Crudes Oils & Refining – Outlook and Impacts of Regulations

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Crude Oil Quality Association (COQA)
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Overview

• Global downstream outlook
  – Where we are - Recession’s impacts
  – Drivers in future supply, demand, refining
  – Potential legislative impact – marine fuels
  – Implications for heavy/opportunity crudes

• Energy / climate legislation
  – Status & prospects: Europe, USA and other regions
  – Potential to re-arrange refining and oil markets
  – Implications for heavy/opportunity crudes

• Summary comments
EnSys Energy

• 40 years of experience – refining, engineering back grounds

• Focus on regional and especially global integrated studies using our WORLD model
  – Bottom up detail matched to top down scenarios
WORLD Model Overview

**INPUTS**
- Global petroleum product demand and quality by type and region.
- Crude and non-crudes production and pricing. World oil/marker crude price.
- Existing refining capacity and known projects by region and type.
- Pipeline, marine and port to port transportation costs. World-Scale basis.

**ANALYSIS**
- Emulates the activities and economics of the petroleum industry.
- Captures the interactions between crude supply, refining, product demand and pricing.
- Simulates and interlinks each of the World’s major refining regions.
- Employs EnSys’ proprietary RTEC refinery model.

**OUTPUTS**
- Refinery operations, product blending, and capacity additions.
- Prices for all crudes, non-crudes, and products by region, vs. marker.
- Refining spreads and margins. Refining investments.
- Inter-regional crude and product trade.
Global Modeling “Total Liquids”

- WORLD calculates 22 global refining regions and captures their interactions on a global scale

Study used version with US sub-regional refining detail
Recession’s Impacts - Demand Loss

- 4 million bpd demand loss for 2010, 8 million for 2015/2020 versus prior expectation

### Projected Demand Loss
AEO 2009 Stimulus - AEO 2007

- 2006
- 2008: 4 million bpd
- 2020: 8 million bpd
- 2025
- 2030
Recession’s Impacts -
Refining economics reverse - again
• Refining’s golden age short-lived
Recession’s Impacts -
Pre-recession refinery projects still under way

- Announced refinery projects have steadily risen:
  - early 2007 - 14 mb/d
  - early 2008 - 20 mb/d
  - early 2009 - 35 mb/d

- 6 mbpd actual expansions expected by 2015
  - Mainly capacity already under construction
  - Sustains capacity overhang, low utilizations

Source: OPEC World Oil Outlook 2009
Recession’s Impacts - Capacity Overhang

• Implication is significant refinery closures
  – Emphasis on USA, Europe, Japan
    • Refineries that are smaller, inefficient, gasoline oriented, no specialty products/petrochemical integration, no geographic protection, no local crude
      – n.b. 200,000bpd / 10 mtpa is no longer “big”
    – 3+ million bpd of closures needed to restore regional refinery utilizations to 80-85% level by 2015
  
• This would not be the first time
  – 1980’s global capacity dropped by 9 mbd from 82 to 73 mbd
Recession’s Impacts – Growing Competition

- Increasing inter-regional competition for product markets:
  - Capacity surpluses / imbalances in USA and Europe
    - US product exports have nearly doubled since 2005
    - Europe drive to export gasoline
  - New large scale export refining capacity
    - India: Reliance / Essar
    - Middle East: ARAMCO
  - High crude prices make product/crude relatively cheaper to move long distance
    - Effect augmented by short term tanker over-supply, depressed freight rates
Looking Ahead- Baseline Outlook is Tough

• Severe reversal for refiners from growth/tightness to surplus/poor margins
  – Collapsing demand has lead to an oversupply of product
  – Continued refinery investments and biofuels growth are exacerbating excess refining capacity
  – Prospects for poor margins and closures – especially OECD / Atlantic Basin
Looking ahead –
Global crude slate quality relatively stable

- Slowly declining proportion of sweet/light crudes
- Slowly rising heavy
  - Oil sands / Ven Orinoco offsetting dropping Mex/Ven conventional
- Gradually rising proportion of medium gravity
- Rising opportunity crude volumes

Source: OPEC World Oil Outlook 2009
Looking ahead – Non-crudes grow in importance

- Strong growth of NGL’s, condensates, biofuels
- Rising proportion of non-crudes in total supply

* Including other natural gas based streams like hydrogen, methanol and petrochemical returns.

