SIMRAF
LP OPTIMISER

Technical & Economic Simulation/Optimisation Software for the Oil Industry

Refining Industry Challenges:

Medium and long-term Planning, Raw Materials and Products Evaluation, Feasibility Studies, are daily challenges for Refinery Managers.
Experienced Planning specialists face these challenges supported by Linear (and non) Programming Techniques, the most adequate to model Refining systems.
Nevertheless to build and use a good LP model is not easy and requires an good background in Operation Research: this hinders the diffusion of these techniques outside Planning Departments.

Prometheus Decision Support System

Prometheus DSS is a user-friendly suite of applications for refinery planning and scheduling activities covering the entire supply chain from crude oil logistics to finished products distribution.

CUTS
crude oil database

SIMRAF
refinery LP optimiser

OTTMIX
blending LP optimiser

PROLAV
plant operation scheduling

PRORAF
logistics scheduling

SIMRAF helps to forecast the impact of alternative business decisions, in a dynamic market, environmental and regulatory scenario. Applying Linear (and non) Programming techniques supports medium - long term planning of complex downstream systems.

SIMRAF in Prometheus Vision:

Reliable Computer Models are crucial to calculate the economic impact of thousands of technical and marketing variables affecting Refinery performances.
Nevertheless the availability of these systems might not be effective enough: to take good decisions Refinery Planning Manager needs to be self confident of Model results and this feeling can be achieved only when he directly operates it.
Frequently who is directly charged of taking decisions cannot spend time to deepen Operation Research Technologies and ends with delegating Refinery LP Model use to his staff.

Differently from other commercial applications, *SIMRAF has been specifically designed to assist Oil Industry Professional to achieve reliable modelling and complex systems optimisation with no need of specific Linear Programming expertise*.

SIMRAF Advantages

The program, coupling LP and plant simulation technologies, allows fast and accurate analysis of refinery's profitability in alternative operating conditions and marketing scenarios.

LP Optimisation:

Linear Programming and recursive methods are bundled together in a easy to use interface.

Adaptive Simulators:

Easy to set-up and fully customisable plant simulation models are embedded. Models are quickly adapted to actual plants' performances. Any Refinery processing scheme can be replicated.

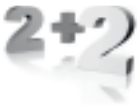
Key Characteristics

1. Manager Oriented

Delivers Economic Simulation directly into managers hands. Allows distinct use of simulation's economic and technical layers.

2. Easy to Use

User-friendly application: data tables are very easy to update and maintain. Simulation's aspects are Fully Customisable.



3. Flexible

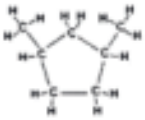
Plant models can be picked from the library and quickly set up. Operating Modes let you explore a full range of processing options.

4. Reliable

Crude Oils "narrow cuts" data enables the use of embedded plant simulators. These models give reliable results, replicating actual plant performances.

5. Accurate

SIMRAF accurately calculates yields, qualities, fractionation tails, using consolidated Blending Methods.



6. Reporting Capability

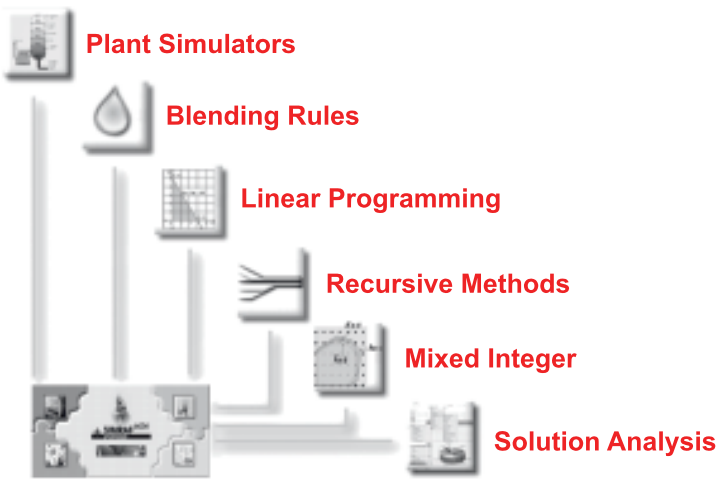
Extended reporting of Economics, Plants, Utilities, Hydrogen Networks, Products Composition and Quality. Ranges and solution analysis methods are available.

Technologies

Advanced linear and non-linear modelling techniques (recursive methods, mixed integer) are integrated with plant simulators dramatically reducing the time (and cost) for model construction and updating.

Intermediate products yields and properties are automatically calculated facilitating the simulation of alternative processing schemes with new units, new processing modes, and product specifications.

The tool combines extended reporting, communication, and integration capabilities with innovative methods for solution analysis, such as, model diagnostic, ranges inspection and infeasibilities management.



Managers Applications

Planning:
Medium & Long Term Planning with support for Multi Period simulation.

Bottle-necks Detection:
Identify obstacles to profit increase and evaluate possible workarounds and solutions.

Feasibility Studies:
Simulate the economic impact of new plants investments and revamps.

Feedstock Selection:
Select the most suitable crude oils and imports to achieve the desired products.

Products Evaluation:
Evaluate new production options, complying to law and market specifications.

Marketing Strategies:
Define commercial margins and break-even sale prices for each marketed product.

