 where the average costs increased by about 11¢/gallon from 68 to 79¢/gallon, while the incremental costs increased by about 36¢/gallon from 70¢/gallon in the base case to $1.06/gallon in the no oxygenates case. This chart illustrates that the cost of removing the last fourth of the MTBE from gasoline is very high compared to the costs of removing the first three-fourths of the MTBE.

refining economics

There would probably be no returns on any added refining investments, because gasolines are commodities and there have been essentially no returns on prior refining investments to achieve government mandated product quality improvements. The base returns on refining assets have been extremely low in the range 2-6% over the last fifteen years. Significant added investment requirements would probably destroy the economic viability of several marginal and smaller refineries and increase RFG import requirements.

COMPARISON OF RESULTS WITH OTHER STUDIES

MathPro for CEC

Compared to the MathPro study for the CEC in 1998, our calculated investments for the refining industry are almost five times as high. Investment cost for the MathPro CEC cases were $1.1 billion for the no-oxygenates case, and $0.5 billion for the ethanol substitution case. These refining investment levels are only about 20% of what we calculated. Our results are higher than the MathPro study partly because MathPro assumed a significant increment of free capacity creep in the refining industry. In addition, MathPro's model poorly represented gasoline properties, especially distillation, and over-optimized theoretical components which drastically reduced required investment cost.

Similarly, our RFG unit costs results for ether bans in California were almost triple those calculated by MathPro as shown on enclosed Exhibit 4. MathPro calculated 2.4-2.7¢/gallon average costs for replacing MTBE with ethanol in CARB RFG compared to our 7.6¢/gallon. Similarly MathPro calculated 3.7-4.3¢/gallon average costs for banning all oxygenates in CARB RFG compared to our 11.4¢/gallon. As shown in Exhibit 4, the primary reason for the lower ethanol substitution costs is MathPro's use of a 4.2¢/gallon of CARB RFG tax subsidy for ethanol. From the overall state economy viewpoint, this tax subsidy would be directly subtracted from federal tax fund rebates to California to offset the lost federal revenue; however, MathPro failed to take this state economy cost into account. The other basis for difference in the ethanol case costs is the low MathPro pricing of ethanol and alkylate purchases. For the no-oxygenates cases costs comparison shown in Exhibit 4, the primarily differences are due to the MathPro free refining capacity and LP over-optimization problems cited above. Some of the differences are also due to low pricing of alkylate purchases in the MathPro study.

TM&C for Auto/Oil

The study for Auto/Oil by TM&C in 1990–92, showed incremental cost of 7.4¢/gallon for eliminating 75% of the MTBE (from 15 to 3.8% MTBE in RFG) and elimination of premium RFG. Adjustments to this case to eliminate the rest of the ether and to create premium RFG would make the cost results very comparable to our current results.

ORNL for DOE

An analysis by Oak Ridge National Lab (ORNL) for DOE presented by Barry McNutt on March 1, 1999, to the EPA Blue Ribbon Panel, showed long–term added costs of about 3¢/gallon of EPA RFG for ethanol substitution for MTBE in PADD I. This ORNL study indicated costs increase is only about 40% of our calculated costs increase. These costs were admittedly low according to DOE due to: 1) including the ethanol tax subsidy of 3.2¢/gallon of RFG without the equivalent federal tax rebate loss to the states; and 2) modeling only gasoline pools in a ratio–free model instead of individual grades in a ratio-controlled model (which led to over-optimization). The ORNL study for DOE did not include investment costs in the presentation. It also did not include a no-oxygenates case. An optimum oxygenates case by ORNL for DOE showed continued MTBE usage at 85% of the base case level, which is about the same as we calculated.

APPENDIX X-1

Short-Term Impacts of Ether Ban

General

If ether were banned before 2004, the impacts on RFG would be a drastic reduction in RFG supply, which would be politically unacceptable. The refining industry would be unable to supply any premium grade RFG meeting emission limits. The alternative to such major RFG shortages would be much lower quality RFG with significantly increased emissions and smog. Assuming that increased emissions would continue to be illegal, major RFG shortages would occur. These huge shortages would hurt the economy and cause a recession. Gasoline prices in RFG areas would probably spike and could increase several-fold, or government controlled rationing would be implemented with service station lines. There would be strong public reaction and anger. There would be a major increase in gasoline imports and exports as well as shipping traffic and port congestion. These results show that if an MTBE ban is implemented, it needs to be delayed until about 2004 to give the industry ample time to respond by adding process units changes to make sufficient volumes of low emission RFG without ether.

Ethanol Substitution for Ether

Short-term impacts were not included in this study, however, prior studies covering short term impacts were reviewed. A 1997 TM&C study for WSPA showed a probable 43% gasoline shortage with a 20+¢/gallon CARB RFG cost increase. The MathPro study for CEC showed a 17% CARB RFG shortage with a 7.5¢/gallon cost increase. Significant logistics problems would result: 1) domestic ethanol supply would be inadequate leading to huge ethanol price increases and imports of ethanol from Brazil; 2) most terminals are currently unable to splash blend ethanol; 3) there would be a significant increase in ethanol railroad traffic. Use of ethanol in RFG would increase its summer RVP and VOC emissions and exceed CARB RVP limits, and EPA VOC limits.

Oxygenates Ban

The MathPro study for CEC showed a 42% CARB RFG shortage with 12.8¢/gallon increased cost. The ORNL study for DOE of the East Coast showed a 26% EPA RFG shortage with no premium gasoline and a 10¢/gallon increase in cost. Without oxygenates there would be a significant increase in toxics emission with the inability to meet the toxics emission standards of RFGs.

APPENDIX X-2

Gasoline Blending Impacts of MTBE Ban

As a simplified approach we reviewed the gasoline blending impacts of removing ether from CARB RFG assuming all oxygenates are banned. The results of this blending exercise are presented in Exhibit X-2 and are quite instructive. They help one understand the beneficial effects of MTBE and the negative effects of removal of MTBE from CARB RFG. We used the EPA complex model to show the emissions impacts, because several properties exceeded the limits of the linearized CARB predictive model. The first column shows the basis for the study as the average CARB RFG pool for the summer of 1997 according to the CEC survey. The second column shows the impacts of MTBE removal with only a small butane adjustment to maintain RVP. The third column shows the CARB RFG pool with no MTBE, with the R + 2/M octane as well as RVP adjusted to the base 1997 level. The results of the third column compared to the base are summarized in the fourth column.

