Refining Economics of the 2007 Amendments to the Phase 3 CaRFG Regulations

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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

Overview of the presentation

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

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

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%

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)

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

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

Model's data content derived from. . .

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

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.

4. Primary results and findings

Without refinery investment

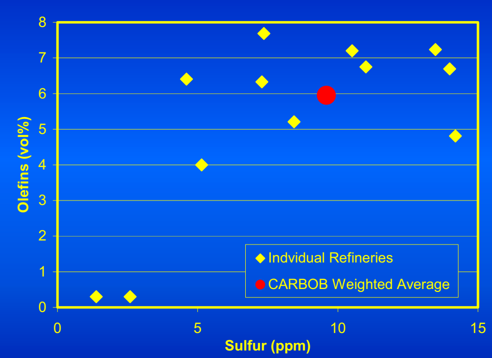
Model indicates changes in CaRFG3 production capability

- 0% EtOH: Operations infeasible
- 5.7% EtOH: > 10% loss, with excessing of C_5s and FCC naphtha
- 7.7% EtOH: 2-3% loss, with excessing of C_5s
- 10% EtOH: CaRFG3 volume maintained, with excessing of C_5s

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

Average sulfur and olefins in 2006 CARBOB



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%

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

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

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

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%

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