REVIEW AND CRITIQUE OF THE ECONOMICS PORTION OF

"HEALTH AND ENVIRONMENTAL ASSESSMENT OF MTBE"

UNIVERSITY OF CALIFORNIA AT DAVIS - NOVEMBER 1998

Titled "An Integral Cost-benefit Analysis of Gasoline
Formulations Meeting California Phase II
Reformulated Gasoline Requirements"
by Keller, Et Al - UCSB, Santa Barbara

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INTRODUCTION/OBJECTIVE

The enclosed is an independent Turner, Mason & Company (TM&C) review and critique of the economics of a University of California at Davis (UCD) 11/98 study entitled “Health and Environmental assessment of MTBE” sponsored by SB521. The economics section of this UCD study is titled “An integral cost-benefit analysis of gasoline formulations meeting California Phase II Reformulated Gasoline requirements” (CBAGF) by Keller, et al of the Bren School of Environmental Science and Management, UCSB, Santa Barbara, California. This TM&C review was requested by the staffs of the California Energy Commission (CEC) and the California Air Resources Board (CARB). It is completely independent based on our expertise, even though part of our costs were funded by the Oxygenated Fuels Association (OFA). OFA did not impact or modify this independent TM&C review.

TM&C is a chemical engineering consulting firm located in Dallas, Texas, which is highly experienced in studies of economics and feasibility of alternative gasoline formulations. TM&C has studied gasoline formulation economics for the Auto/Oil Air Quality Improvement Research Program (Auto/Oil), the National Petroleum Council (NPC), the New York State Energy Research and Development Authority (NYSERDA), the California Energy Commission (CEC), the American Petroleum Institute (API), the National Petrochemical and Refiners Associations (NPRA), the Western States Petroleum Association (WSPA), the National Institute for Petroleum and Energy Research (NIPER) and numerous refining industry clients. A partial list of related TM&C reports and publications is attached (Exhibit 1). By this experience, TM&C is highly qualified to comment on the feasibility and direct costs of the alternative California Phase II Reformulated Gasolines (CaRFG2). TM&C does not claim to be expert in the analysis of health costs or other (environment cleanup) costs as presented in CBAGF and can only comment as analytical engineers on these other analysis.

EXECUTIVE SUMMARY

The CBAGF compares three alternate formulations for California Phase II Reformulated Gasoline (CaRFG2). They are: i) 2% oxygen content CaRFG2 with 11% MTBE; ii) 2% oxygen content CaRFG2 containing 5.7% ethanol; and iii) non-oxygenated CaRFG2. The latter two no-MTBE formulations do not even come close to meeting CaRFG2 specifications; so, the comparisons are invalid.

The authors made an incorrect cost benefit analysis (CBA) of the three formulations, compared to conventional gasoline, presented in Table 2 of the study. As presented, the three formulations have a huge variance in cost ($1.1-3.0 billion in the case of CaRFG2 blended with MTBE) and unbelievable lower but still widely variable costs for the invalid alternate formulations. Based on these flawed alternative formulations and unbelievable economics, the CBAGF makes a strong recommendation for their claimed economic optimum of CaRFG2 without oxygenates. In review of this primary conclusion, we find significant flaws in their method of study, the feasibility of the alternates, the computation of fuel price increase and the computation of the fuel efficiency changes of the alternates. We have also discovered major errors in the CBAGF pricing methodology for MTBE, ethanol and toluene. The impacts of these CBAGF combined errors are huge understatements of the true costs of the CaRFG2 ethanol and non-oxygenated alternates to CaRFG2 with MTBE of about $1 billion to $4+ billion per year, which contradict the claimed CBAFG results and conclusions. CaRFG2 with MTBE is really much less costly than ethanol or non-oxy CaRFG2, even after a much larger health cost penalty (see summary table below).

	Annual Costs in $ Billion/Yr. CaRFG2 with		
	MTBE	Ethanol	Non-Oxy
Health/Air/Other	0.5 - 1.7	0.0 - 0.1	0.0 - (0.1)
Fuel Manufacture/Mileage*	0.0	0.9 - 2.6	0.6 - 2.4+
Revised Total	0.5 - 1.7	0.9 - 2.7	0.6 - 2.3+
Net Over MTBE			
Revised	Base	0.4 - 1.0	0.1 - 0.6+
[CBAGF]	[Base]	[(0.6) - (1.8)]	[(1.1) - (3.4)]
CBAGF Low By	0.0	1.0 - 2.8	1.2 - 4.0+

* True costs from other sources for valid alternate blends using refinery linear programs (LP) models.

A simple further economics reality check is found in the current industry practice. If these CaRFG2 alternates to MTBE use were feasible and had direct cost savings as the CBAGF claims, why has the refining industry not already adopted these alternates? Why hasn't industry even reduced non-mandated MTBE usage in CaRFG2? By deductive reasoning, there must be real problems with both the feasibility and costs of the alternate CBAGF blends without MTBE.