Source: OPEC World Oil Outlook 2009
Looking ahead –
Non-crudes cut refining, upgrading needs

- Non-crudes:
  - Are mainly light clean streams
  - Satisfy around half of the growth in liquids demand
  - Reduce need for refinery production and upgrading

Growth in Non-crudes Supply and Total Oil Liquids Demand vs 2010

- Non-crudes: NGL's, condensates, biofuels, CTL/GTL, petchem returns, other

<table>
<thead>
<tr>
<th>Year</th>
<th>Non-crudes growth</th>
<th>Oil demand growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>4.5</td>
<td>10.0</td>
</tr>
<tr>
<td>2020</td>
<td>6.5</td>
<td>12.0</td>
</tr>
<tr>
<td>2025</td>
<td>12.0</td>
<td>15.0</td>
</tr>
<tr>
<td>2030</td>
<td>20.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>
Looking Ahead –
Demand growth emphasizes distillates

- Projected to resume growth dominance – n.b. marine fuels

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**Global product demand changes between 2008 and 2030**
*(Source: OPEC World Oil Outlook 2009)*

*Includes refinery fuel oil.

**Includes bitumen, lubricants, waxes, still gas, coke, sulphur, direct use of crude oil etc.*
Looking Ahead –
Land-based fuels quality tightening continues

- OECD regions relatively stable at ULS standards, but:
  - US, possible “national clean gasoline”, EPA revised ozone standard
  - Europe: Euro VI, marine fuel ECA’s, in port rule

- Non-OECD progressively moving to EURO III/IV/V standards
Looking Ahead – Demand Growth is in non-OECD

- Atlantic basin demand flat
- Bulk of growth in Pacific basin

_Growth in oil demand, 2008–2030_

- OECD oil demand peaked in 2005
- 79% of the net growth in oil demand is in developing Asia

Source: OPEC World Oil Outlook 2009
Looking Ahead - Marine fuels regs could have massive impact on demand / quality

- Official statistics seriously understate global marine fuel consumption
  - Recent work by Navigistics & others estimates demand at around 370 million tpa (6.7 mmbpd) twice that reported by the IEA
    - assessment is supported by IMO
  - Implication is around 450 mmtpa, 8.2 mmbpd, by 2020 of which 6 mmbpd is IFO
  - IEA acknowledge the issue
    - misreported barrels
Looking Ahead - Marine fuels regs could have massive impact on the downstream

- Recent MARPOL AnnexVI regulations set out a timetable for improved marine fuel environmental performance – standards are SOx, PM, NOx

  - Today’s MGO/MDO can readily be desulfurized to 0.1/0.5%
  - But IFO must be converted to distillate to meet 0.1/0.5%

**Proposed implementation schedule has four steps**
Ratified at the October 2008 IMO MEPC meeting

1. All ECA 1.0% S (July)
2. Global cap 3.5% S (January)
3. All ECA 0.1% S (January)
4. Global cap 0.5% S (January)

Global cap 4.5% Baltic and North Sea SOx ECA 15%
Looking Ahead - Marine fuels regs could have massive impact on the downstream

• Annex VI rule is clearly written but leaves open major uncertainties:
  1. Future extent of ECA’s
  2. Timing of global 0.5% rule (2020 / 2025?)
  3. Potential extent of compliance by use of low sulfur fuel versus on-board scrubbing

• Current scrubber sea trials could mean their commercial potential will be clearer with the next 1-2 years
  – Scrubbers could enable SOx standards to be fully met with existing fuel mix, may be needed for PM
  – Outlook is anything from limited fuel change (0.1% MGO/MDO for current ECA’s) to total IFO conversion
  – Uncertainty leads to “wait and see” by refiners and shippers
  – But implementation by 2020/2025 requires long lead times
Looking Ahead - Marine fuels regs could have massive impact on the downstream

- Depending on scrubber success, refiners are likely to see either partial or total shift from IFO (residual) bunkers to marine distillate
  - Studies by EnSys for EPA, API and IMO showed related additional upgrading capacity needed
    - Still substantial even if conversion only partial
    - Major implications for upgrading capacity, utilization, coke production

### Impacts of Total Global IFO Conversion to Marine Distillate

<table>
<thead>
<tr>
<th></th>
<th>EnSys WORLD Model</th>
<th>EnSys IMO 11/2007 Report</th>
<th>Current Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFO converted 2020 mmtpa</td>
<td>381</td>
<td>354</td>
<td></td>
</tr>
<tr>
<td>IFO converted 2020 mmbpd</td>
<td>6.75</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td><strong>Global refining capacity impacts million bpcd</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>crude distillation</td>
<td>1.6</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>vacuum distillation</td>
<td>5.8</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>coking</td>
<td>2.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>hydro-cracking</td>
<td>6.7</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>sulfur tons pd</td>
<td>28,140</td>
<td>26,150</td>
<td></td>
</tr>
<tr>
<td>Incremental investment $bn</td>
<td>$150</td>
<td>$150+(1)</td>
<td></td>
</tr>
<tr>
<td><strong>Incremental pet coke output million tpa</strong></td>
<td>47</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