Technical Applications

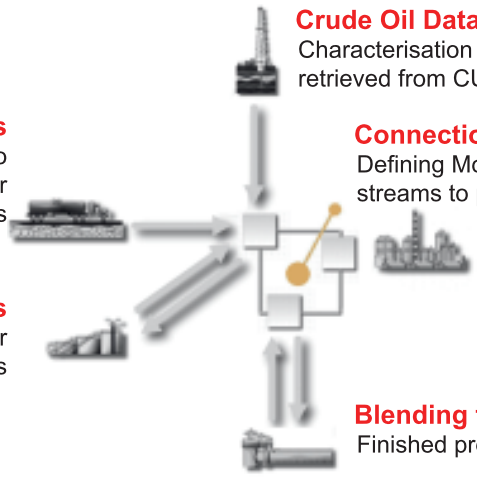
Model management:
The process scheme is simulated through a model, easily and quickly set up thanks to proprietary short-cut plant simulators technology.

Evaluation of Plant Changes:
Technicians will be able to simulate alternative operating conditions for each plant and evaluate the profitability of plant changes.

Process Optimisation:
It will be possible to find the best process set-up and configuration with available raw materials and current products prices.

Environmental Impact Control:
It is possible to monitor processing emissions (greenhouse gases or other pollutants) and to include environmental costs and limits in the refinery Model.

Refinery Model Objects:
The application includes different objects permitting to build, manage and update Model data and structure. Economical and Technical layers are separated to ease data access to different types of user.



Crude Oil Database
Characterisation data are directly retrieved from CUTS Library

Imports
Intermediates fed to Refinery for processing or blending purposes

Connections
Defining Model structure: connects intermediate streams to plants, blending and storage

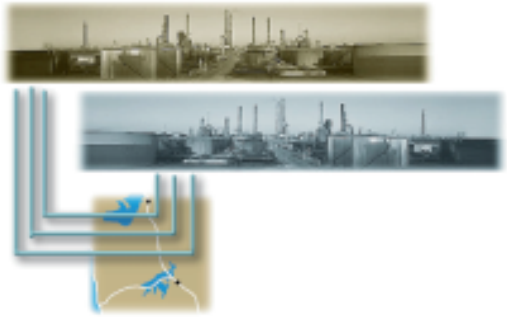
Plants & Utilities
Calculation of intermediate streams yields and quality with shortcut simulators and utility balances

Tanks
Storage constraints for Multi Period Simulations

Blending facilities
Finished products blending

Multi Refinery

This option enables simulation and operation optimisation of a group of refineries sharing raw materials and product markets; the Multi-refinery model exploits the production potential of each refinery accounting for territory global demand and logistics.

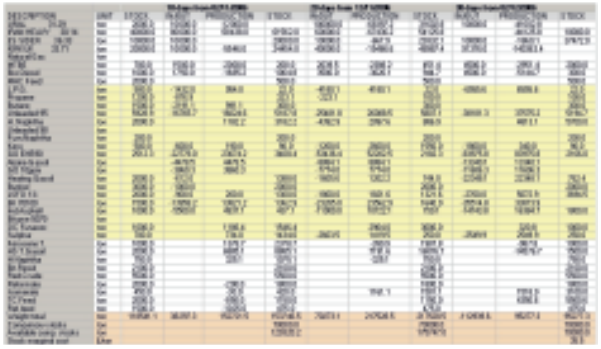


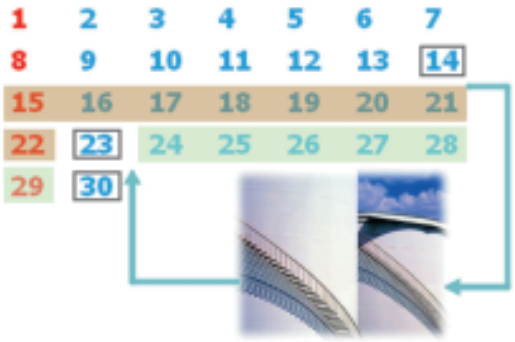
Multi-refinery schemes are simulated, including crude oil and product distribution to demand areas, pipelines and other means of transportation and loss control.
Additional refineries are quickly integrated into a global simulation. Detailed solution reports are available for each refinery as well as for the Global system.

Multi Period

This option extends the simulation to the time dimension permitting accurate planning of medium term refinery operations; for each period it is possible to define different economics, plant capacities, raw materials.

Intermediate tanks stock capacity controls the transfer of streams, products and crude oils from one period to another. Detailed reports are available either for each period and for Global simulation.





Advanced Options

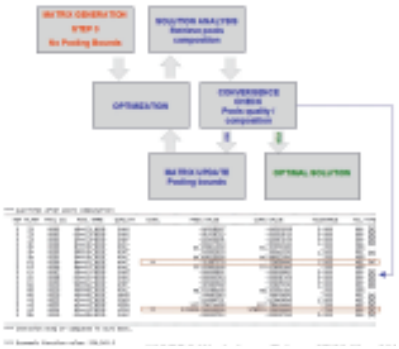
Various types of non-linear behaviours are handled through these functions: to reach this goal either recursive methods and specific solution algorithms are used. Advanced methods for solution inspections and infeasibility management are available to avoid unreliable solutions.

Streams Pooling

A recursive technique preventing from impossible segregation of intermediate streams.

Ranges Analysis

Associates to marginal values retrieved in case of limited variables to the correspondent validity extent.



Investment Cost Recursion

Adjusts the capital cost associated to a new unit according to the capacity chosen by the model.

Solution Inspection

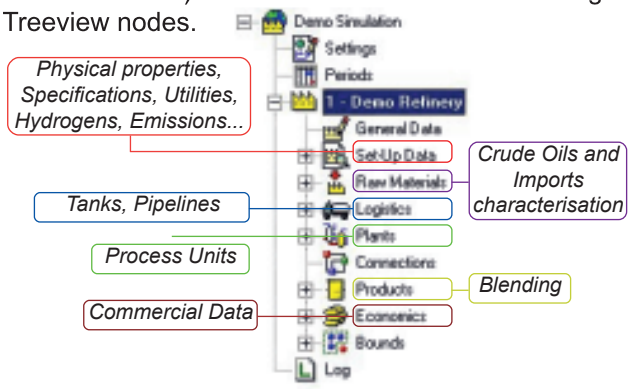
Uneconomical Processing and Blending options and Intermediate products shadow prices are listed to check simulation reliability.