Unlike previous and other recent reformulated gasoline studies, the CBAGF is not based on refining industry LP modeling or even the most rudimentary gasoline property blending calculations. The CBAGF economic costs of the alternate formulations are wrongly based on simple substitution of alternate blendstocks to MTBE without consideration of the effects on the qualities of the resulting gasoline blends. The study implies that the three formulations are compliant with CaRFG2 specifications and that the three formulations have essentially the same air quality benefits. However, without drastic changes in the non-MTBE portion of the two no-MTBE formulations, this is not possible. For the ethanol blended CaRFG2 case, substitution of 5.7% ethanol for 11% MTBE would significantly increase the RVP of gasoline and increase the T50 and T90 distillation points of the gasoline, making the fuel non-compliant with CaRFG2 RVP specifications and hydrocarbon emission limits. For the non-oxygenated CaRFG2 alternate, substitution of 11% toluene for 11% MTBE would exceed maximum aromatics and T50 specifications for CaRFG2 gasolines. It would also exceed allowable hydrocarbons and toxics emissions. Previous studies and the recent MathPro study for the California Energy Commission show that the costs of drastically changing the non-MTBE portion of the two no-MTBE alternate formulations to meet CaRFG2 specifications are very significant and cannot be ignored as in the CBAGF study.

Although it is not our purpose in this report to evaluate the health-related costs calculated in the CBAGF, we are obliged to make note of a number of apparent inconsistencies and biases which are mentioned at the end of the following detailed critique.

CRITIQUE

UCSB COSTS RESULTS CRITIQUE

Comparison to Prior Studies

Results from all other prior studies, which have all been based on refinery linear program models, have shown RFG blends with MTBE to have significantly lower costs than those with ethanol or without oxygenates. They have also shown that it was impossible to supply the same amount of reformulated gasoline with no oxygenate content, or by substituting ethanol for MTBE, without refining capital investment. The Auto/Oil Economics Committee in its Economics Bulletin No. 2, published in January 1992, stated that it was impossible to make all reformulated gasoline with 20% aromatics, 5% olefins and 280°F T90 (which is similar to CaRFG2 typicals and specs) even with added process investments without using MTBE (or another oxygenate). The Auto/Oil Study Economics Bulletin No. 2, indicated the costs of minimizing MTBE (eliminating three-fourths of the MTBE – down from 15% to 3.7%) would be about 3.8¢/gallon. This is equivalent to about $0.6 billion per year higher cost for eliminating only 67% of the ether for the annual California volume of CaRFG2. A June 1997 TM&C study for WSPA of the cost of banning MTBE and substituting 5.7% ethanol in CaRFG2 gasoline showed that calculated costs would be over 17¢/gallon of CaRFG2, or over $2.6 billion dollars with a loss in 43% of California's RFG supply. This lost supply of CaRFG2 would be almost impossible to make up from out-of-state refineries. It stated that a no-oxygenate case would be even more costly and restrictive because California refineries were modified to make CaRFG2 containing 11% MTBE in order to meet its extremely restrictive specifications.

Comparison to Concurrent Studies

The MathPro study of a MTBE ban for the California Energy Commission, which was issued in October 1998, indicates costs over current CaRFG2 with MTBE of 6.1-7.5¢/gallon of CaRFG2 for ethanol substitution and 4.3-8.8¢/gallon of CaRFG2 for a no-oxygenate CaRFG2 case. These increased costs over CaRFG2 with MTBE are equivalent to $0.9-1.2 billion per year for ethanol substitution and $0.7-1.4 billion per year for no-oxygenate usage. In initial hearings held by the California Energy Commission on this report, these recent MathPro costs have been criticized as follows:

- The LP was significantly over-optimized.
- The assumptions regarding the costs of ethanol, alkylate, CARBOB and CARB supplies from out-of-state were too low.
- The costs of rejected MTBE were too high.

Because of these problems, the MathPro study results have been criticized as overly optimistic, very low costs for a MTBE ban. Yet, they are still astronomically greater than the unbelievable CBAGF costs.

Similarly, an Oak Ridge National Lab study by Jerry Hadder for Barry McNutt in DOE in October 1998 indicated Federal RFG (which is much easier to make than CaRFG2) would cost 2-6¢/gallon more and lose 25-35% of production in PADD I (East Coast) if 10% ethanol were substituted for 11% MTBE.

Range of Probable Error in Direct Cost

These other studies indicate higher cost for using ethanol of $0.9-2.6 billion per year for an error on the part of CBAGF for using ethanol in CaRFG2 of $1.0-2.8 billion per year. For the non-oxygenated CaRFG2 case, the direct fuel cost increased by $0.7 billion to $2.6+ billion. This is an increase over the CBAGF results of $1.2 to $4.0+ billion per year. These costs are summarized in the following table.