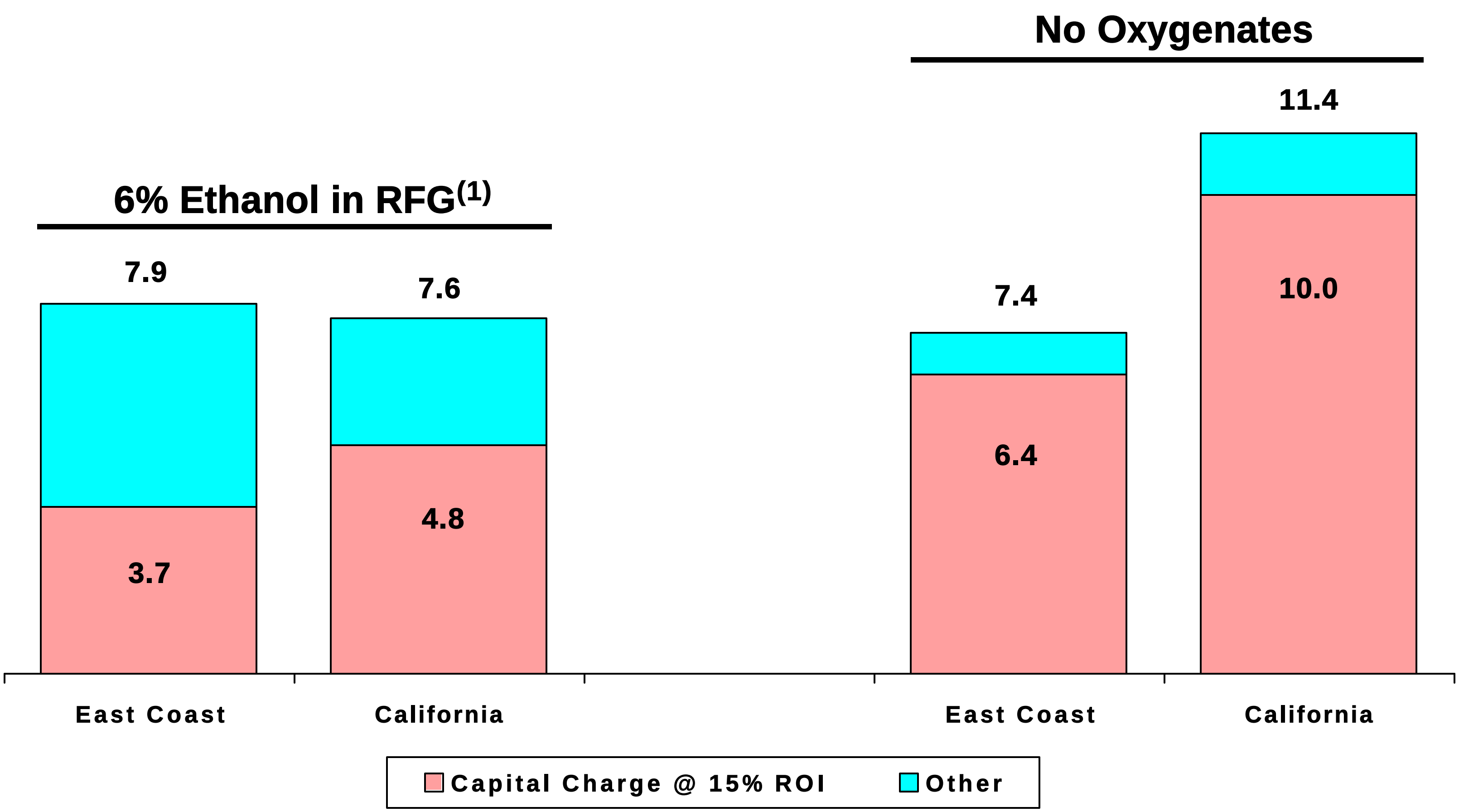
The results of the second column, with MTBE removed, shows that the most significant change was a loss of 2.6 octane numbers. The CARBOB RFG pool becomes sub-regular. Other significant changes are the obvious loss of 11.5% of gasoline volume, 12EF higher T50, 12% toxics emission increase and a driveability index increase of 44 numbers. The third column presents CARB RFG qualities at the base octane and RVP level. The octane was restored by increasing reformer severity and changing FCC catalyst to make higher FCC gasoline octane. The most significant changes from the base CARB RFG pool are an increase in toxics of 21% along with a increase in aromatics of almost 10%. The driveability index goes up by 63 numbers based on a 17E F increase in T50. Volume loss is 15% and the VOC emissions increase by 5%. In conclusion, one can say that MTBE usage is very significant in raising CARB RFG octane, lowering T50, driveability index, toxics, and aromatics. It also has some significance for reducing the VOC and NOx emissions as well as reducing olefins, benzene and T90.

LIST OF TABLES

COST OF POTENTIAL BAN OF MTBE IN GASOLINES

REC – 4/30/99

EXHIBIT 1
REFINING COSTS OF ETHER BAN IN 2005
(¢/gallon of RFG*)



*** In 1997 dollars.**
(1) Excludes federal tax credit of 3¢/gallon.

REC – 4/28/99

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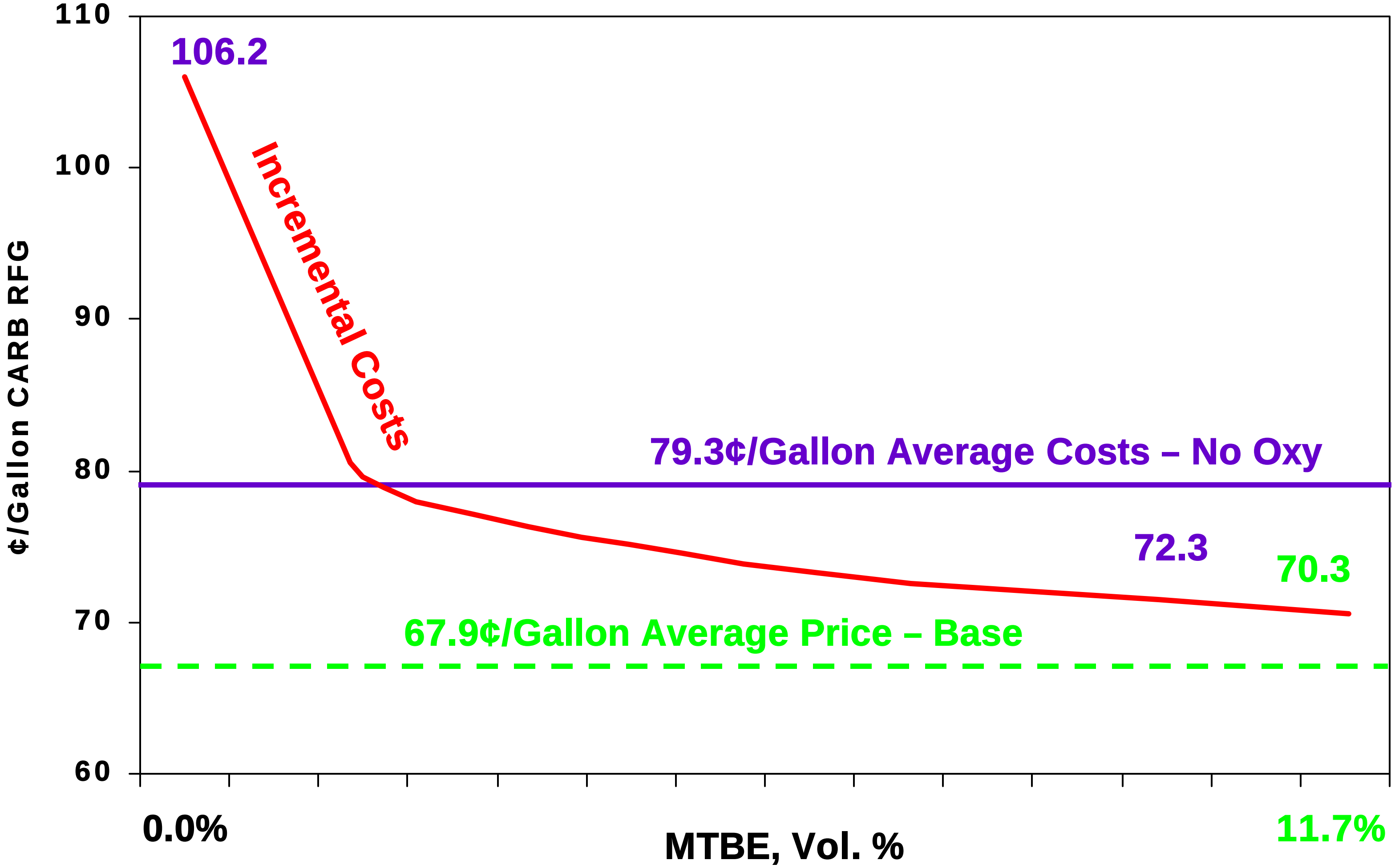
Consulting Engineers