(1) Construction costs have since risen
Looking ahead –
Refining margins depend on configuration

• Gasoline/naphtha projected to be in surplus, depressed margins, distillate re-strengthens

*Price differentials for major products*
*Historical and projected*

Source: OPEC World Oil Outlook 2009

*Made little difference whether refinery produced gasoline or distillate*

*Makes major difference whether refinery produces gasoline or distillate*

*Price differentials are for Rotterdam market calculated versus Brent.*
Looking ahead –
Refining margins depend on configuration

• Unlike pre 2005, distinct margin differences depending on whether refinery emphasizes gasoline or distillates
  – **Upgrading:**
    • FCC, coking surplus, lower margins
      – FCC increasing resid feed, distillate yield
    • Hydro-cracking / distillates in demand, higher margins
      – High crude prices relative to gas, coal/coke create incentives for less carbon rejection, more hydrogen addition
  – **Quality:**
    • Premiums remain for high quality products
  – **Scale:**
    • Larger refineries (300,000 – 600,000 bpd) drive economies of scale (e.g. Reliance)
Looking ahead –
Relative crude, gas, coal prices a driver

• Potential for continued high price of raw material (crude) relative to coal/fuel grade coke, natural gas alters historical relationship
  
  – Makes carbon rejection (coking, FCC) less attractive
  
  – Hydrogen addition (hydro-cracking / HDS) more attractive
    
    Which also fits with trend to distillates and LS/ULS products

Crude:NGS
Outlook: 12 – 16:1
Recent history 8-9:1
Btu equivalent 6:1
**Looking Ahead – Implications for heavy/opportunity crudes**

<table>
<thead>
<tr>
<th>Driver / trend</th>
<th>Impact on opportunity crudes value relative to markers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand growth mainly light products</td>
<td>Depress/wider differentials</td>
</tr>
<tr>
<td>Rising volume of marine fuel</td>
<td>Raise/narrower differentials</td>
</tr>
<tr>
<td>Potential marine fuel conversion to distillates</td>
<td>Depress</td>
</tr>
<tr>
<td>Rising importance of non-crudes (mainly clean light)</td>
<td>Raise</td>
</tr>
<tr>
<td>Refinery expansions</td>
<td>Raise</td>
</tr>
<tr>
<td>Refinery closures</td>
<td>Minor</td>
</tr>
<tr>
<td>High crude price of itself &amp; vs. coal</td>
<td>Depress</td>
</tr>
</tbody>
</table>
Energy/Climate Policy – Regulatory Emphasis is Shifting

• 1990’s / early 2000’s
  – Strong emphasis on fuels qualities / air emissions controls:
    • US: RFG/oxy/ULSG/D, EU: Euro III/IV/V
    • SOx, NOx, CO, HC, toxics, ozone, PM
    • Other regions: adopting Euro standards
    • Marine fuels: MARPOL Annex VI

• Mid / late 2000’s
  – Energy efficiency
  – GHG emissions
  – Energy security

Inherent conflict as fuels quality regs lead to more refinery processing
Energy/Climate Policy - Europe

• Climate Action & Renewable Energy Package “20 by 2020”
  – 20% renewables by 2020
  – 20% GHG reduction below 2005 by 2020
  – Expand Emissions Trading System (EU ETS)

• Vehicles Emissions Performance Standards
  – 40% CO₂ emissions reduction in new vehicles by 2020

• Fuel Quality Directive (Dec 2008)
  – Reduction in life cycle greenhouse gas emissions from energy supplied
    • “binding target” of 6% possibly going to 10% by 2020
      » 2012 review
    • 10% ethanol in gasoline, inland waterway fuel 10ppm Jan 2011
Energy/Climate Policy - Europe

- Climate Action & Renewable Energy Package “20 by 2020”
- ETS third phase (2013) introduces new concepts, limits
  - Acknowledges risk of “carbon leakage”
  - But lowers carbon allowances for EU refiners
  - Introduces benchmarking, planned CONCAWE/Solomon scheme
    - Likely to force closures, also switching of refinery fuel from resid to natural gas

**ETS targets for refining sector**

[Graph showing ETS targets for refining sector]