	Annual Costs in $ Billion/Yr. CaRFG2 with		
	MTBE	Ethanol	Non-Oxy
Health	0.34 - 1.54	0 - 0.20	0 - 0.01
Other	0.16 - 0.20	0.00	0.00
Air Quality	(0) - (0.07)	(0) - (0.07)	(0) - (0.07)
Subtotal	0.50 - 1.67	0.00 - 0.13	0.00 - (0.06)
Direct(1)			
Fuel Manufacture(1)	0.00(2)	0.9 - 2.6	0.7 - 2.6+
Mileage(1)	0.00(2)	0.00	(0.1) - (0.2)
Total Costs(1)	0.5 - 1.7	0.9 - 2.7	0.6 - 2.3+
Net Cost Over MTBE Use(1)			
Revised	Base	0.4 - 1.0	0.1 - 0.6+
vs.			
[CBAGF Paper](3)	[Base]	[(0.6) - (1.8)]	[(1.1) - (3.4)]
Discrepancy CBAFG Understated		1.0 - 2.8	1.2 - 4.0+

(1) Revised based on available added costs for alternate CaRFG2 results from other, much more valid studies.

(2) Base-zero added costs for current CaRFG2 product with MTBE.

(3) As reported in CBAGF paper above, CaRFG2 with MTBE case costs.

Fuel Efficiency Cost

The CBAGF fuel efficiency costs were erroneously based on retail costs (including taxes) for gasoline at higher than CaRFG2 oxygen level. Even though use of the retail costs for gasoline would be correct for out-of-pocket consumer cost, such cost usage is not correct for the fuel efficiency cost to the state economy. The cost to the California economy should exclude all taxes because those accrue to the state either directly or indirectly (through federal rebates). Therefore, the fuel efficiency decrease or increase for the CaRFG2 would be about one-third less than calculated by CBAGF. Lower oxygenate levels cut these costs even more to about half the CBAGF levels. As revised by TM&C, the actual fuel economy impacts versus CaRFG2 for the base MTBE and ethanol cases would be zero (same oxygen level) and only $0.1-0.2 billion per year for the no oxygenate case. (See text table above.)

UCSB APPROACH/METHODOLOGY CRITIQUE

Method of Analysis

TM&C and all other investigators contend that the only reasonable method for analysis of changes in gasoline formulations is by refining industry linear program modeling. Such modeling must be built upon an accurate representation of the raw materials supply and products demand in the area, including the processing capabilities of the existing refineries, as well as the pertinent qualities of refinery gasoline intermediates, gasoline blendstocks, gasoline quality specifications and gasoline combustion emission equations and limits. Such modeling was the basis of the Auto/Oil study, the NPC study, the WPSA studies, the API studies, the NYSERDA study, the MathPro Arizona study and the current MathPro CEC study. The CBAGF method of blendstock substitution ignores the realities of supply, demand, refining capabilities and qualities of gasolines, the chemical and physical properties of gasoline components and gasoline combustion emissions equations and limits and it leads to huge errors of analysis and judgment.

The Rowe, et al study of winter oxygenated fuel versus conventional gasoline usage in Denver appears to have reasonably analyzed the added costs of oxygenated fuel for that region. This Rowe approach was reasonable for winter in which oxygenate is simply added to conventional gasoline. However, it is not applicable to RFG where costs are incurred to modify many other gasoline properties. The CBAGF authors, however, incorrectly used this Rowe study as a model to develop their erroneous RFG costs.

As noted under UCSB costs results critique above, the magnitude of the errors introduced by the faulty CBAGF assumptions and methodology were so significant that they drove the authors to the wrong conclusions. In addition to the above objections to the method of analysis, we have examined the details of the blendstock substitution methods and costs used in the CBAGF and have the following comments on these details of analysis.

PRICING CRITIQUE

Price Increases – RFG vs. CG

The overly simplistic blendstock substitution method assigns all of the incremental costs of RFG to the cost of octane enhancement blendstocks, namely MTBE, ethanol and toluene. This approach ignores the significant costs of meeting the more restrictive property specifications for reformulated gasolines: RVP, aromatics, sulfur and benzene for EPA RFG; these four plus olefins, T50, T90 and more restrictive sulfur for CaRFG2. The consumer cost of MTBE blending was computed by CBAGF by comparison of the cost of conventional gasoline to RFG and assigning all of the incremental costs to MTBE. CBAGF used three methods to compute the difference between conventional and RFG gasolines. The methods are: 1) comparison of retail costs of conventional and reformulated gasolines; 2) comparison of “wholesale” prices of conventional and reformulated gasolines; and 3) simple formulation model based on the “wholesale” cost of conventional gasoline plus the cargo cost of pure MTBE.

Retail Price Comparisons – RFG and CG

The use of retail price comparisons between conventional and RFG gasolines has the problem that the markets for these fuels are mutually exclusive. That is, conventional gasoline is excluded by regulation from all geographic areas that require RFG and vice versa. The retail marketing areas are not and cannot be the same. Each marketing area is unique in its gasoline supply logistics and competitive situation, so comparison of marketing area A to marketing area B is like comparing equal sized houses in different locations and assuming that they cost the same.