EXHIBIT 2
INCREMENTAL vs. AVERAGE REFINING COSTS OF BANNING OXYGENATES IN CALIFORNIA GASOLINE



REC – 4/28/99

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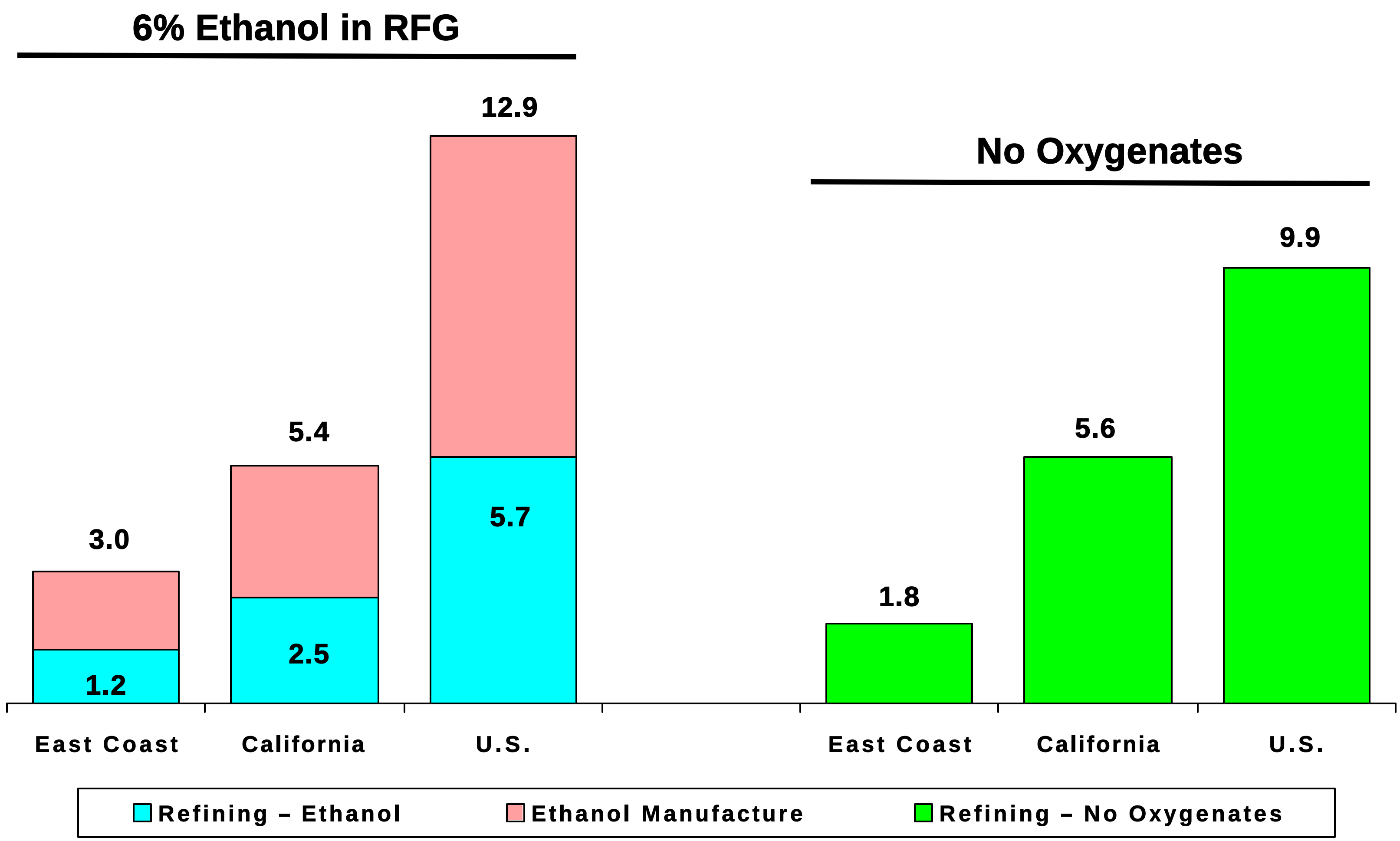
Consulting Engineers

EXHIBIT 3
2005 INVESTMENTS REQUIRED
($ billions*)



*** In 1997 dollars.**

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EXHIBIT 4
2005 CARB RFG COSTS COMPARISONS
COST OF POTENTIAL BAN OF MTBE IN GASOLINES

(¢/Gallon)

	6% Ethanol in RFG			No Oxygenates	
	MathPro[1]			MathPro[1]	
	Original	Supplemental	TM&C	Original	Supplemental
As Reported	2.4	2.7	7.6	3.7	4.3
Adjustments					
CARBOB and Alky Pricing	0.5	–		2.0	–
Isobutane Pricing	–	–		–	0.6
Oxygenates Pricing	1.5	2.0		0.5	0.2
Tax Subsidy	4.2	4.2		–	–
Free Refining Capacity	–	–		1.0	1.0
LP Over-Optimization	–	–		4.2	5.0
As Adjusted	8.6	8.9		11.4	11.1

[1] Based on average CARB 2 RFG limits.

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TABLE A-1
COMBINED GASOLINE POOL PROPERTIES
PADD 1 - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.9	*	88.9	*	88.9	*	88.9	*
Oxygen, Wt. %	1.47	#	1.19		0.00	*	1.45	*
MTBE, Vol. %	8.1	#	6.5		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	4.1	*
Aromatics, Vol. %	31.2	#	32.3	#	33.6		32.9	
Olefins, Vol. %	11.5		12.3		12.0		13.1	
Benzene, Vol. %	1.10	#	1.21	#	0.94		1.14	#
Sulfur, wppm	30	*	30	*	30	*	30	*
RVP, psi	7.3	#	7.2	*	7.2	*	7.2	*
Distillation, °F								
T10	139		140		143		140	
T50	207		210		217	#	214	
T90	350	#	352		351	#	352	#
E200	47.5		46.4		43.3		44.5	
E300	79.5	#	78.8	#	79.1		78.6	#
Driveability Index	1,180		1,193		1,216		1,205	
Distillation Index	1,180		1,193		1,216		1,234	

* Input limit – all grades.
# Input limit – one or more grades.

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TABLE A-1A
EPA REFORMULATED GASOLINE POOL PROPERTIES
PADD 1 - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	89.2	*	89.2	*	89.2	*	89.2	*
Oxygen, Wt. %	2.12	*	1.28		0.00	*	2.10	*
MTBE, Vol. %	11.7	*	7.0		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	6.0	*
Aromatics, Vol. %	27.8	#	29.8	#	30.2		31.0	
Olefins, Vol. %	11.5		12.7		12.2		13.4	
Benzene, Vol. %	0.95	*	0.95	*	0.86		0.95	*
Sulfur, wppm	30	*	30	*	30	*	30	*
RVP, psi	6.7	#	6.5	*	6.5	*	6.5	*
Distillation, °F								
T10	144		146		148		146	
T50	194		208		207		214	
T90	346	#	350		339		345	
E200	51		47		46		43	
E300	83		82		85		84	
Driveability Index	1,144		1,194		1,181		1,206	
Distillation Index	1,144		1,194		1,181		1,248	
% Reduction from EPA-Required Emissions Limits								
VOC	0.8	*	0.4	*	(0.4)	*	(0.1)	*
NOx	3.5		2.6		3.0		2.7	
Toxics	8.5		3.1		0.6	*	0.8	#

* Input limit – both grades.
# Input limit – one grade.