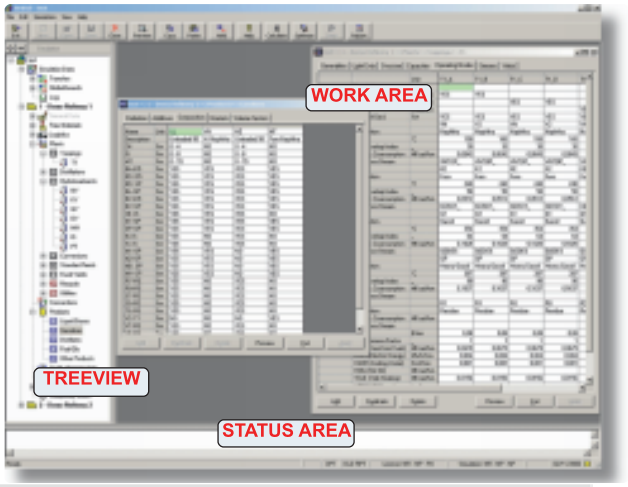
Infeasibility Management

Highlights variables and balances that due to inconsistent constraints lead to infeasibility.

Framework

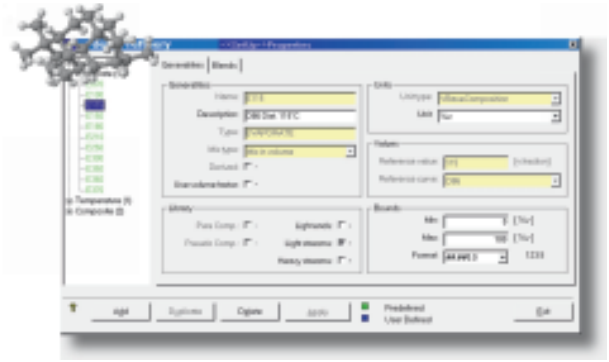
To simplify the task of building the LP model and updating refinery data, SIMRAF provides an object oriented user interface: the Treeview displays different sets of nodes. The “Simulation” node contains the “Refineries” nodes. Refinery Model's data are structured under categories (Raw Material, Plants, Economics etc.). Data tables are accessible through Treeview nodes.

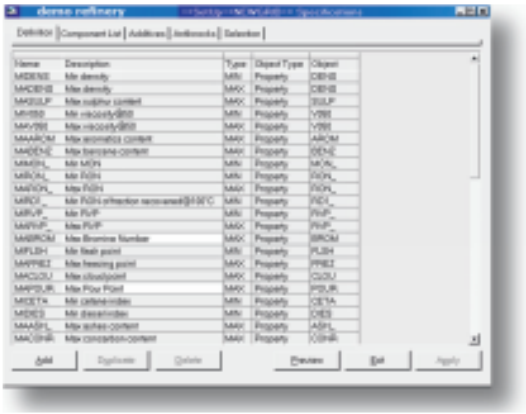




Physical Properties & Product Specifications

Fundamental physical properties (e.g. Density, Viscosity, Evaporates, Sulphur, Antiknock, Cold Properties, Metals) are natively known and managed by the system; moreover it is possible to manage and define additional User Properties.

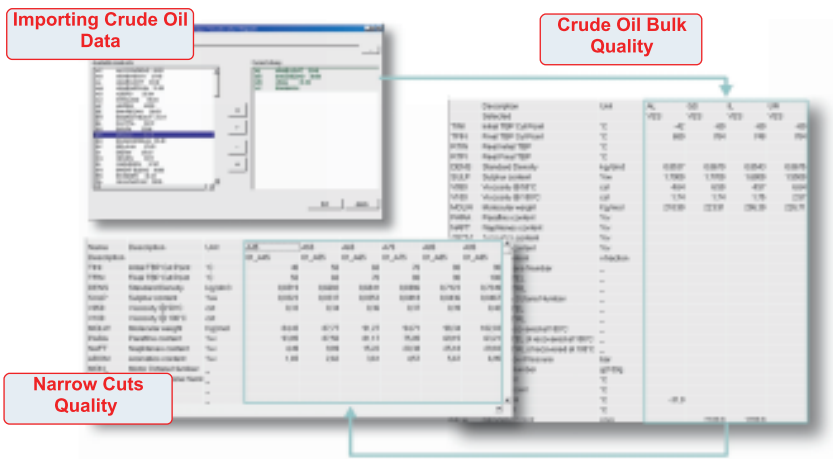




Each property can be monitored through product specifications as well as light components composition, TEL and TML susceptibility and response to Additives (e.g. Cold Property Improvers).

Crude Oils Characterisation

SIMRAF uses a reliable database, which characterises the complex fraction of each Crude Oil by narrow cuts (pseudo-components) with a boiling range of 10°C.

