CRITIQUE OF 10/98 AND 12/98 REPORTS
BY MATHPRO ET AL FOR CEC,
ENTITLED "SUPPLY AND COSTS
OF ALTERNATIVES TO MTBE IN GASOLINE"

For the
Oxygenated Fuels Association

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January 29, 1999

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Background and Focus

We were retained in December by the Oxygenated Fuels Association (OFA) to critique the results of the MTBE ban study by MathPro et al, for the California Energy Commission (CEC). This study is entitled "Supply and Costs of Alternatives to MTBE in Gasoline". Initial results were published in October 1998, and final results were published in December 1998. MathPro modified its linear programming (LP) model to develop a composite model of the California refining industry. MathPro did most of the work in this study. Costs and supply of alkylate and CARBOB into California were developed by Purvin & Gertz. Costs and supply of various oxygenates into California were developed by Energy Security Analysis, Inc. (ESAI).

We were asked by OFA to specifically focus our critique on the two primary alternatives to MTBE: the no oxygenates (no oxy) and the ethanol substitution (ethanol) cases. In addition, much of our critique of the results is general and applies to the entire study as well as these two primary alternatives.

Conclusions

! MathPro misapplied the California Air Resources Board phase 2 reformulated gasoline (CARB 2 RFG) flat limits to over-optimize (CARB 2 RFG) production and to develop ridiculously low costs for the two primary alternatives to MTBE use as follows in ¢/gallon of CARB 2 RFG:

	No Oxy	Ethanol
Intermediate Term (2002)	4.3	6.1
Long Term (2005)	0.9	1.9

- These and all of MathPro's CARB 2 RFG flat limits results are invalid because these flat limits properties are completely unattainable by the California refineries. In 1997, while almost all of the refineries were operating in the flat limits mode, the California refining industry met the CARB 2 RFG emissions limitations with an "average" set of properties, which were well below these MathPro flat limits as shown in attached Table 1. These 1997 average CARB 2 RFG properties were even slightly below the average mode limits and emissions used by MathPro. The flat limits mode is the least limiting and highest properties and emissions mode allowed by CARB. When operating in this mode, refineries were required to submit to CARB their higher than average "not to exceed" flat limits for each property that each and every batch had to meet for all eight controlled properties.

- The margins between these higher "not to exceed" flat limits submitted by refineries and their average property levels attained in 1997 were required for test reproducibilities, effects of potential unplanned unit shutdowns and blend-to-blend variances for each of these 8 properties. These higher “not to exceed” 1997 flat limits were not (and will not ever be) available for usage as higher effective average limits as assumed by MathPro in its flat limit cases. (If they could be, they would also require concomitant, even higher, “not to exceed” flat limits for every batch.) MathPro failed to recognize that most refineries were already using CARB’s flat limits in 1997 and that they must blend with a certain compliance margin for each property to avoid CARB violations and negative publicity.

- By using these unattainable, higher flat limits as allowable averages in these four primary alternative cases, MathPro increased toxics by up to 4.3%, VOCs by up to 2.6%, and NOx by up to 0.3% above their 1997 actual averages, thereby significantly and unrealistically reducing costs. This MathPro strategy would eliminate part of the emissions reductions attained and required by CARB.

! Using MathPro’s much more realistic average CARB 2 RFG limits (which were really slight increases to average attainment under the flat limits), MathPro calculated costs of alternatives to MTBE use in ¢/gallon of CARB 2 RFG as follows:

	No Oxy	Ethanol
Intermediate Term (2002)	8.7	7.5
Long Term (2005)	3.7	2.4

- In our opinion, these costs of these primary alternatives to MTBE use are extremely understated and very misleading, even though they are 0.5 to 4.4¢/gallon higher than the ridiculously low flat limit costs listed above for these cases.

- Even for these average limit cases, MathPro allowed optimizations at 0.2~0.4% above the 1997 average emissions for VOC, NOx and Toxics attained by the industry when using the CARB flat limits. In at least the intermediate term future, industry compliance margins for CARB 2 RFG properties will be greater, not smaller as industry attempts to avoid infringing the Unocal gasoline patent while meeting CARB 2 RFG specs. Average emissions will be lower than in 1997, and therefore, the costs of banning MTBE will be higher than calculated in these MathPro average cases.