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TABLE A-1B
CONVENTIONAL GASOLINE POOL PROPERTIES
PADD I - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.3	*	88.3	*	88.3	*	88.3	*
Oxygen, Wt. %	0.00		0.99		0.00	*	0.00	*
MTBE, Vol. %	0.0		5.4		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	0.0	*
Aromatics, Vol. %	39.0		37.7	#	41.2		37.1	
Olefins, Vol. %	11.3		11.3		11.7		12.3	
Benzene, Vol. %	1.42		1.79		1.14		1.58	
Sulfur, wppm	30	*	30	*	30	*	30	*
RVP, psi	8.7	*	8.7	*	8.7	*	8.7	*
Distillation, °F								
T10	130		127		132		126	
T50	227		215		238	#	212	
T90	353		353		356	*	356	*
E200	40		45		37		48	
E300	71	#	70	#	67		66	#
Driveability Index	1,229		1,188		1,269		1,180	
Distillation Index	1,229		1,188		1,269		1,180	
% Reduction from Average 1990 Baseline Emissions Limits								
VOC	N/A		N/A		N/A		N/A	
NOx	11.4		11.0		11.2		10.0	
Toxics	0.2	*	0.1	*	0.2	*	0.4	*

* Input limit – both grades.
# Input limit – one grade.

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TABLE A-2
REFINERY MATERIAL BALANCE
PADD 1 - SUMMER AVERAGE PER REFINERY*
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

		2005			
				Ether Banned	
	1997 Actual	Base Case	Optimum MTBE	No Oxygenates	Ethanol In RFG
Raw Materials, BPCD					
Crudes	139,385	157,737	160,175	177,210	175,026
Gasoline Components	17,017	11,000	11,000	11,000	11,000
Oxygenates	6,801	6,500	5,552	0	3,951
LPG	416	329	100	2,286	100
Other	9,289	9,039	8,861	8,625	8,625
Total	172,908	184,605	185,688	199,121	198,702
Products, BPCD					
Gasolines					
Conventional	31,168	29,500	29,500	29,500	29,500
EPA RFG	61,373	65,846	65,846	65,846	65,846
Other Finished	11	0	0	0	0
Components	1,598	1,197	1,200	1,200	1,200
Subtotal Gasolines	94,149	96,543	96,546	96,546	96,546
Distillates - Finished	49,773	55,400	55,400	55,400	55,400
No. 6 Finished	12,464	10,783	11,459	24,161	22,455
Other Black Oils	11,536	9,877	9,657	9,757	9,841
LPG	4,505	5,521	5,871	5,377	7,168
Other	1,231	1,000	1,000	1,000	1,000
Plant Fuel	5,675	11,393	11,691	12,230	12,139
Loss	(6,425)	(5,913)	(5,936)	(5,352)	(5,846)
Total	172,909	184,604	185,688	199,119	198,703

*Based on 10 operating conversion refineries.

TABLE A-3
REFINERY PROCESS UNIT RATES
PADD I - 2005 SUMMER AVERAGE PER REFINERY
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base Case	Optimum MTBE	No Oxygenates	Ethanol In RFG
Unit Charge Rates, BPCD				
Crude Distillation	157,737	160,175	177,210	175,026
Coker Delayed	4,100	4,100	4,100	4,100
Coker Fluid	4,900	4,900	4,900	4,900
Coker L Gaso DS/SPL				280
Solvent Deasphalter	1,900	1,900	1,900	1,900
Naphtha Hydrotreater	38,900	39,542	42,102	41,169
FCC/Coker C6 H2 Tr			107	29
Distillate HDS	34,352	33,797	32,335	31,799
FCC Feed Hydrofiner	21,460	23,351	23,750	24,761
Cat Reformer 450 P (92.3)	9,300	9,300	9,300	9,300
Cat Reformer 200 P (97.5)	12,593	14,176	18,525	14,845
Cat Ref(Cont)100 P (100.6)	10,900	10,900	10,900	10,900
Reformate Fractionation	11,586	15,000	20,546	19,765
Aromatic Extract/Fractionation	4,103	3,387	8,100	8,100
Benzene Saturation			1,528	43
Fluid Cat Cracker (78.4)	60,629	63,670	65,400	65,400
FCC Gaso Splitter	34,470	35,664	36,930	36,675
FCC Gaso Fractionation	14,133	14,622	15,457	15,037
FCC Gaso Desulfurization	8,753	9,219	9,246	9,482
Hydrocracker – 2-Stage	2,400	2,400	2,400	2,400
Pen/Hex Isomerization	1,624	1,530	6,502	6,148
TIP Pen/Hex Isomerization			110	
Product Rates, BPCD				
Ethylene Alkylation			2,293	207
Alkylation Plant	7,800	7,800	9,824	8,048
Olefin Cat Poly	1,075	1,600	1,116	1,961
MTBE Unit	1,184	673		
Lube/Wax Plant	1,000	1,000	1,000	1,000
Butane Isomerization	1,100	1,100	1,100	1,100
Hydrogen Plt MBPD FOE	270	270	270	270
Sulfur Plant, MLT/D	91	93	101	100

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TABLE A-4
NEW PROCESS UNIT CAPACITIES, MBPSD
PADD I - 2005 AVERAGE PER REFINERY
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Charge				
Crude Distillation	4.3	6.8	24.3	22.1
Crude Depentanizer				
Heavy Naphtha Splitter				
Coker Lt Gaso DS/Splitter				0.3
Naphtha Hydrotreater	4.8	5.5	8.3	7.2
FCC/Ckr C6 Hydrotreater			0.1	0.0
Distillate HDS				
FCC Feed Hydrofiner	10.3	12.3	12.8	13.9
Cat Reformer 200 psi	4.6	6.3	11.0	7.0
Cat Ref (Cont) 100 psi				
Reformate Fractionation			6.0	5.2
Benzene Saturation			1.7	0.0
Fluid Cat Cracker				
FCC Gaso Splitter	16.0	17.3	18.6	18.4
FCC Gaso Fractionation	15.0	15.6	16.4	16.0
FCC Gaso Desulfurization	0.3	0.8	0.8	1.1
Pen/Hex Isomerization	0.1	0.0	5.4	5.1
TIP Pen/Hex Isomerization			0.1	
Butane Isomerization				
Product				
Ethylene Alkylation			2.6	0.2
Alkylation Plant			2.3	0.3
Alkylate Splitter				
Olefin Cat Poly				0.4
MTBE Unit	0.8	0.2		
Hydrogen Plant, MBPD FOE				

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TABLE A-5
COMBINED GASOLINE POOL COMPOSITION, VOL.%
PADD 1 - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	21.3	22.1	22.5	22.7
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)				0.1
FCC Gasoline (180-225)				
FCC Gasoline (225-300)	0.6	0.2		
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul				
FCC Gasoline (300-375) Desul	5.8	6.0	6.2	6.2
FCC Gasoline (375-430) Desul	3.5	3.8	3.6	3.9
Total FCC Gasoline	31.3	32.1	32.4	32.9
Pentenes			0.1	0.1
Poly Gasoline	1.1	1.7	1.2	2.1
Total Olefinic	1.1	1.7	1.2	2.1
Reformate	24.1	21.7	15.3	14.7
Reformate (220-300 Feed)	0.7	0.7	4.7	2.4
BT Reformate		0.1		1.6
HC Reformate (210-300)	5.7	7.4	7.5	7.4
Heavy Reformate (300+)	2.1	3.0	4.0	4.8
Toluene/Xylenes	0.1	0.1	2.2	1.8
Total Reformates [1]	32.7	32.9	33.6	32.7
Lt. Reformate		1.8		
Lt. Raffinate Bz (C5-210) [2]	3.4	2.6	6.4	5.3
Ethylene Alkylate			2.4	0.2
Alkylate/Lt Alkylate (C3/C4)	9.5	9.6	12.2	10.2
Alkylate/Lt Alkylate (C5)				
Heavy Alkylate				
Butane	3.3	3.0	3.2	1.7
Natural/LSR Gasoline Desul	4.8	4.9		
BT Naphtha (150-220) Desul	3.0	2.1	0.6	3.1
Pentanes			0.0	0.1
Isomerate (C5-C6)	1.7	1.6	6.7	6.3
Isomerate (C6)			0.1	0.0
Lt Hydrocrackate (C5-180)	0.6	0.6	0.6	0.6
Medium Hydrocrackate (180-225)	0.6	0.6	0.6	0.6
MTBE & TAME	8.1	6.5		
Ethanol				4.1
Total Low Arom., Saturated	34.9	33.4	32.8	32.2
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
CLM 4/20/1999