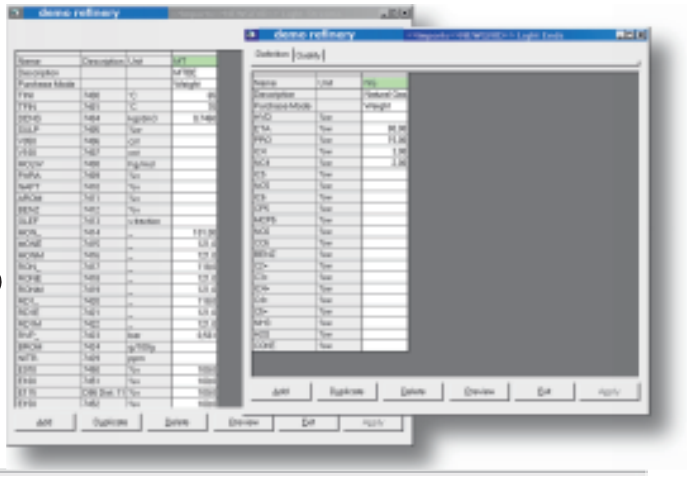


Crude oil data are easily retrieved from the database produced by CUTS and thanks to narrow cuts characterisation are immediately available for intermediate streams quality calculation, with no need of further elaboration.

Imports Characterisation

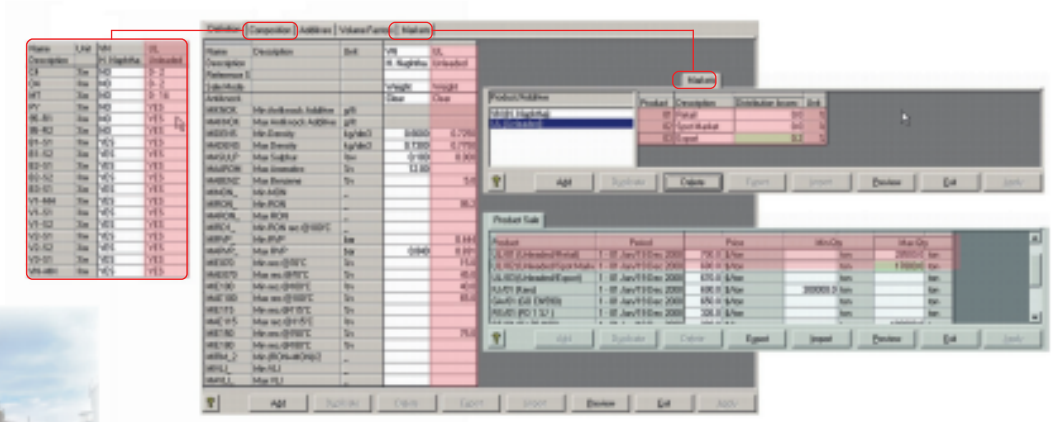
Imports permit to model the intermediate streams fed to the refinery and not processed in CDUs (e.g. MTBE). Depending on the boiling range they are sorted in three types:

Light Ends:	mixtures of low-boiling pure components
Light Streams:	light hydrocarbons streams (gasoline boiling range)
Heavy Streams:	heavy hydrocarbons streams (mid distillate and fuel oil boiling range)



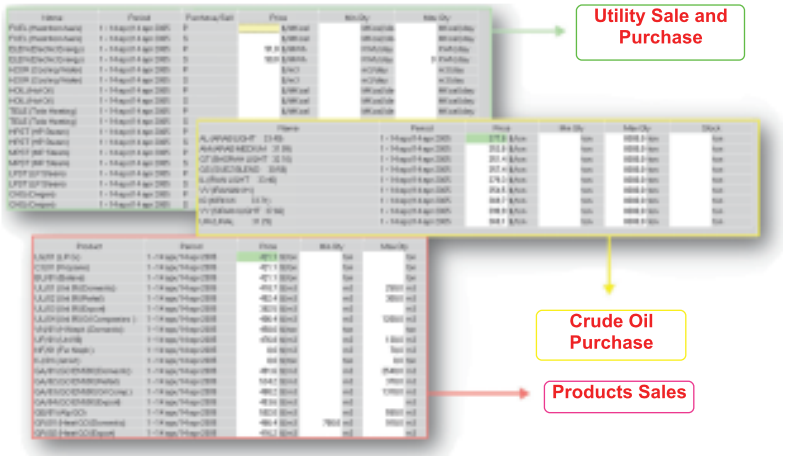
Products Specifications and Markets

For each product user can define Quality Specifications, Blending Components and Recipe Limits. Each product can be sold in different markets with different volumes, prices and distribution losses.



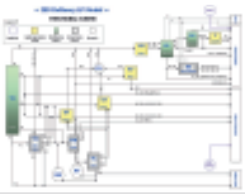
Economics

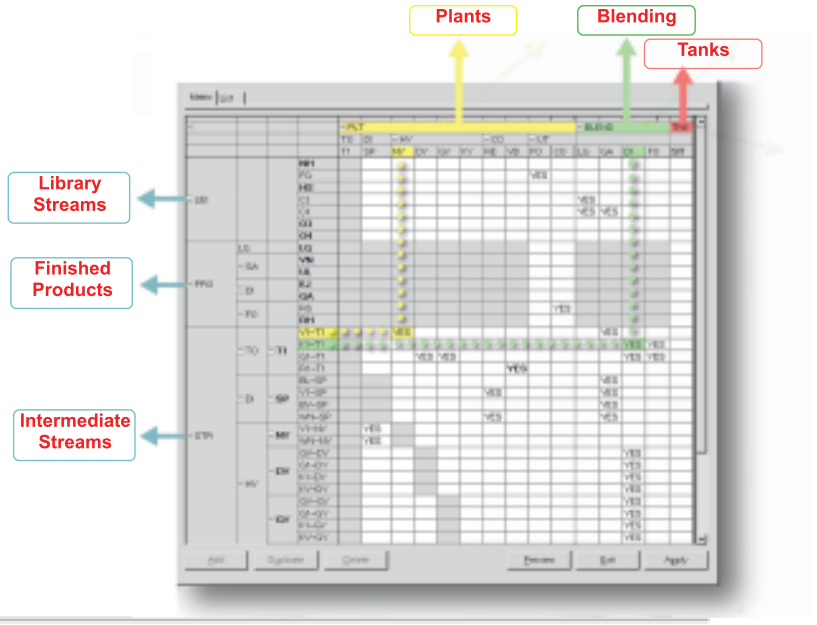
Beside economics data tables for crude oils, imported streams, products, hydrogen and utilities, specific data tables are available for third party processing costs and to account / optimise investments. Items' purchase/sale prices and volumes are set for each period defined in the simulation; importing facilities permitting to automate the updating of economic data are available. Items can be purchased or sold in lots applying MIP (Mixed Integer) algorithm.