! The largest errors, which would dramatically increase these MathPro costs fall into two classes: calculated pricing adjustments and estimated LP costs adjustments. These costs adjustments for both the intermediate term and long term, are bracketed in ¢/gallon of CARB 2 RFG below:

	No Oxy	Ethanol
Calculated Pricing Adjustments		
Add Costs of Ethanol Tax Subsidy	–	4
Adjust Pricing of CARBOB and Alkylate	1 - 2.5	0.5 - 1
Correct Mispricing of Oxygenates	0.5	2.5
Estimated LP Cost Adjustments		
Eliminate MathPro LP Over-Optimizations	5 - 10	5 - 10
Eliminate Free Added Refining Facilities	1 - 4	1 - 4
Total Increase	7 - 17	13 - 21

- The magnitude of the range of these combined probable cost errors would increase MathPro's average limit CARB 2 RFG costs by factors of about 2-4 for the intermediate term cases, and by factors of about 4-10 for the long term cases.

! In our opinion, correcting for these errors would dramatically increase costs to above 15¢/gallon for both of these alternatives in the intermediate term and to above 10¢/gallon in the long term based on results of prior TM&C studies as shown below.

- In June 1997, prior results of a preliminary California MTBE ban study for WSPA by TM&C showed much higher costs of about 17¢/gallon for the intermediate term with ethanol substitution. It also showed a much higher loss of 43% (or 380 MBPCD) of CARB 2 RFG production in California refineries. These refinery LP results were specifically noted as lower costs than actual due to recognized over-optimization problems and exclusion of added costs for the ethanol tax subsidy.

- In a 1992 study for Auto/Oil, TM&C determined that an MTBE ban for a California gasoline similar to CARB 2 RFG, with no oxygenate substituted, had long term costs of about 7.4¢/gallon. However, this result also required a significant gasoline pool octane drop of 1.4 number to 96% regular to attain feasibility, which reduced this cost by over 5¢/gallon.

Adjustments to Costs for Ethanol Tax Subsidy

! The federal ethanol tax subsidy is 54¢/gallon of ethanol. Use of ethanol in California would significantly reduce federal gasoline excise tax receipts from California. This lost federal tax revenue would directly reduce (dollar for dollar) the federal rebates to California from the Highway Trust Fund. Hence, this federal tax subsidy becomes a state subsidy and thereby a true cost to the California economy. Therefore, this tax subsidy cost should be included in the ethanol substitution case costs. It was omitted by MathPro in their cost results.

- This tax subsidy cost increase and corrections for improper pricing of alkylate, CARBOB, MTBE and ethanol, which are discussed below, are shown in detail in the attached Table 2.

Adjustments to Costs of Alkylate and CARBOB Supply

! The alkylate, CARB 2 RFG and CARBOB supply and cost estimates by Purvin & Gertz are very optimistic. Low cost supply curves for alkylate, CARB 2 RFG and CARBOB gasoline led to low MathPro cost results. We estimate much lower supply availabilities at higher costs, especially when both alkylate and CARBOB are utilized, for the reasons listed below.

- Starting in 2000, U.S. refineries will have to make EPA Phase II RFG with more stringent limits on VOC and NOx. Meeting these tighter RFG limits while still meeting the EPA anti-dumping requirements (no increase in conventional gasoline (CG) emissions), will enhance the refining value of very low sulfur, low RVP, low NOx, low toxics gasoline components like alkylate and those used to blend CARBOB.

- Further, starting about 2004, U.S. refineries will have to drastically reduce the average sulfur of CG to meet probable EPA regs. This long term shift will further increase the value of potential alkylate or CARBOB sales to California.

- Transport costs of alkylate will be higher by several cents per gallon due to the need to load and unload composited cargos at several refineries due to limited tankage and available supply at source refineries plus limited tankage and incremental demand usage rates.

- Large movements of CARBOB and alkylate into California and surplus gasoline components out of California will dramatically increase tanker traffic, cause more accidental spills and increase demurrage costs.

