US Crude Supply Outlook
Implications for Refining

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Implications for Refining

Disclaimer

The authors would like to acknowledge that, although this paper draws on research and WORLD modeling undertaken for and with the US API and OPEC Secretariat, the views expressed herein are solely those of the authors.
Presentation Overview

- Activities, methodology & sources
- Crude supply outlook
- Refining outlook / implications
- Conclusions
EnSys Activities
quantitative refining analyses
20 years track record: DOE OSPR, EIA, EPA API, OPEC, major & specialty oil/chemical/catalyst companies

• Global, regional & single refinery LP modeling:
  – WORLD model includes some 150 crudes

• Recent/current project examples:
  – OPEC Secretariat:
    • Keen interest in crude price differentials
  – Bloomberg:
    • Updated & expanded netbacks system, now 130 netbacks, 39 crudes
  – World Bank, African Refiners Association:
    • Analysis of sub-Saharan African refining
    • Added / reworked 15 regional crudes

• Extensive interest in crude assays & quality
Methodology
Integrated WORLD modeling of the global supply & refining system

• Analytical results - physical:
  – Refinery throughputs, operations, crude slates, capacity additions
  – Product blending & qualities
  – Crudes, non-crudes, products, intermediates inter-regional trade movements & pipeline throughputs
  – CO2 emissions: refinery, products

• Analytical results - economic:
  – Refining $ investments
  – Marginal costs / prices of all crudes, products by region
    • relative to marker crude
  – Refining margins / crack spreads
Sources – Recent EnSys Studies

- OPEC Secretariat “World Oil Outlook 2008”

- Supply Constrained Outlook

- EPA, API, IMO marine fuels analyses
Crude Supply Outlook
global supply is increasing proportion of non-crudes – light sweet
crude slate getting lighter at least medium term

Global Crude Average API - OPEC WOO 2008

2005 2010 2015 2020 2025 2030
heavy crude supply impacts US

• Domestic heavy mixed / getting lighter
  – California declining
  – GOM rising but mainly medium
  – ANS has become lighter
heavy crude supply impacts US

- Mexican Mayan declining rapidly
heavy crude supply impacts US

• Venezuelan production open to question

[Graph showing Venezuela Crude Production from 2003 to 2019, with syncrude and conventional crude production indicated.]
heavy crude supply impacts US

- Brazilian expansion offsets Mex/Ven
heavy crude supply impacts US

• Canadian developments are key
heavy crude supply impacts US

- Saudi mix has moved lighter
  - Iran is holding heavy crude in tankers
crude supply mix impacts US

- Longer term major resources of heavy crudes exist:
  - Saudi Arabia, Iraq, Russia, other

- But medium term supply of heavies looks flat
  - Growth is in condensates & sweet crudes
Refining Impacts
global outlook for export trade

• North Sea – declines, stays essentially in Europe

• North Africa – grows, trades mainly Europe/Med, US EC/GC
• West Africa – major growth, trades to essentially all regions
• East Africa – moves to Asia, Med

• Caspian – moves mainly west, major competition in Med
• Russia FSU – growing Pacific output

• ME Gulf – balancing supplier to all regions, growth is predominantly to Asia Pacific
US regional crude slate outlooks to 2020

• PADD1
  – Retains significant sweet
    • North Sea replaced by African
  – Heavy sour (for asphalt)
  – Medium sour balance

• PADDs 2 & 4
  – Increasingly saturated with Canadian
  – Limited imports:
    • West African, Caribbean, Middle East
US regional crude slate outlooks to 2020

- **PADD3**
  - Growing GOM
  - Sustains Latin American:
    - Brazil partially replaces Mex/Ven
  - Slowly increasing Canadian
  - Rising West/North African
  - Middle East maintained (geopolitical)

- **PADD5**
  - Rising Middle East imports
  - Growing Canadian
    - Depends in part on Canadian export routes
crude supply mix impacts US

- Total western hemisphere heavy flat medium term
- Overall quality depends on syncrude mixes
  - Fully upgraded SCO contains no vac resid

### Heavy & Syncrude Supply

<table>
<thead>
<tr>
<th>Year</th>
<th>Ven syncrude</th>
<th>Canada syncrude</th>
<th>Canada heavy</th>
<th>Brazil heavy</th>
<th>Ecuador</th>
<th>Ven heavy</th>
<th>Mex hvy (EnSys)</th>
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<td>2003</td>
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crude supply mix impacts US

• Outlook from recent WORLD studies is Canadian mix too light i.e. too much upgrading upstream
  – Note Shell Canada considering not expanding Scotford upgrader and feeding DilBit? to USGC / WC refineries