Refinery Connections

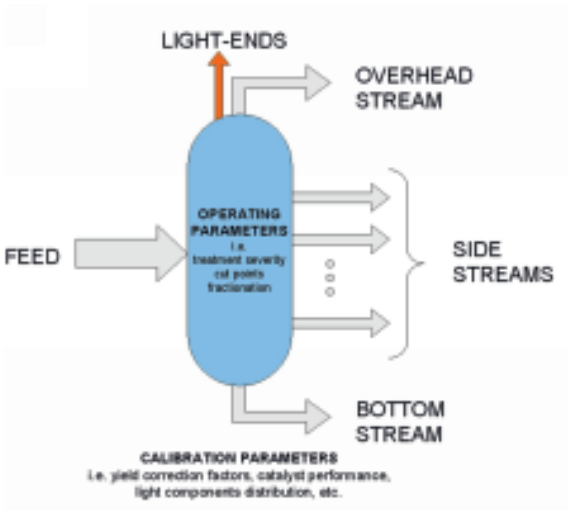
The refinery processing scheme is built connecting intermediate streams, light ends and products to different facilities and destinations.
Refinery Processing Scheme is defined within the model by setting intermediate stream's possible destinations (process plant, blending or storage).
Refinery units are independent blocks whose connection arrangement can be easily modified ("what if" analysis).





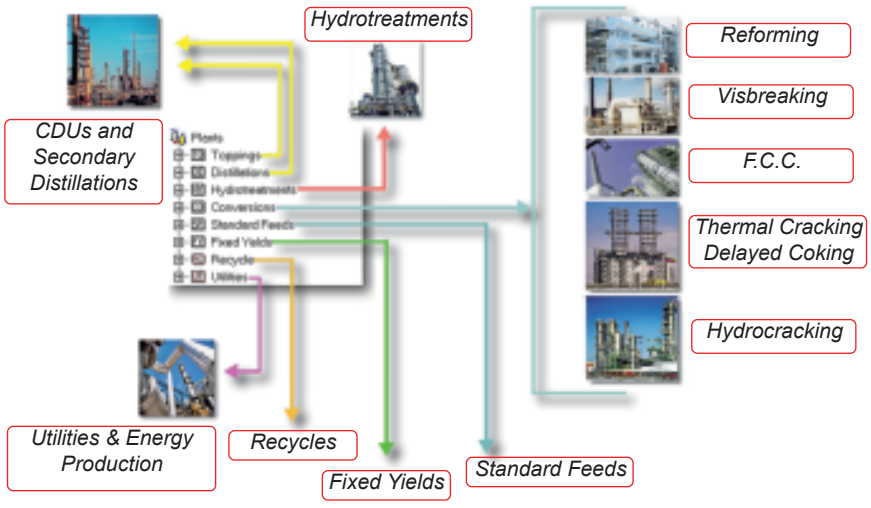
Plant Models

SIMRAF embeds Plant Simulation Technology based on shortcut models, replicating the refinery distillation and conversion units performances.
Effluents yields and properties are calculated basing on feed quality, operating parameters (e.g. number of effluents, cut temperatures, operating severity, fractionation efficiency depending on the type of process).
Calibration parameters permit to adjust the simulator to actual unit performance.
Plant simulators are calculated in sequence following the refinery processing scheme.
Internal recycling, plant refills from auxiliary tanks, as well as any other process peculiarity can be also accounted for and implemented.
Plant simulators use Crude Oil data produced by Prometheus CUTS software (narrow cuts approach).
Crude Oil Data can be also imported from third party databases provided the same level of accuracy and reliability.



Available Plant Models

Even though simulators library adequately represents main refinery processes (Distillation, Hydrotreating, Catalytic and Thermal Conversion) additional algorithms are available for plant modelling; the integration of Recycles, Fixed Yields and Standard Feeds permits to model any type of plant behaviour and arrangement.

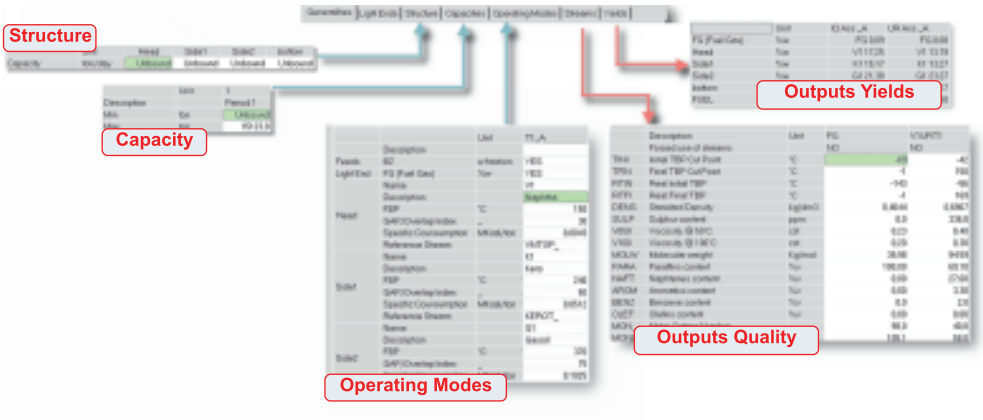


Plant Model Set-up

Although each model has its own calculation algorithms, the adopted user interface is very similar. For a basic plant set-up, few input parameters are mandatory: type of treatment, plant structure (type and number of outputs), capacity and operating parameters (type and number depending on the specific treatment).

