

07-6-3
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**Refining Economics of the 2007 Amendments
to the Phase 3 CaRFG Regulations**

**California Air Resources Board
Public Hearing
June 14, 2007**

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Assignment

- Estimate effects in the California refining sector of the proposed 2007 Amendments to the Phase 3 CaRFG3 regulations
- Assess amendments' effects on
 - ▶ CaRFG3 production capability with current refining process capacity
 - ▶ CaRFG3 refining cost, after investment in new process capacity
- Consider the full range of allowable ethanol concentrations
- Identify key sensitivities and uncertainties

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Overview of the presentation

1. Background
2. Scope of the analysis
3. Technical approach
4. Primary results and findings

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1. Producing CaRFG3 Under the Amended PM3

- Amended PM3. . .
 - ▶ Introduces increase in VOC emissions due to ethanol permeation; and
 - ▶ Requires improvements in CARBOB quality to offset permeation effect

- To produce complying gasoline and meet forecast demand, California refiners must
 - ▶ Invest in new process capacity,
 - ▶ Modify refining operations, and/or
 - ▶ Use more ethanol

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2. Scope of the analysis

- Objective: estimate the magnitude of the changes in refining operations and economics induced by amendments

 - Analyze prospective CARB gasoline production
 - ▶ With *no* new refining investment, and
 - ▶ With new refining investment
- at four levels of ethanol blending: 0, 5.7, 7.7, and 10 vol%

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Interpreting the cases analyzed

- Cases *without* refining investment
 - ▶ Can be viewed as denoting "short-term" refining operations
 - ▶ Primarily, are analytical artifacts used to delineate requirements for refining investments
- Cases *with* refining investment
 - ▶ Denote "long-term" refining operations
 - ▶ "Long-term" means time required to bring new process capacity online (≈ 4 years)

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3. Technical approach

- Used a refinery LP model to analyze
 - ▶ Short-term and long-term baseline cases
 - ▶ Eight study cases (2 periods, 4 levels of ethanol blending)
 - ▶ Two additional cases
- Model incorporates amended PM3
- Model represents *aggregate* operations of all California refineries producing gasoline
- Model calibrated to closely match reported aggregate operations of California refineries in Summer 2006

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Key premises and assumptions

- Steady-state operations (no upsets, 2006 capacity utilization rate)
- Excessed refinery streams can be sold, but at distress prices
- No degradation in emissions performance of gasolines produced for sale out of state (e.g., AZ CBG, Las Vegas gasoline)
- Price of ethanol = marginal cost of CARBOB

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Model's data content derived from . . .

- Public data on California refineries
- Technical information, in aggregated form, obtained by CEC in confidential survey of refiners
- Information and insights obtained by MathPro Inc. in confidential discussions with some individual refiners

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Aggregate refinery modeling

- Standard analytical approach in studies such as this, due to limits on time, resources, and availability of refinery-specific data
- Represents refining operations as though every refinery were "average," in terms of capacity, gasoline properties, etc.
- Tendency to "over-optimize" – to return results somewhat better than what can be achieved in practice
- Best used to estimate *differences* between cases – baseline and regulatory cases, cases denoting different levels of ethanol use, etc.

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4. Primary results and findings

Without refinery investment

Model indicates changes in CaRFG3 production capability

- 0% EtOH: Operations infeasible
- 5.7% EtOH: > 10% loss, with excessing of C₅s and FCC naphtha
- 7.7% EtOH: 2-3% loss, with excessing of C₅s
- 10% EtOH: CaRFG3 volume maintained, with excessing of C₅s

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These results likely over-state refining sector's short-term capability

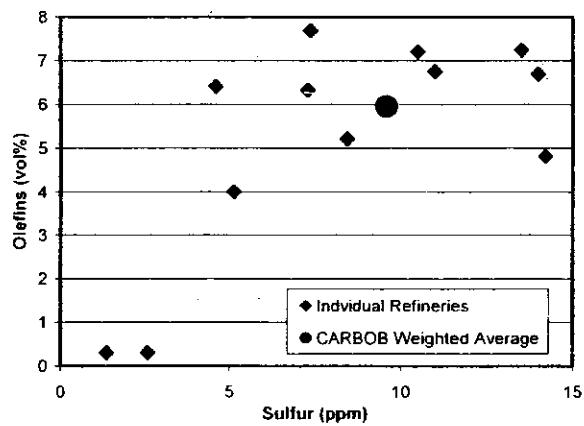
- Emissions reductions returned by PM3 are highly sensitive to changes in gasoline properties
- Over-optimization with aggregate refining model masks differences in capabilities of individual refineries
- Significant differences among California refineries in certain processing capabilities – especially with respect to sulfur control
- Sulfur is a key property affecting NOx emissions

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Average sulfur and olefins in 2006 CARBOB



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4. Primary results and findings

With refinery investment

Category	Weight Percent Oxygen			
	0.0%	2.0%	2.7%	3.5%
Refinery Investment (\$B)	1.5	0.2	-0.2	-0.2
Refining Cost (\$/g)	6.2	2.4	0	-0.3
Change in Fuel Economy (%)	0.8%	-0.2%	-0.7%	-1.5%

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Interpreting the long-term results

- Reflect refiners' investing to comply with the amended PM3 regulations *and* to meet projected demand growth to 2012
- Represent difference in refinery economics between operating under existing PM3, with 5.7% ethanol blending (*Reference case*), and operating under amended PM3 at various ethanol blending levels

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Interpreting the long-term results

- Likely to somewhat understate refining investments and costs due to over-optimization with aggregate refining model
- In particular, do not account for likely investments in sulfur control by refineries with above-average sulfur content

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Additional cases yield estimates of magnitude and effects of likely investments in sulfur control

- Aggregate refining model cannot directly estimate investment requirements of individual refineries
- But additional model runs returned estimates of total investments likely for sulfur control in refineries with sulfur content above average
- Additional runs stipulate that all medium and heavy FCC naphtha be hydrotreated

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Effects of investment in sulfur control (“long-term” cases): all Med and Hvy FCC naphtha hydrotreated

Category	Weight Percent Oxygen	
	2.7%	3.5%
Refinery Investment (\$B)	0.5	0.6
Refining Cost (\$/g)	1.5	0.9
Change in Fuel Economy (%)	-0.7%	-1.4%

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Our analysis leads to these conclusions

- Refineries likely will blend ethanol in the range of 2.7 – 3.5 wt% oxygen
- Some refineries will invest in additional sulfur control directed at FCC naphtha

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