Adjustments to Costs of Oxygenates Supply

! Except for MTBE, in their oxygenate supply/cost curves, ESAI wrongly projected much lower than current market prices for most of the oxygenate supply required to make CARB 2 RFG. This led to invalid very low cost alternative oxygenate scenario MathPro results.

! A California switch away from MTBE will greatly reduce its price as MTBE producers with surplus capacity will then sell at incremental costs and eliminate their capital charge part of its costs to try to restore demand. Therefore, backing MTBE out in California will depress its price. In this circumstance, refineries will save less than they would with current MTBE purchase costs and thereby make the alternative cases more costly.

! ESAI wrongly projected much cheaper ethanol and ETBE prices for the long term than for the intermediate term. ESAI wrongly projected significantly bigger long term unit costs savings for ethanol and ETBE than for MTBE and TBA.

! A California switch to ethanol will force a massive shift in its market and will greatly increase costs of ethanol in the intermediate term. Almost all of the supply would have to be taken away from current users in the Midwest farm belt, who plan to continue blending it to gasohol and have generous state tax subsidies for current usage. Ethanol producers would have no assurance that the new California market would continue for the long term in view of the current California market uncertainties for MTBE. Therefore, long term ethanol prices will also be much higher than assumed by ESAI.

Over-Optimizations – General

! Most California conversion refineries have only about 12-14 gasoline components. In comparison, the MathPro LP model has 49 theoretical gasoline components. This theoretical flexibility was used to easily overcome the actual difficulties of the potential MTBE ban in the MathPro cases via over-optimization.

! The MathPro LP has selectively segregated theoretical multiple fractions of the light straight run gasoline, light naphtha, light and medium hydrocrackate, alkylate, FCC gasoline and light and heavy reformate blendstocks that have different theoretical properties. These are actually mostly single streams with single properties. The theoretical LP fractions are being used separately to unrealistically meet the differing product specifications for CARB 2 RFG as well as other types and grades of finished gasoline.

! To correct these over-optimization and understated property improvement costs problems, MathPro's refining LP program needs the addition of either gasoline component recursion or gasoline component ratio control equations. Gasoline component recursion or ratio control equations are needed for $C_3/C_4/C_5$ alkylates, light/medium hydrocrackate, low/medium/high octane light straight run gasolines, light naphthas, light/heavy reformates at two severities and various FCC gasoline cuts.

! MathPro might incorrectly argue that although this base case is over-optimized, the cases developed to determine the costs required to modify CARB 2 RFG gasoline specifications are also over-optimized. MathPro thus may have concluded that the differentials between its cases are valid. Our experience has been that as study cases become more restrictive and costly, the level of over-optimization increases as the product restrictions and incremental product costs increase. Hence, costs for more restrictive properties cases are understated due to increased over-optimization.

! The MathPro base case solution includes light and heavy reformate streams with multiple octanes and fractions. No California refinery has adequate fractionation, tankage or reformer blocked operation capability to segregate reformer feeds into light and heavy types and produce two or three different octane levels of each type for selectively blending into the different finished gasoline products. Thus no California refinery has these theoretical light and heavy reformates which made it much easier and cheaper to meet T50 and T90 limits of CARB 2 RFG without MTBE in MathPro's LP model cases.

! Similar over-optimization has occurred for MathPro FCC gasolines. These have dramatic effects on gasoline olefins, aromatics and sulfur due to MathPro's incorrect and exaggerated differences in these properties at different FCC conversion levels and for different FCC gasoline boiling ranges. The light straight run, light naphtha, alkylate and hydrocrackate gasoline blendstocks have similar problems of excessive segregation of theoretical fractions and properties, which geometrically increase the implausibility of the low cost MathPro LP solutions.

Over-Optimization and Input Errors – Specific Examples

! FCC Gasoline

- Exhibit 9 (Gasoline Composition and Volume) for intermediate term, averaging mode shows 19.7% full range, untreated FCC gasoline in the reference 2002 case and 16.4% in the no oxygenates case for CARB 2 gaso. These results are unreasonable. All FCC gasoline is split into light and heavy in California refineries, per the “1996 API/NPRA Survey of Refining Operations and Product Quality.”