**ETS refining benchmark curve**

[Graph showing ETS refining benchmark curve]
Energy/Climate Policy - Japan

• Long history of climate action & efficiency
  – 1997 Keidanren voluntary cap & trade
  – 2005 voluntary ETS, expanded 2008
    • Covers 70% of industry
  – 2009 Innovation for Green Economy & Society Bill
    • Stimulate energy efficiency, nuclear, renewables
  – 2010 draft comprehensive cap & trade legislation
    • Carbon tax starting 2011, opposed by industry

• 2010 Refinery upgrading rule
  – METI rule requires refiners in Japan to increase resid upgrading ratios – and/or close distillation capacity
    • Impact uncertain but primary effect could be closures
      – Up to 1.3 million bpd needed to balance supply and demand
Energy/Climate Policy - China

- Has opposed emissions cap
  - But moving to increase energy efficiency, renewables
    - Wind, solar – but also CTL output
  - Experimenting with cap & trade, carbon tax schemes
  - Goal to cut carbon intensity 40-45% by 2020
    - Stimulate energy efficiency, nuclear, renewables

Energy/Climate Policy - Canada

- Kyoto signatory but wait & see pending US legislation
  - Most provinces – but not Alberta – potentially covered under US/Canada Western Climate Initiative
  - Focus more on carbon tax than cap & trade
  - BC initiative
Energy/Climate Policy - USA

• **Multiple initiatives**
  – Administration “command & control”
    • RFS-2, CAFE, EPA GHG Tailoring Rule, (EPA ozone)
  – **Federal cap & trade**
    • Passed house May 2009, apparently dead in Senate
  – **States/Regions cap & trade**
    • California, western states, midwest, northeast
  – **Federal & States Low Carbon Fuel Standard**
    • California: AB32
    • Northeast states: MoU Dec 2009
    • EISA 2007: Section 526, federal fuels
      » (was component of W-M – could reappear)
Energy/Climate Policy - USA

- **RFS-2 Renewable fuel standard**
  - *Energy Independence & Security Act, 2007*
  - *Greatly increases total mandated renewable fuel consumption vs RFS-1*
    - 36 billion gpy by 2022
    - = 2.3 million bpd
    - displaces energy of 1.3 million bpd conventional gasoline
Energy/Climate Policy - USA

• National Fuel Efficiency Program
  – Obama Administration, May 2009
  – Requires 35.5 mpg “CAFE” national new vehicle standard by 2016

• Compares to 28.2 2009 CAFE standard and about 25 mpg in 2009 for total US light vehicle fleet
• Equates to approx EU fleet today

Average Required Fuel Economy (mpg) under Proposed Standards

- Passenger Cars
- Light Trucks
- Combined

- 2012
- 2013
- 2014
- 2015
- 2016
Energy/Climate Policy - USA

- **EPA**
  - **Mandatory CO₂ reporting from 2010**
    - Foundation for GHG programs
  - **GHG Tailoring Rule (NPRM Sept 30th 2009)**
    - Supreme Court ruled CO₂ comes under Clean Air Act
    - First phase 14,000 large emitters > 25,000 tpy CO₂ e
    - 68% of stationary source emissions
  - **Revised Ozone Rule (NPRM Jan 6th 2010)**
    - 65-70 instead of 75 ppb standard
    - Aug 31st, 2010 - EPA target for Final Rule
    - August 2011 – final area designations
    - Implementation: 2014 – 2031 depending on severity
    - Implications for NOx, VOC, more low RVP gasoline
Energy/Climate Policy - USA

• Regional Emissions Trading Regulation
  – 3 Regional Blocs have emerged
Energy/Climate Policy - USA

• Several initiatives include Low Carbon Fuel Standard (LCFS)

• Energy Independence & Security Act, Sec. 526
  – Fuels to military, other Federal agencies must have life cycle GHG emissions <= conventional

• California AB32
  – Cuts carbon intensity 10% by 2020
  • Requires assessment of CO₂ footprint on life-cycle “well to wheels” basis (not just fuel carbon content)

• Northeast & mid-Atlantic (11) States
  • Memo of Understanding, Dec 29th 2009
Energy/Climate Policy - USA

LCFS: Combustion is primary life cycle GHG contributor

Figure ES-3. Life Cycle GHG Emissions for Conventional Transportation Fuels in kg CO₂E per MMBtu LHV Fuel Consumed

