FINAL REPORT

ANALYSIS OF THE PRODUCTION OF CALIFORNIA PHASE 3 REFORMULATED GASOLINE WITH AND WITHOUT AN OXYGEN WAIVER

Submitted to

U.S. Environmental Protection Agency
Office of Transportation and Air Quality

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By

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1. INTRODUCTION AND SUMMARY

MathPro Inc. is pleased to submit this draft report to the U.S. Environmental Protection Agency, Office of Transportation and Air Quality (OTAQ), pursuant to EPA Purchase Order 0W-2026-NASX (September 22, 2000).

EPA commissioned this study to support its consideration of the California Air Resources Board's (CARB) request for a waiver of the oxygen content requirement in federal (and hence most California) reformulated gasoline (RFG).

The objective of the study was to estimate

- The average physical properties of California Phase 3 RFG (CaRFG3) with and without the oxygen waiver;
- The shares of ethanol-blended and non-oxygenated CaRFG3 if the oxygen waiver were granted; and
- The oxygen content (i.e., 2.0 wt% or 2.7 wt%) of ethanol-blended CaRFG3 with and without the oxygen waiver.

The most reliable and credible method for developing such estimates is refinery LP modeling. Refinery LP modeling captures the interactions between the technical and economic aspects of refining and simulates operations of the refining sector in response to economic and regulatory driving forces. In this study, we used our proprietary refinery LP modeling system (ARMS) to simulate cost-minimizing operations of the California refining sector (in the Summer season) in meeting demands for refined products, with and without an oxygen waiver.

Exhibit 1 (immediately following the text of the report) summarizes, for the eight (8) scenarios considered, results of the analysis of primary interest to EPA: (1) estimated properties of the Summer CaRFG3 pool, with and without an oxygen waiver in place; and (2) estimated volume shares of ethanol-blended and non-oxygenated CaRFG3 in the Summer, with a waiver in place.

Our analysis also indicates that, with an oxygen waiver, the refining economics of ethanol blending at 2.0 wt% and 2.7 wt% in the Summer are too close to call, given the premises and assumptions of this study. Our analysis shows a small, but not significant, cost advantage for the higher ethanol volume. In practice, the choice between the two levels of ethanol blending would depend on many economic and technical factors.

The balance of the report comprises five sections. Section 2 discusses the rationale for the study. Section 3 lays out the methodology (including key premises). Section 4 defines the scenarios analyzed. Section 5 deals with the results of the analysis. Section 6 lists references.

2. PRIOR ANALYSES

Prior to this study, MathPro Inc. had produced estimates of gasoline pool properties and ethanol usage as part of analyses of the prospective economics of California's ban on MTBE blending [Refs. 1, 2, 3, and 4]. These analyses focused on the technical implications and costs of the various alternatives to MTBE blending. They were not commissioned or designed to assess the likely effects of an oxygen waiver on vehicle emissions.

Moreover, the prior analyses did not have the benefit of new analytical elements, data, and improvements now in our refinery LP modeling system (ARMS), such as:

- The actual CaRFG3 program (and the Beta 3 Predictive Model) – rather than the CaRFG*2* program or provisional versions of the CaRFG*3* program;
- Estimates of prospective supplies and prices of crude oil and imported gasoline blendstocks (e.g., ethanol, alkylate, and isomerate) that reflect recent analyses and forecasts;
- Technical data on key blending properties of certain blendstocks – including ethanol and various alkylate streams;
- Estimates (consistent with measurement tolerances published by CARB) of the average minimum "property deltas" used by California refiners in certifying gasoline batches with the Predictive Model;
- Representation of the property deltas as variables rather than as constants; and
- Representation of the Unocal patents on RFG blending.

All of these elements are incorporated in this analysis.

3. METHODOLOGY

We used refinery LP modeling to represent aggregate operations of the gasoline-producing refineries in California in the Summer season, with and without an oxygen waiver in place. We analyzed eight scenarios (discussed in Section 3.3); each scenario represents a unique combination of policy (e.g., waiver/no waiver) and technical factors. In each scenario, we represented the California sector meeting a specified set of product demands at minimum cost.

3.1 Enhancements to the California Refining Model

For this analysis, we enhanced the aggregate refining model used in our prior studies of the California refining sector. This section summarizes the most important enhancements.

3.1.1 Economic Data Elements

We updated economic data elements to sharpen the representation of the economics governing refinery investments and operations in the wake of an MTBE ban.

- Updated capital cost and capital charge factors to 2000 $s.
- Changed the investment location factor for California from 1.2 to 1.35.
- Reduced from 15% to 10% the after-tax return on capital investment for new capacity.
- For expanding and debottlenecking certain units, set (1) on-site unit investment costs at 50% of those for grass roots units and (2) off-site investments at zero.

3.1.2 CARB Phase 3 Predictive Model (Beta 3)

We modified the model to (1) bring the Beta 3 Predictive Model into the analysis and (2) simulate how refiners use the Predictive Model for certifying batches of CARB gasoline – flat limits (for the most part), variable compliance margins, and grade-specific certification. None of our previous analyses incorporated these elements.

- Estimated reduced form versions of the Beta 3 Predictive Model (analogous to our representation of the Phase 2 Predictive Model), in each of six variants:

  -- Flat limits (for 0, 1.8-2.2, and 2.7 wt% oxygen)
  -- Averaging (for 0, 1.8-2.2, and 2.7 wt% oxygen)

- Extended the LP model formulation so that the Predictive Model applies to individual gasoline grades (e.g., regular, premium) within each gasoline class (e.g., ethanol-blended CaRFG3, non-oxygenated CaRFG3).
- Extended the LP model formulation to treat refiners' reported compliance margins ("property deltas") as endogenous variables, with lower bounds equal to CARB's enforcement tolerances.

3.1.3 Ethanol-Related Data Elements

The first of the two changes listed below expressed ethanol price as a function of net supply available to California. The second endowed the refinery model with blending data embodied in the CARBOB Version of the Beta 3 Predictive Model and sharpened the representation of ethanol blending (especially its effect on T_{50}).

- Incorporated estimated ethanol prices (CIF California) for both California-only and national bans on MTBE blending.

- Revised ethanol blending properties (especially the T_{50} depression) to match the values incorporated in the CARBOB Version of the Beta 3 Predictive Model.

3.1.4 Representation of Key Gasoline Blendstocks

We modified the properties of certain gasoline blendstocks to incorporate newly-obtained data and, more importantly, to improve the refinery model's representation of certain operating and blending practices in the California refining sector aimed at compliance with CARB RFG standards.

- Revised certain blending properties of FCC naphtha and alkylate, based on review of existing values and published information.

- Revised and extended the representation of FCC naphtha streams.

  -- Changed distillation cut-points and sulfur distribution factors for FCC naphtha fractions.
  -- Represented additional dispositions for heavy FCC naphtha: hydrocracking and distillate blending (jet and diesel fuel).
  -- Extended representation of FCC naphtha splitting to apply to all variants of FCC naphtha.

- Revised and extended representation of alkylate streams.

  -- Improved the distillation curves for C_3 and C_4 alkylates.
  -- Changed blending properties of C_5 alkylate to reflect presence of mixed C_5 paraffins (un-reacted feed plus by-product material).
  -- Represented alkylate splitting for T_{90} control and set alkylate cut-point for T_{90} control.

3.1.5 Blending Constraints Imposed by Unocal Patents

We extended the model formulation to represent, by gasoline grade within class, the blending practices needed to avoid infringement of the Unocal '393 patent.

This extension comprises a set of constraints on gasoline blend properties to ensure that they do not infringe on the Unocal patent. The constraints are more binding (i.e., impose higher costs of compliance) for premium gasoline than for regular.

3.1.6 Technical and Economic Data

We revised estimates of the prices and supplies of crude oil and key gasoline blendstocks.

- Updated price estimates for crude oil, alkylate, and other refinery inputs.

- Updated estimates of potential supplies to the California refining sector of iso-octane, alkylate streams, and C_6 isomerate.

