Bottom of the Barrel Conversion

What does the future hold?

Nicola Knight
Regional Consulting Operations Manager - EFA
Bunker shifts from by-product to ‘on-purpose’ product

**TODAY**

Crude purchases to produce the highest value of regulated products at the “lowest” cost given the asset configuration

Bunker fuel is a by-product, if the refiner could make high value product they would

**TOMORROW**

- On purpose bunker production means
  - Higher priced, low sulphur crude
  - Major capital investment for bottoms upgrading and desulphurisation
  - Capacity rationalisation
  - Its cost → build or buy

Not all crudes are created equal, i.e. not all crudes or blends of crude make an acceptable IMO Fuel
Anticipate European and USA compliance to be very high in 2020.

**BEYOND 2020**

Expect full global compliance by 2025
Less compliance initially due to availability of global fuels and weaker regulation

**EXPECTATION 2020**

European ports already have a 0.1% requirement
EU water regulations strong with common rule book since 2012
North Sea, English Channel and Baltic at ECA-level compliant (0.1% S) since 2015
Shift In global refining

Decreasing crude quality, increasing hydro-processing / conversion / maximum value lift

Simple
Hydroskimming
Economics unfavorable
- Crude diet limited to sweet options
- Nelson CI 5 or less

Cracking refinery complex with HS Bunker product at risk
- Crude diet low to medium sour to blending to HS Bunker
- Nelson CI 6 to 9

Full conversion refinery positioned for profit
- Crude diet only limited by metallurgy and hydroprocessing assets
- Nelson CI 9 to 12

Full conversion integrated Petrochemical complex insulated from nearly all threats
- Complete crude diet flexibility
- Nelson CI 13 plus
Changing Market Drivers and Consumer Demands

• Petrochemical and LNG
  • Demand increasing globally

• Motor Fuels:
  • EU and North America: flat to declining
  • slight increase in South America.
  • Increasing in East

• Pet coke:
  • Biggest players are India and China.
  • Power Generation decline – switch to gas.
  • Growth Industries (by 2025): Cement (7%), Steel (8%) and Aluminium (4%)
Future of Heavy Carbon Rich Fuel sources?

Global Fuel Oil Demand

Share of Total Oil Product Demand

Historical Decline

Potential Utility Demand

Continuing the Decline

Historical Decline

Potential Utility Demand

Continuing the Decline

Share %

mil bpd

0% 2% 4% 6% 8% 10% 12%

0% 2% 4% 6% 8% 10% 12%

2005 2010 2015 2020 2025

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Technology Development: What are the bottom of the barrel options?

- **Vac Res**
  - Coking - Delayed or Fluid / Flexi
    - Conversion to C3+ ≈ 75-78 wt%
  - Resid FCC
    - Conversion to C3+ ≈ 85-90 wt%
  - SDA
    - Conversion to C3+ ≈ 95-98 wt% \(^1\)
  - Resid Hydrotreating Eb Bed / Slurry Hydrocracking

- **Vac Res**
  - Hydrogen Addition

- **Additional processing required for all options**
  - 25-35 wt% Coke
  - 5-10 wt% Coke

\(^1\) Advertised
Global Technology Choices

Emerging

- Delayed Coker Expansions in US / EU
  - Proven technology and access to discounted sour crude
    - US: Canadian WCS
    - EU: will be Urals (IMO impact)

- Mix of Technologies in the East
  - Delayed Coking in India
  - Slurry Hydrocracking in China / Russia
  - Flexicokers re-emerging

- Factors
  - Cost
  - Reliability of technology
  - Disposition of coke (will it be banned?)
The reality

- Renewables (bio diesel / ethanol) still emit CO₂
- Wind / Solar power are inconsistent to a population that demands consistency
- Infrastructure does not and will not sufficiently exist for 30 years.

Oil use continue forward

- Fuel flat to decline
- Plastics increasing overall

What does this mean to bottom of the barrel?

- Light Crude vs Heavy Sour
- What technology options are available for managing the bottom of the barrel efficiently

Future Refining Drivers

Environmental & Energy Efficiency - Reducing CO₂ Emissions

- Crude & Operation Efficiency & Flexibility

- Technology Development

Proprietary Information
Future Refinery Efficiency Drivers to maintain Asset Performance

• There is no easy solution or answer, but it will be a combination of initiatives
• Decisions will be driven by margin
• **Crude Flexibility**: Ability to process a wide range of crudes – optimise supply chain
• Integrating Process and Energy solutions – robust modelling solutions to drive real-time process and energy optimisation
• **Flexible Operations**: ability to adapt to the market changes
• Technology Options: cost and maturity is limiting the pathway to adopting hydrogen approach
• Strong Operational Excellence: Utilising the latest software to improve reliability and margin (Digitalization).
Future Refinery Optimization

- **Production Accounting**
  - Corrected data

- **Data Reconciliation**
  - Raw data

- **Rigorous Simulation**
  - Corrected data

- **Operational Planning**
  - Corrected model
  - Corrected data

- **Supply Chain Scheduling**
  - Corrected model
  - Corrected data
    - Crude selection
    - Product trades
    - Expected profitability
  - Corrected data
    - Set targets
    - Plan movements
    - Confirm shortfalls / surpluses

- **Process and Offsites Control & RTO**
  - Corrected data
Shared Digital Twin in the cloud facilitates integrated optimisation environment
Improving Process and Energy Operating Costs

- Historically designed and modeled in isolation by completely different teams.
  - Data transfer manual and iteratively:
    ▲ Increased capital cost.
    ▲ Increased operating costs due to oversized equipment.
  - Utilities and off-sites represent a major cost:
    ▲ 40% of capital costs.
    ▲ Over 60% of operating costs.

- Process and energy systems are tightly integrated:
  ▲ A major compressor which limits the unit throughput is constrained by a turbine.
  ▲ The turbine is further constrained by steam supply and cooling water availability.
Example cat cracker model, with unit optimizer to determine optimum daily operating targets.

Unit steam objects included.

Major turbine driving wet gas compressor constrains the unit.
Petro-SIM breaks through the arbitrary boundaries between process and utility modeling by creating a truly integrated simulation tool.

Using this approach allows you to:
- Debottleneck production by 2-3%
- Reduce energy use by 5-15%
- Save capital in new designs, increases your total project IRR by 1-2%

Achieved in a quicker design cycle, with fewer risks, errors and re-work.
The future involves industry becoming more efficient – regardless of technology choice

- Reduced variable costs and energy efficiency.
- Consider raw material to finished product and the value chain optimization
- Being responsive and agile through Digitalization
Thank You

Nicola Knight
Regional Consulting Operations Manager - EFA

+44 1932 236289
NKnight@kbcat.com
www.kbc.global

Excellence

is never an accident. It is always the result of high intention, sincere effort, and intelligent execution; it represents the wise choice of many alternatives - choice, not chance, determines your destiny.