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REFCOMM
ROTTERDAM
30 September–3 October 2019

Bottom of the Barrel Conversion

What does the future hold?

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Bunker shifts from by-product to 'on-purpose' product

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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

European and USA compliance to be very high in 2020.

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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

BEYOND 2020

Expect full global compliance by 2025

Less compliance initially due to availability of global fuels and weaker regulation

Anticipate European and USA compliance to be very high in 2020.

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

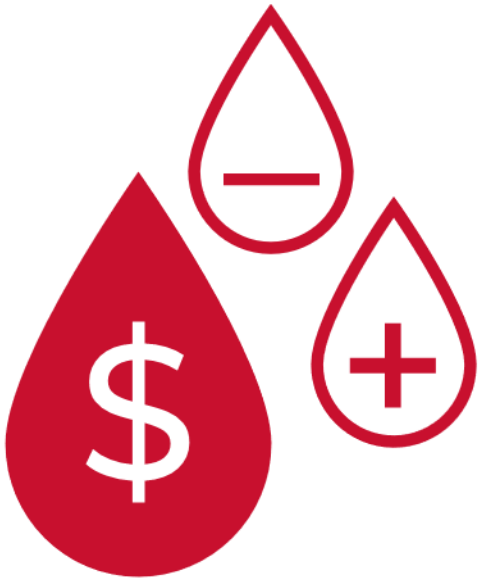
Full conversion refinery positioned for profit

- Crude diet only limited by metallurgy and hydroprocessing assets
- Nelson CI 9 to 12

Full conversion integrated Petrochemical complex insulated from nearly all threats

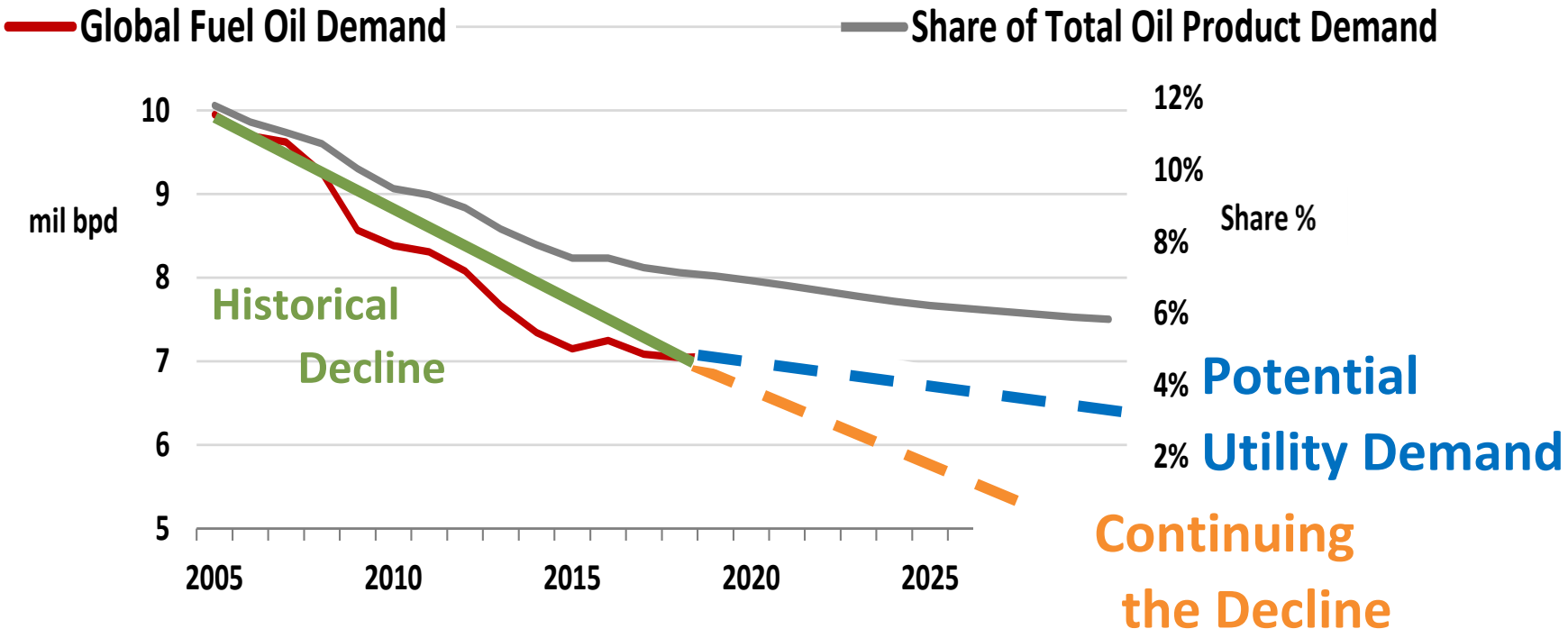
- Complete crude diet flexibility
- Nelson CI 13 plus