"Wholesale" Price Comparisons – RFG and CG

Comparison of "wholesale" prices is no more reasonable. The data have problems similar to the retail price data due to the mutual exclusion of the ultimate markets. The authors used the same data source, U.S. Department of Energy, but in this instance, the price termed "wholesale" by the authors is really an average of three different price series (Dealer Tank Wagon, Rack and Bulk Sales). None of these prices is really wholesale, and when taken together, they have no explicit meaning. Actual wholesale prices are for larger volumes at the refinery level and do not have location exclusiveness problems.

Because the authors referenced and had access to data published by *Platt's*, which is the standard for the industry, they could have derived a much more accurate and representative historic series of data for California gasoline prices. Starting in February 1996, *Platt's* began publishing wholesale prices of unleaded regular and premium gasoline, both conventional and CaRFG2 gasoline delivered by pipeline from the Los Angeles and San Francisco refineries. The difference in these prices of conventional and CaRFG2 specification gasoline obviously give a highly accurate representation of the recoverable cost difference at the refinery/true wholesale level. Referring to Tables 2 and 3, it appears that the difference in price between conventional and CaRFG2 is consistently about 4.5¢/gallon for regular gasoline. The prices for premium gasoline show a bit more variation over time, with an average difference of about 2.7¢/gallon.

MTBE Formulation Model – RFG vs. CG

The simplistic formulation proposed by the authors takes the average wholesale cargo price of MTBE at the U.S. Gulf Coast for the period 1995-97 (83.7¢/gallon) and erroneously combines it with a wrong national average "wholesale" price for conventional gasoline of 72¢/gallon which applies to much smaller truckload quantities. Using an 11% MTBE content, the authors obtained a "hypothetical wholesale price for reformulated gasoline of 73.3¢/gallon. The authors then claim that the 1.3¢/gallon difference in prices represents the premium charged for wholesale reformulated gasoline.

If the authors had correctly compared the U.S. Gulf Coast price of conventional gasoline cargos or pipeline tenders to the U.S. Gulf Coast price of MTBE cargos, they would have obtained a difference of about 24¢/gallon, as shown in Table 4. They would then have to add transportation costs of 10-12¢/gallon for getting the cargos of MTBE from the Gulf Coast to California, making the cost differential significantly larger.

Other Studies Referenced by the CBAGF Authors
<u>of RFG Price Increase (MTBE CaRFG2 case)</u>

The National Petroleum Council study estimated a range of 3.0-7.0¢/gallon for the increased cost to produce EPA RFG. The authors are correct in stating this; however, these prices included unrecoverable capital charges for new U.S. facilities outside of California of about $3 billion dollars.

The U.S. Department of Energy study authored by Lidderdale is correctly quoted by the authors.

The Energy Information Administration analysis authored by Zyren, et al mentions California, but it explicitly states that the 5.7-6.1¢/gallon average cost to produce EPA RFG is for a "typical PADD I (East Coast) refinery".

The California Air Resources Board (CARB)1991 study concluded that CaRFG2 would cost about 15¢/gallon over conventional gasoline, including a large capital charge based on results of work done by TM&C for WSPA in 1991, plus CARB's survey of California refiners. CARB staff accepted as realistic TM&C's total costs of CaRGF2 of about 17¢/gallon as well TM&C's incremental variable costs of about 5¢/gallon to produce CaRFG2.

Due to the wide variation of the above methods, the authors chose a spread of 2-7¢/gallon for the price increase attributable to all RFG production, including capital charge. Considering that RFG production is now well established, we feel that a more accurate estimate would be about 2.5¢/gallon for EPA RFG (Table 4) and about 4.5¢/gallon for CaRFG2, based on added variable costs only and no return on investment or recovery of fixed costs.

<u>Ethanol Retail Price Data – CG vs. RFG</u>

The erroneous price differential between ethanol blended CaRFG2 and conventional gasoline was estimated by comparing the national average and the Minnesota average price of oxygenated gasoline to the national average price for conventional gasoline. The CBAGF study computed a price differential of 5¢/gallon using the national average and 2¢/gallon using the Minnesota average. The CBAGF authors presented a consumer price increase of 5¢/gallon and used that figure in their final analysis. There are several problems with the comparison that tend to grossly understate the cost differential.

