Integration of crude characterization, planning and scheduling tools to optimise refinery assets

Author and Speaker

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Present Refining Scenario

The oil refining industry has faced the last year, for the excess production of oil from fracking in the US, a sharp and unexpected drop in oil prices.

A fall of 50% that producing countries could have avoided with a modest reduction of their productions, if Saudi Arabia had not chosen to forgo impose on the world that high energy prices that was taking its greatest ally and client to become independent with fracking, while his primary area competitors, Iran and Iraq are taking place in the market and the easing of China's development makes it uncertain when the new growth of the price.

How can react in this scenario who has responsibility for the management of an industrial plant in which the shareholders and the financial system has invested considerable resources and that employs thousands of people?

We all know that in the world oil sector the market laws work well: in stable conditions without stress in supply and refining facilities, profit margins are dwindling fast; instead they get bigger in times of instability, either in case the prices of crude and products rise or if they fall, while the profits of refining depend by the market differentials between light and heavy products.

To ensure a profit in this state of change cannot be based solely on management experience gained in recent years, it is necessary to have tools together increasingly easy to use and sophisticated, to identify the most profitable solutions, maybe never experienced before, which are dictated by market conditions and price differentials in that geographical area in the present moment.

Along with this action continues to profit from market conditions, it should be a constant action to improve operation efficiency in order to reduce costs and quality give away, increase energy performance and maximize assets optimization

We are experiencing that in the same area some refineries close for poor margins while others with comparable characteristics (similar processing scheme and no upstream activities) keep on operating with profits: these lasts are like the bumblebee, that according to theoretical physics should not be able to fly and instead succeeds very well because it can move wings at an impressive rate.

The gap between closing and surviving is linked to many factors but one of the most important is certainly the management, the ability to work as a team and to use in a widespread mode the most advanced computer techniques directly, not entrusting its use to a computer expert, which often is not even expert in refining.

In this context refinery operation planning and scheduling activities become more and more crucial:

- Planning models must reliably represent any processing option and operative mode possible with the refinery scheme permitting to quickly evaluate and grab any opportunity at the horizon.
- Scheduling models must always orient themselves towards the most economical feasible solution and be flexible enough to keep this tendency even when coping with unforeseen plan changes.

Vision: management is the key

The Prometheus Decision Support System was conceived basing on the personal experience of its founder who was managing director of an Italian refinery that entered in production being described as "the wrong refinery, in the wrong place at the wrong time": thanks to an optimization refinery model, they could conceive changes in the refinery scheme, and evaluate the profitability of unusual feedstock processing.

On several occasions they faced negative economics processing reconstituted crudes that – thanks to the low prices of finished and intermediate products – were more profitable than the traditional crude oils: that refinery in few years paid back all its investments and ultimately has been sold to a state company for a billion and half Euros.

But to calculate and verify these possibilities it is mandatory to dispose of flexible and sophisticated methods of evaluation, a real Decision Support System.

Prometheus DSS tools

We realised this vision developing a Decision Support System to be used directly by managers or refinery technicians who were not computer specialists; a software to be used by multiple refinery sectors as a unifying factor of their business, in order to make them a team capable of acting with decision in the same direction.

We developed a set of proprietary technologies (crude data management, plant simulation and blending calculation) and exploited them throughout tools specifically designed to support the various tasks of refinery operation planning and scheduling (row materials characterization, refinery LP modelling, logistics and processing operation management, blending optimization).

Crude characterization, handling and processing

Crude oil characterization

Accurate feedstock characterization is the fundamental starting point for a successful refinery operation Planning and Scheduling.

Prometheus developed technologies permitting to assess reliable characterization data from various alternative sources (assays, basic characterization, mixes, plant data) in order to simulate the impact of any feedstock on refinery processing.

Irrespective of the original source, form, and consistency of the input crude oil data are elaborated and converted into a library of congruent data and can be queried for all the properties of any fraction.

Through the application of a proprietary "Multi-dimensional Regression Technique", Crude oils and intermediate products are characterized as a mix of pure components (C5 minus) and "pseudo-components" (C6 plus), which cover the entire crude boiling range. Each pseudo component envelops pure components boiling in a narrow range of 10°C.

The method accurately predicts the values of key properties for Operation Planning and Scheduling (e.g. Viscosity, Cold Properties, and Octane) that are not easy to correlate with main thermodynamic variables.