Changing Market Drivers and Consumer Demands

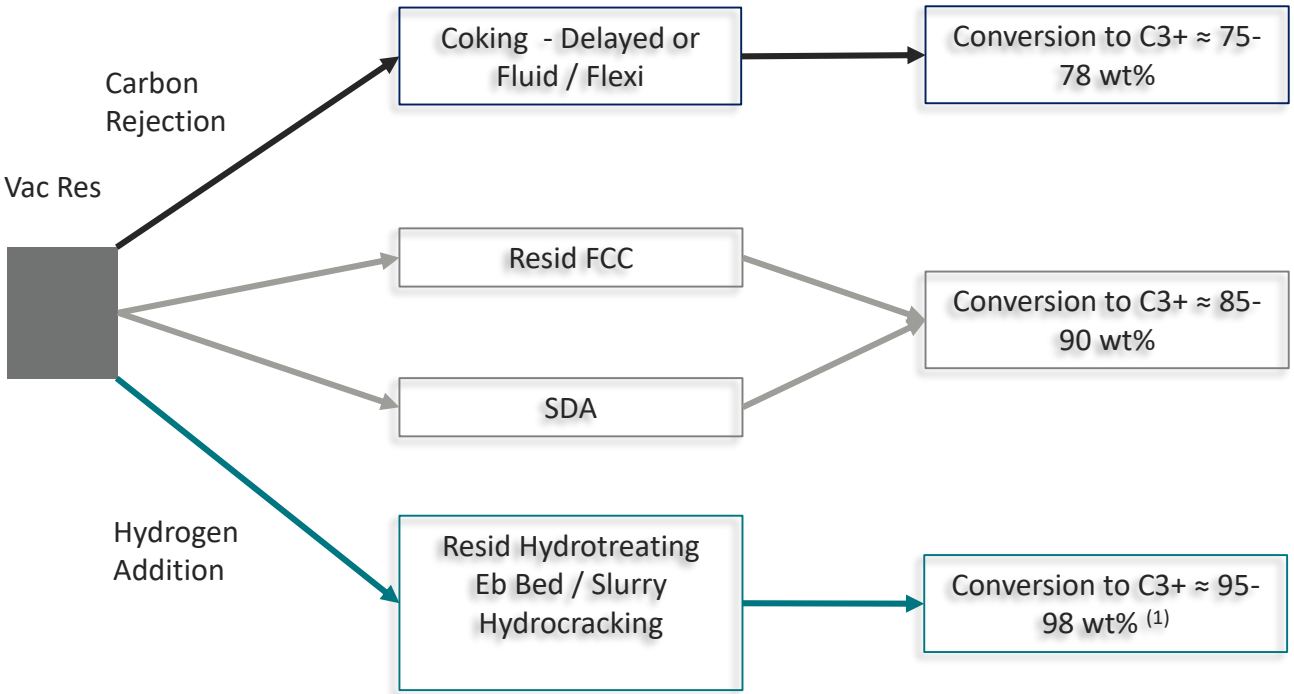


- **Petrochemical and LNG**
  - Demand increasing globally
- **Motor Fuels :**
  - EU and North America: flat to declining
  - Slight increase in South America
  - Increasing in East
- **Pet coke:**
  - Biggest players are India and China.
  - Power Generation decline – switch to gas.
  - Growth Industries (by 2025): Cement (7%), Steel (8%) and Aluminium (4%)

Future of Heavy Carbon Rich Fuel sources?



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



25-35wt% Coke

Additional processing required for all options

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 CO_2
- 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

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Future Refining Drivers

Environmental & Energy Efficiency - Reducing CO2 Emissions

Electrification

Future Refinery Efficiency Drivers to maintain Asset Performance

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- There is no easy solution or answer, but it will be a combination of initiatives
- All decisions will be driven by **margin & flexibility**
- Short Term Operation:
  - Crude Flexibility
  - Real-time process & energy optimisation
  - Flexible Operations
  - Digitalization
- Longer Term Investment:
  - Electrification
  - Crude availability
  - Product demand

Short Term Operation – the future?

