Operational Excellence: the key role of integrated planning and scheduling in a merchant oil refinery

Budapest, 14th October 2015
### Saras’ businesses

<table>
<thead>
<tr>
<th>Refining (Sarlux)</th>
<th>Power (Sarlux)</th>
<th>Supply &amp; Trading, Marketing</th>
<th>Wind Energy</th>
<th>Other Activities</th>
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<td><img src="image1" alt="Refining" /></td>
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<td><img src="image3" alt="Supply &amp; Trading" /></td>
<td><img src="image4" alt="Wind Energy" /></td>
<td><img src="image5" alt="Other Activities" /></td>
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<tr>
<td>Located in Sardinia, one of the largest high complexity refineries in the Mediterranean Sea</td>
<td>The largest liquid fuel gasification plant in the world (IGCC)</td>
<td>~180 crude cargoes supplied every year from wide range of crude sources</td>
<td>Wind farm with capacity of 96 MW in Ulassai (Sardinia)</td>
<td>Presence in industrial engineering services for the oil sector – Environmental monitoring and protection, industrial efficiency (Sartec, 141 employees)</td>
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<td>300k barrels per day of refining capacity</td>
<td>575 MW of installed power - conversion of heavy refining residues into clean gas</td>
<td>Marketing activities in Italy and Spain</td>
<td>Gas exploration activities – Two site permits for exploration in Sardinia (Eleonora and Igia)</td>
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<td>Integrated with petrochemical units (propylene and aromatics)</td>
<td>Electricity production of approximately 4.4 TWh</td>
<td>11% wholesale market share in Italy with reference to the sales of diesel/gasoil, 7% wholesale market share in Spain</td>
<td>Wind farm with capacity of 96 MW in Ulassai (Sardinia)</td>
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<td>80% of production is of medium and light distillates</td>
<td>a large commercial coastal refinery</td>
<td>112 retail stations in Spain</td>
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Saras’ businesses

- Refining (Sarlux) located in Sardinia, one of the largest high complexity refineries in the Mediterranean Sea, with 300k barrels per day of refining capacity. Integrated with petrochemical units (propylene and aromatics), with 80% of production being medium and light distillates.

- Power (Sarlux) featuring the largest liquid fuel gasification plant in the world (IGCC) with 575 MW of installed power, converting heavy refining residues into clean gas and producing electricity of approximately 4.4 TWh.

- Supply & Trading, Marketing providing ~180 crude cargoes supplied every year from a wide range of crude sources. Marketing activities in Italy and Spain, with 11% wholesale market share in Italy and 7% in Spain, and 112 retail stations in Spain.

- Wind Energy with a wind farm having a capacity of 96 MW in Ulassai (Sardinia).

- Other Activities including presence in industrial engineering services for the oil sector, with environmental monitoring and protection, industrial efficiency (Sartec, 141 employees), and gas exploration activities with two site permits for exploration in Sardinia (Eleonora and Igia).
SARLUX refinery: main processing units

Atmospheric and Vacuum distillation
- T1
- T2
- T3
- V1
- V2
- CRUDE OIL
- 3 CDU
- 2 VDU
- Heavy residue
- 1 VSB
- VSB
- TAR
- 3 GASIFIERS

Conversion units
- MHC1
- MHC2
- 2 MHC
- 2 REFORMERS
- CCR
- Semi-Reg
- Hydrogen

Desulphurization & finishing
- 1 ETHERIFICATION
- 1 ALKYLATION
- 1 GASOLINE DESULPHURISATION
- 4 HDS UNITS FOR KERO/GASOIL
- GASOLINE
- DIESEL
- ELECTRICITY

IGCC: syngas generation & power production
- G1
- G2
- G3
- SYNGAS
- 3 GAS-STEAM TURBINES

Complex and highly integrated set up
Products mix geared to Diesel

Minimal fuel oil production: heavy bottoms converted into electricity
Refining margins: higher for longer?

Yearly EMC benchmark

2009-2014: market downturn

($/bl)