Simulation of supply logistics

The development of a scheduling plan involves the assessment of the quality of the crude oil tanks that will be fed to Crude Distillation Units during the scheduling period as well as the date of their availability to processing.

Depending on the specific logistic structure and on segregation requirements, the prediction of feedstock quality and availability can become a complex issue that when not properly faced can deeply affect the scheduling results.

Prometheus has developed a calculation engine that, considering the scheduled events (supply, handling, and processing) and the logistic constraints (volume, pumping rates, connections, assets availability) calculates the hourly evolution of each tank status, returning volume and composition for each tank to be processed.

Each event scheduled for the period generates a list of service requests for the objects (tanks, pipelines) represented in the logistic structure. The calculation engine manages the service requests (accounting for priorities and given inputs) to terminate each event as soon as possible.

The simulation checks the feasibility of the supply program highlighting the logistics bottlenecks and constraints that need to be managed to prevent operational problems.

Plant simulation Models

The availability of accurate raw material characterization data permits to use plant simulation models to calculate yields and qualities on the basis of the feed quality, having the opportunity to change or to assess different process configurations.

Developed by internal research and validated through field data, shortcut plant simulation models provides the flexibility of fine-tuning the refinery models using few parameters to reproduce the actual performance of their refinery units.

The following refining processes are currently available in plant simulation models library:

- CDU and other Distillation processes
- Desulphurization and Hydro treatment
- Catalytic conversion (Reforming, Catalytic Cracking, Hydrocracking)
- Thermal conversion (Visbreaking, Thermal Cracking, Delayed Coking)
- Lubricant production (Solvent Extraction, Catalytic Dewaxing)

The availability of Plant Simulation Models within the LP Optimization Model environment permits to improve the adherence of the LP Optimization Model to real operation: the operating performance of each model can be fine-tuned to reproduce the actual performance of real units avoiding the logical assumptions and rough simplifications typical of the standard delta-based approach.

Integrating Tasks

These technologies are used to build solutions focused on client's specific operative structure:

- respecting the existing business processes (the solution fits the organization, not the opposite) and consolidated workflows
- integrating with other tools / systems already in place

The technological framework characteristic of DSS tools permits to develop applications focused on the specific tasks involved by Refinery Supply Chain Management and Optimization accordingly with Organization's business processes.

Even if focused on a specific task each tool works as a part of a whole body as long as it is integrated with the others.

Integrating functions between DSS Tools and external applications are realized by a centralized data exchange platform specifically designed considering the specific organization requirements (see example in Figure 1).

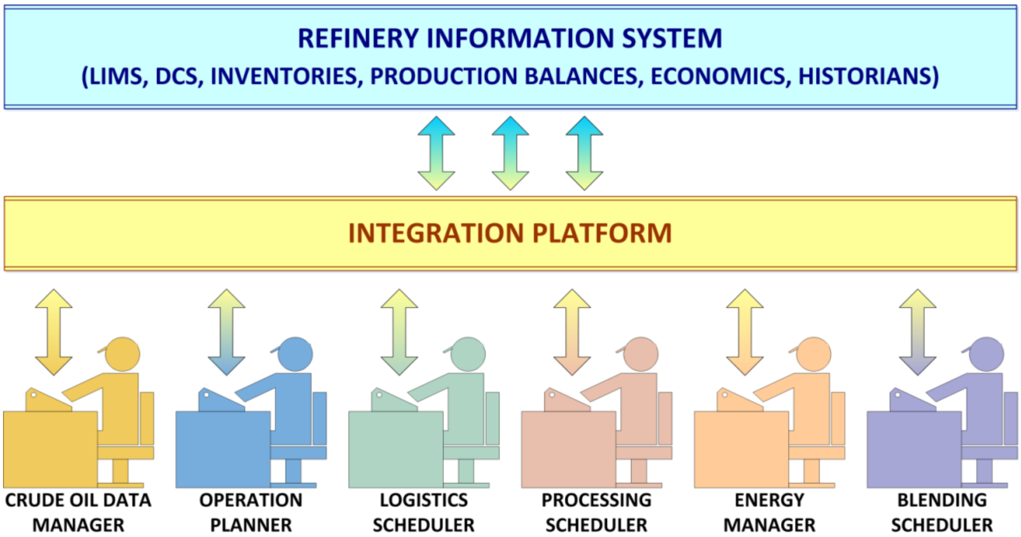

Figure 1 – Supply Chain Management tools integration

Turning planning into reality

Planning is aimed to identify the best possible plan for a given economic scenario (in terms of feedstock selection and production targets) while Scheduling defines the operative instructions to put it in practice considering the current structural constraints.