- Day to day refinery optimisation
- Digital Twin
- Real time process & energy optimisation

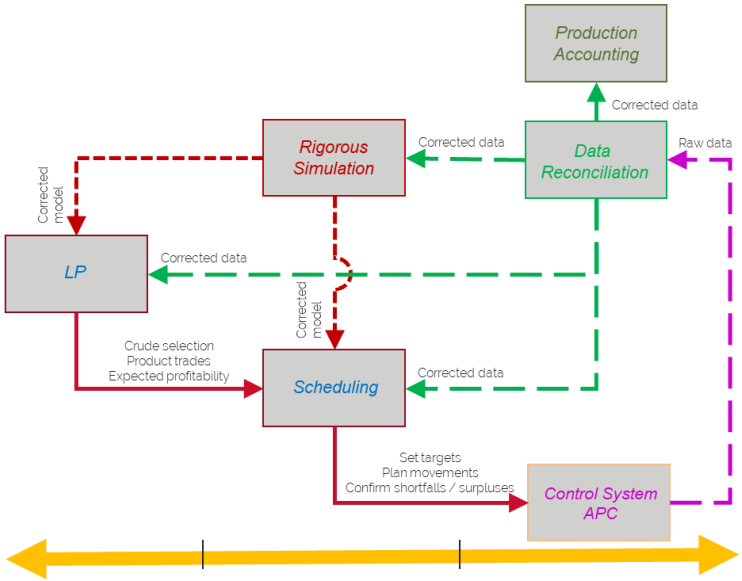
Refinery Optimization

Today

Highly manual and dependent on skilled process engineers with subject matter expertise.

- Linear model has limited range of validity.
- Updating/synchronization of process, LP and scheduling models is time-consuming and SME dependent.
- Largely heuristic reconciliation process
- Data siloed, difficult to manage, different versions of the truth
- Control strategies not updated with schedule changes
- Limited integration between tools

Traditional Organization → Knowledge based Organization



Future

Invoke machine learning and/or cognitive computing functions, using live data, to deliver a step change in refining optimization.

- Data driven, automated identification of optimization using advanced computing.
- Intelligent, automated work processes
- Automated data management and tool integration
- One version of the truth
- Cloud enabled to facilitate;
  - Scalability
  - Collaboration
  - Support
  - Rapid development and delivery of enhancements

Shared Digital Twin in the cloud facilitates integrated optimisation environment

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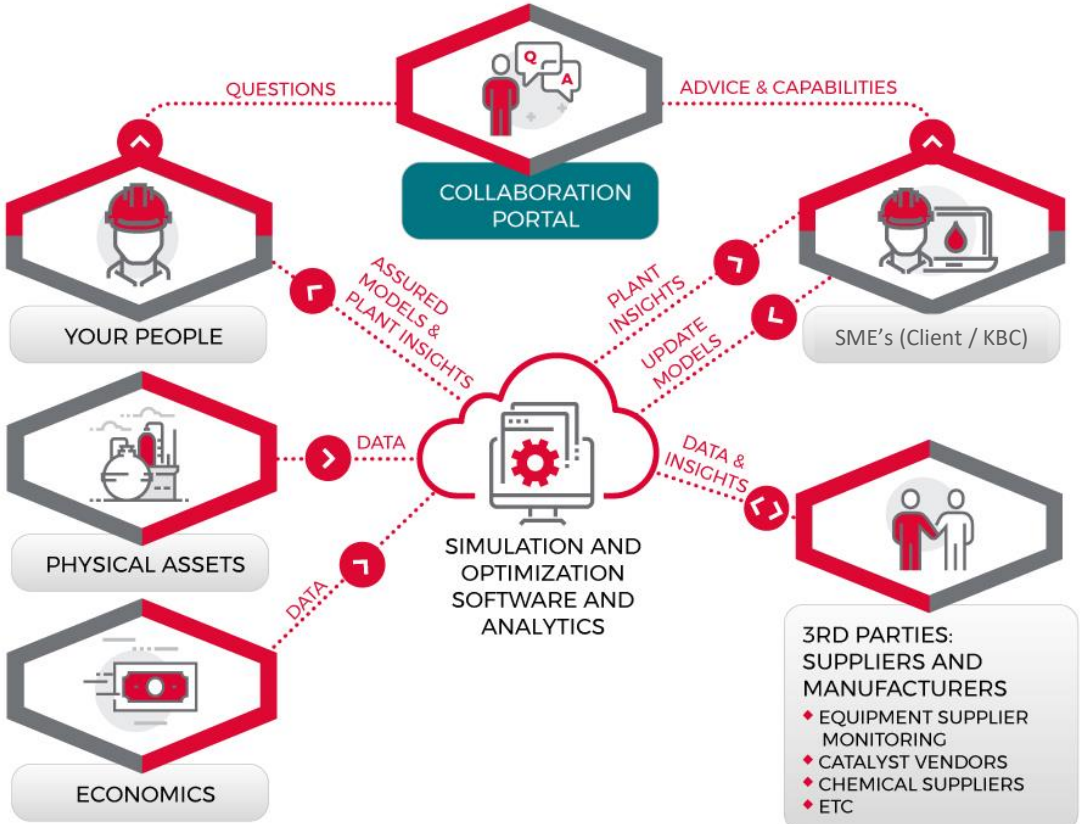
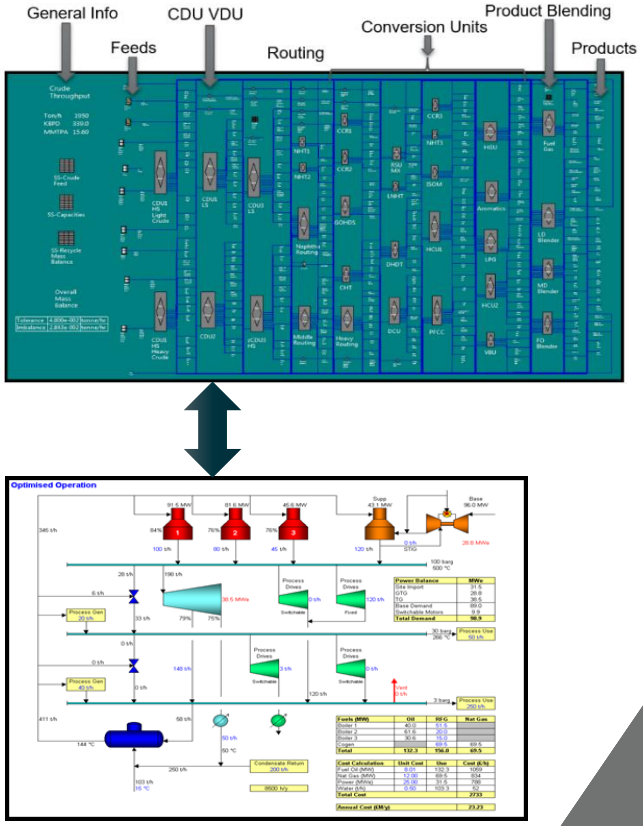
Customer facility