TABLE A-5A
EPA REFORMULATED GASOLINE POOL COMPOSITION, VOL.%
PADD 1 - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	20.3	21.5	21.7	21.5
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)				0.2
FCC Gasoline (180-225)				
FCC Gasoline (225-300)	0.9			
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul				
FCC Gasoline (300-375) Desul	2.7	0.2	0.7	0.2
FCC Gasoline (375-430) Desul	4.9	5.5	4.6	5.3
Total FCC Gasoline	28.7	27.3	26.9	27.2
Pentenes			0.1	0.0
Poly Gasoline	1.6	2.4	1.7	3.0
Total Olefinic	1.6	2.4	1.8	3.0
Reformate	18.9	17.3	11.7	17.2
Reformate (220-300 Feed)	0.7	1.0	6.1	2.0
BT Reformate				
HC Reformate (210-300)	8.3	10.7	8.0	10.8
Heavy Reformate (300+)	1.5	3.8	3.4	2.0
Toluene/Xylenes	0.1	0.1	3.2	2.6
Total Reformates [1]	29.4	32.9	32.4	34.5
Lt. Reformate				
Lt. Raffinate Bz (C5-210) [2]	4.9	3.8	9.3	7.7
Ethylene Alkylate			3.5	
Alkylate/Lt Alkylate (C3/C4)	10.1	13.9	16.6	14.7
Alkylate/Lt Alkylate (C5)				
Heavy Alkylate				
Butane	1.3	1.2	1.3	0.6
Natural/LSR Gasoline Desul	7.0	7.1		
BT Naphtha (150-220) Desul	1.0	0.4		4.5
Pentanes				
Isomerate (C5-C6)	2.4	2.3	8.1	
Isomerate (C6)			0.2	0.0
Lt Hydrocrackate (C5-180)	0.9	0.9	0.0	0.8
Medium Hydrocrackate (180-225)	0.9	0.9		0.8
MTBE & TAME	11.7	7.0		
Ethanol				6.0
Total Low Arom., Saturated	40.2	37.4	38.9	35.2
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
CLM 4/20/1999

TABLE A-5B
CONVENTIONAL GASOLINE POOL COMPOSITION, VOL.%
PADD 1 - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	23.7	23.3	24.4	25.3
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)				
FCC Gasoline (180-225)				
FCC Gasoline (225-300)		0.5		
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul				
FCC Gasoline (300-375) Desul	12.9	19.0	18.7	19.6
FCC Gasoline (375-430) Desul	0.4		1.4	0.8
Total FCC Gasoline	36.9	42.8	44.5	45.7
Pentenes				0.1
Poly Gasoline				
Total Olefinic				0.1
Reformate	35.9	31.6	23.4	9.2
Reformate (220-300 Feed)	0.6		1.6	3.3
BT Reformate		0.2		5.3
HC Reformate (210-300)			6.3	
Heavy Reformate (300+)	3.6	1.1	5.3	10.9
Toluene/Xylenes				
Total Reformates [1]	40.1	32.9	36.5	28.7
Lt. Reformate		5.9		
Lt. Raffinate Bz (C5-210) [2]				
Ethylene Alkylate				0.7
Alkylate/Lt Alkylate (C3/C4)	8.1		2.3	
Alkylate/Lt Alkylate (C5)				
Heavy Alkylate				
Butane	7.6	7.1	7.3	4.1
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul	7.3	5.9	1.9	
Pentanes			0.2	0.2
Isomerate (C5-C6)			3.7	20.4
Isomerate (C6)				
Lt Hydrocrackate (C5-180)			1.9	0.1
Medium Hydrocrackate (180-225)			1.8	
MTBE & TAME		5.4		
Ethanol				
Total Low Arom., Saturated	23.0	24.3	19.0	25.5
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
CLM 4/20/1999

TABLE A-6
SUMMARY OF AVERAGE COSTS @ 15% ROI
PADD I - 2005 SUMMER CASE RESULTS - INCREASE OVER BASE CASE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES
(in constant 1997 dollars)

		ETHER BANNED	
	OPTIMUM MTBE	NO OXYGENATES	ETHANOL IN RFG
New Investments, MMM$			
Refining	0.10	1.82	1.24⁾
Ethanol			1.75
Total	0.10	1.82	2.99⁾
Daily Costs, MM$/D			
Refining			
Capital Charge	0.07	1.76	1.02⁾
Fixed Operating	0.01	0.34	0.21
Upgrading & Variable	(0.09)	(0.05)	0.97
Ethanol Fed Tax (Subsidy)			(0.89)
Subtotal Refining	(0.01)	2.05	1.31⁾
Other			
Ethanol Fed Funds Loss			0.89
Milage	(0.11)	(0.54)	(0.29)
Combined	(0.12)	1.51	1.91⁾
RFG Unit Costs, ¢/G			
Refining (Pump)	(0.0)	7.4	4.7⁾
Other			
Ethanol Fed. Funds Loss			3.2
Milage	(0.4)	(1.9)	(1.0)
Combined	(0.4)	5.5	6.9⁾

⁾ Ethanol case includes added ethanol tank at each terminal.

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TABLE B-1
COMBINED GASOLINE POOL PROPERTIES
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.4	*	88.4	*	88.4	*	88.3	*
Oxygen, Wt. %	1.89	#	1.67		0.00	*	1.77	*
MTBE, Vol. %	10.4	#	9.2		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	5.1	*
Aromatics, Vol. %	22.3	#	22.9	#	26.5		25.3	
Olefins, Vol. %	5.6	#	5.5		4.4	#	5.5	#
Benzene, Vol. %	0.85	#	0.85	#	0.77	#	0.85	#
Sulfur, wppm	30	*	30	*	20	#	29	#
RVP, psi	6.9	*	6.9	#	7.0	*	7.0	*
Distillation, °F								
T10	134	#	133	#	136		139	
T50	199		201		194	#	203	
T90	321		322	#	295	#	314	#
E200	50.4		49.7		53.2	#	48.6	
E300	87.2	#	87.2	#	90.6	#	87.7	#
Driveability Index	1,119		1,122		1,082		1,130	
Distillation Index	1,119		1,122		1,082		1,165	

* Input limit – all grades.
# Input limit – one or more grades.

AZ/CLM – 4/20/1999

TABLE B-1A
CARB REFORMULATED GASOLINE POOL PROPERTIES
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.4	*	88.4	*	88.4	*	88.4	*
Oxygen, Wt. %	2.12	*	1.84		0.00	*	2.10	*
MTBE, Vol. %	11.7	*	10.1		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	6.0	*
Aromatics, Vol. %	19.0		19.3		22.6		22.1	
Olefins, Vol. %	4.6	#	4.6		3.5	#	3.6	
Benzene, Vol. %	0.80	*	0.80	*	0.80	*	0.80	*
Sulfur, wppm	30	*	30	*	10		18	
RVP, psi	6.8	*	6.8	*	6.8	*	6.8	*
Distillation, °F								
T10	134	#	132		132		138	
T50	195		195		183		200	
T90	298		298		286		289	
E200	52		52		59		50	
E300	90		90		94	#	92	
Driveability Index	1,084		1,081		1,033		1,097	
Distillation Index	1,084		1,081		1,033		1,139	
<u>% Reduction from CARB Average Emissions Limits</u>								
VOC	1.0	#	0.6	*	0.4	*	(0.1)	*
NOx	(0.1)	*	0.1	*	0.7	*	0.3	*
Toxics	0.2	*	0.3	*	6.6		0.7	*

* Input limit – both grades.
# Input limit – one grade.