Basing on these data Outputs yields and properties are calculated for each feed.

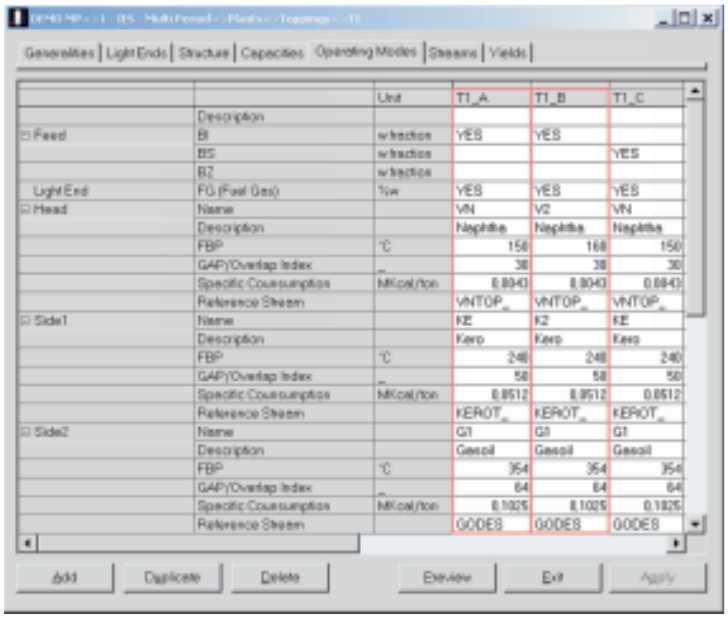
Some algorithms (e.g. F.C.C.) may require a pre-tuning step useful to line-up the model to real plant and catalyst performance.



Plant Processing Options

Plant simulators give great flexibility evaluating alternative processing options: within each plant it is possible to define the alternative operating options that the optimiser will be able to choose.

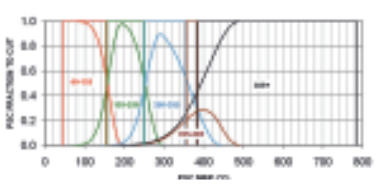
The example aside shows two Operating Modes in a Topping Unit with different cut temperatures for the naphtha fraction (Cut VN with FBP 150 and Cut V2 with FBP 160): the simulator will automatically calculate Yields and Quality of the two Cuts for each Crude Oil fed to the Topping Unit and the optimiser will choose the optimal FBP considering market and operating requirements.

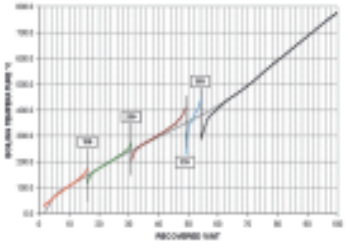


		Unit	T1_A	T1_B	T1_C
	Description				
Feed	BI	w fraction	YES	YES	
	BS	w fraction			YES
	BZ	w fraction			
Light End	FG (Fuel Gas)	%w	YES	YES	YES
Head	Name		VN	V2	VN
	Description		Naphtha	Naphtha	Naphtha
	FBP	°C	150	160	150
	GAP/Overlap Index	_	30	30	30
	Specific Coussumption	MKcal/ton	0.0043	0.0043	0.0043
	Reference Stream		VNTOP_	VNTOP_	VNTOP_
Side1	Name		KE	K2	KE
	Description		Kero	Kero	Kero
	FBP	°C	248	248	248
	GAP/Overlap Index	_	50	50	50
	Specific Coussumption	MKcal/ton	0.0512	0.0512	0.0512
	Reference Stream		KEROT_	KEROT_	KEROT_
Side2	Name		G1	G1	G1
	Description		Gasoil	Gasoil	Gasoil
	FBP	°C	354	354	354
	GAP/Overlap Index	_	64	64	64
	Specific Coussumption	MKcal/ton	0.1025	0.1025	0.1025
	Reference Stream		GODES	GODES	GODES

A Model example: Distillation

Distillation Unit is modelled estimating the distribution of "narrow cuts" (or pseudo-components) over plant effluents: distribution functions are calculated setting a Fractionation Index for each output. These distribution functions are used to estimate calculated outputs quality (including distillation tails) while yields are determined through the TBP cut. Model fine tuning is very easy: fractionation indexes are determined by trial and error trying to match the test run results obtained with a well characterised feed.