Even though the execution of these tasks requires a continuous interaction between planners and schedulers the different technologies that are typically applied to address these problems (optimization for planning and simulation for scheduling) involve a communication barrier between these two worlds that occasionally may lead to non-optimization and loss of revenues.

The structural constraints are characteristic of each refinery: depending on cases logistics (supply and distribution), feedstock segregation issues, processing capabilities or intermediate products inventory may limit the daily operation. The scheduling solution must be developed to target the specific production goals that vary from case to case.

Typically for a given period the planning model produces the lists of foreseen feedstock supply and products shipping events (grade, quantity and date).

The scheduling solution processes this information together with the additional constraints to build a short term operating program detailing – on a daily base – the sequence of crude tank processing, secondary units feedstock composition and operating conditions, inventory operations, blending operations, utility balances etc.

In this level the manager normally lacks of an instrument permitting to calculate the differential in the economic result between the planning solution and its application into real operation.

Planning Feasibility Check

As soon as the planner publishes the operative plan for a given period, the scheduler is involved to check its practical feasibility, deepening the potential logistical and operational obstacles that might affect the successful realisation of the program.

To support the execution of this validation phase, Prometheus has added a new feature to his LP planning environment called "Planning Feasibility check".

This feature permits to turn the LP Optimization Model into an Optimised Scheduling model, where crude tank quality, availability and yields are accurately calculated through simulation techniques and operation is optimised through a Multi-Period model covering the scheduling horizon (10-15 days) with small periods of 1 to 3 days.

This model gives also to a refinery with limited personnel dedicated for Planning and Operation Scheduling activities, the chance to define an optimized pattern of their production.

From the other side it offers to a big refinery organized in sectors for the scheduling of pier and crude oil tank farm operation, for the scheduling of refinery process operation, for products blending and products delivery operation, the input data for their specific programs, insuring a global feasibility of the planning detailed program that is offered.

Step 1: crude unloading

The optimization of the refining process scheduling starts from the unload of the crude oil into refinery tanks: in them it should be mixed with different crude oils to prepare a mix with an adequate quality for processing.

The availability at this level of extended characterization data may be very useful as long as it permits to drive this process considering beyond the typical bulk properties (TAN, Sulphur, Density) characterization properties of crude fractions (Like Yields, VGO Nitrogen content, Vacuum Residue Viscosity).

The scheduling of crude oils unload in the refinery tank is usually carried out manually performing calculations for each single tank and ship; instead all the supply events of the time frame are represented together and optimized holistically:

- targeting the desired quality specifications for each tank
- minimizing the possible unloading demurrage cost for each ships
- highlighting a solution assuring always at least one tank for the supply of each CDU.

This optimization is realized through a complex interactive optimization that considers the initial tanks status, quantity and quality and also the desired status at the end of the period, the scheduled processing sequences of the distillation units, the arrival dates of crude oil ships and the quality specifications required for each tank in view of its future processing.

At this stage it is possible to calculate the convenience to modify according to the needs of the refinery feed quality the sequence of the ships of crude oil to unload.

Step 2: crude tank mixes quality and availability

When the sequence of the optimal unloads is defined, the model assesses – basing on the composition of crude tanks during the period – the detailed quality of each mix that according to unload program will become available at a defined date (each one characterized by a comprehensive set of pseudo components, typically 1-3 mixes for each tank) and calculates the yields and the qualities of the intermediate products resulting from the processing of the same ones in refinery units.

This process is automated thanks to the availability in the LP model environment both of crude characterization and of plant simulation technologies permitting to dispose of the same level of accuracy of a scheduling environment.

Step 3: feasibility check optimization

The calculated mixes (as well as related economics and processing results) are used in the same optimization model to replace the original planning pure crude oils.

The problem is multiperiod LP optimization with period length of one or two days, directly calculating the refinery process and blending scheduling, according to the product delivery dates.

The holistic problem solving approach that is characteristic of LP optimization models jointly with the improved accuracy of processing results prediction provided by Plant Simulation Models, permits to address the technical constraints in the short term finding at the same time the most economical feasible scheduling solution.

