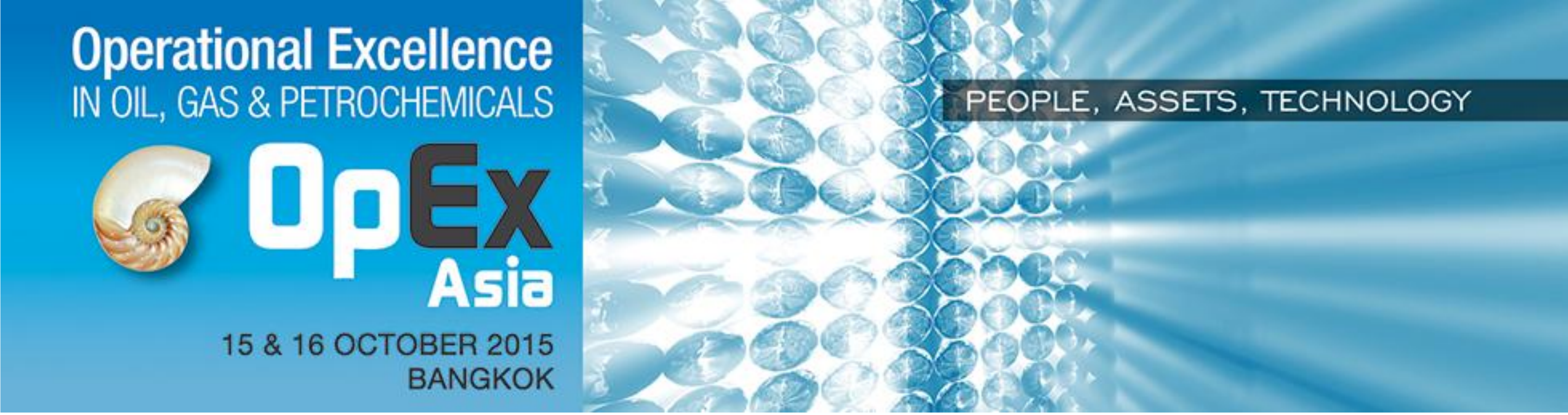

Use smart LP tools to support the development of refinery configuration studies

PROMETHEUS

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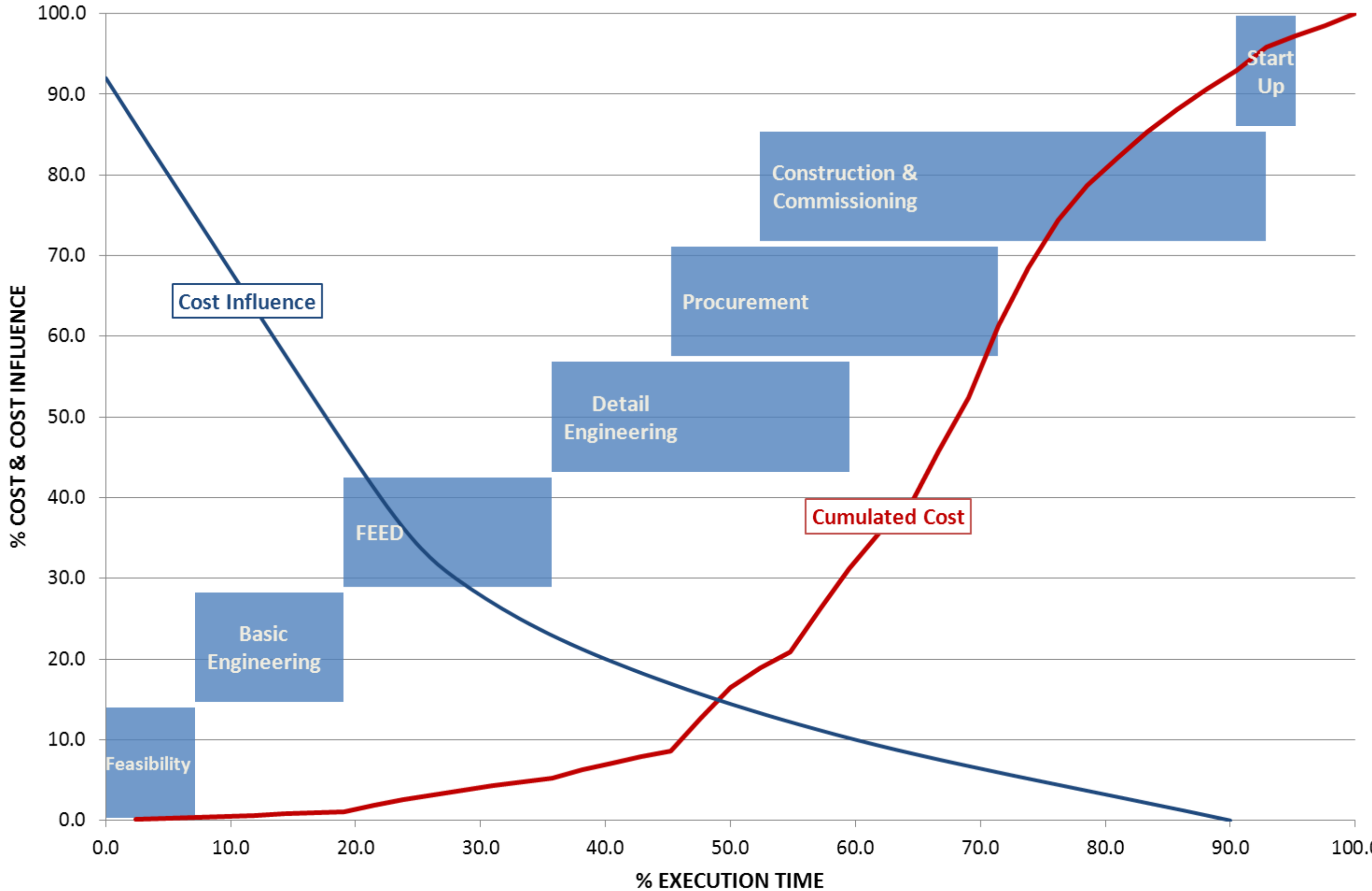
Feasibility & project life