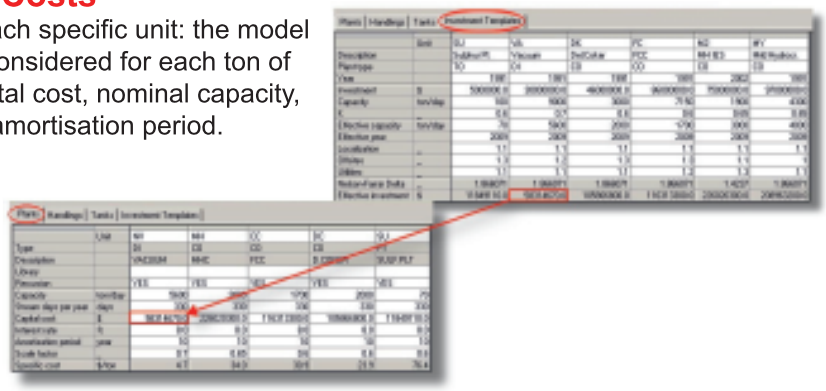




		FEED	NAPH	KERO	LGO	HGO	RESID
Initial TBP Cut Temperature	°C	-60	28	150	250	350	385
Final TBP Cut Temperature	°C	704	155	250	350	385	704
Density@15C	Kg/lec	0.875	0.720	0.808	0.847	0.900	0.990
UOPK		11.73	12.11	11.68	11.71	11.67	11.53
Viscosity@50C	Cst	6.79	0.43	1.02	4.12	11.45	1945.96
Viscosity@100C	Cst	2.46	0.33	0.62	1.49	2.86	96.36
Sulphur content	% m - [ppm]	1.92	[740]	0.35	1.45	1.92	5.11
Bromine number	gr Br /100 gr	0	0	0	0	0	0
Aromatics Content	% v		0.9				
Naphtenes Content	% v		21.4				
Benzene Content	% v						
Reid Vapour Pressure	PSI		6.4				
Clear RON			53.8				
Clear MON			51.3				
Cetane Index				46.7	47.1	42.1	
Cloud Point	°C			-42.3	-0.8	21.8	
Pour Point	°C			-45.6	-5.2	16.8	
Flash Point	°C			54.9	124.4	189.3	
Nitrogen content	% m - [ppm]	0.165	[0]	[10]	[218]	[888]	0.341
Ash content	% m						
Conradson carbon	% m	5.00	0.00	0.00	0.00	0.02	10.72
Nickel content	ppm m	24.0	0.0	0.0	0.0	0.1	58.0
Vanadium content	ppm m	70.0	0.0	0.0	0.0	0.2	168.6
Recovered@175°C	D86 % v	4.1	16.6	0.0	0.0	0.0	0.0
Recovered@180°C	D86 % v	0.1	54.4	0.0	0.0	0.0	0.0
Recovered@180°C	D86 % v	22.9	100.0	18.9	0.0	0.0	0.0
Recovered@250°C	D86 % v	36.9	100.0	97.2	3.3	1.5	0.0
Recovered@300°C	D86 % v	47.6	100.0	100.0	56.1	4.6	1.3
Recovered@350°C	D86 % v	58.3	100.0	100.0	91.2	36.7	4.6
Recovered@360°C	D86 % v	60.4	100.0	100.0	94.0	49.9	6.4

Investments and Capital Costs

Capital costs can be charged to each specific unit: the model calculates the specific cost to be considered for each ton of feed processed as function of capital cost, nominal capacity, days on stream, interest rate and amortisation period.

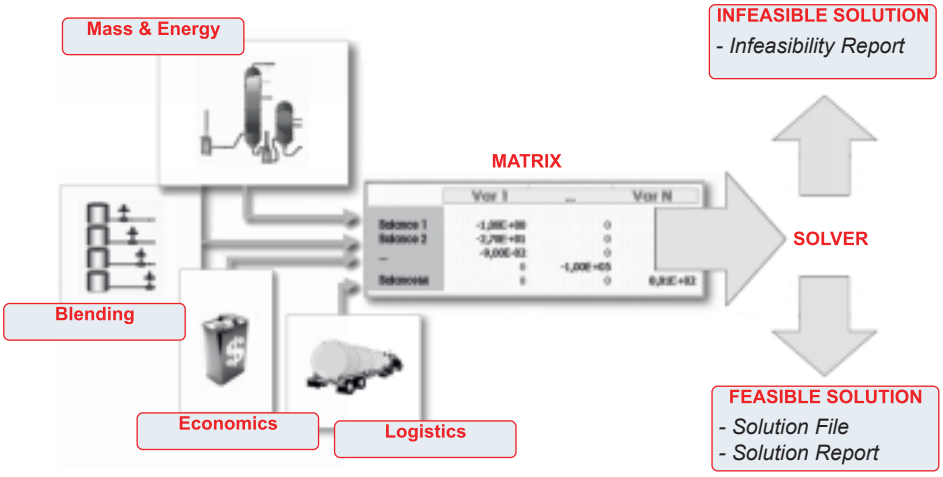


A recursive method, adjusting specific investment cost with chosen plant capacity, permits to compare the profitability of alternative technologies, during the development of strategic feasibility studies.

Investment historical data can be updated and retrieved from an internal database: Capital Costs are brought up to date applying Nelson Farrar General Construction Indexes. Moreover it is possible to correct the capital costs applying factors related to Plant Location, offsite and utility investments.

Matrix Generation and Optimisation

Once intermediate streams quality and yields have been calculated, it is possible to run Matrix Generation and Optimisation Processes: no specific mathematical skills are requested to the User since the system manages this phase autonomously.
This feature does not prevent expert users from directly checking matrix (produced in standard MPS code) and solution files.



Reports

SIMRAF provides complete reporting and solution analysis tools. All Reports can be easily exported to MS Excel format.

Economic Results

The refinery's economic balance: for each sale and purchase the Marginal Value is calculated.

Processing Results

Information about Plants, Utilities, Logistics and Processing, including incentives in exceeding operational constraints.