AZ/CLM – 4/20/1999

TABLE B-1B
EPA REFORMULATED GASOLINE POOL PROPERTIES
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.4	*	88.4	*	88.4	*	88.4	*
Oxygen, Wt. %	2.12	*	1.62		0.00	*	2.10	*
MTBE, Vol. %	11.7	*	8.9		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	6.0	*
Aromatics, Vol. %	35.1	#	38.0	*	34.5		39.9	
Olefins, Vol. %	12.0	*	11.8		17.8	#	15.0	*
Benzene, Vol. %	0.95	*	0.95	*	0.45		0.54	
Sulfur, wppm	30	*	30	*	30	*	30	*
RVP, psi	6.7	*	6.5		6.5	*	6.5	*
Distillation, °F								
T10	135	#	139	#	141		138	
T50	200		210		239	#	234	#
T90	330		337		282		289	
E200	52		47		34		37	
E300	84		84		96		93	
Driveability Index	1,133		1,177		1,210		1,199	
Distillation Index	1,133		1,177		1,210		1,241	
% Reduction from EPA-Required Emissions Limits								
VOC	(0.2)	*	(0.3)	*	(1.2)	*	(0.2)	*
NOx	3.4		3.9		0.6	*	2.9	
Toxics	4.0		(1.1)	*	(0.1)	*	(0.2)	*

* Input limit – both grades.
# Input limit – one grade.

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TABLE B-1C
CONVENTIONAL GASOLINE POOL PROPERTIES
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base		Optimum MTBE		Ether Banned: No Oxygenates		Ether Banned: Ethanol in RFG	
Octane, (R+M)/2	88.2	*	88.2	*	88.2	*	88.2	*
Oxygen, Wt. %	0.00		0.42		0.00	*	0.00	*
MTBE, Vol. %	0.0		2.3		0.0	*	0.0	*
Ethanol, Vol. %	0.0	*	0.0	*	0.0	*	0.0	*
Aromatics, Vol. %	40.7		42.6		47.2		40.0	
Olefins, Vol. %	9.9		9.2		5.0		9.5	
Benzene, Vol. %	1.23		1.16		0.76		1.40	
Sulfur, wppm	30	*	30	*	30	*	30	*
RVP, psi	7.8	*	7.8	*	7.8	*	7.8	*
Distillation, °F								
T10	133		137		136		131	
T50	239		246	*	244	#	227	
T90	355		355		354	#	356	#
E200	37		33		30	#	44	
E300	65	#	65	#	71	#	65	*
Driveability Index	1,272		1,298		1,289		1,232	
Distillation Index	1,272		1,298		1,289		1,232	
% Reduction from 1990 Average Baseline Emissions Limits								
VOC	N/A		N/A		N/A		N/A	
NOx	3.5		4.2		5.6		3.0	
Toxics	0.9	*	0.1	*	0.7	*	1.0	*

* Input limit – both grades.
\# Input limit – one grade.

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TABLE B-1D
EXPORT GASOLINE POOL PROPERTIES
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base	Optimum MTBE	Ether Banned No Oxygenates		Ether Banned Ethanol in RFG	
Octane, (R+M)/2			87.2	*	87.2	*
Oxygen, Wt. %			0.00	*	0.00	*
MTBE, Vol. %			0.0	*	0.0	*
Ethanol, Vol. %			0.0	*	0.0	*
Aromatics, Vol. %			39.7		28.7	
Olefins, Vol. %			5.0		18.0	
Benzene, Vol. %			0.62		0.87	
Sulfur, wppm			180	*	180	*
RVP, psi			8.7	*	8.7	*
Distillation, °F						
T10			120		116	
T50			250	*	200	
T90			356	*	356	*
E200			30.0	*	50.1	
E300			74.7		65.0	*
Driveability Index			1,286		1,128	
Distillation Index			1,286		1,128	

* Input limit

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TABLE B-2
REFINERY MATERIAL BALANCE
CALIFORNIA - SUMMER AVERAGE PER REFINERY*
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

		2005			
				Ether Banned	
	1997 Reference	Base Case	Optimum MTBE	No Oxygenates	Ethanol In RFG
Raw Materials, BPCD					
Crudes	140,517	157,725	160,192	194,942	174,073
Gasoline Components	2,000	2,001	2,001	2,001	2,001
Oxygenates	8,583	8,648	7,525	0	5,028
LPG	954	990	873	204	2,385
Other	7,710	7,539	7,536	7,209	7,196
Total	159,764	176,903	178,127	204,356	190,683
Products, BPCD					
Gasolines					
Conventional	10,192	10,192	10,192	10,192	10,192
EPA RFG	4,667	5,231	5,231	5,231	5,231
CARB RFG	76,003	78,564	78,564	78,564	78,564
Other Finished	494	462	462	4,379	5,784
Components	753	693	693	693	693
Subtotal Gasolines	92,109	95,142	95,142	99,059	100,464
Distillates - Finished	43,295	52,077	52,077	52,077	52,077
No. 6 Finished	7,088	14,068	14,853	31,235	19,057
Other Black Oils	12,256	8,653	8,817	8,854	8,834
LPG	5,094	5,412	5,310	8,327	8,050
Other	2,268	2,384	2,384	2,384	2,384
Plant Fuel	9,862	11,687	12,081	15,417	12,939
Loss	(12,207)	(12,520)	(12,538)	(12,997)	(13,122)
Total	159,764	176,903	178,126	204,356	190,683

*Based on 13 operating refineries in California which produce CARB RFG.

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TABLE B-3
REFINERY PROCESS UNIT RATES
CALIFORNIA - 2005 SUMMER AVERAGE PER REFINERY
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base Case	Optimum MTBE	No Oxygenates	Ethanol In RFG
Unit Charge Rates, BPCD				
Crude Distillation	157,725	160,192	194,940	174,073
Crude Depentanizer			3,700	5,050
Heavy Naphtha Splitter	3,117	4,700	5,522	8,787
Coker Delayed	27,800	27,800	27,800	27,800
Coker Fluid	5,200	5,200	5,200	5,200
Flexi-Coker	1,800	1,800	1,800	1,800
Solvent Deasphalter	3,500	3,500	3,500	3,500
Naphtha Hydrotreater	30,385	30,849	45,555	31,900
FCC/Coker C6 H2 Tr			1,576	114
Distillaty HDS	25,200	25,200	33,406	30,681
FCC Feed Hydrofiner	50,141	51,432	58,153	51,700
Cat Reformer 450 P (91.2)	14,600	14,600	14,600	14,600
Cat Reformer 200 P (91.8)	5,987	7,084	17,854	8,564
Cat Ref(Cont) 100 P (97.1)	8,000	8,000	18,300	15,257
Reformate Fractionation	14,073	16,779	43,535	20,792
Aromatic Extract/Fractionation	726	726	770	770
Benzene Saturation	3,501	4,222	9,591	6,212
Fluid Cat Cracker (70.0)	45,164	46,327	52,383	48,435
FCC Gaso Splitter	28,221	28,809	32,607	29,104
FCC Gaso Fractionation	21,600	21,600	31,052	21,600
FCC Gaso HDS	7,100	7,100	3,600	7,100
Diesel Aromatics Saturation	1,388	1,370	4,487	5,356
Hydrocracker - 2-Stage (73.6)	28,644	28,481	28,800	28,800
Alkylate Splitter			1,361	
Pen/Hex Isomerization	6,517	6,630	8,100	5,671
TIP Pen/Hex Isomerization			1,180	
Product Rates, BPCD				
Ethylene Alkylation			1,428	1,292
Alkylation Plant	10,496	11,000	13,368	12,005
Olefin Cat Poly	400	400	308	308
MTBE Unit	820	820		
TAME Unit	340	340		
Lube/Wax Plant	1,638	1,638	1,638	1,638
Butane Isomerization	1,400	1,400	1,400	4,613
Hydrogen Plant, BPD FOE	4,250	4,250	4,565	4,493
Sulfur Plant, LT/D	196	200	219	217