First, oxygenated gasoline is not the same as reformulated gasoline. It is a form of conventional gasoline and its specifications are much less restrictive than reformulated gasoline specifications. In addition, there is a national waiver of 1 psi on RVP specifications for conventional or oxygenated gasoline blended with 10% ethanol. There is no RVP waiver for either California or Federal RFG. The RVP waiver keeps the added costs lower than that for an ethanol blended RFG. Second, the national average oxygenated gasoline price used by the authors was for all oxygenated gasoline and is not specific to ethanol blended RFG gasoline. Third, the computed premium for Minnesota ethanol blended gasoline is abnormally low because Minnesota had a high state tax subsidy for ethanol blending over and above the federal tax subsidy available in the other states, including California. The Minnesota state plus federal subsidy was a total of 74¢/gallon of Minnesota produced ethanol compared to only 54¢/ethanol gallon available in California. Logically, Minnesota ethanol blended gasoline would be significantly cheaper than California ethanol blended gasoline due to the higher Minnesota subsidy and much lower ethanol transport costs. In addition, the federal and state tax subsidies for ethanol are real costs to the state economy by reducing state and federal tax receipts and federal rebates to states.

Ethanol "Wholesale" Price Comparisons

The authors compared oxygenated fuel to conventional fuel at the "wholesale" level and stated about the same differentials, i.e., 2¢/gallon in Minnesota and 5¢/gallon for the national averages. The authors then selected 5¢/gallon for California and ignored the real costs of the ethanol tax subsidy and much higher transportation costs to deliver ethanol from its current area of usage (the Midwest) to California.

Ethanol Formulation Model with Demand-Based Pricing

The authors used a demand-based pricing model for ethanol that was developed by the California Energy Commission. This model prices the first block of ethanol at $1.60/gallon of ethanol plus 3¢/gallon transportation. The second block of ethanol was priced at $1.60 plus 6¢/gallon transportation. These first two transport costs are unrealistically low to get ethanol from the Midwest to California. The third block of ethanol was priced at $1.64/gallon plus 15¢/gallon transportation. The fourth and last block of ethanol supply was to be imported from abroad at a cost of $2.22 per gallon, including transportation and tariffs. These prices were adjusted by the 54¢/gallon federal tax subsidy. As stated earlier, the simplistic blendstock substitution model makes no allowances for the adjustments that would have to be made in the hydrocarbon portion of the fuel formulation. In the case of ethanol, C_3 and C_5 olefins would have to be alkylated with isobutane at the refineries, and pentanes would have to be excluded from gasoline blends to comply with RVP specifications and maintain T50. Both of these techniques would add significantly to the cost of ethanol blended CaRFG2.

Direct Cost of Non-Oxygenated CaRFG2

The formulation assumed for non-oxygenated CaRFG2 was based on a barrel-for-barrel substitution of toluene for MTBE. This formulation would cause both the gasoline aromatics and the T50 distillation point to increase to above the caps, making the formulation non-compliant with California specifications. Thus, the results are infeasible.

Referring to Table 1, the California Flat Limit on aromatics is 25% by volume and California refiners are adhering to that standard. The National Institute for Petroleum and Energy Research (NIPER) conducts semi-annual surveys of gasoline and the March 1998 NIPER report shows an average U.S. aromatics content of 30.7% for the summer of 1997 for unleaded regular conventional gasoline. For this same time period, NIPER reported that CaRFG2 containing about 11% MTBE had an aromatics content of 24.4%. Replacement of MTBE with 11% toluene, which is 100% aromatic, would increase aromatics well above the California cap of 30%.

Toluene Pricing Error

The authors made a significant error in toluene pricing, compared to gasoline pricing using different time periods and volumes. The CBAGF states that the U.S. Gulf Coast wholesale cargo spot price for commercial toluene was 54.5¢/gallon according to *Platt's Petrochemical Marketwire* in 1998. They then wrongly state that the "comparable price" of unblended reformulated gasoline is 72¢/gallon, without stating the earlier time period or much smaller volume of the gasoline data. Our review of the *Platt's* data for 1997, as shown in Table 4, indicates that the cargo price of toluene averaged 81.7¢/gallon. In the same time period, Gulf Coast unleaded conventional gasoline averaged about 58.3¢/gallon, or about 23.4¢/gallon less than toluene. In fact, our review of the *Platt's* data showed that at no time has the monthly cargo price of toluene been less than 20¢/gallon above the monthly cargo price of gasoline. Also, the considerable cost of shipping toluene from the Gulf Coast by ship to the West Coast could easily add another 10-12¢/gallon to the price of toluene. Considering that Gulf Coast toluene and MTBE wholesale cargo prices are almost equal, as shown in Table 4, 11% toluene blended CaRFG2 would cost about the same as 11% MTBE blended CaRFG2, rather than much less, as incorrectly shown by CBAGF.

FUEL EFFICIENCY CRITIQUE

The theoretically expected effect of oxygenates on gasoline fuel energy is shown in the following table:

Oxygenate	Weight % Oxygen	Volume % Oxygenate	% Reduction in Gasoline Energy
MTBE	2.0	11.0	1.6
MTBE	2.7	15.0	2.1
Ethanol	2.0	5.7	1.7
Ethanol	2.7	7.7	2.3

Source: EPA. "Fuel Economy and Engine Performance", Vol. 3, p.3-8, Table 3.1.