3.2 Representation of Gasoline Sulfur Control

The representation in the refining model of the processes used to achieve gasoline sulfur control is a crucial element of the analysis.

- The specification of sulfur control technology can influence the preferred level of ethanol blending – 2.0 wt% or 2.7 wt% oxygen.

- Careful representation of gasoline sulfur control is essential to minimizing "over-optimization" in the refinery modeling. (Over-optimization is discussed in Section 5.2.4).

In the Predictive Model, sulfur control is the primary means of achieving NOx emission reductions and contributes to VOC emission reduction. Depending on the technology of choice, sulfur control can have the side effect of reducing the olefins content of the gasoline pool. In the Predictive Model, reducing olefins content (all else equal) reduces NOx emissions and increases VOC emissions. This is part of a larger pattern of emissions and economic trade-offs between oxygen content, sulfur content, and olefins content in the gasoline pool.

The least-cost resolution of these trade-offs is influenced by the choice of sulfur control technology. For example, a NOx-limited refinery might favor sulfur control technology that also reduces olefins content. A VOC-limited refinery might favor sulfur control technology that does not reduce olefins content.

California refineries could achieve the sulfur control needed for CaRFG3 production through a combination of FCC feed hydrotreating (pre-treating), sulfur-reducing FCC catalysts, and FCC naphtha hydrotreating (post-treating). "Non-selective" post-treating processes substantially reduce olefins content; "selective" post-treating processes do not.

Because reducing olefins content (all else equal) serves to reduce NOx emissions, use of non-selective post-treating (again, all else equal) tends to favor ethanol blending at 2.7 wt% oxygen over 2.0 wt% oxygen.

For this analysis, we specified a non-selective (i.e., olefin-reducing) post-treating process, for both existing capacity and possible new capacity.

At present, some California refineries practice only severe pre-treating for sulfur control; others practice a combination of conventional pre-treating and post-treating. The two approaches lead to significant differences in FCC naphtha properties. Representing both approaches in one aggregate refining model produces (1) a proliferation of FCC naphtha blendstocks, well beyond the number available in any real refinery, and (2) an apparent capability, unattainable in any real refinery, to tailor the sulfur content of small volumes of special FCC naphtha streams. These two effects can give rise to unrealistic and misleading results.

Consequently, for this analysis, we used separate representations of each sulfur control approach. That is, we configured our California refining model as two parallel models – one representing

refineries that practice severe pre-treating; the other representing refineries that practice conventional pre-treating and post-treating. The reported results of the analysis are the volume-weighted sums of the results generated by each model.

3.3 Key Modeling Premises and Assumptions

- The target year for the analysis is 2005.

- The California refining sector has invested as needed to meet the federal Tier 2 sulfur standard for gasoline (produced for sale outside of California) and to meet demand growth.

- The price of Saudi Light crude oil is $25/Bbl (FOB Persian Gulf), and the average acquisition cost of the California crude slate is consistent with that marker crude price.

- The prices of imported gasoline blendstocks (CIF California) are as follows:

  -- iso-octane: $48.80/Bbl
  -- alkylate: $42.35/Bbl
  -- C_6 isomerate: $41.70/Bbl

- Import volumes of these blendstocks are subject to *upper bounds* (corresponding to their estimated availability). That is, import volumes are *not fixed*.

- The prices of ethanol (CIF California, and net of the federal subsidy) are as follows:

  -- California-only MTBE ban: $40-45/Bbl
  -- National MTBE ban: $50-55/Bbl

  These ethanol prices reflect no oxygen waiver outside of California, and continuation of the federal Winter oxygenated gasoline program and all state programs – incentives or mandates – for ethanol blending.

- Gasoline volume lost by the elimination of MTBE is made up by the least-cost combination of ethanol blending, blending of various refinery-produced and merchant-produced blendstocks (e.g., iso-octane/iso-octene, alkylates, and isomerate), and increased crude runs (with accompanying investments in new refining capacity.) That is, the California refining sector meets all product demands without importing finished products or CARBOB.

- Essentially all CaRFG3 is certified with the flat limits variant of the Predictive Model.

- The VOC, NOx, and Toxics emissions targets in the Predictive Model are lower bounds, not fixed targets. Each class (ethanol-blended and non-oxygenated) and grade of CaRFG3 must be certified as complying with the CaRFG3 emission standards.

- Captive MTBE plants can be retro-fitted (and expanded) to produce iso-octane/iso-octene.
- Arizona CBG produced in California refineries is CBG Type 1, corresponding to federal RFG2 but without the oxygen requirement and the limit on toxics emissions.
- The California refining and distribution system has the physical capability to produce and distribute two CaRFG3 pools – one ethanol-blended, the other non-oxygenated – under an oxygen waiver. Volume shares of the two pools are determined by refining economics.
- Under an oxygen waiver, the California refining sector allocates ethanol to both premium and regular gasoline. That is, it does *not* restrict ethanol blending to premium gasoline.
- California refiners have sales outlets for excess C_4 and C_5 streams (rejected for RVP control) and for heavy reformate and heavy FCC naphtha (which could be rejected for aromatics, T_{50}, and T_{90} control).

4. SCENARIOS

4.1 Scenario Definitions

We analyzed the eight (8) scenarios indicated in **Table 1**.

Table 1: Scenarios Analyzed

Descriptors	Scenarios							
	1	2	3	4	5	6	7	8
➢ Oxygen Waiver								
No	X		X		X		X	
Yes		X		X		X		X
➢ MTBE Ban								
National	X	X			X	X		
California			X	X			X	X
➢ Technical Premises								
Set 1	X	X	X	X				
Set 2					X	X	X	X

The symbols (**X**) denote the premises or assumptions represented in the various scenarios. For example, Scenario 1 represents no oxygen waiver, a national MTBE ban, and the first set of technical premises (defined below).

- *Oxygen Waiver* denotes a waiver of the oxygen mandate for federal RFG2 produced in California.

- *MTBE Ban* denotes the geographic scope of a ban on MTBE blending: California-only or nation-wide.

  The assumed scope of an MTBE ban affects only the delivered price of ethanol (CIF California), via our ethanol supply function.

  In turn, the ethanol price influences (1) the relative economics of ethanol blending at 2.0 and 2.7 wt% oxygen and (2) the optimal shares of ethanol-blended and non-oxygenated CaRFG3 in the oxygen waiver scenarios.

- *Technical Premises* denotes two alternative sets of modeling premises used in the analysis.

  -- Set 1: Unocal patents *not* represented in the refinery model;
  Flat limits version of Predictive Model applied to *entire CaRFG3 pool*; and
  "Property deltas" submitted to the Predictive Model are *fixed*.

  -- Set 2: Unocal patents represented in the refinery model;
  Flat limits version of Predictive Model applied to *each grade of CaRFG3*; and
  "Property deltas" submitted to the Predictive Model are *endogenous variables*.

  Set 2 is the more realistic of the two, in terms of capturing the way California refiners comply with the CaRFG program, and incorporates the modifications to the refining model discussed in Section 3. Set 1 represents the way that such compliance has been modeled in prior analyses.

All of the scenarios incorporate the federal RFG2 program and the California CaRFG3 program. All apply to the long term – the time period in which (1) the refining industry and its blendstock suppliers would have completed their investments to deal with an MTBE ban and (2) the new federal standards for low sulfur gasoline (30 ppm average) would be in full effect.

4.2 Estimating Gasoline Pool Shares in the Waiver Scenarios

In each scenario involving an oxygen waiver, we found the cost-minimizing volume shares of ethanol-blended and non-oxygenated gasolines, for ethanol blending at 2.0 wt% oxygen and at 2.7 wt% oxygen. In each such scenario, we analyzed a series of cases. Each case represented a fixed volume ratio of the ethanol-blended and non-oxygenated CaRFG3 pools (e.g., 70%

ethanol-blended/30% non-oxygenated). The cost-minimizing volume share corresponds to the case for which the refining model returns the smallest objective function (adjusted for the cost of ethanol purchases).