Energy/Climate Policy - USA

- LCFS: but much of focus has been on production
Energy/Climate Policy - USA

• Federal climate bills
    • “American Clean Energy and Security Act”
    • Cap & trade
  – Kerry-Boxer, Senate Bill, drafts Sept, Nov 2009
    • “Clean Energy Jobs and American Power Act”
    • On-going negotiations
    • Passage of cap & trade bill questionable in 2010
Climate Legislation is Likely to Rearrange Oil Markets

- Carbon allowance costs / taxes will act to raise refinery energy/hydrogen efficiencies but scope is limited
  - Several areas of potential exist:
    - Heat integration, co-generation
    - New technologies for heat exchanger cleaning / performance and for inspection
    - Process catalysts operating at lower P, T, H2 consumption
    - H2 plant higher efficiencies, (possible CCS)
  - But high crude/fuel prices arguably will drive part of this anyway
  - Potential may be 10% to possibly 20% over time
  - Cannot “wish away” the energy/H2/processing disadvantages of heavy/opportunity crudes
Climate Legislation is Likely to Re-arrange Oil Markets

- Depending on the way legislation is written, could relocate refining capacity over time
  - Generally out of OECD into non-OECD regions
    - Results from EnSys’ 2009 study of Waxman-Markey for the API illustrate
  - Produce more refinery CO2 “leakage” than reduction

Source: EnSys study of Waxman-Markey for the API 2009
Climate Legislation is Likely to Re-arrange Oil Markets

- Light/heavy crude differentials widen

![Impact of Carbon Allowance Cost on WTI-Mayan Crude Differentials](source: EnSys Waxman-Markey Analysis)
Climate Legislation is Likely to Re-arrange Oil Markets

- Carbon regime regions, e.g. US, Europe, likely to take in more light, sweet crude, less heavy, sour
  - Changed crude trading patterns
  - Less upgrading in carbon region refineries
  - Investments in heavy crude refineries hardest hit
- LCFS likely to further extend these impacts
  - e.g. Canadian oil sands, Ven syncrudes to US

![Impacts of Carbon Cost on Refining Investments - to 2020](chart.jpg)

Source: EnSys Waxman-Markey Analysis

<table>
<thead>
<tr>
<th>Type</th>
<th>Base</th>
<th>Low Cost</th>
<th>High Cost</th>
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<tbody>
<tr>
<td>Large/Heavy</td>
<td>$70</td>
<td>$40</td>
<td>$10</td>
</tr>
<tr>
<td>Medium/Cracking</td>
<td>$10</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>Small</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
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</table>
Climate Legislation is Likely to Rearrange Oil Markets

- Carbon regimes (and the often related transport efficiency measures) cut demand
  - IPCC scenarios show the potential for demand reduction and differences between OECD and non-OECD
    - A recent EPA study projected potential for US transport fuel demand reduction of 4-7 mmbpd by 2030 versus “reference” outlook
    - Adding demand and price differential factors together, carbon legislation could cut opportunity crude production
## Climate Legislation - Implications for heavy/opportunity crudes

<table>
<thead>
<tr>
<th>Climate legislation impact</th>
<th>Impact on opportunity crudes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crude valuations:</strong> Shift to reflect carbon content / LCFS profile</td>
<td>Heavy / opp crudes values drop relative to markers / light sweet</td>
</tr>
<tr>
<td><strong>Crude trade:</strong> Incentives to move heavy/opp crudes out of carbon regime regions, light sweet crudes in, medium grade (Middle East) crudes balance</td>
<td>Latin American crudes to China, India, other? Canadian oil sands to Asia? California heavy grades to Asia?</td>
</tr>
<tr>
<td><strong>Crude runs:</strong> Potentially cut in carbon regime areas, increased outside</td>
<td>Reinforces potential routing changes for heavy / opp crudes</td>
</tr>
<tr>
<td><strong>Supply/demand:</strong> Carbon regimes aim to cut oil products demand, raise alternative fuels supply</td>
<td>Reduced need for, value of / production of heavy / opp crudes</td>
</tr>
</tbody>
</table>
Summary Comments

2010/2012: Key time

- We are in a period of exceptional uncertainty and potential for change
- 2010-2012 could be a key period for achieving some form of clarification:
  - Hopefully post-recession economic growth more set
  - Production.exports progress: WCSB, ESPO, Orinoco, Kuwait, Iraq
  - Marine fuels – scrubbing potential, ship efficiency/CO2 measures
  - Progress in EU on new carbon rules and implementation
  - Japan, Australia, China initiatives
  - US new energy legislation, Federal “energy” else regional??
- A clearer picture for crude producers & refiners 2+/- years from now?
Thank you!

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