Connected experts

Real time process & energy optimisation

- 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.



Integrated Process – Utility Petro-SIM® Model

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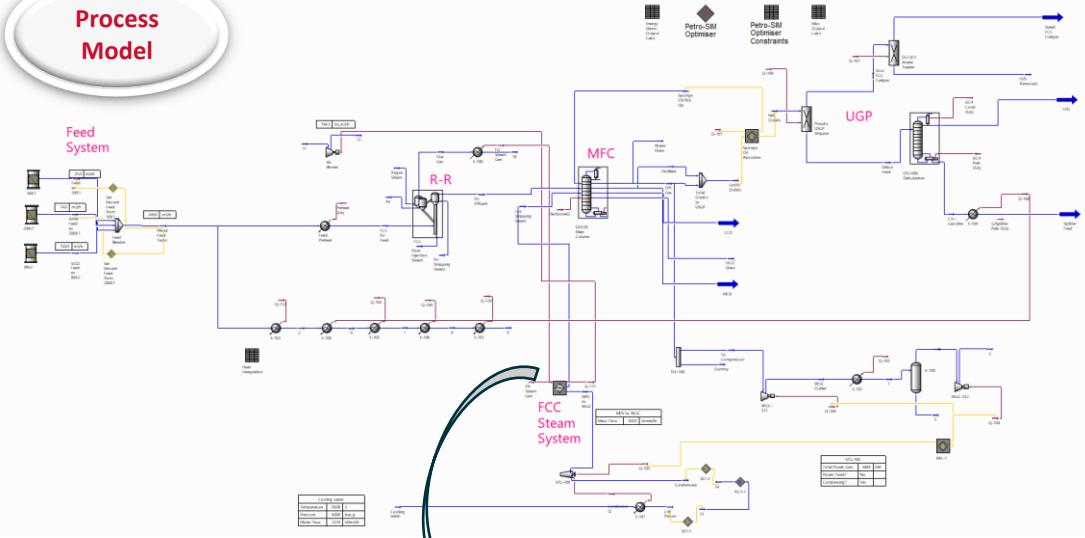
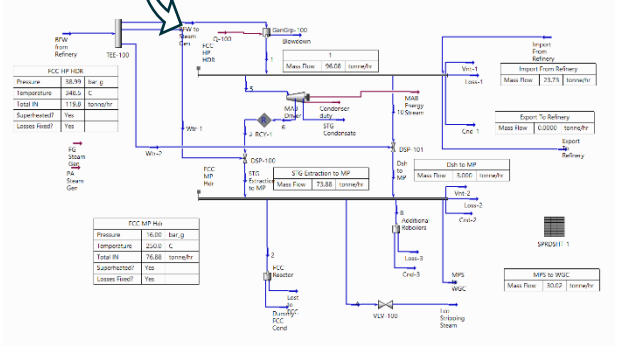
Process Model



Utility Model



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 Integrated Modeling Approach

- 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 our industry becoming more flexible & efficient – regardless of technology choice

- Reduce variable costs & improve energy efficiency
- Value chain optimisation
- Being responsive & agile through digitalization

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All about EXCELLENCE

Thank You

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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.