All of the results described in Section 5 for the oxygen waiver scenarios apply specifically to the cost-minimizing volume shares found in this manner.

5. RESULTS

5.1 Summary

The principal results of the analysis are tabulated in **Exhibits 1 through 6**.

Exhibit 1 shows – for each of the scenarios defined in Section 4 – the estimated properties of the CaRFG3 pool, with and without an oxygen waiver in place, and the estimated volume shares of ethanol-blended and non-oxygenated CaRFG3, with a waiver in place.

Exhibits 2 through 5 convey a detailed technical description of the refining model's representation of aggregate California refining operations in each scenario.

- Exhibit 2 shows computed capacity utilization, process capacity additions, and key operating indices.
- Exhibit 3 shows refinery charges (crude oil and other feedstocks), energy use, and refined product slates.
- Exhibit 4 shows pool-average gasoline properties, by gasoline type.
- Exhibit 5 shows pool-average gasoline compositions and pool volumes, by gasoline type.

Exhibit 6 summarizes the primary economic results of the analysis: estimated changes in refining costs and investment requirements associated with an oxygen waiver under various scenarios.

5.2 Discussion

5.2.1 Estimated Average Blend Properties and Emissions Reductions

The estimated gasoline properties summarized in Exhibit 1 lead to these findings:

- In all scenarios – that is, for all combinations of ethanol price level and technical premises considered in the analysis – an oxygen waiver would produce a NOx benefit, *as measured by the Beta 3 Predictive Model*.

The NOx benefit arises from "NOx over-compliance" in the non-oxygenated CaRFG3 pool, as a consequence of the relationships between gasoline properties and emissions embodied in the Beta 3 Predictive Model.

- In all scenarios, an oxygen waiver would induce a lower pool-average RVP.

  The advantage in pool-average RVP is small, but significant with respect to the refining model's resolution of RVP.

As is usual in an analysis such as this, we analyzed many exploratory cases in developing the ones covered in this report. Each of the exploratory cases showed a NOx benefit and an RVP reduction flowing from an oxygen waiver, just as the cases in the main scenarios did.

Hence, we judge that the findings of the analysis are robust with respect to the NOx benefit and RVP reduction associated with an oxygen waiver – even though other results (e.g., preferred volume of ethanol blending) are sensitive to technical and economic premises.

5.2.2 Estimated Shares of Ethanol-Blended and Non-Oxygenated CaRFG3 Under a Waiver

The analysis indicates that, under an oxygen waiver:

- The ethanol-blended share of the CaRFG3 pool would be in the range of 25% – 65%, depending mainly on ethanol price and ethanol blending level.

- The ethanol-blended share would likely be somewhat higher if refiners chose ethanol blending at 2.7 wt% oxygen than if they chose blending at 2.0 wt% oxygen.

- The ethanol-blended share would be lower under a national MTBE ban than under a California-only ban, because of the higher ethanol prices induced by a national ban.

5.2.3 Relative Economics of Ethanol Blending at 2.0 and 2.7 wt% Oxygen

The analysis indicates that:

- *Without* an oxygen waiver, ethanol blending would be more attractive at 2.7 wt% oxygen than at 2.0 wt% oxygen for the California refining sector as a whole. The difference in estimated cost between the two is small.

- *With* an oxygen waiver, ethanol blending would be more attractive at 2.7 wt% oxygen – but the cost difference is even smaller than in the no waiver scenarios. In our view, with a waiver, the choice of ethanol concentration (2.7 wt% vs. 2.0 wt% oxygen) is "too close to call" on the basis of economics within the framework of this analysis.

These results correspond explicitly to the premises listed in Section 4. Other premises could lead to different findings.

Discussions with California refiners indicate that some would prefer ethanol blending at 2.0 wt% oxygen, for reasons of refining economics, prospective markets for rejected streams, and/or logistics system limitations. These discussions support the conclusion that – with or without an oxygen waiver – the choice between ethanol blending at 2.7 wt% and 2.0 wt% oxygen would, in practice, turn on a number of technical and economic factors. These factors include:

- Whether or not California refiners would have sales outlets for volumes of C_5 streams (which could be rejected for RVP control) and heavy FCC naphtha and heavy reformate (which could be rejected for aromatics, T_{50}, and T_{90} control).

  Selling some heavy FCC naphtha and/or heavy reformate (either as "neat" streams or blended with rejected pentanes) would tend to tilt the economic balance toward use of the lower ethanol volume.

- The actual extent to which key blendstocks, mostly notably alkylates and ethanol, affect T_{50}.

  The T_{50} effect of alkylate streams is almost stream and blend-specific. It is hard to capture in a refinery-specific LP model, let alone an aggregate model such as we used in this study. A larger T_{50} effect than the one we estimate would favor use of the lower ethanol volume; a smaller T_{50} effect would favor use of the higher ethanol volume.

- The actual CIF price of ethanol and other gasoline blendstocks in California.

  Clearly, the lower the price of ethanol (all else equal), the larger the economic incentive to blend ethanol at the higher volume. Similarly, the lower the price(s) of imported blendstock(s), the smaller the economic incentive to blend ethanol at the higher volume.

5.2.4 Over-Optimization from Aggregate Refinery Modeling

The estimated gasoline pool properties reported in Exhibit 1 probably *understate* the NOx over-compliance discussed in Section 5.2.1, because of a modeling artifact called "over-optimization".

“Over-optimization” denotes the tendency of refinery LP modeling to indicate economic performance – usually higher aggregate profit contributions and/or lower incremental costs of a given refining operation – superior to what one could achieve in practice for a given set of refinery capital stock, product specifications, and market conditions. Over-optimization can occur as the result of various modeling devices. Its extent in a given analysis is hard to quantify.

In this analysis, "over-optimization" produces estimated gasoline pool properties that, in turn, lead to understated emissions benefits from an oxygen waiver. This form of over-optimization arises from two aspects of the modeling approach: representation of aggregate refining capacity and the consequent profusion of gasoline blendstocks represented.

- Aggregate models represent totally coordinated operation of the individual refineries in the specified region or refining aggregate. In this idealized realm, refineries trade intermediate

streams and blendstocks freely, making optimal use of all refining capacity, process by process, regardless of the refinery(s) in which the processing capacity resides. Considerable trading of this kind occurs in the refining sector, but in volumes limited by physical and institutional barriers and by the capabilities of the capital stock in place.

- Aggregate models or notional refinery models typically represent more processing options than any one refinery has and, hence, more gasoline blendstocks than any one refinery produces. This profusion of blendstocks gives the refinery model more degrees of freedom in gasoline blending than a real refinery has.

These modeling artifacts lead to computed gasoline blending recipes that lie closer to the blending frontiers defined by specifications and standards – e.g., the Predictive Model emissions targets – than can the gasoline blends produced by real refineries. This phenomenon reduces the reported "give-away" of blending properties and "over-compliance" with emissions standards.

We sought to minimize such over-optimization by reconfiguring our California refining model into two parallel variants, each representing a particular sulfur control regime, as discussed in Section 3.2. This modeling approach dampens "over-optimal" allocation of low-sulfur gasoline blendstocks to particular gasoline pools – with consequent understatement of emissions reductions – which would occur with a single aggregate model. For this reason, the "two-model" approach proved essential to the analysis.

Estimating the extent of over-optimization in a given analysis is difficult and is beyond the scope (budget and temporal) of this project.

5.2.5 Ethanol Use in the Winter Gasoline Season

Los Angeles is the primary California area still in the Winter oxygenated gasoline program. With or without an oxygen waiver for the federal RFG2 program waiver, the Los Angeles area would receive ethanol blended gasoline under the Winter program, at 2.0 or 2.7 wt% oxygen.

In our view, the lower ethanol volume appears the more likely in the Winter. Blending to the higher ethanol volume does not seem to offer economic or emissions benefits. Using the higher ethanol volume offers the refiner no CO emissions credit in the context of the Winter program, because the program deems CO control accomplished by oxygenate blending at any permitted volume. The higher RVP standard in the Winter allows some butane blending. The butane contributes to T_{50} and T_{90} control and delivers some octane-barrels, which permit a reduction in aromatics content. These factors reduce the blending value of incremental ethanol volumes in the Winter.