Citing the above table in conjunction with a review of numerous independent studies, the same EPA document states " . . . research in this area indicates that any fuel economy loss experienced as a result of oxygenate use agrees with the theoretical prediction . . ."

The CBAGF report uses the 1.6% and the 2.1% reductions in energy in its calculation of fuel efficiency loss which are associated with 2.0% and 2.7% MTBE weight percent oxygen. However, the Flat Limit for oxygen content ranges from only 1.8-2.2%. Thus, the fuel efficiency reduction should be reduced proportionally. Calculating this on a purely arithmetic basis, the fuel reduction efficiency should be in the range of 1.4-1.7%. The CBAGF study claims a reduction in fuel efficiency due to MTBE results in a cost of $310-400 million. Using the data in the CBAGF report of 13.5 billion gallons of gasoline sold at an average refinery pipeline price of about 70¢/gallon excluding tax (Tables 2 and 3) combined with the fuel efficiency decreases of 1.4-1.7%, the costs are calculated as $130-150 million, or about half of the CBAGF calculation. Fuel efficiency costs for 5.7% ethanol and 11% MTBE blended CaRFG2 are about equal.

ACTUAL COSTS OF CaRFG2

Our estimates of the incremental costs of producing EPA RFG and CaRFG2 are based on our modeling work of both the federal and CARB reformulated gasoline programs. As we described earlier in this review, refiners invested enormous sums to modify their refineries to produce reformulated gasoline for both the Federal and CARB programs. Our analysis of the cost to produce CaRFG2 established the capital and fixed costs associated with the investment at approximately 10¢/gallon. We projected that an additional recoverable variable cost of 5¢/gallon would raise the cost of manufacture of CaRFG2 gasoline to the 15¢/gallon above the cost of conventional gasoline described in the CARB 1991 study.

Due to competition, consumers have not paid the entire cost of CaRFG2 production. Because the capacity to produce CaRFG2 slightly exceeds demand, the market has reduced the price difference that refiners can charge for the more demanding specifications of CaRFG2 to the variable cost of production. Thus, the incremental cost of producing CaRFG2 remains obvious, while the capital and fixed costs remain hidden in the form of reduced refinery income and lower returns on overall capital employed.

We have confirmed our incremental cost determinations by observing the differences in the wholesale prices between conventional and reformulated gasolines in the markets that serve the EPA and CARB reformulated gasoline programs. For the CaRFG2 market, as shown on Tables 2 and 3, the price difference between regular CaRFG2 and conventional gasoline is approximately 4.5¢/gallon. This is a close match to the approximately 5¢/gallon that we projected.

MAJOR HEALTH-RELATED COST ISSUES

Although it is not our purpose in this report to evaluate the health-related costs calculated in the UCSB report, we are obliged to make note that one of the primary conclusions of the Koshland, et al laboratory experiments is that the amount of by-product formaldehyde formed by combustion was "roughly comparable" for non-oxygenated RFG and for RFG containing 11.6% MTBE. Despite this conclusion, the CBAGF report estimates the additional health-related costs of formaldehyde emissions from the use of RFG containing MTBE at $27 million, but ascribes no health-related costs from formaldehyde emissions to non-oxygenated RFG. This is such a prominent conclusion in the Koshland, et al report that it strains credibility to attribute the exclusion of this conclusion as an oversight on the part of the CBAGF authors.

Moreover, the physical evidence offered by the CBAGF authors shows that an analysis of data from more than 20 monitoring stations showed "no clear increasing trend" in formaldehyde concentrations over the period in which the data were analyzed. Despite these monitoring station results, the authors conclude that formaldehyde concentrations “could” increase by 10-12%. Based on Koshland et al and the monitoring station empirical data it appears more plausible that formaldehyde concentrations should continue to show no increasing trend.

The CBAGF authors state that in regions of the U.S. where ethanol based RFG has been introduced “concentrations of acetaldehydes have increased in <u>some</u> *(emphasis added)* regions, but differences in air basins and annual variations in meteorology result in variable effects.” The authors do not specify the regions examined, the number of regions that showed increases versus those that did not and do not present any evidence that the increases in some regions is statistically significant. Surely the authors are not ignorant of the rudimentary standards of scientific technique and presentation of supporting evidence. This lack of evidence tends to give the impression that the authors withheld the quantitative information since it did not fit their preconceived agenda.

The authors go on to estimate a total cost from $3-200 million based on data from New Mexico because those data are well documented, not because of any similarity in the meteorology of New Mexico with that of California. Until credible evidence is presented, regarding the effect of ethanol based RFG on acetalhyde formation, the authors conclusions must be considered speculative and self-serving.