Feasibility phase deeply affects CAPEX and ROI: results are used to select the best possible configuration basing on calculated performance



Feasibility study tasks

The typical execution steps are:

- Select location, size and logistics (grassroots refineries) or define the current profitability baseline (existing refineries).
- Characterize feedstocks and define product specifications
- Define market scenarios
- Rate alternative schemes; for each one:
  - estimate capital and operative costs
  - calculate economic result
- Assess yields, quality, consumption (from licensors)
- Compare financial results (IRR, NPV, Pay Out)
- Select optimal scheme and processing licenses

The growing complexity of refineries obliges to carry out these tasks with the support of LP Modelling

Optimal scheme?

Market can suddenly turn a brand new complex into:

"the wrong refinery in the wrong place in the wrong moment"

The optimal scheme does not exist because scenario changes (already during project execution). Should be a good compromise between:

- Investment
- Added value
- Resilience

Why LP Modelling?

LP modelling accounts at the same time all the technical and economic constraints required to evaluate the performance of alternative processing options in different market scenarios.

Typical LP strengths and weaknesses

STRENGTHS

- Holistic approach (allows to model the entire supply chain)
- Find best possible performance in different market scenarios
- Handles complex problems
- Economic driven solution

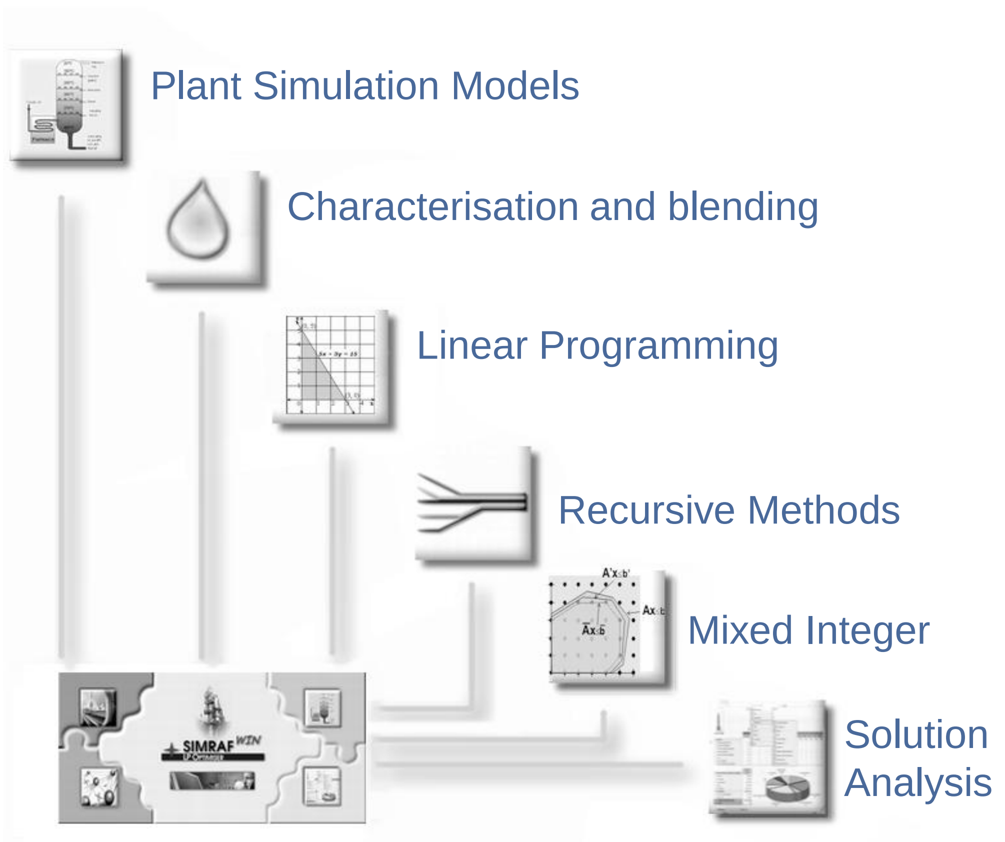
WEAKNESSES

- Difficult to modify processing scheme
- Rough plant performance representation
- Improper modelling of non linear behaviours may lead to wrong results.

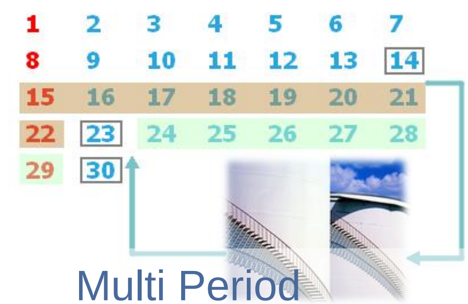
The unique features of SIMRAF™ overcome these weaknesses and make this tool particularly adequate for refinery configuration studies

Why SIMRAF™ is different?

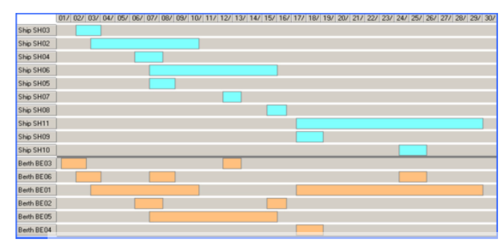
It makes available in the same environment both simulation and optimisation technologies:



Multi Refinery



Multi Period



Optimised Scheduling

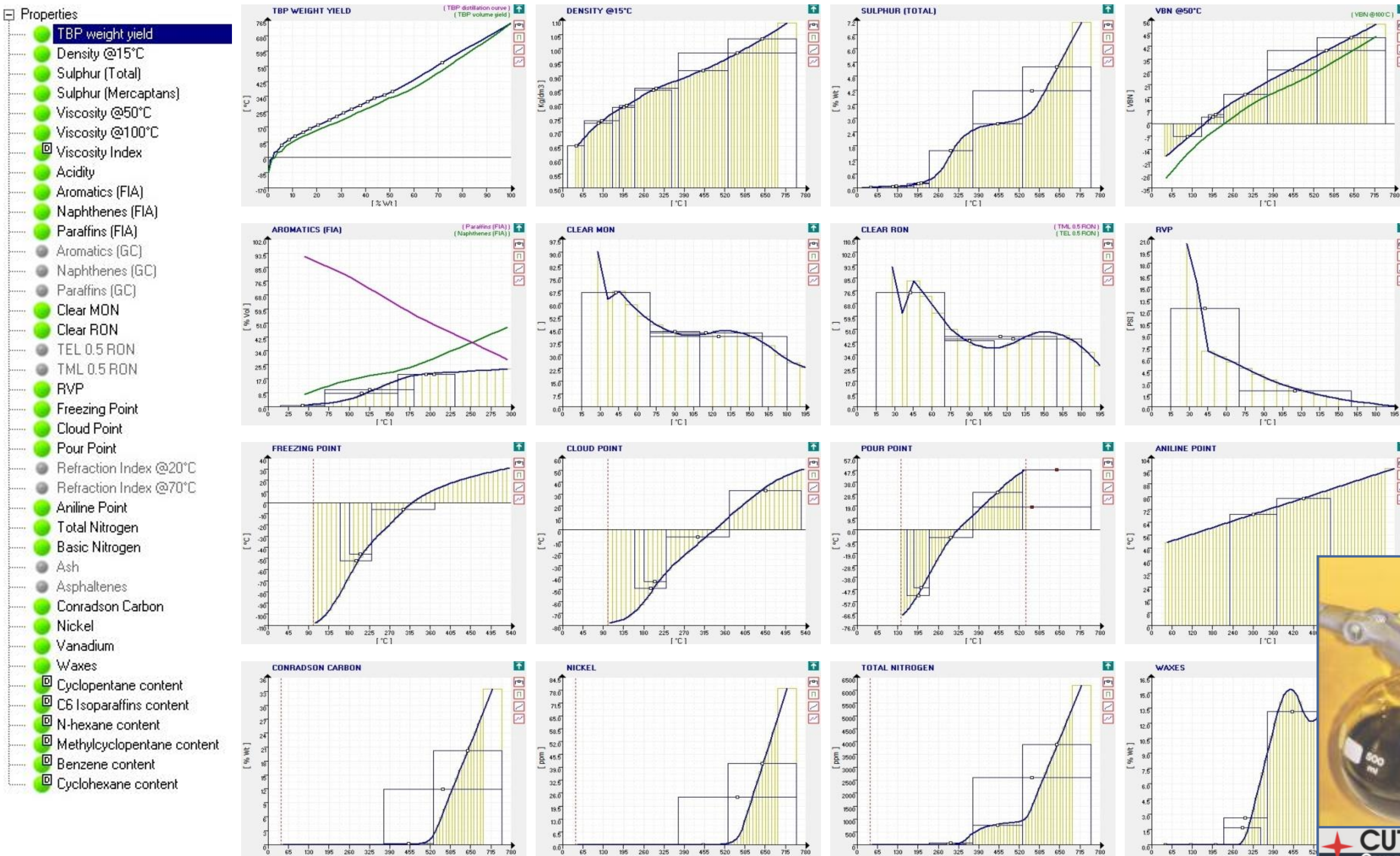
LP model data

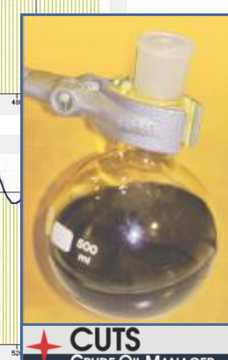
To support the investment study a LP model needs to handle at least the following information:

- Raw material characterisation (crude oils and import)
- Process units results (quality and material balances)
- Auxiliary units (hydrogen, fuel and utilities balances)
- Blending operation (products quality and composition)
- Economics (raw materials, products, utilities, emissions)
- Operating costs and consumption
- Logistics constraints
- Capital and Financial costs