- Actual average full range, untreated California FCC gasoline has about 411 ppm average sulfur and cannot be blended into 20 ppm sulfur CARB 2 gasolines in these concentrations at this average sulfur content without hydrotreating. These concentrations of average untreated whole FCC gasoline would contribute 67-81 ppm sulfur to the CARB 2 RFG and greatly exceed its sulfur specs of 30-40 ppm by themselves.

- MathPro shows that only 18-26% of total California FCC gasoline is hydrotreated, while the API/NPRA survey showed that 52% was hydrotreated in the summer of 1996.

- Actual average California FCC gasoline was undercut by over 30°F in 1996 and was not a “full range” FCC gasoline as described by MathPro. By blending “full range” FCC gasoline, the CARB 2 RFG T90s for these two cases would be 11-23°F higher than claimed by MathPro in Exhibit 8.

! CARBOB RVP

- In the intermediate term averaging mode, MathPro Ethanol Case 1 with 100 MBPD of purchased alkylate, the RVP calculated for the MathPro CARBOB components listed in Exhibit 9 would actually be about 6.7, due to lack of complete depentanizing. With ethanol added, the CARB 2 RFG RVP would be about 1.3 psi higher at 8.0, or about 1.2 psi above the maximum allowable at the refineries. Obviously the MathPro LP model component RVPs do not reflect actual component RVPs for California refineries, as MathPro listed the RVP for this CARBOB plus ethanol blend at only 6.8 psi in Exhibit 8. Hence, the costs of this case for required component depentanizers and pentane sales were greatly understated, and the CARB 2 RFG production was overstated.

! CARB 2 RFG Distillation

- The MathPro components include only 9 distillation temperatures with % off listed. The MathPro model is especially inadequate in the T50 range with only 175/200/212 and 257°F and in the T90 range with only 280/300 and 356°F. More than double this number of distillation temperatures covering about every 10°F are needed to attain required accuracy and avoid significant over-optimization. (In contrast, the TM&C CARB 2 RFG LP model includes data for 24 distillation temperatures.)

- Further, in the MathPro LP, a number of gasoline components with the same TBP boiling range have different and therefore invalid distillation data, especially in the T50 and T90 regions. These distillation errors and inadequate representations have allowed the MathPro LP to over-optimize and more easily meet T50 and T90 limits of CARB 2 RFG without MTBE than is actually possible for the California refineries.

! Heavy Naphtha Sales

- California refineries will not sell heavy reformer feed naphthas as assumed by MathPro in its modeling configuration. If good prefractionation of reformer feeds were modeled, California refineries would undercut the heavier part of the theoretical MathPro 250-350°F fraction of hydrocrackate and heavy straight run naphtha into kerosene jet fuel and offset the added jet by making less hydrocracked jet. This undercutting approach would accomplish the same CARB 2 RFG T90 impact with a much smaller reduction in reformer feed rate.

- Further, selling the theoretical 250-350°F heavy naphtha would require added fractionation of whole naphtha which would not be available in the intermediate term. Such a sale should reduce reformer hydrogen make and require added hydrogen plant capacity which would make this approach uneconomic, if it were modeled correctly.

! Tankage Costs

- Ancillary refining costs assumed by MathPro of only 0.1¢/gallon for added blendstock tankage and inventory are extremely low, especially due to California costs of land, permitting difficulty and tankage emissions limitations (double seals requirements).

- Rental tankage is scarce and costs about 40¢/barrel/month plus a fee of about 0.1¢/gallon/transfer in California.

Free Added Refining Facilities

! MathPro wrongly assumed significant free refining capacity creep to provide surplus refining capacity in their future time periods, which greatly reduced MathPro's calculated MTBE alternatives costs and made them much too low.

! Most refineries in California and the U.S. have been running at maximum gasoline output, not with significant surplus gasoline capacity as MathPro assumed. By assuming free added capacity, MathPro reduced product costs below recent and current as well as projected reality and allowed their model to utilize this free surplus capacity to reduce the costs of the potential MTBE ban.