Areas of California – e.g., San Diego and Sacramento – that are in the federal RFG2 program but not the Winter oxygenated gasoline program could receive non-oxygenated or ethanol-blended CaRFG3 in the Winter. Consideration of refining economics suggests that the non-oxygenated share would likely be higher in the Winter than in the Summer. However, practical

considerations in the gasoline distribution system could alter this outlook and determine the extent of ethanol blending in the Winter.

The same considerations would apply to those areas of California that are in neither the federal RFG2 program or the Winter oxygenated gasoline program.

6. REFERENCES

1. *Analysis of the Refining Economics of California Phase 3 Gasoline*, MathPro Inc., prepared for the California Energy Commission, January 5, 2000.

2. *Analysis of Alternative California Phase 3 RFG Standards*, MathPro Inc., prepared for the Western States Petroleum Association, December 7, 1999

3. *Potential Economic Benefits of the Feinstein-Bilbray Bill*, MathPro Inc., prepared for Chevron Products Company and Tosco Corporation, March 18, 1999

4. *Evaluating the Cost and Supply of Alternatives to MTBE in California's Reformulated Gasoline*, Task 3: Supply Scenario Modeling Runs, MathPro Inc., prepared for the California Energy Commission, December 9, 1998.

Exhibit 1: Summary of Refinery Modeling Results -- Gasoline Pool Splits and Gasoline Properties

	Model Formulation											
	No Unocal Patent, Pool Flat Limits, Fixed Property Deltas						Unocal Patent, Grade by Grade Flat Limits, Variable Property Deltas					
	California Only MTBE Ban*			National MTBE Ban**			California Only MTBE Ban*			National MTBE Ban**		
	No Waiver	Waiver		No Waiver	Waiver		No Waiver	Waiver		No Waiver	Waiver	
	All Oxy	Oxy	NoOxy	All Oxy	Oxy	NoOxy	All Oxy	Oxy	NoOxy	All Oxy	Oxy	NoOxy
ETHANOL @ 2.0 wt%												
Share of Gas Pool	100%	50%	50%	100%	35%	65%	100%	50%	50%	100%	26%	74%
Properties												
RVP	6.66	6.60	6.60	6.66	6.60	6.60	6.74	6.62	6.60	6.74	6.60	6.60
Oxygen	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0	2.0	2.0	0.0
Aromatics	24.1	26.5	23.0	24.1	19.1	28.6	23.3	24.3	26.9	23.3	28.6	24.3
Benzene	0.64	0.62	0.57	0.64	0.77	0.51	0.57	0.60	0.46	0.57	0.51	0.49
Olefins	4.4	3.4	5.9	4.4	4.6	4.7	3.9	3.7	2.4	3.9	2.9	3.9
Sulfur	15	17	8	15	17	7	10	13	8	10	12	10
E200	47.2	46.8	47.7	47.2	45.2	48.7	46.4	46.2	48.1	46.4	46.1	47.7
E300	87.6	88.3	87.4	87.6	90.6	87.6	88.7	87.7	87.2	88.7	88.2	88.0
T50	208	208	206	208	213	203	210	210	205	210	210	206
T90	307	305	307	307	298	307	304	307	308	304	305	306
ETHANOL @ 2.7 wt%												
Share of Gas Pool	100%	60%	40%	100%	40%	60%	100%	65%	35%	100%	46%	54%
Properties												
RVP	6.85	6.76	6.60	6.85	6.60	6.60	6.84	6.73	6.60	6.84	6.69	6.60
Oxygen	2.7	2.7	0.0	2.7	2.7	0.0	2.7	2.7	0.0	2.7	2.7	0.0
Aromatics	23.2	25.7	24.8	23.2	22.4	28.6	23.3	26.3	21.2	23.3	25.3	25.7
Benzene	0.70	0.66	0.52	0.70	0.71	0.53	0.68	0.63	0.52	0.68	0.65	0.49
Olefins	3.8	2.8	6.0	3.8	2.8	4.1	3.8	1.9	6.3	3.8	2.8	3.9
Sulfur	10	10	12	10	12	10	9	8	12	9	10	9
E200	46.9	46.2	49.0	46.9	44.9	49.2	46.6	45.4	47.6	46.6	45.4	47.9
E300	88.1	88.6	85.8	88.1	87.7	87.4	88.0	89.0	86.8	88.0	88.3	87.6
T50	208	210	203	208	214	202	209	212	206	209	212	206
T90	305	304	312	305	307	307	306	303	309	306	305	307

* Delivered ethanol price of $40 to $45 per barrel.
** Delivered ethanol price of $50 to $55 per barrel.

Exhibit 2: Process Unit Utilization, Additions, and Operations
(K bbl/d)

Type of Process	Process	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas					
		Wt% Oxygen in Oxygenated Gasoline					
		2.0 Percent			2.7 Percent		
			Waiver			Waiver	
		No Waiver	Calif. Ban	Nat'l Ban	No Waiver	Calif. Ban	Nat'l Ban
USE OF EXISTING CAP.							
Crude Distillation	Atmospheric	1975	1960	1987	1996	1988	1994
Conversion	Fluid Cat Cracker	732	732	732	732	732	732
	Hydrocracker - Distillate Feed	291	291	291	291	291	291
	Hydrocracker - Gas Oil Feed	120	115	124	127	125	128
	Coking - Delayed	342	354	351	336	354	355
	Coking - Fluid & Flexi	106	106	106	106	106	106
Upgrading	Alkylation	176	175	162	177	177	175
	Dimersol			2			
	Pen/Hex Isom. (Once Thru)	53	75	82	63	76	76
	Pen/Hex Isom. (Recycle)						
	Polymerization						
	Reforming (150-350 psi)	387	403	418	367	405	418
Oxygenate Prod.	MTBE Plant -- Captive						
	Tame Plant						
Hydrotreating	Naphtha & Isom Feed Desulf.	68	74	75	106	78	79
	Reformer Feed Desulfurization	306	314	314	268	308	318
	Distillate Desulfurization	365	359	385	382	369	388
	Distillate Dearomatization	149	157	154	148	152	136
	FCC Feed Desulf. -- Conv.	349	351	351	349	351	351
	FCC Feed Desulf. -- Deep	377	377	377	377	377	377
	FCC Naphtha Desulf. (Non-Selective)	30	30	30	30	30	30
	Benzene Saturation	58	66	66	64	66	66
Hydrogen (MM scf/d)	Hydrogen Plant	1294	1302	1308	1308	1308	1308
Other	Aromatics Plant						
	Butane Isomerization	18	18	9	18	18	16
	Lubes & Waxes	25	25	25	25	25	25
	Merox Treatment of MTBE/IsoOctene						
	Solvent Deasphalting	50	50	50	50	50	50
	Sulfur Recovery (tons/d)	6557	6595	6606	6556	6611	6619
Fractionation	Debutanization	189	189	192	190	191	192
	Depentanization	113	113	113	113	113	113
	Lt. Naphtha Spl. (Benz. Prec.)	153	153	153	153	153	153
	Naphtha Splitter (T90 Control)	24	70	70	3	38	70
	FCC Naphtha Splitter	298	327	339	338	314	289
	FCC Naphtha T90 Control	56	54	54	57	56	56
RETROFIT CAPACITY							
IsoOctane/Octene*	From Captive MTBE	4	4	7	4	4	4
NEW CAPACITY							
Crude Distillation	Atmospheric						
Upgrading	Alkylation	38	19	20	29	21	23
	IsoOctane/ene	8	7	5	7	4	
Hydrotreating	Naphtha Desulfurization						
	FCC Naphtha Desulf. (Non-Selective)	85	107	108	110	115	116
	Benzene Saturation		6	14		0	9
Hydrogen (foeb)	Hydrogen Plant (MM scf/d)	43	70	121	71	80	96
Other	Benzene Extraction						
	FCC Gas Processing	178	95	111	116	77	56
	Merox Treatment of MTBE	12	11	12	11	8	4
	Butane Isomerization						
	Sulfur Recovery (tons/d)						
Fractionation	Alkylate Fractionation (Lt. Alkylate)						
	Debutanization	169	73	100	19	19	19
	Depentanization	105	46	14	225	136	92
	Lt. Naphtha Spl. (Benz. Prec.)	30	49	50	6	51	51
	Naphtha Splitter (T90 Control)		4	62			35
	FCC Naphtha Splitter	2	15	18	9	18	25
	FCC Naphtha (T90 Control)	10	9	25	24	6	2
OPERATIONS							
Operating Indices	FCC Conversion (Vol %)	69	69	69	70	70	70
	Reformer Severity (RON)	100	100	100	100	100	100
Charge Rates	Fluid Cat Cracker	730	732	732	730	732	732
	Reformer (150-350 psi)	387	403	418	367	405	418
FCC Olefin Max Cat. (%)		22	12	14	15	10	7

