Implications of Residual Fuel Oil Phase Out

David J. Ramberg
and Sam A. Van Vactor
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http://globalchange.mit.edu/
How will refineries adapt to phase-out of high-sulfur fuel oils?

1. 2010 ≈40% of residual fuel oil (RFO) usage was for vessel bunkering – mostly 380 CST at 3.5% sulfur

2. Non-bunker RFO usage declining in all regions since 1980s

3. MARPOL 2010 agreement:
   1. 2010 Emission Control Areas (ECAs): only fuel < 1% sulfur
   2. 2015 ECAs: only fuel ≤ 0.1% sulfur
   3. 2020 global bunker fuels ≤ 0.5% sulfur
Only Bunker Fuel Consumption Increases

Source: EIA

http://globalchange.mit.edu/
A look at refineries (1)

• Simple vs. complex refineries
  • All refineries have atmospheric distillation tower
    • Basic cuts:
      • LPGs/Refinery gases
      • Naphthas/gasolines
        • Marketable after blending
      • Light and heavy distillates
        • Marketable after blending or further refining
      • Residuum
        • Marketable only after further processing
  • Complex Refineries have additional processing equipment for distillate and residuum processing
A look at refineries (2)

- Complex refineries
  - Catalytic cracking – convert heavier cuts into range of lighter cuts through chemical reactions
    - Residuum processing possible, but fouls catalyst, needs $$$ sulfur removal
  - Coking – convert heaviest cuts into range of lighter cuts and petroleum coke
    - Residuum broken to lighter, ultra-low sulfur cuts, plus petroleum coke
Residuum Upgrading Economics

Price Difference
Light Products & Residual Oil
Or Heavy & Light Crude Oils

ΔP₂
ΔP₁

Coker Capacity
Other Upgrading Processes
All Upgrading Capacity

SRMC

Long-Run Coker Cost
Variable Coker Cost

D₂
D₁

Quantity of Light Products Refined from Residuum

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Data for Model Testing

$\Delta P$ (heavy-light spread):
- Light crude/product price series (monthly)
  - Brent crude oil (EIA), 5/1987-2/2014
  - Los Angeles ULSD (Bloomberg), 4/1984-3/2014
- Heavy crude/product price series (monthly)
  - Maya crude oil (EIA), 1/1983-12/2013

Annual Coker Capacity (US, EIA and global, Oil & Gas Journal), 1996-2013


Coker Variable and Total Cost per barrel (FERC, Phillips), PADD 5 “representative” coking unit
Confounding Factors

Reasons why these data may not be strongly correlated:

1. Each refinery (and coking unit) unique – FERC cost data not reflective of overall market
2. Refiners may make processing decisions in advance – or require sustained price spreads before reacting
3. Changes to maximize profits for single unit might not maximize profits for full refinery
4. Integrated majors may choose to maximize crude throughput rather than refiner profitability
5. Independent refiners may have long-term take-or-pay crude supply contracts
6. Maintenance outages not likely in response to price signals
7. Capacity increases will make capacity utilization appear lower until refiner ramps up to new capabilities
Results of Empirical Test

\[ \Delta Q = \alpha + \beta((\Delta P - MC_c)_{t-3}) + \varepsilon \]

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<th></th>
<th>Coefficients</th>
<th>Std. Error</th>
<th>LCL</th>
<th>UCL</th>
<th>t Stat</th>
<th>p-level</th>
<th>H0 (2%) rejected?</th>
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<td>( \alpha )</td>
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$1$ increase in \( \Delta P - MC_c \) results in $1,700$ bbl/d increase in coker inputs to PADD 5, on average.

Preliminary Results Only – Do Not Cite
What the model suggests

1. If refiners choose not to blend to residual fuel oil, they will use cokers to upgrade residuum before using other equipment.

2. Demand for coker investment depends on balance of heavy and light crude oil production and on regulatory constraints on the use of heavy fuel oils.
Crude slates getting heavier?

- Light oils cheaper to produce, process, and transport
- Incentive to develop light crude fields first
- Large discoveries of heavy deposits (Venezuela, Canadian oil sands, etc.)
  - Massive expansion plans for Canada
- Recent discoveries of shale crudes in Bakken and Eagle Ford
  - But whether shale tech widely adoptable uncertain
- Heavier slate should imply widening price differential between heavy and light crudes
  - Heavy-light spread is key incentive for whether to upgrade residuum through coking
Potential Outcomes

• 1997-2010:
  - Coking capacity increased by 1.0 mmb/d
  - RFO consumption decreased by 2.2-2.4 mmb/d
  - Result: ≈ 50% of RFO decline replaced with coking capacity

• Implications:
  - MARPOL regs remove ≈ 3.2 mmb/d from RFO demand
  - Implies ≈ 1.5 mmb/d additional coking capacity may be needed to dispose surplus residuum
  - Rough cost ≈ $35 billion

• Alternative possibility:
  - RFO could become very inexpensive. In absence of environmental restrictions, RFO use could sharply increase in developing countries
Questions?