The model optimizes what can be really optimized in the short term, that is the sequence of crude tank processing that best fits the finished products shipping plan, the management of intermediate tanks and processing units and the blending operations.

For example, the multiperiod optimization model manages holistically the intermediate streams tanks, that have a crucial function in the effort to keep as constant as possible the feed quality of the secondary refining and conversion plants in order to optimize their capacity utilization and their yields.

Depending on cases it can be useful to manage crude processing using the Mixed Integer Programming Technique, in order to avoid unrealistic crude oil thanks sequence changes to obtain minor theoretical optimizations.

Results

The optimal solution is processed to extract the results that are detailed for each period and for the whole scheduling horizon, so that the scheduler can easily compare the scheduling solution with the original planning (and eventually modify the monthly plan in case of inconsistencies) and, at the same time, produce the daily operative instruction for facilities management.

The feedstock composition of each unit (from previous units or from surge tanks) as well as the destination of each intermediate stream (to following units, storage or blending) is made available for each period and can be directly used for operators instruction or as input for a conventional scheduler that calculates the sequence of the processing of each tank.

Furthermore the report details for each period the material and utilities balances as well as the status of the refinery tanks (crude oils, intermediate, products).

Finally it is possible to retrieve from the solution the optimized blending recipe of each product to be delivered, done both with the intermediates produced in the current period and with the ones produced in previous periods and stored in tanks.

Case Study: Minimize the switch between alternative types of crude

Problem definition

A Diesel oriented refinery (see scheme at Figure 2) processes two types of feedstock: sweet (low Sulphur) and sour (high Sulphur) crude oils. The switch between the two modes of operation triggers a transitory period that induces off-spec production and a reduction of profitability (a loss that is difficult to account for with an LP model), thus one of the targets pursued by the scheduling department is to minimize the number of switches between type of crude.

At the same time:

- the limited Hydrogen Sulfide treatment capacity forces the refinery to balance the Sulphur content of HDS and HC units feedstock surging intermediate streams from tank (low Sulphur intermediates when CDU processes Sour crudes and vice versa),
- to keep the steady performance of the Hydrocracking unit it is mandatory to minimize the variability of feed Nitrogen Content.

The two feedstock are prepared at the maritime depot by mixing the ships with extremely different quality into crude tanks while the destination of SR products to following units or to tank is managed daily to cope with the above constraints.

Thus the goal is to maximize the conversion and the plant utilization and to feed at the same time the distillate desulfurizers to produce the maximum quantity of hydrogen sulfide that the Sulfur plant is able to process.