Exhibit 2: Process Unit Utilization, Additions, and Operations
(K bbl/d)

		Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas					
		Wt% Oxygen in Oxygenated Gasoline					
		2.0 Percent			2.7 Percent		
			Waiver			Waiver	
Type of Process	Process	No Waiver	Calif. Ban	Nat'l Ban	No Waiver	Calif. Ban	Nat'l Ban
USE OF EXISTING CAP.							
Crude Distillation	Atmospheric	1969	1984	1973	1988	1987	2002
Conversion	Fluid Cat Cracker	732	732	732	729	727	732
	Hydrocracker - Distillate Feed	291	291	291	291	291	291
	Hydrocracker - Gas Oil Feed	117	123	123	129	130	130
	Coking - Delayed	330	351	368	344	354	352
	Coking - Fluid & Flexi	106	106	106	106	106	106
Upgrading	Alkylation	171	163	162	178	167	164
	Dimersol			2			
	Pen/Hex Isom. (Once Thru)	61	76	76	62	76	76
	Pen/Hex Isom. (Recycle)						
	Polymerization			1			
	Reforming (150-350 psi)	378	411	418	367	394	410
Oxygenate Prod.	MTBE Plant -- Captive						
	Tame Plant						
Hydrotreating	Naphtha & Isom Feed Desulf.	59	79	75	99	80	79
	Reformer Feed Desulfurization	292	325	317	274	299	321
	Distillate Desulfurization	374	385	384	386	391	390
	Distillate Dearomatization	163	138	155	147	149	140
	FCC Feed Desulf. -- Conv.	347	351	350	349	351	351
	FCC Feed Desulf. -- Deep	377	377	377	374	372	377
	FCC Naphtha Desulf. (Non-Selective)	30	30	30	30	30	30
	Benzene Saturation	62	66	66	60	66	66
Hydrogen (MM scf/d)	Hydrogen Plant	1308	1308	1308	1308	1308	1308
Other	Aromatics Plant						
	Butane Isomerization	15	9	9	18	12	9
	Lubes & Waxes	25	25	25	25	25	25
	Merox Treatment of MTBE/IsoOctene						
	Solvent Deasphalting	50	50	50	50	50	50
	Sulfur Recovery (tons/d)	6511	6605	6645	6559	6591	6619
Fractionation	Debutanization	188	190	192	190	190	192
	Depentanization	113	113	113	113	113	113
	Lt. Naphtha Spl. (Benz. Prec.)	153	153	153	153	153	153
	Naphtha Splitter (T90 Control)	13	67	70	3	35	62
	FCC Naphtha Splitter	339	339	339	339	339	339
	FCC Naphtha T90 Control	57	57	57	57	57	57
RETROFIT CAPACITY							
IsoOctane/Octene*	From Captive MTBE	8	8	8	4	8	8
NEW CAPACITY							
Crude Distillation	Atmospheric		1				1
Upgrading	Alkylation	29	22	21	29	23	23
	IsoOctane/ene	7	10	12	6	4	8
Hydrotreating	Naphtha Desulfurization						
	FCC Naphtha Desulf. (Non-Selective)	105	117	118	117	114	119
	Benzene Saturation		6	21			5
Hydrogen (foeb)	Hydrogen Plant (MM scf/d)	61	96	142	71	106	131
Other	Benzene Extraction						
	FCC Gas Processing	128	91	140	120	73	91
	Merox Treatment of MTBE	15	19	21	10	12	17
	Butane Isomerization						
	Sulfur Recovery (tons/d)						
Fractionation	Alkylate Fractionation (Lt. Alkylate)			60		8	10
	Debutanization	20	21	18	19	20	20
	Depentanization	243	173	80	208	162	85
	Lt. Naphtha Spl. (Benz. Prec.)	38	50	53	13	44	43
	Naphtha Splitter (T90 Control)		12	41			35
	FCC Naphtha Splitter	14	21	26	14	21	31
	FCC Naphtha (T90 Control)	33	6	11	20	22	14
OPERATIONS							
Operating Indices	FCC Conversion (Vol %)	70	70	70	70	70	70
	Reformer Severity (RON)	100	100	100	100	100	100
Charge Rates	Fluid Cat Cracker	728	732	730	727	727	732
	Reformer (150-350 psi)	378	411	418	367	394	410
FCC Olefin Max Cat. (%)		16	11	18	15	9	11

Exhibit 3: Crude Oil, Other Inputs, and Refined Product Outputs

(K barrels/day)

	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas					
	Wt% Oxygen in Oxygenated Gasoline					
	2.0 Percent			2.7 Percent		
		Waiver			Waiver	
Inputs/ Outputs	**No Waiver**	**Calif. Ban**	**Nat'l Ban**	**No Waiver**	**Calif. Ban**	**Nat'l Ban**
Crude Oil						
Composite	1,975	1,960	1,987	1,996	1,987	1,994
Other Inputs						
Isobutane	15			6		
Butane						
Natural Gas Liquids						
C6 Isomerate	97	82	70	49	68	69
Full Range Alkylate	14	43	52	33	31	31
IsoOctane	33	33	33	12	18	28
Reformate						
Heavy Gas Oil	19	19	19	19	19	19
Residual Oil	38	38	38	38	38	38
MTBE						
Ethanol	59	30	21	79	48	33
Methanol						
Energy Use						
Electricity (K Kwh)	19,666	19,747	20,471	19,548	19,885	20,302
Fuel (foeb)	243	246	253	244	248	251
Refined Product Out-turns						
BTX						
Propane	37	37	37	37	37	37
Propylene	7	7	7	7	7	7
Butane						
Mixed Butylenes	4	4	4	4	4	4
Naphtha	3	3	3	3	3	3
Gasoline:						
Calif. RFG3 (Oxy)	1,022	526	374	1,022	622	426
Calif. RFG3 (No Oxy)		496	648		400	596
Arizona CBG	68			68		
Conventional	161			161		
Arizona CBG & Conv.		229	229		229	229
Aviation Gasoline	5	5	5	5	5	5
Jet Fuel	333	333	333	333	333	333
CARB Diesel	204	204	204	204	204	204
On-road Diesel (< 0.05% Sulf)	122	122	122	122	122	122
Other Diesel/Heating Oil	18	18	18	18	18	18
Carbon Black Feed						
Residual Oil	98	79	92	108	84	86
Asphalt						
Lubes & Waxes	25	25	25	25	25	25
Coke	130	134	133	128	134	134
Sulfur (k tons/d)	7	7	7	7	7	7
Rejected Blendstocks	28			7		

Exhibit 3: Crude Oil, Other Inputs, and Refined Product Outputs

(K barrels/day)

	Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas					
	Wt% Oxygen in Oxygenated Gasoline					
	2.0 Percent			2.7 Percent		
		Waiver			Waiver	
Inputs/ Outputs	**No Waiver**	**Calif. Ban**	**Nat'l Ban**	**No Waiver**	**Calif. Ban**	**Nat'l Ban**
Crude Oil						
Composite	1,968	1,984	1,973	1,988	1,987	2,002
Other Inputs						
Isobutane	6			6		
Butane						
Natural Gas Liquids						
C6 Isomerate	82	84	79	47	51	61
Full Range Alkylate	52	36	46	34	53	47
IsoOctane	19	28	30	12	12	15
Reformate						
Heavy Gas Oil	19	19	19	19	19	19
Residual Oil	38	38	38	38	38	38
MTBE						
Ethanol	59	30	16	79	52	37
Methanol						
Energy Use						
Electricity (K Kwh)	19,475	20,153	20,540	19,609	19,991	20,430
Fuel (foeb)	242	250	254	244	248	253
Refined Product Out-turns						
BTX						
Propane	37	37	37	37	37	37
Propylene	7	7	7	7	7	7
Butane						
Mixed Butylenes	4	4	4	4	4	4
Naphtha	3	3	3	3	3	3
Gasoline:						
Calif. RFG3 (Oxy)	1,022	526	271	1,022	674	478
Calif. RFG3 (No Oxy)		496	751		348	544
Arizona CBG	68			68		
Conventional	161			161		
Arizona CBG & Conv.		229	229		229	229
Aviation Gasoline	5	5	5	5	5	5
Jet Fuel	333	333	333	333	333	333
CARB Diesel	204	204	204	204	204	204
On-road Diesel (< 0.05% Sulf)	122	122	122	122	122	122
Other Diesel/Heating Oil	18	18	18	18	18	18
Carbon Black Feed						
Residual Oil	101	88	65	95	85	92
Asphalt						
Lubes & Waxes	25	25	25	25	25	25
Coke	126	133	139	131	134	133
Sulfur (k tons/d)	7	7	7	7	7	7
Rejected Blendstocks	21			8		

Exhibit 4: Gasoline Properties, by Case and Gasoline Type

Property & Volume	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas											
	2.0 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB Oxy	Ariz	Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool
Property												
RVP (psi)*	6.66	6.60	7.70	6.79	6.60	6.60	7.37	6.74	6.60	6.60	7.37	6.74
Oxygen (wt%)	2.0	0.0	0.0	1.6	2.0	0.0	0.0	0.8	2.0	0.0	0.0	0.6
Aromatics (vol%)	24.1	18.8	34.4	25.2	26.5	23.0	30.4	25.9	19.2	28.6	30.4	26.1
Benzene (vol%)	0.64	0.76	0.76	0.67	0.62	0.57	0.71	0.62	0.77	0.51	0.80	0.64
Olefins (vol%)	4.4	8.7	6.1	4.9	3.4	5.9	5.7	4.8	4.6	4.7	8.1	5.3
Sulfur (ppm)	14	25	25	16	17	8	19	14	17	7	17	12
E200 (vol% off)	47.2	40.2	38.9	45.7	46.8	47.7	39.2	45.7	45.2	48.7	39.2	45.9
E300 (vol% off)	87.6	83.4	76.4	86.0	88.3	87.4	79.0	86.2	90.6	87.6	79.0	86.9
T10**	137	129	125	135	137	137	129	136	136	139	128	136
T50**	208	215	226	210	209	206	221	210	213	203	222	210
T90**	307	331	348	313	305	307	339	312	298	307	333	309
Estimated DI***	1,174	1,170	1,213	1,179	1,176	1,132	1,196	1,163	1,180	1,125	1,193	1,154
En. Den. (MM Btu/bbl)	5.133	5.213	5.252	5.153	5.139	5.188	5.234	5.176	5.131	5.194	5.229	5.181
Volume (K bbl/d)	1,022	68	161	1,251	526	496	229	1,251	374	648	229	1,251

* Final blended RVP.

** Linear interpolations from ARMS generated distillation curves for T10 and T50 & T90 for Arizona CBG and Conventional Gasoline.;
T50 = (125.3846 - E200)/0.3769 and T90 = (196.1538 - E300)/0.3538 for California RFG

*** Calculated as follows: 1.5*T10 + 3.0*T50 + 1.0*T90 + 20*(wt% oxygen from ethanol).

Note: Emissions calculations based on: Phase II Complex Model for Arizona gasoline; Phase 2 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG2; and Phase 3 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG3.

Exhibit 4: Gasoline Properties, by Case and Gasoline Type

Property & Volume	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas											
	2.7 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB Oxy	Ariz	Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool
Property												
RVP (psi)*	6.85	6.64	7.70	6.95	6.76	6.60	7.37	6.82	6.60	6.60	7.37	6.74
Oxygen (wt%)	2.7	0.0	0.0	2.2	2.7	0.0	0.0	1.3	2.7	0.0	0.0	0.9
Aromatics (vol%)	23.2	18.3	34.4	24.4	25.7	24.8	30.3	26.3	22.4	28.6	30.3	26.8
Benzene (vol%)	0.69	0.80	0.71	0.70	0.66	0.52	0.80	0.64	0.71	0.53	0.80	0.64
Olefins (vol%)	3.8	10.0	6.3	4.4	2.8	6.1	6.1	4.4	2.8	4.0	7.7	4.3
Sulfur (ppm)	9	25	25	12	10	12	25	13	12	10	20	13
E200 (vol% off)	46.9	40.0	38.9	45.5	46.1	49.1	39.3	45.8	44.9	49.2	39.3	45.9
E300 (vol% off)	88.1	83.5	76.4	86.4	88.6	85.8	78.8	85.9	87.7	87.4	78.8	85.9
T10**	136	129	124	134	136	139	127	135	135	139	127	136
T50**	208	213	225	211	210	202	221	210	214	202	221	210
T90**	305	328	348	312	304	312	343	314	307	307	339	313
Estimated DI***	1,189	1,160	1,208	1,190	1,193	1,127	1,196	1,173	1,205	1,122	1,194	1,164
En. Den. (MM Btu/bbl)	5.098	5.205	5.244	5.123	5.103	5.199	5.241	5.159	5.090	5.213	5.241	5.176
Volume (K bbl/d)	1,022	68	161	1,251	622	400	229	1,251	426	596	229	1,251

* Final blended RVP.

** Linear interpolations from ARMS generated distillation curves for T10 and T50 & T90 for Arizona CBG and Conventional Gasoline.;
T50 = (125.3846 - E200)/0.3769 and T90 = (196.1538 - E300)/0.3538 for California RFG

*** Calculated as follows: 1.5*T10 + 3.0*T50 + 1.0*T90 + 20*(wt% oxygen from ethanol).

Note: Emissions calculations based on: Phase II Complex Model for Arizona gasoline; Phase 2 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG2; and Phase 3 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG3.

Exhibit 4: Gasoline Properties, by Case and Gasoline Type

Property & Volume	Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas											
	2.0 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB Oxy	Ariz	Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool
Property												
RVP (psi)*	6.74	6.63	7.70	6.86	6.62	6.60	7.39	6.75	6.60	6.60	7.39	6.74
Oxygen (wt%)	2.0	0.0	0.0	1.6	2.0	0.0	0.0	0.8	2.0	0.0	0.0	0.4
Aromatics (vol%)	23.3	19.3	34.4	24.5	24.3	26.9	29.9	26.4	28.6	24.3	29.9	26.3
Benzene (vol%)	0.57	0.77	0.80	0.61	0.60	0.46	0.76	0.57	0.51	0.49	0.80	0.55
Olefins (vol%)	3.9	9.4	6.3	4.5	3.7	2.4	6.6	3.7	2.9	3.9	6.1	4.1
Sulfur (ppm)	10	18	25	12	12	8	19	12	12	10	20	12
E200 (vol% off)	46.4	40.0	38.9	45.1	46.2	48.1	39.2	45.7	46.1	47.6	39.2	45.8
E300 (vol% off)	88.7	84.2	76.4	86.9	87.7	87.2	78.8	85.9	88.2	88.1	78.8	86.4
T10**	136	129	124	134	137	139	126	136	138	138	128	136
T50**	210	213	226	212	210	205	222	210	210	206	221	210
T90**	304	327	349	311	307	308	343	314	305	306	340	312
Estimated DI***	1,177	1,159	1,212	1,180	1,182	1,132	1,198	1,165	1,184	1,132	1,195	1,155
En. Den. (MM Btu/bbl)	5.124	5.218	5.251	5.145	5.147	5.188	5.239	5.180	5.148	5.195	5.237	5.192
Volume (K bbl/d)	1,022	68	161	1,251	526	496	229	1,251	271	751	229	1,251

* Final blended RVP.