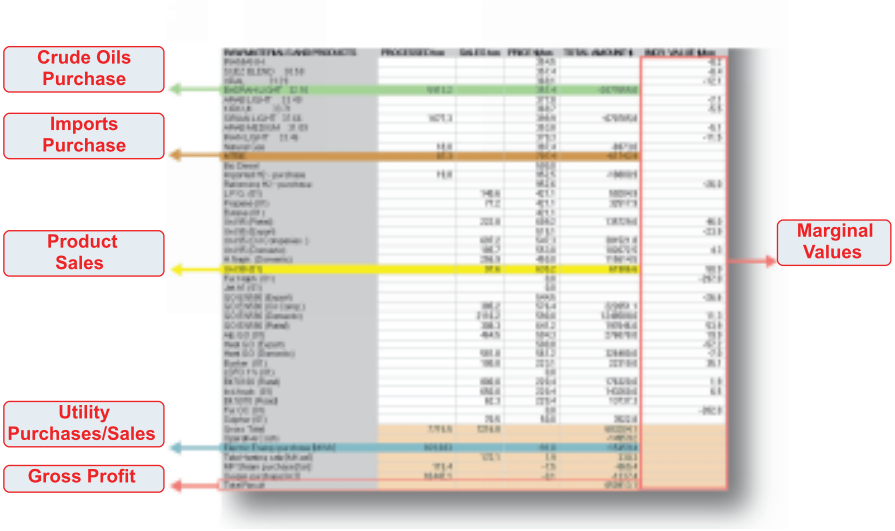
Production Results

Quality and composition for every finished product.

Report Example: Economic Balance

Available for each refinery/period defined in the simulation, this report extracts from the solution the best Economic Balance obtainable given all the constraints.

Marginal values quantify the specific incremental advantage (e.g. US$/ton) achievable relaxing the limiting constraint.



Report Example: Blending Composition

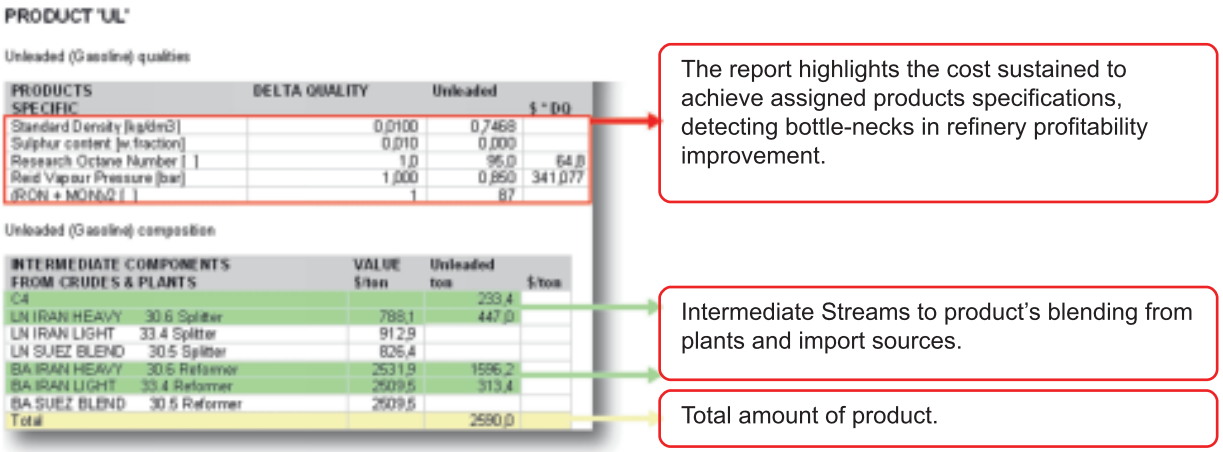
This report summarises how the optimal solution distributes the intermediate streams over finished products thus reporting the optimal blending recipes considering production specifications and intermediate values.

	INPUTS	GPL	Virgin Naphtha	Unleaded	Diesel	Jet Fuel	Fuel OIL
Outputs + Losses		-300.7	-338.3	-2573.8	-2446.8	-2192.8	-11791.3
C3 (Propane)	-240.3	-240.3					
C4 (Butane)	-283.5	-60.4		-223.1			
VN - Topping							
KE - Topping	-2658.9				-466.1	-2192.8	
GO - Topping	-1395.0						-1395.0
BA - Topping	-10396.3						-10396.3
LN - Splitter	-741.2		-319.8	-421.4			
BA - Splitter							
BA - Unifining VN							
BA - Unifining Diesel	-1980.8				-1980.8		
BA - Reformer	-1947.8		-18.5	-1929.4			

In this example the Model produces 2573.8 tons of Unleaded Gasoline, blending 223.8 tons of Butane, 421.4 tons of Light SR Naphtha and 1929.4 tons of Reforming Naphtha.

Report Example: Product Quality

This report details finished product's quality and composition. When the production is limited either by a specification or by a composition bound, the corresponding marginal value is reported.



PRODUCT 'UL'

Unleaded (Gasoline) qualities

PRODUCTS SPECIFIC	DELTA QUALITY	Unleaded	$ * DQ
Standard Density [kg/dm3]	0,0100	0,7468	
Sulphur content [w fraction]	0,010	0,000	
Research Octane Number [ ]	1,0	95,0	64,8
Reid Vapour Pressure [bar]	1,000	0,850	341,077
dRON + MON/2 [ ]	1	87	

Unleaded (Gasoline) composition

INTERMEDIATE COMPONENTS FROM CRUDES & PLANTS	VALUE $/ton	Unleaded ton	$/ton
C4		233,4	
LN IRAN HEAVY 30.6 Splitter	788,1	447,0	
LN IRAN LIGHT 33.4 Splitter	912,9		
LN SUEZ BLEND 30.5 Splitter	826,4		
BA IRAN HEAVY 30.6 Reformer	2531,9	1586,2	
BA IRAN LIGHT 33.4 Reformer	2609,5	313,4	
BA SUEZ BLEND 30.5 Reformer	2609,5		
Total		2580,0	

The report highlights the cost sustained to achieve assigned products specifications, detecting bottle-necks in refinery profitability improvement.

Intermediate Streams to product's blending from plants and import sources.

Total amount of product.

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