1. For FOB Med complex refineries
Source: Energy Market Consultants
6 structural changes in oil market ....

<table>
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<th>Market from 2009 to 2014</th>
<th>Market from 2015 onwards</th>
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<tr>
<td><strong>1</strong> High crude prices</td>
<td>More balanced oil prices, robust supply</td>
</tr>
<tr>
<td><strong>2</strong> Low availability of heavy sour crudes</td>
<td>Significant increase in production of heavy crudes</td>
</tr>
<tr>
<td><strong>3</strong> Falling product demand in Europe</td>
<td>Improved product demand in Europe and worldwide</td>
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<tr>
<td><strong>4</strong> Overcapacity of European refineries</td>
<td>Ongoing rationalization of European refining capacity</td>
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<td>Strong competition from:</td>
<td>Correction of market distortions (e.g. Brent-WTI spread)</td>
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<tr>
<td>- Wide Brent-WTI spread</td>
<td>Reduction of spare capacity</td>
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<tr>
<td>- Non-OECD refineries</td>
<td>Increase of international freight rates</td>
</tr>
<tr>
<td>- Low freight rates</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Tight light-heavy product differentials</td>
<td>Widening of light-heavy product differentials</td>
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<tr>
<td>- Advantage for complex refineries</td>
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14th October 2015
CEE and Turkey Refining and Petrochemicals Forum, Budapest
.... But the future is still challenging

European refining industry will still face a challenging scenario:

- Major upgrades will hardly find adequate returns
- Competitive position improvements will mostly rely on operational excellence
- Operational excellence is not just safety, reliability, advanced controls, good practices in the field, ....
- .... but also the ability to operate effectively the business at a higher level with an integrated process that goes from the trading desk to the panel operator

Gross margin generation through an integrated trading-planning-scheduling-field operations process is one of the most powerful leverages for business competitiveness
Value generation for a merchant refinery

Gross Margin is the key driver of profitability
Main drivers of gross margin

It’s all about the crude

Crude oil selection

1

Crude oil selection

2

Crude oil selection

3

It’s all about the crude
Saras: Crude Oil sourcing

50 different crudes and feedstocks from 25 different Countries

(2014/15 data)
The first step for commercial optimization of a refinery

“I don’t care what anything was designed to do, I care about what it can do”

quote from Apollo XIII

The real technical challenge is the deep understanding of flexibilities and constraints.
Optimizing a merchant refinery

- No pre-determined constraints on crudes and feedstocks supply
- Open access to export markets for products, intermediates and blendstocks
- The realm of pure economic optimization

Common objective and single KPI: Gross Margin maximization
Planning and Scheduling

Planning: LP based and price driven

*monthly/quarterly basis*

- optimal crude selection
- average plant set-up
- optimal product mix

Scheduling: sequence based

*daily/weekly basis*

- routing of in-tank crude
- daily plant set-up
- stock management
- cargo-by cargo product shipping

Streamlining Planning and Scheduling is crucial for margin capture
About Planning and Scheduling

Planning and Scheduling need to define a common ground

“I think you should be more explicit here in step two.”
Streamlining Planning and Scheduling

Three themes need to be addressed as a precondition:

• Crude segregation

• Modes of operation

• Time slicing

They imply deep knowledge of the refinery plants, tank farm, logistics and LP techniques.

Goal: getting to an optimized and feasible plan
Crude segregation

• Every refinery has its own optimal crude TBP shape, with specific preferred qualities for each cut

• Typically no real crude can match these requirements exactly

• A good LP solution suggests how many different categories of crudes are strictly necessary to achieve the “perfect mix”

• If you want to reproduce in real life the LP theoretical optimization, you need to have all the different categories of crudes in separate tanks, that means segregation

• The more complex the refinery is, the more chance you have to want a higher number of segregations

From LP to real life: how many segregations can you really afford?
Examples of crude segregation

- Condensates/Heavy Condensates
- Light sweet naphtha rich
- Light sweet middle distillates rich
- Sweet VGO rich
- Extra sweet paraffinic
- Heavy sweet low TAN
- Heavy napthenic high TAN
- Light sour
- Heavy sour
- Extra heavy (very high sulphur, viscosity, asphaltenes, metals ....)

And on top of these
- Straight Run materials for CDU, VDU or conversion units (HDC, FCC, VSB, Coker, ...)

Segregations also driven by potential incompatibility between crudes
Segregations and storage constraints

- Number of desired segregations
- Volumes to be processed for each segregation
- Typical cargo size for each grade

Solving the equations and analysing trade-offs

- The final outcome could see a significant reduction of segregations vs desired number
- Number of segregations is quite proportional to inventory level, therefore the trade-off analysis should include working capital requirements/constraints

... Without forgetting working capital requirements
Segregation: the Saras case

- 7 desired crude segregations
- Potential incompatibility issues
- Cargo size from 200 kbbls to 1Mbbls

- 11 crude tanks with capacity ranging from 300 to 950 kbbls
- Different equipments for each tank

Violating the segregations is the first step to the infeasibility of a plan

Tight control of working capital

The current decision is to adopt a 5 segregations scheme
Crudes (by segregation) processed by Saras in 1H15

Is crude oil a commodity in real terms?
Q&A