• Same issue applies for Venezuela syncrude projects (now reviving?)
Canadian export routes East/West issue

- Multiple expansions proposed
Other factors are impacting US refining

• Capacity / Projects / Demand balance
  – Recent strong margins have led to 24 mmbpd of listed refinery projects
  – Assessed 6-8 million bpd likely to be on stream by 2015
  – Nearly as much (4.5-6 million bpd) associated conversion capacity of which 1.5+ coking (0.5 in USA)
  – Translates into requirement for approx 4.5 million bpd additional heavy crude for coker feed
  – Does not appear available
  – Issue of syncrude
    • No vac resid

![Coking Capacity & Additions by 2015](image)
Other factors are impacting US refining

• Capacity / Projects / Demand balance
  – Projection from WORLD studies is for declining coker utilizations through at least 2015
  – Heavy crude increments longer term may rebuild utilizations
    • Saudi Manifa + 0.9 mmbpd starting 2011
    • Other Middle East, Brazil etc. 2015+
  
  – But there is another factor weighing against coking
    • At high crude prices / under supply constraints, need to is to convert all available crude into liquid fuel not solids
      – Favors hydrogen addition, hydro-cracking
      – Especially with worldwide trend to distillates
Other factors are impacting US refining

• Demand growth
  – Predominantly in Pacific Basin
  • Not Atlantic Basin
Other factors are impacting US refining

- **Demand growth**
  - Predominantly for distillates

![Bar chart showing change in global demand from 2005 to 2020](chart.png)
Other factors are impacting US refining

- **Demand mix**
  - US-Europe gasoline / distillate imbalance set to continue

<table>
<thead>
<tr>
<th>Product demand changes and additional refinery plus biofuels output</th>
<th>USA - Canada - Europe 2007 to 2015</th>
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<tbody>
<tr>
<td></td>
<td>Demand change</td>
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<td>million bpd</td>
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<tr>
<td>Gasoline/naphtha</td>
<td>0.4</td>
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<td>Middle distillates</td>
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<td>Residual fuel</td>
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<tr>
<td>Other products</td>
<td>0</td>
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</tbody>
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*Source: OPEC World Oil Outlook 2008 Tables 7.5, 7.6*
Other factors are impacting US refining

• Demand uncertainty
  – Low demand growth outlooks look increasingly likely
    • Lead to potential increase in surplus refining capacity by 2015
Other factors are impacting US refining

- EIA data show US throughputs have already been on an easing trend
Other factors are impacting US refining

• Throughput cuts especially evident in PADD1
  – “cockpit” of gasoline competition:
    • EU refineries, eastern Canada, US Gulf
• Pressure on PADD1 throughputs evident for some time in EnSys WORLD studies
Net effects on US refining

• Refining margins & light / heavy differentials look set to decline
  – High crude prices (> $100/bbl) would help offset

• Margins / differentials will favor distillates
  – Even more so if/as IMO marine fuels regs lead to potential partial / total conversion from IMO to MGO/MDO

• Gasoline adverse situation exacerbated by:
  – EU continuing (if slowing) dieselization
  – US ethanol growth / emphasis / regs
Net effects on US refining

• Current US projects
  – Emphasize hydro-cracking
  – But will still significantly boost gasoline output in a region that
    • projects little incremental demand net of ethanol
    • Must compete with rising supply / surplus from Europe, Canada east
Net effects on US refining

• Geographic contrast
  – Pacific basin – predominantly non-OECD
    • Continued growth expected (+/- 2% p.a.)
    • Demand growth reasonably balanced across product range
    • Mid conversion projects look broadly in line with demand growth
    • Additional capacity needed by 2011/2012 beyond firm projects
  – Atlantic basin – predominantly OECD
    • Minimal demand growth plus dieselization in EU
    • Moderate demand growth in US but rising ethanol (& biodiesel) supply
    • Firm projects are contributing to supply surplus / imbalance
And these assessments were pre financial crisis

- EIA and IEA continue to revise down US, Europe, OECD demand for 2008, 2009
  - but latest adjustments do not take full account of crisis
Conclusions
Conclusions

- Condensates, NGLs, biofuels, CTL/GTL are bringing increasing light streams into supply
- At same time, sweet crude supply rising while heavy crude growth limited – medium term
- Potential excess coking until/unless heavy crude increases longer term
- Issue of where to do syncrude upgrading
- Multiple supply / demand impacts on US refining
- Difficult outlook for US refining