Assumptions – General

! Most of the study assumptions for probable future oxygenate policy used to set the CEC/MathPro array of cases and scenarios were not supported by either the Federal EPA or Congress in 1998.

- Federal MTBE ban (Recent EPA testimony favored expanded EPA RFG with continued MTBE use. This potential should be included only for the long term cases. A federal MTBE ban should cause the cost of ethanol to skyrocket.)

- No tax credit extension for ethanol (Congress extended tax credit for ten years.)

- California exemption from Federal oxygen mandate (Proposed oxygen mandate exemption was opposed by EPA and did not get out of Congressional committee. The no oxygenate cases require this exemption.)

- RVP waiver of 1.0 psi for gasohol for RFG (EPA and CARB continue to reject this waiver with its corollary increased hydrocarbons, NOx and toxics emissions.)

! MathPro wrongly assumed constant crude composition instead of allowing rate changes on only one or two non-West Coast crudes. Almost all California and Alaska crude production is baseload in West Coast refineries, as only foreign crudes have varied to meet requirements. In extreme crude cutbacks, Alaska North scope crude would also be backed out and shipped to the Gulf Coast.

Other Errors

- Exhibit 4 describing the cases and scenarios for long term are incorrect duplicates of the intermediate term cases description.

TABLE 1
CARB 2 RFG SUMMER PROPERTIES AND LIMITS
ACTUAL VERSUS "NOT TO EXCEED" VERSUS CARB LIMITS

	1997 Survey by CEC and CARB[1]		CARB Limits		
Property	Actual Average	Not to Exceed Average	Average	Flat	Cap
Actual and CARB					
RVP, PSI	6.8	N/A	N/A	7	7
Aromatics, V%	23.0	24.9	22.0	25.0	30.0
Benzene, V%	0.57	0.72	0.80	1.00	1.20
Olefins, V%	4.1	5.9	4.0	6.0	10.0
Sulfur, wppm	19	24	30	40	80
T50, °F	198	203	200	210	220
T90, °F	303	311	290	300	330
Oxygen, Wt.%, (Max.)	2.1	N/A	2.2[2]	2.7	2.7
Oxygen, Wt. %, (Min.)[3]			1.8	1.8	1.8
Oxygen, Wt. %, (Min.)[4]			0.0	0.0	0.0
MathPro Basis	Average Limits[5]	Flat Limits			

(1) Attained while almost all refineries were operating under the flat limits mode.
(2) Without predictive model use. Also applies to flat limits.
(3) Federal non-attainment areas (65% of state demand).
(4) Federal attainment areas (35% of state demand).
(5) Plus small increases to allow 0.2-0.4% more emissions for VOC, NOx and Toxics.

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TABLE 2
CALCULATED PRICING AND TAX SUBSIDY CORRECTIONS TO MATHPRO COST RESULTS FOR MTBE BAN WITH AVERAGE CARB RFG SPECS

	Increased CARB 2 RFG Costs			
	No Oxygenate		Ethanol Substitution	
	¢/Gallon	MM$/Season	¢/Gallon	MM$/Season
Intermediate Term				
MathPro Results	8.7	660	7.5	560
TM&C Pricing Corrections	3.2	240	3.5	260
Tax Subsidy Costs Adj.	–	–	4.2	310
Total Revised	11.9	900	15.2	1230
Long Term				
MathPro Results	3.7	290	2.4	190
TM&C Pricing Corrections	1.3	100	2.9	230
Tax Subsidy Costs Adj.	–	–	4.2	330
Total Revised	5.0	390	9.5	750
TM&C Pricing Corrections Detail				
Intermediate Term				
Alkylate	0.7-	50	0.7-	50
CARBOB	1.9+	150-	0.4+	30
MTBE	0.6	40+	0.6	40
Ethanol	–	–	1.8	140
Long Term				
Alkylate	0.6	50	0.6	50
CARBOB	0.3-	20	–	–
MTBE	0.4-	30	0.4-	30
Ethanol	–	–	1.9+	150

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