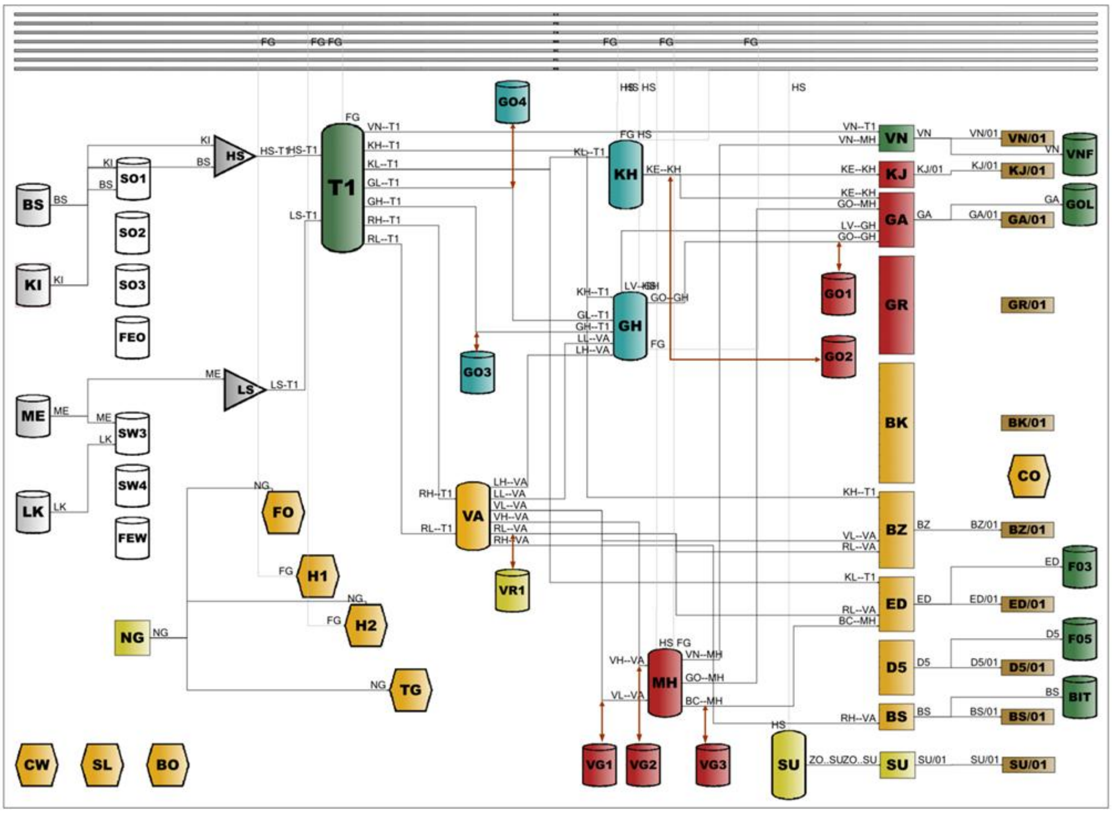

Figure 2 – Case study: refinery processing scheme

The schedule is currently realized applying various simulation tools to develop day-by-day the results of the LP Planning model of a two weeks period. This process is quite time consuming and this brings the scheduler to look for a solution that fits all the technical constraints without caring if it is the best possible one, especially for what concerns the duration of the processing of each type of crude.

To give an answer to this requirement we focused on the goal of minimizing the switches between the two types of feedstock also because – thanks to the holistic approach that is possible with optimization techniques – the other technical constraints (inventories, processing capacities, feed quality bounds for secondary units) are intrinsically managed by the model.

Table 1 summarizes the basic assumptions as well as the main results of the two weeks plan that have been considered as starting point. The gross economical result calculated by the present demo planning model is equal to 525.872 USD/Day corresponding to a specific profitability of 105.2 USD/Ton.

The supply of 70,000 Tons of Crude Oil in the period has been modelled basing on the arrival dates reported at Table 1.

ITEM	UNIT	VALUE
Storage Capacity		
Crude Oil	ton	64,000
Low Sulphur Diesel	ton	10,000
High Sulphur Diesel	ton	10,000
Low Sulphur VGO	ton	7,200
High Sulphur VGO	ton	9,000
Sour Crude oils		
Inventory (Average Mix 31.9 API)	ton	18,000
Supply Event (day 4, Kirkuk 34.3 API)	ton	11,000
Supply Event (day 5, Basrah 30.2 API)	ton	11,000
Supply Event (day 9, Basrah 30.2 API)	ton	11,000
Sweet Crude Oils		
Inventory (Average Mix 25.2 API)	ton	16,000
Supply Event (day 2, Mellitah 41.5)	ton	10,000
Supply Event (day 3, Lokele 21.3)	ton	11,000
Supply Event (day 3, Lokele 21.3)	ton	5,000
Supply Event (day 10, Lokele 21.3)	ton	11,000
Processing Constraints		
CDU Processing Capacity	ton/day	5,000
CDU Processing Lots	ton	5,000
Processing Contiguity (*)	($/ton)^(1/days)	2
Max Sulphur production	ton/day	40
Max Nitrogen in MHC Feed	ppm	2,300

(*) Incentive = ƒ(Contiguity, Days,Lot)