EXHIBIT 1
TURNER, MASON & COMPANY
REPORTS AND PUBLICATIONS RELATED TO GASOLINE REFORMULATION

- “Study of the Summer Impacts of Replacing MTBE with Ethanol on California Gasoline Costs and Supply”, for Western States Petroleum Association (WSPA), by Robert E. Cunningham, June, 1997; 1997 CEC Paper.

- “Initial TM&C Critique of MathPro (Arizona) Gasoline Blending for West Notional Refinery Base Case”, for Western States Petroleum Association (WSPA), by Robert E. Cunningham, October, 1996.

- “CARB 2 and EPA RFG Costs; Supplemental Supply Problems and Variance Fee Solution”, Issue Paper for the 1995 Fuels Report by the California Energy Commission, prepared by Robert E. Cunningham, May 10, 1995.

- “Reformulated Gasoline Study”, prepared for the New York State Energy Research and Development Authority, by Robert E. Cunningham and George W. Michalski, Turner, Mason & Company; DRI/McGraw-Hill, Inc., and Sierra Research, Inc., Energy Authority Report 94-18, October 1994.

- “API Refining Cost Study of Potential EPA FCAAA Regs for 2000" tabular results by Robert E. Cunningham, George W. Michalski, Charles L. Miller, Mark A. Heersema December 1993.

- “NPC Refining Study Results of NPC, API and WSPA Refining Industry Studies of Regulatory Compliance Cost and Impacts”, paper by Robert E. Cunningham, included in “California Petroleum Industry Environmental Workshop”, papers published by National Institute for Petroleum and Energy Research, November 16-17, 1993.

- “U.S. Petroleum Refining - Meeting Requirements for Cleaner Fuels and Refineries”, published by the National Petroleum Council, August 1993. Volume V - “Refining Capability Appendix”, prepared by Robert E. Cunningham, George W. Michalski, Charles L. Miller, Tom R. Hogan and Mark A. Heersema.

- “Cost and Impacts of California Phase 2 Gasoline Regulations”, paper by Robert E. Cunningham and Charles L. Miller; presented at the 1992 NPRA Annual Meeting (March 22-24, 1992).

! “Alternate Gasoline Formulations Costs Results of U.S. Refining Study”, for Economics Committee of the Auto/Oil Air Quality Improvement Research Program, by Robert E. Cunningham, George W. Michalski, Charles L. Miller, David R. Anderson, John R. Auers, and Robert M. Adams, April 1992.

! “WSPA Study of the Cost Impacts of Potential CARB Phase 2 Gasoline Regulations”, by Robert E. Cunningham, George W. Michalski, and Charles L. Miller, November 18, 1991.

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TABLE 1

PROPERTIES AND SPECIFICATIONS

FOR CALIFORNIA PHASE 2 REFORMULATED GASOLINE

Fuel Property	Units	Flat Limit	Averaging Limit	Cap Limit
Reid Vapor Pressure	psi, max.	7.00(1)	none	7.00
Sulfur	ppmw	40	30	80
Benzene	vol. %, max.	1.00	0.80	1.20
Aromatic HC	vol. %, max.	25.0	22.0	30.0
Olefin	vol. %, max.	6.0	4.0	10
Oxygen	wt. %	1.8 (min.)(2) 2.2 (max.)	none	1.8(min.)(2) 2.7 (max.)
Temperature at 50% Distilled (T50)	deg. F	210	200	220
Temperature at 90% Distilled (T90)	deg. F	300	290	330

(1) Applicable during the summer months.

(2) Applicable during the winter months and year round in EPA non-attainment areas (65% of California consumption).

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TABLE 2
PLATT'S PIPELINE GASOLINE LOWS
LOS ANGELES PRICING

	Conventional		CaRFG2		CaRFG2 – Conventional	
	Regular	Premium	Regular	Premium	Regular	Premium
Jan-96	na	na	na	na	-	-
Feb-96	59.95	67.26	69.45	75.08	9.50	7.82
Mar-96	69.13	76.70	71.62	77.13	2.49	0.43
Apr-96	84.87	92.95	92.89	99.37	8.02	6.42
May-96	73.31	80.60	75.90	80.69	2.59	0.09
Jun-96	66.06	72.10	73.55	76.84	7.49	4.74
Jul-96	68.75	74.79	73.12	76.37	4.37	1.58
Aug-96	64.08	71.28	68.16	72.28	4.08	1.00
Sep-96	68.03	76.73	71.65	78.66	3.62	1.93
Oct-96	63.01	68.95	67.76	72.57	4.75	3.62
Nov-96	59.16	63.46	63.05	66.79	3.89	3.33
Dec-96	69.18	72.70	71.51	74.76	2.33	2.06
Jan-97	75.85	81.82	78.36	82.15	2.51	0.33
Feb-97	69.79	76.36	74.59	78.50	4.80	2.14
Mar-97	75.08	81.25	78.64	82.16	3.56	0.91
Apr-97	66.73	74.09	71.45	76.63	4.72	2.54
May-97	60.39	68.08	63.01	67.50	2.62	(0.58)
Jun-97	53.39	59.29	55.50	59.50	2.11	0.21
Jul-97	55.08	61.97	58.38	62.39	3.30	0.42
Aug-97	73.83	81.24	77.71	82.25	3.88	1.01
Sep-97	73.62	79.96	78.93	83.10	5.31	3.14
Oct-97	67.68	73.86	72.46	76.42	4.78	2.56
Nov-97	56.39	61.85	61.06	64.85	4.67	3.00
Dec-97	57.13	62.81	61.48	65.43	4.35	2.62
Jan-98	52.19	57.95	56.56	60.71	4.37	2.76
Feb-98	49.51	54.59	54.71	58.74	5.20	4.15
Mar-98	47.10	52.58	52.08	56.98	4.98	4.40
Apr-98	57.10	62.94	61.82	67.77	4.72	4.83
May-98	52.31	58.06	57.31	62.74	5.00	4.68
Average	63.88	70.22	68.31	72.80	4.43	2.58