** Linear interpolations from ARMS generated distillation curves for T10 and T50 & T90 for Arizona CBG and Conventional Gasoline.;
T50 = (125.3846 - E200)/0.3769 and T90 = (196.1538 - E300)/0.3538 for California RFG

*** Calculated as follows: 1.5*T10 + 3.0*T50 + 1.0*T90 + 20*(wt% oxygen from ethanol).

Note: Emissions calculations based on: Phase II Complex Model for Arizona gasoline; Phase 2 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG2; and Phase 3 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG3.

Exhibit 4: Gasoline Properties, by Case and Gasoline Type

Property & Volume	Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas											
	2.7 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB Oxy	Ariz	Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool	CARB Oxy	CARB No Oxy	Ariz & Conv.	Pool
Property												
RVP (psi)*	6.84	6.60	7.70	6.94	6.73	6.60	7.37	6.81	6.69	6.60	7.37	6.77
Oxygen (wt%)	2.7	0.0	0.0	2.2	2.7	0.0	0.0	1.5	2.7	0.0	0.0	1.0
Aromatics (vol%)	23.2	20.0	34.4	24.5	26.3	21.2	29.8	25.5	25.4	25.7	29.8	26.3
Benzene (vol%)	0.68	0.79	0.70	0.69	0.63	0.52	0.71	0.61	0.65	0.49	0.77	0.60
Olefins (vol%)	3.8	9.7	6.3	4.4	1.9	6.3	6.2	3.9	2.8	3.9	6.3	3.9
Sulfur (ppm)	9	18	25	12	8	12	23	12	10	9	20	11
E200 (vol% off)	46.6	40.0	38.9	45.3	45.4	47.6	39.2	44.9	45.4	47.9	39.2	45.4
E300 (vol% off)	88.0	84.0	76.4	86.3	89.0	86.8	78.5	86.5	88.3	87.6	78.5	86.2
T10**	136	129	124	134	137	138	126	135	136	139	128	136
T50**	209	213	224	211	212	206	221	212	212	205	222	211
T90**	306	328	348	312	303	309	344	312	305	307	341	312
Estimated DI***	1,191	1,160	1,206	1,191	1,199	1,135	1,196	1,181	1,201	1,131	1,197	1,170
En. Den. (MM Btu/bbl)	5.099	5.221	5.242	5.124	5.111	5.182	5.234	5.153	5.110	5.198	5.237	5.171
Volume (K bbl/d)	1,022	68	161	1,251	674	348	229	1,251	478	544	229	1,251

* Final blended RVP.

** Linear interpolations from ARMS generated distillation curves for T10 and T50 & T90 for Arizona CBG and Conventional Gasoline.;
T50 = (125.3846 - E200)/0.3769 and T90 = (196.1538 - E300)/0.3538 for California RFG

*** Calculated as follows: 1.5*T10 + 3.0*T50 + 1.0*T90 + 20*(wt% oxygen from ethanol).

Note: Emissions calculations based on: Phase II Complex Model for Arizona gasoline; Phase 2 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG2; and Phase 3 Predictive Model in Flat Limits Mode, with "Property Compliance Margins" specified by ARB, for CaRFG3.

Exhibit 5: Gasoline Composition and Volume, by Gasoline Type

Composition & Volume	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas											
	2.0 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB				CARB		Ariz &		CARB		Ariz &	
	Oxy	Ariz	Conv.	Pool	Oxy	No Oxy	Conv.	Pool	Oxy	No Oxy	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Butenes												
I-Butane											0.3	0.0
N-Butane	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.5
C5s & Isomerate	14.5		8.5	12.9	11.9	18.6	4.6	13.2	7.7	18.8	9.5	13.8
Raffinate												
Natural Gas Liquids												
Naphtha	3.6		3.9	3.4		4.7	3.4	2.5		2.6	3.6	2.0
C5-160	2.2		2.4	2.1		4.7	3.4	2.5		2.6	3.6	2.0
Coker Naphtha												
160-250	1.3		1.5	1.3								
Alkylate	20.2	34.5	20.1	21.0	17.7	24.9	24.6	21.8	23.6	20.6	18.1	21.1
Hydrocrackate	6.8	13.6	16.9	8.5	9.1	2.2	18.1	8.0	11.8	5.1	14.0	8.7
Poly Gasoline										0.4		0.2
FCC Gasoline:	25.6	36.3	10.1	24.2	31.8	23.6	15.8	25.6	36.4	19.3	22.8	25.1
Full Range	3.4	14.3		3.6	4.2			1.8			3.2	0.6
Full Range - Desulf.												
Light	3.5	13.7		3.6	1.3	9.2	3.2	4.8	5.5	4.6	4.6	4.9
Light - Desulf.												
Medium	8.5	4.8		7.2	13.3	5.0	0.7	7.7	19.0	3.3	4.5	8.2
Medum - Desulf.	5.9			4.8	8.2	5.3		5.5	10.3	4.9		5.6
Heavy	1.5	2.0	7.9	2.3	1.2	1.7	7.7	2.6		3.0	4.9	2.5
Heavy - Desulf.	2.8	1.5	2.2	2.7	3.7	2.5	4.1	3.3	1.6	3.4	5.6	3.3
Reformate	23.0	15.2	40.1	24.8	23.2	25.4	33.1	25.9	14.3	32.7	31.4	26.9
Light	11.6		7.9	10.5	16.8	10.2	8.2	12.6	4.8	22.0	2.6	13.3
Medium		1.4	7.1	1.0			17.0	3.1	0.4		28.2	5.3
Heavy	11.4	13.8	25.1	13.3	6.5	15.2	7.9	10.2	9.1	10.6	0.6	8.3
Oxygenate	5.7			4.7	5.7			2.4	5.7			1.7
MTBE												
TAME												
Ethanol	5.7			4.7	5.7			2.4	5.7			1.7
Gasoline Volume (K Bbl/day)	1,022	68	161	1,251	526	496	229	1,251	374	648	229	1,251

Exhibit 5: Gasoline Composition and Volume, by Gasoline Type

Composition & Volume	Model Formulation: No Unocal Patent, Pool Flat Limits, Fixed Property Deltas											
	2.7 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB				CARB		Ariz &		CARB		Ariz &	
	Oxy	Ariz	Conv.	Pool	Oxy	No Oxy	Conv.	Pool	Oxy	No Oxy	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5
Butenes												
I-Butane												
N-Butane	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5
C5s & Isomerate	10.8		8.5	9.9	14.1	13.5	4.7	12.2	17.6	11.6	4.8	12.4
Raffinate												
Natural Gas Liquids												
Naphtha	6.0		3.8	5.4	1.0	5.2	1.8	2.5		4.6	1.7	2.5
C5-160	2.6		2.4	2.4	1.0	5.2	1.7	2.5		4.6	1.7	2.5
Coker Naphtha							0.2	0.0				
160-250	3.4		1.5	3.0								
Alkylate	19.8	31.2	20.9	20.5	13.3	28.2	23.7	20.0	17.7	21.7	20.8	20.2
Hydrocrackate	8.7	8.9	16.5	9.7	11.2	1.2	19.1	9.4	9.9	5.2	15.8	8.7
Poly Gasoline												
FCC Gasoline:	24.2	48.8	12.9	24.1	26.9	27.4	18.3	25.5	24.8	27.0	26.3	26.1
Full Range	2.9	7.3	0.1	2.8	1.4	3.9	7.0	3.2	1.2	5.2	11.4	5.0
Full Range - Desulf.												
Light	3.7	18.0	0.1	4.0	1.5	9.3	3.2	4.3	1.3	5.8	6.3	4.4
Light - Desulf.												
Medium	8.5	16.0		7.9	11.1	4.0		6.8	15.3	1.2		5.8
Medum - Desulf.	7.4			6.0	12.2			6.1	6.9	7.8		6.1
Heavy	1.6	2.4	10.3	2.8	0.7	4.0	4.9	2.5		3.0	3.1	2.0
Heavy - Desulf.	0.0	5.0	2.3	0.6		6.3	3.2	2.6		4.1	5.5	2.9
Reformate	22.3	10.6	36.9	23.5	25.2	24.0	31.9	26.1	21.8	29.4	30.1	26.9
Light	10.0	0.0	12.5	9.7	9.3	21.2	5.6	12.4	2.7	24.3	3.0	13.1
Medium		0.8	0.5	0.1			8.6	1.6			23.3	4.3
Heavy	12.3	9.8	23.9	13.7	15.9	2.8	17.7	12.1	19.1	5.1	3.8	9.6
Oxygenate	7.8			6.3	7.8			3.9	7.8			2.6
MTBE												
TAME												
Ethanol	7.8			6.3	7.8			3.9	7.8			2.6
Gasoline Volume (K Bbl/day)	1,022	68	161	1,251	622	400	229	1,251	426	596	229	1,251