		START	IN/OUT	PROD	END
CRUDE OIL	Basrah 30.2	5,900	22,000	- 14,058	13,842.0
	Kirkuk 34.3	12,100	11,000	- 17,892	5,208.0
	Lokele 21.3	13,000	27,000	- 32,158	7,842.0
	Mellitah 41.5	3,000	10,000	- 10,892	2,108.0
PRODUCTS	V.Naphtha	10,000	- 20,663	12,063	1,400.0
	Jet A1		- 4,854	4,854	
	ULSD	15,000	- 54,546	42,246	2,700.0
	Heating Gasoil		- 1,938	1,938	
	Bunker		- 729	729	
	LSFO 1%		- 722	722	
	LSSF 0.3%	10,000	- 17,055	11,255	4,200.0
	LSFO 0.5%	10,000	- 6,800		3,200.0
	Bitumen	10,000	- 14,151	6,651	2,500.0
	Sulphur		- 582	582	
INTERMEDIATES	LS LGO	5,000		-4,000	1,000.0
	HS LGO	5,000		-1,561	3,439.0
	MHC RES	800			800.0
	HS VGO	3,000		-2,100	900.0
	HD Diesel	3,000		-2,240	760.0
	LD Diesel	2,000		-1,000	1,000.0
	LS VGO	2,000		-1,100	900.0
	VAC RES	2,000		4,500	6,500.0
		MIN	**USED**	**MAX**	**% USE**
PLANTS	Topping		75,000	75,000	100.0
	Vacuum		36,334	45,000	80.7
	Gasoil Hydr.		26,250	26,250	100.0
	Kero Hydr.		8,628	12,750	67.7
	Mild Hydrocr.		20,305	21,600	94.0
	Sulfur Plant		600	600	100.0
		HS FEED	**LS FEED**	**% S**	**ppm N IN**
	Mild Hydrocr.	8953	11352	1.81	2,300
	Gasoil Hydr.	11007	15242	0.69	360
	Kero Hydr.	2860	5768	0.22	

Table 1 – Case study: Main basic assumptions and two weeks planning results

Results

The feasibility check function has been applied to develop the results of the LP Planning model: the time horizon has thus been divided into 10 periods: 9 periods of 1 day and one period of 6 days covering the remaining part.

The impact of Crude Supply over logistics has been calculated by the model: the resulting mixes qualities are reported at Table 2.

	Crude Tank	SO1		SO2		SW3			SW4		SO3
Date		01-mar	06-mar	05-mar	10-mar	01-mar	06-mar	11-mar	03-mar	08-mar	10-mar
Description	Unit	A0	A1	B1	B2	C0	C1	C2	D1	D2	E1
Initial Boiling Point - TBP	°C	-88.6	-88.6	-88.6	-88.6	-88.6	-88.6	-88.6	-88.6	-88.6	-88.6
Final Boiling Point - TBP	°C	730	730	730	730	700	700	700	700	700	730
Density	kg/dm3	0.860	0.868	0.854	0.871	0.911	0.927	0.932	0.834	0.874	0.869
Molecular weight	Kg/mol	206	214	201	216	235	252	258	177	203	214
Sulphur	%w	2.49	2.72	2.32	2.79	0.39	0.44	0.45	0.17	0.36	2.73
Viscosity @50°C	cst	5.0	6.0	4.4	6.3	11.9	18.5	21.3	2.6	5.2	6.0
Viscosity @100°C	cst	2.1	2.3	1.9	2.4	3.6	4.7	5.1	1.3	2.1	2.3
Acidity	mgr KOH/gr	0.09	0.10	0.09	0.10	2.21	2.57	2.68	0.45	1.37	0.10
Total Nitrogen	ppm	981	1049	932	1071	3620	4068	4151	1674	3338	1052
Basic Nitrogen	ppm	272	285	263	289	949	1061	1095	406	689	286
Asphaltenes	%w	2.32	2.35	2.29	2.37	0.21	0.19	0.18	0.31	0.26	2.36
Conradson Carbon	%w	5.12	5.7	4.7	5.89	3.66	3.99	4.09	2.02	2.87	5.72
Nickel	ppm	7	9	5	10	25	28	29	10	18	9
Vanadium	ppm	31	33	30	34	5	4	4	9	7	33
Waxes	%w	4.44	4.67	4.26	4.75						4.68
CO2 Emission	ton/ton	3.127	3.128	3.125	3.129	3.137	3.140	3.141	3.121	3.129	3.128
Atm. Distillates	%w	52.0	49.2	54.2	48.2	48.2	44.7	43.6	65.3	56.4	49.0

Table 2 – Case study: Calculated Crude Mixes

The goal of minimizing the number of switches between type of crude has been addressed providing the scheduling with an additional feature that incentivizes the solutions characterized by contiguous periods processing the same type of crude.

The comparison of the results highlights that the best economical return is not obtained keeping the operating conditions identified by the planning model; this behavior is not surprising since the scheduling case typically copes with additional quality and logistic constraints that are not considered by the planning case.

The analysis of marginal values highlights that – in this specific case – the most limiting constraint is the Nitrogen Content specification set for Mild Hydrocracking Feed (<= 2300 ppm).