Source: *Platt's Price Average Supplement* and *Platt's Handbook*.

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TABLE 3
P*LATT'S* PIPELINE GASOLINE LOWS
SAN FRANCISCO PRICING

	Conventional		CaRFG2		CaRFG2 - Conventional	
	Regular	Premium	Regular	Premium	Regular	Premium
Jan-96	na	na	na	na	-	-
Feb-96	53.89	60.85	67.80	73.48	13.91	12.63
Mar-96	65.76	73.19	68.50	74.45	2.74	1.26
Apr-96	84.76	92.56	92.68	98.88	7.92	6.32
May-96	73.20	80.38	75.99	80.83	2.79	0.45
Jun-96	66.13	72.16	75.43	78.68	9.30	6.52
Jul-96	68.65	74.69	74.68	77.92	6.03	3.23
Aug-96	61.31	68.06	65.15	69.28	3.84	1.22
Sep-96	65.96	74.99	69.23	76.33	3.27	1.34
Oct-96	61.32	67.05	65.95	70.83	4.63	3.78
Nov-96	56.20	60.70	59.75	63.55	3.55	2.85
Dec-96	67.75	71.23	69.96	73.35	2.21	2.12
Jan-97	74.26	80.20	76.76	80.51	2.50	0.31
Feb-97	67.59	74.13	71.97	75.99	4.38	1.86
Mar-97	73.28	79.51	76.98	80.49	3.70	0.98
Apr-97	65.65	78.90	70.36	75.56	4.71	(3.34)
May-97	58.68	66.37	61.33	65.80	2.65	(0.57)
Jun-97	53.06	58.89	55.21	59.24	2.15	0.35
Jul-97	55.50	62.36	59.03	63.19	3.53	0.83
Aug-97	73.33	80.63	77.42	82.04	4.09	1.41
Sep-97	75.35	81.71	80.86	85.04	5.51	3.33
Oct-97	67.70	74.07	72.57	76.55	4.87	2.48
Nov-97	54.15	59.61	58.58	62.36	4.43	2.75
Dec-97	58.34	63.86	62.73	66.73	4.39	2.87
Jan-98	52.08	57.86	56.56	61.46	4.48	3.60
Feb-98	45.22	50.14	50.03	54.91	4.81	4.77
Mar-98	45.58	51.09	50.51	56.26	4.93	5.17
Apr-98	57.20	63.11	62.21	68.96	5.01	5.85
May-98	51.39	56.94	56.43	62.93	5.04	5.99
Average	62.62	69.12	67.31	71.99	4.69	2.87

Source: *Platt's Price Average Supplement* and *Platt's Handbook*.

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TABLE 4
PLATT'S GULF COAST PRICING

	Pipeline Gasoline Lows				Cargo (FOB) Lows	
	Conventional		EPA RFG			Commercial Grade
	Regular	Premium	Regular	Premium	MTBE	Toluene
Jan-97	66.82	69.67	68.45	71.27	84.85	89.80
Feb-97	61.89	64.04	62.79	64.95	77.93	83.75
Mar-97	61.11	64.73	62.53	66.13	77.19	79.63
Apr-97	58.24	61.78	60.86	64.40	74.63	82.13
May-97	60.61	64.85	62.56	67.01	77.05	86.30
Jun-97	54.95	60.19	56.65	61.90	81.38	84.75
Jul-97	58.48	64.08	61.81	67.33	92.38	81.75
Aug-97	64.45	70.56	67.67	73.57	91.10	85.70
Sep-97	56.52	61.92	59.21	64.60	82.88	80.50
Oct-97	54.7	57.89	57.52	60.75	88.10	75.40
Nov-97	52.75	54.56	56.40	58.18	87.19	75.00
Dec-97	49.48	52.02	53.28	55.78	77.08	76.00
Average	58.33	62.19	60.81	64.66	82.65	81.73

Source: *Platt's Price Average Supplement* and *Platt's Handbook*.

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