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TABLE B-4
NEW PROCESS UNIT CAPACITIES, MBPSD
CALIFORNIA - 2005 AVERAGE PER REFINERY
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Charge				
Crude Distillation	10.7	13.3	49.1	27.6
Crude Depentanizer				1.4
Heavy Naphtha Splitter			0.8	4.2
Coker Lt Gaso DS/Splitter				
Naphtha Hydrotreater			14.8	
FCC/Ckr C6 Hydrotreater			1.7	0.1
Distillate HDS			8.9	6.0
FCC Feed Hydrofiner			7.0	
Cat Reformer 200 psi	2.8	4.0	15.7	5.6
Cat Ref (Cont) 100 psi			11.2	7.9
Reformate Fractionation			27.5	2.8
Benzene Saturation			5.8	2.1
Fluid Cat Cracker			3.6	
FCC Gaso Splitter	0.3	1.0	5.0	1.3
FCC Gaso Fractionation			10.1	
FCC Gaso Desulfurization				
Pen/Hex Isomerization				
TIP Pen/Hex Isomerization			1.3	
Butane Isomerization				3.6
Product				
Ethylene Alkylation			1.6	1.5
Alkylation Plant			2.7	1.1
Alkylate Splitter			1.5	
Olefin Cat Poly				
MTBE Unit				
Hydrogen Plant, MBPD FOE			0.4	0.3

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TABLE B-5
COMBINED GASOLINE POOL COMPOSITION, VOL.%
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base	Optimum MTBE	Ether Banned: No Oxygenates	Ether Banned: Ethanol in RFG
Lt FCC Gaso (255-)	7.0	7.7	1.3	7.8
Hvy FCC Gaso (255+)			0.3	0.3
FCC Gasoline (100-180)	3.6	3.5	4.6	3.2
FCC Gasoline (180-225)	2.2	2.1	1.9	2.0
FCC Gasoline (225-300)	3.4	3.5		1.0
FCC Gasoline (300-375)				1.0
FCC Gasoline (225-300) Desul	2.8	2.7	3.7	4.9
FCC Gasoline (300-375) Desul	4.9	5.0		2.4
FCC Gasoline (375-430) Desul				
Total FCC Gasoline	23.9	24.5	11.9	22.6
Pentenes	0.2	0.1	1.6	0.5
Poly Gasoline	0.1	0.1		
Total Olefinic	0.3	0.2	1.6	0.5
Reformate	7.2	4.4		6.9
Reformate (220-300 Feed)	6.5	7.0		6.5
BT Reformate		0.1		0.3
HC Reformate (210-300)	7.2	8.6	21.6	9.5
Heavy Reformate (300+)	3.3	4.0	7.3	4.3
Toluene/Xylenes	0.0	0.0	0.1	0.0
Total Reformates [1]	24.1	24.1	28.9	27.5
Lt. Reformate		0.0	3.6	
Lt. Raffinate Bz (C5-210) [2]	4.4	5.2	10.7	7.0
Ethylene Alkylate			1.5	1.3
Alkylate/Lt Alkylate (C3/C4)	10.0	10.4	12.5	11.3
Alkylate/Lt Alkylate (C5)	1.6	1.8	1.6	1.4
Heavy Alkylate	0.0	0.0	0.2	0.0
Butane	2.2	2.2	1.3	0.7
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul [3]	2.4	1.7	0.4	0.8
Pentanes	1.7	1.7	4.3	3.4
Isomerate (C5-C6)	6.8	6.9	5.3	2.2
Isomerate (C6)			4.0	3.4
Lt Hydrocrackate (C5-180)	6.1	6.1	8.5	7.2
Medium Hydrocrackate (180-225)	6.0	6.0	3.7	5.6
MTBE & TAME	10.4	9.2		
Ethanol				5.1
Total Low Arom., Saturated	51.7	51.2	57.6	49.3
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
[3] Includes untreated BT Naphtha
CLM 4/20/1999

TABLE B-5A
CARB REFORMULATED GASOLINE POOL COMPOSITION, VOL.%
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	3.8	4.4		3.0
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)	4.3	4.2	5.8	4.0
FCC Gasoline (180-225)	2.6	2.5		2.5
FCC Gasoline (225-300)	3.9	4.2		1.0
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul	3.3	3.2		5.4
FCC Gasoline (300-375) Desul	5.0	3.6		
FCC Gasoline (375-430) Desul				
Total FCC Gasoline	22.9	22.1	5.8	15.9
Pentenes			1.3	
Poly Gasoline				
Total Olefinic			1.3	
Reformate	4.0	3.8		5.9
Reformate (220-300 Feed)	7.7	8.2		8.2
BT Reformate				
HC Reformate (210-300)	7.4	6.8	22.8	10.0
Heavy Reformate (300+)	0.7	2.0	4.3	3.5
Toluene/Xylenes			0.0	
Total Reformates [1]	19.9	20.8	27.2	27.5
Lt. Reformate			4.5	
Lt. Raffinate Bz (C5-210) [2]	5.3	6.0	13.3	8.9
Ethylene Alkylate			1.8	1.6
Alkylate/Lt Alkylate (C3/C4)	11.9	12.4	15.5	14.0
Alkylate/Lt Alkylate (C5)	1.9	2.1	1.2	1.7
Heavy Alkylate	0.0	0.0	0.1	
Butane	1.7	1.5	0.5	0.5
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul [3]	1.5	1.0		0.2
Pentanes	1.8	2.0	2.6	0.4
Isomerate (C5-C6)	7.4	8.3	6.1	2.8
Isomerate (C6)			5.0	4.3
Lt Hydrocrackate (C5-180)	7.0	7.0	10.6	9.0
Medium Hydrocrackate (180-225)	6.7	6.5	4.5	7.1
MTBE & TAME	11.7	10.2		
Ethanol				6.0
Total Low Arom., Saturated	57.1	57.0	65.8	56.6
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
[3] Includes untreated BT Naphtha
CLM 4/20/1999

TABLE B-5B
EPA REFORMULATED GASOLINE POOL COMPOSITION, VOL. %
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	19.5	23.5	19.2	11.4
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)				
FCC Gasoline (180-225)				
FCC Gasoline (225-300)	1.6			4.4
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul			16.9	11.2
FCC Gasoline (300-375) Desul		5.5		
FCC Gasoline (375-430) Desul				
Total FCC Gasoline	21.1	29.0	36.1	27.0
Pentenes	3.7	1.4	10.8	9.9
Poly Gasoline	0.9	1.8		
Total Olefinic	4.6	3.2	10.8	9.9
Reformate	5.1			
Reformate (220-300 Feed)		3.3		
BT Reformate				
HC Reformate (210-300)	17.0	23.8	30.7	31.5
Heavy Reformate (300+)	14.4	9.9		6.1
Toluene/Xylenes	0.3			0.3
Total Reformates [1]	36.8	37.1	30.7	37.9
Lt. Reformate				
Lt. Raffinate Bz (C5-210) [2]		2.7	0.0	
Ethylene Alkylate				
Alkylate/Lt Alkylate (C3/C4)				4.0
Alkylate/Lt Alkylate (C5)			12.3	0.5
Heavy Alkylate			2.8	0.3
Butane	2.5	2.8	0.5	0.5
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul [3]	20.7	15.8		12.4
Pentanes	1.3	0.5	0.2	1.4
Isomerate (C5-C6)	1.5		6.6	
Isomerate (C6)				
Lt Hydrocrackate (C5-180)				
Medium Hydrocrackate (180-225)				
MTBE & TAME	11.6	8.9		
Ethanol				6.0
Total Low Arom., Saturated	37.6	30.8	22.4	25.1
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
[3] Includes untreated Bt Naphtha
CLM 4/20/1999