Beyond the quality of the feed, the operating variable that most affects the Nitrogen content of MHC Feed is the cut point of the Vacuum Gasoil; as long as a big contribution to VGO's Nitrogen content is provided by sweet crude oils, a sensitivity analysis has been carried out to evaluate the impact of "sweet crudes" VGO cut point over Mild Hydrocracking Operation and global profitability.

For Sour feedstock the cut point remained constant at 555°C (corresponding to the maximum operative limit), while for Sweet feedstock the cut point ranged between 518°C and 538°C.

Results are summarized in Table 3 and Figure 3:

- The highest economical return is reached with a cut point of 526°C by the feasibility check against the 530°C of the planning case.
- The highest economical return reached by the Feasibility check case is the 97.2% of the optimal result of the planning case; for all cut points the gap between Planning and Feasibility Check ranges between 2.5 and 3.5%.
- With deeper VGO cuts profitability drops also because the model is not able to keep the same MHC Capacity achieved by the Planning model.

CUT POINT VGO (1)	ECONOMIC RESULT FEASIBILITY CHECK [USD/DAY]	ECONOMIC RESULT PLANNING [USD/DAY]	MHC CAPACITY FEASIBILITY CHECK [% MAX CAPACITY]	MHC CAPACITY PLANNING [% MAX CAPACITY]
518	506,749	519,613	87.0	86.0
522	509,175	523,084	88.0	86.9
526	**511,130**	525,363	89.3	89.4
530	509,527	**525,872**	93.1	94.0
534	505,099	524,363	92.5	**96.7**
538	500,442	518,719	92.0	94.3

(1) SWEET OPERATION; VGO CUT OF SOUR OPERATION = 555°C

Table 3 – Case study: VGO Cut Point Study

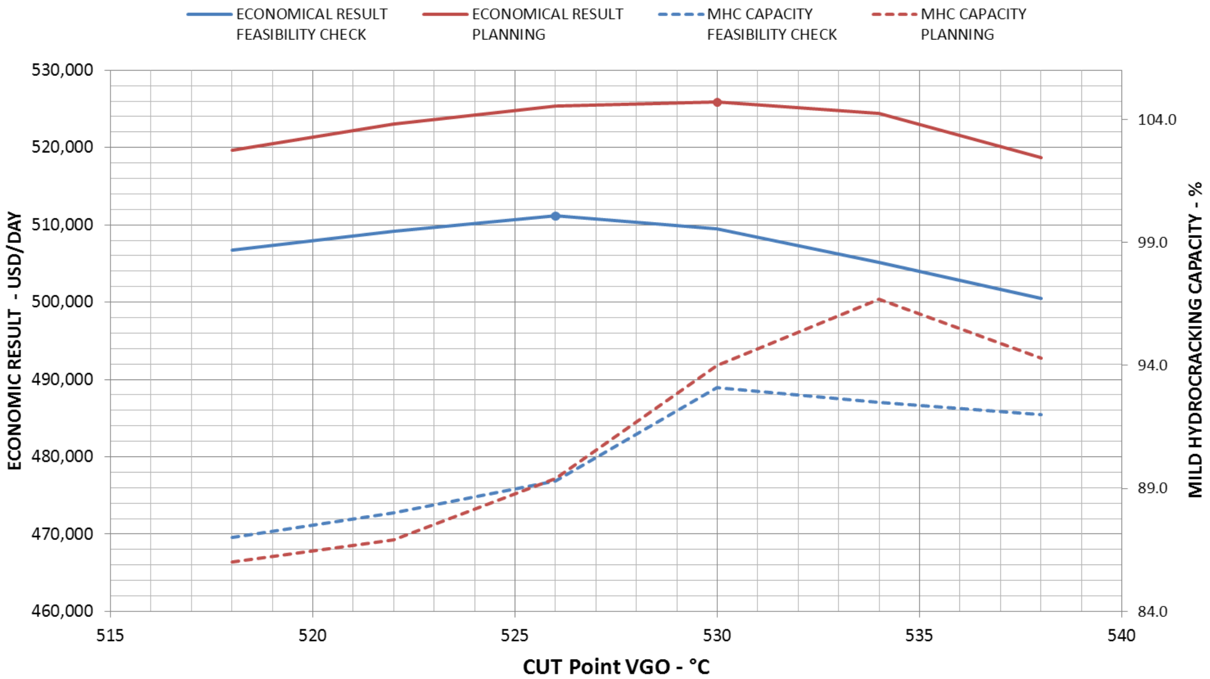

Figure 3 – Case study: Economical Result and MHC Capacity versus sweet feedstock VGO Cut Point