Exhibit 5: Gasoline Composition and Volume, by Gasoline Type

Composition & Volume	Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas											
	2.0 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB				CARB		Ariz &		CARB		Ariz &	
	Oxy	Ariz	Conv.	Pool	Oxy	No Oxy	Conv.	Pool	Oxy	No Oxy	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	1.0	0.8
Butenes												
I-Butane										0.1	0.2	0.1
N-Butane	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7
C5s & Isomerate	13.8		8.5	12.4	11.4	19.8	4.4	13.4	22.2	12.3	2.6	12.7
Raffinate												
Natural Gas Liquids												
Naphtha	2.0		3.8	2.2		5.4	1.7	2.5		3.2	3.2	2.5
C5-160	1.8		2.4	1.7		5.4	1.7	2.5		3.2	3.2	2.5
Coker Naphtha												
160-250	0.3		1.5	0.4								
Alkylate	22.2	31.0	20.2	22.4	18.9	21.7	25.1	21.2	12.2	24.2	24.9	21.7
Hydrocrackate	8.4	11.6	17.5	9.8	7.9	4.8	18.0	8.5	1.1	8.5	17.6	8.5
Poly Gasoline										0.5		0.3
FCC Gasoline:	24.7	42.0	10.9	23.8	34.6	17.3	20.0	25.1	26.2	25.7	22.6	25.2
Full Range												
Full Range - Desulf.												
Light	3.9	20.0	0.1	4.3	4.8	3.5	5.7	4.5	2.5	5.7	5.8	5.0
Light - Desulf.										0.1		0.1
Medium	8.6	14.8	0.8	7.9	16.0	1.7	2.9	7.9	20.0	4.3	2.8	7.4
Medum - Desulf.	7.5			6.1	9.1	6.0		6.2	1.8	10.1		6.5
Heavy	2.1	5.2	7.7	3.0	1.5	3.4	6.9	3.2	1.9	3.2	5.3	3.3
Heavy - Desulf.	2.6	1.9	2.3	2.6	3.2	2.8	4.5	3.2		2.3	8.7	2.9
Reformate	22.6	15.0	38.6	24.3	20.9	30.4	30.4	26.4	32.1	24.7	28.0	26.9
Light	12.5	0.6	7.5	11.2	8.9	18.3	6.3	12.2	14.3	13.5	10.8	13.2
Medium	0.2	0.8	2.6	0.6	3.3		10.2	3.2	4.9	5.1	2.2	4.5
Heavy	9.9	13.6	28.5	12.5	8.7	12.1	14.0	11.0	12.8	6.2	15.0	9.2
Oxygenate	5.7			4.7	5.7			2.4	5.7			1.2
MTBE												
TAME												
Ethanol	5.7			4.7	5.7			2.4	5.7			1.2
Gasoline Volume (K Bbl/day)	1,022	68	161	1,251	526	496	229	1,251	271	751	229	1,251

Exhibit 5: Gasoline Composition and Volume, by Gasoline Type

Composition & Volume	Model Formulation: Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas											
	2.7 wt% Oxygen &											
					Waiver							
	No Waiver				California Ban				National Ban			
	CARB				CARB		Ariz &		CARB		Ariz &	
	Oxy	Ariz	Conv.	Pool	Oxy	No Oxy	Conv.	Pool	Oxy	No Oxy	Conv.	Pool
Composition (vol%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
C4s:	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
Butenes												
I-Butane											0.0	0.0
N-Butane	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
C5s & Isomerate	10.6		8.6	9.7	10.9	14.8	5.2	10.9	12.0	14.4	2.6	11.3
Raffinate												
Natural Gas Liquids												
Naphtha	5.5		3.8	5.0	2.2	3.8	2.7	2.7	1.2	3.9	1.7	2.5
C5-160	2.6		2.4	2.5	2.1	3.8	1.7	2.5	1.2	3.9	1.7	2.5
Coker Naphtha												
160-250	2.9		1.5	2.5	0.1		1.0	0.3				
Alkylate	19.9	29.6	20.6	20.5	15.4	28.4	26.1	21.0	17.0	21.8	25.2	20.6
Hydrocrackate	9.3	11.1	15.7	10.2	12.4	2.5	18.1	10.7	11.9	4.8	18.8	10.1
Poly Gasoline												
FCC Gasoline:	24.5	42.6	14.5	24.2	24.1	30.2	17.4	24.6	24.9	27.5	22.3	25.5
Full Range												
Full Range - Desulf.												
Light	3.8	14.9		3.9	1.7	10.6	3.7	4.5	2.8	5.7	7.0	4.8
Light - Desulf.												
Medium	8.5	22.6	0.5	8.3	9.5	14.8	1.0	9.4	12.3	9.7	1.2	9.1
Medum - Desulf.	7.5			6.1	10.9	1.4		6.3	5.9	9.1		6.2
Heavy	1.3	5.1	10.2	2.6	0.8	3.4	8.9	3.0		2.9	8.8	2.9
Heavy - Desulf.	3.4		3.7	3.2	1.3		3.8	1.4	3.9		5.3	2.5
Reformate	22.0	16.2	36.3	23.5	26.7	19.7	30.0	25.4	24.7	27.0	28.8	26.4
Light	9.6	0.5	14.5	9.7	11.4	14.7	8.8	11.8	11.4	15.0	6.5	12.1
Medium		1.0	0.3	0.1			8.0	1.5		0.7	19.9	3.9
Heavy	12.4	14.6	21.5	13.7	15.3	5.0	13.3	12.1	13.3	11.3	2.4	10.4
Oxygenate	7.8			6.3	7.8			4.2	7.8			3.0
MTBE												
TAME												
Ethanol	7.8			6.3	7.8			4.2	7.8			3.0
Gasoline Volume (K Bbl/day)	1,022	68	161	1,251	674	348	229	1,251	478	544	229	1,251

Exhibit 6: Estimated Savings in Refining Costs and Investment from a California Oxygen Waiver, by Case
Summer Season

	Model Formulation:			
	No Unocal Patent, Pool Flat Limits, Fixed Property Deltas		Unocal Patent, Grade-by-Grade Flat Limits, Variable Property Deltas	
Type of Ban/Cost	**2.0 wt% Oxygen**	**2.7 wt% Oxygen**	**2.0 wt% Oxygen**	**2.7 wt% Oxygen**
California Ban				
Variable Cost & Capital Charge (¢/gal)	1.3	0.2	1.0	0.2
Investment ($MM)	79	78	-48	33
National Ban				
Variable Cost & Capital Charge (¢/gal)	2.0	1.1	1.8	0.8
Investment ($MM)	-15	87	-174	-76