TABLE B-5C
CONVENTIONAL GASOLINE POOL COMPOSITION, VOL.%
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

			Ether Banned	
	Base	Optimum MTBE	No Oxygenates	Ethanol in RFG
Lt FCC Gaso (255-)	25.6	25.1	2.3	25.9
Hvy FCC Gaso (255+)				
FCC Gasoline (100-180)				
FCC Gasoline (180-225)			13.9	
FCC Gasoline (225-300)				
FCC Gasoline (300-375)				
FCC Gasoline (225-300) Desul	0.3		14.4	
FCC Gasoline (300-375) Desul	6.7	15.6		19.4
FCC Gasoline (375-430) Desul				
Total FCC Gasoline	32.7	40.7	30.6	45.4
Pentenes				
Poly Gasoline	0.5			
Total Olefinic	0.5			
Reformate	32.5	10.6		22.4
Reformate (220-300 Feed)				
BT Reformate		1.0		2.8
HC Reformate (210-300)	0.0	14.3	15.6	
Heavy Reformate (300+)	17.8	16.1	29.2	8.8
Toluene/Xylenes		0.1	0.3	
Total Reformates [1]	50.3	42.1	45.1	34.0
Lt. Reformate		0.2		
Lt. Raffinate Bz (C5-210) [2]		0.3		
Ethylene Alkylate				
Alkylate/Lt Alkylate (C3/C4)				
Alkylate/Lt Alkylate (C5)				
Heavy Alkylate				
Butane	5.3	6.7	6.0	1.6
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul [3]			2.5	
Pentanes	1.2		15.0	19.0
Isomerate (C5-C6)	5.0			
Isomerate (C6)				
Lt Hydrocrackate (C5-180)	1.7	2.5	0.5	
Medium Hydrocrackate (180-225)	3.4	5.1	0.2	
MTBE & TAME		2.3		
Ethanol				
Total Low Arom., Saturated	16.6	17.2	24.3	20.6
Total	100.0	100.0	100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
[3] Includes untreated BT Naphtha
CLM 4/20/1999

TURNER, MASON & COMPANY
Consulting Engineers

TABLE B-5D
EXPORT GASOLINE POOL COMPOSITION, VOL.%
CALIFORNIA - 2005 SUMMER AVERAGE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES

	Base	Optimum MTBE	Ether Banned: No Oxygenates	Ether Banned: Ethanol in RFG
Lt FCC Gaso (255-)				41.9
Hvy FCC Gaso (255+)			8.1	5.4
FCC Gasoline (100-180)				
FCC Gasoline (180-225)			12.5	
FCC Gasoline (225-300)				
FCC Gasoline (300-375)				19.5
FCC Gasoline (225-300) Desul			33.5	
FCC Gasoline (300-375) Desul				7.3
FCC Gasoline (375-430) Desul				
Total FCC Gasoline			54.1	74.0
Pentenes				
Poly Gasoline				
Total Olefinic				
Reformate				
Reformate (220-300 Feed)				
BT Reformate				
HC Reformate (210-300)				
Heavy Reformate (300+)			19.7	5.5
Toluene/Xylenes				
Total Reformates [1]			19.7	5.5
Lt. Reformate				
Lt. Raffinate Bz (C5-210) [2]				
Ethylene Alkylate				
Alkylate/Lt Alkylate (C3/C4)				
Alkylate/Lt Alkylate (C5)				
Heavy Alkylate				
Butane			7.0	1.5
Natural/LSR Gasoline Desul				
BT Naphtha (150-220) Desul [3]			4.2	
Pentanes			15.0	19.0
Isomerate (C5-C6)				
Isomerate (C6)				
Lt Hydrocrackate (C5-180)				
Medium Hydrocrackate (180-225)				
MTBE & TAME				
Ethanol				
Total Low Arom., Saturated			26.2	20.5
Total			100.0	100.0

* Due to rounding, columns may not total.
[1] Excluding Lt Reformate and Lt Raffinate
[2] Includes dearomatized Lt. Reformate
[3] Includes untreated BT Naphtha
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TABLE B-6
SUMMARY OF AVERAGE COSTS @ 15% ROI
CALIFORNIA - 2005 SUMMER CASE RESULTS - INCREASE OVER BASE CASE
COSTS OF POTENTIAL BAN OF MTBE IN GASOLINES
(in constant 1997 dollars)

		ETHER BANNED	
	OPTIMUM MTBE	NO OXYGENATES	ETHANOL IN RFG
New Investments, MMM$			
Refining	0.14	5.56	2.45)
Ethanol			2.91
Total	0.14	5.56	5.36)
Daily Costs, MM$/D			
Refining			
Capital Charge	0.09	4.60	2.18)
Fixed Operating	0.02	0.95	0.42
Upgrading & Variable	(0.16)	(0.33)	0.87
Ethanol Fed Tax (Subsidy)			(1.48)
Subtotal Refining	(0.05)	5.22	1.99)
Other			
Ethanol Fed Funds Loss			1.48
Milage	(0.11)	(0.63)	(0.22)
Combined	(0.16)	4.59	3.25)
RFG Unit Costs, ¢/G			
Refining (Pump)	(0.1)	11.4	4.4)
Other			
Ethanol Fed Funds Loss			3.2
Milage	(0.2)	(1.4)	(0.5)
Combined	(0.3)	10.0	7.1)

) Ethanol case includes added ethanol tank at each terminal.

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EXHIBIT X-2
GASOLINE BLENDING IMPACTS OF REMOVING MTBE ON CARB 2 RFG PROPERTIES, EMISSIONS AND VOLUME

	Base 1997Average CARB 2 RFG CEC Survey	Revised Base w/o MTBE – Sub-Regular (@ Base RVP)	Adjusted Base w/o MTBE – Normal Grades[(1)] (@ Base Octane, RVP)	Adjusted Base Less Base
Octane, (R+M)/2	88.5	85.9	88.5	0.0
MTBE, Vol. %	11.7	0.0	0.0	(11.7)
Aromatics, Vol. %	23.0	26.4	32.6	9.6
Olefins, Vol. %	4.1	4.6	5.8	1.7
Benzene, Vol. %	0.57	0.65	0.75	0.18
RVP, psi	6.8	6.8	6.8	0.0
Distillation				
T10, ^oF	138	140	141	3
T50, ^oF	198	210	215	17
T90, ^oF	303	308	310	7
E200, %	50.5	45.2	42.4	(8.6)
E300, %	88.4	88.0	87.5	(1.7)
Driveability Index	1,104	1,148	1,167	63
Sulfur, wpm	19	20	21	2
Volume, MBPD	899	796	762	(137)
Emissions, MG/mi[(2)]				
VOC	1,027	1,054	1,074	47
NOx	1,143	1,152	1,163	20
Toxics	54.47	61.14	66.10	11.63
Change From Base, %				
VOC	0.0	+2.6	+4.6	+4.6
NOx	0.0	+0.8	+1.8	+1.8
Toxics	0.0	+12.2	+21.4	+21.4

[(1)] Restore octane by increasing reformer severity and FCC octane.
[(2)] Based on EPA complex model Phase 2 (some properties exceed CARB model limits).

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