Figure 4 shows the sequence of processing events identified by the model; Table 4 summarizes the development of the two weeks plan to the short term obtained by the feasibility check model:

- The model alternates the operation of SWEET and SOUR crudes with processing lengths ranging between 2 and 2.8 days optimizing the management of Intermediate streams from storage to fit MHC quality constraints and global Sulphur Production.
- Refinery operation is limited by MHC Feedstock quality and global Sulphur production: these constraints are quite always at the maximum limit both for planning and feasibility check models.
- Extensive use of intermediate tanks surge is required to fit these constraints both for HDS and MHC units; this requirement is not highlighted by the planning model which adjusts the specifications within the 15 days horizon.

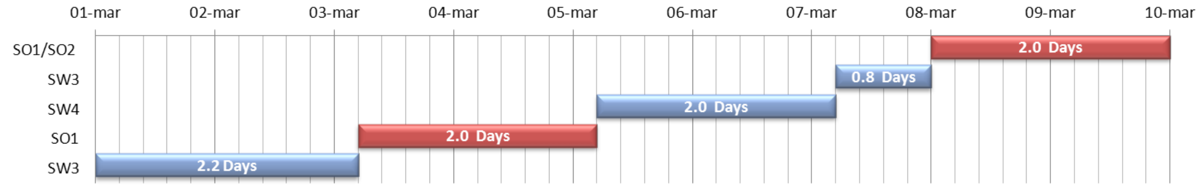

Figure 4 – Case study: Sequence of Crude Tank processing highlighted by the model

		PLANNING (1)	FEASIBILITY CHECK (2)						
	DAY	1 - 15	1 - 2	3	4	5	6 - 7	8 - 9	10 - 15
CDU Operation		SOUR / SWEET	SWEET	SWEET / SOUR	SOUR	SOUR / SWEET	SWEET	SOUR	SOUR / SWEET
TANK			SW3	SW3/SO1	SO1	SO1/SW4	SW4/SW3	SO1/SO2	SO1/SO2/SO3/SW3
Feed Density	Ton/M3	0.883	0.911	0.870	0.860	0.839	0.869	0.857	0.904
Feed Sulphur	% Wt	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diesel + LVGO Yield	ton/day	1203	1368	1088	1018	1117	1252	1027	1253
VGO Yield	ton/day	1180	1196	1163	1155	926	1030	1141	1247
MHC Operation	Capacity	94 %	71.6 %	77.3 %	62.8 %	98.4 %	96.7 %	96.0 %	95.4 %
Hot Feed	ton/day	1180	577	491	399	345	0	177	931
Surge Feed	ton/day	173	455	622	505	1072	1392	1205	443
%S Feed	% Wt	1.81	1.77	1.77	1.77	1.88	1.77	1.16	2.18
%N Feed	% Wt	0.23	0.23	0.23	0.23	0.22	0.23	0.23	0.20
HDS Operation	Capacity	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Hot Feed	ton/day	1750	743	803	962	169	251	758	1188
Surge Feed	ton/day	0	1008	947	788	1581	1500	992	562
%S Feed	% Wt	0.69	1.05	0.93	1.07	0.92	0.71	0.88	0.63
Sulphur Plant Operation	Capacity	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

(1) VGO CUT: SOUR FEED 555°C, SWEET FEED 530°C

(2) VGO CUT: SOUR FEED 555°C, SWEET FEED 526°C

Table 4 – Case study: Detailed operation compared to Planning Result

Conclusions

Integration of Crude Characterization, Logistic simulation and Plant Simulation technology with LP Optimization Models can generally improve the adherence of Planning Model results to real operation.

The straight consequence of this technological contamination is the integration of the tools used to develop the different phases of supply chain management optimization, from crude oil characterization to mid-term planning to short-term scheduling.

An example of technologies integration is SIMRAF's planning feasibility check, that explores the actual workability of planning results developing it into a short term scenario with reduced degrees of freedom.

If the plan does not result feasible it is possible to modify it in the same environment turning back from scheduling to planning.

In a scenario characterized by very poor refining margins, the improvement in the economic result obtainable using the DSS tools might turn the global result of refining operation from negative to positive.