- Fixed costs

Feedstock characterization

CUTS™ characterises crude oils by pseudo - components producing detailed information for meaningful properties useful for process simulation.





Process units representation

The LP model needs to simulate the behaviour of each process unit considered in the refinery scheme.

Depending on feedstock quality and operating modes must calculate:

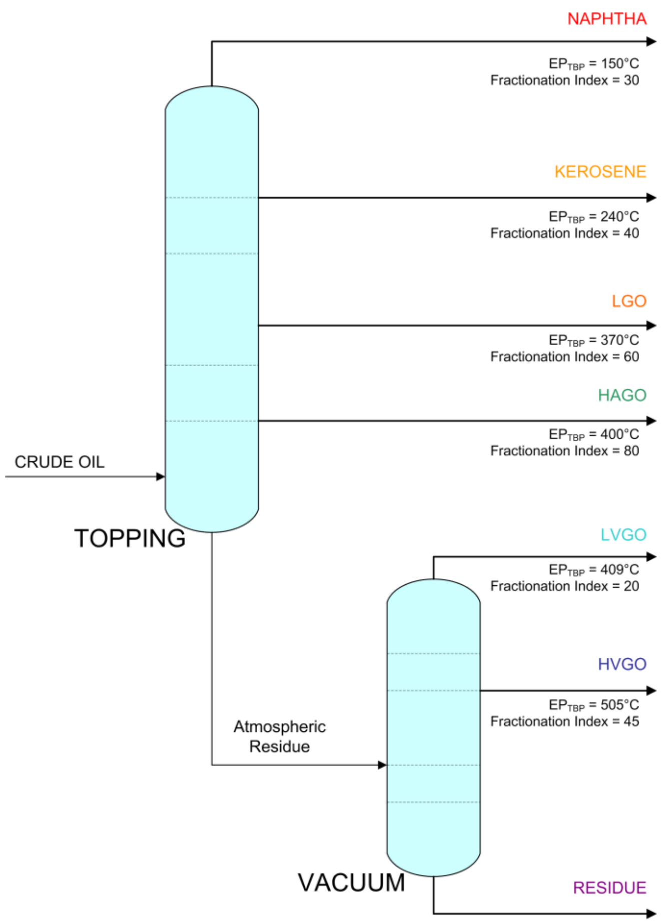
- Unit products yields and quality
- Fuel and Utilities consumption
- Operative costs (chemicals, catalyst, royalties)
- Capacity constraints and encumbrance factors
- Feed quality constraints

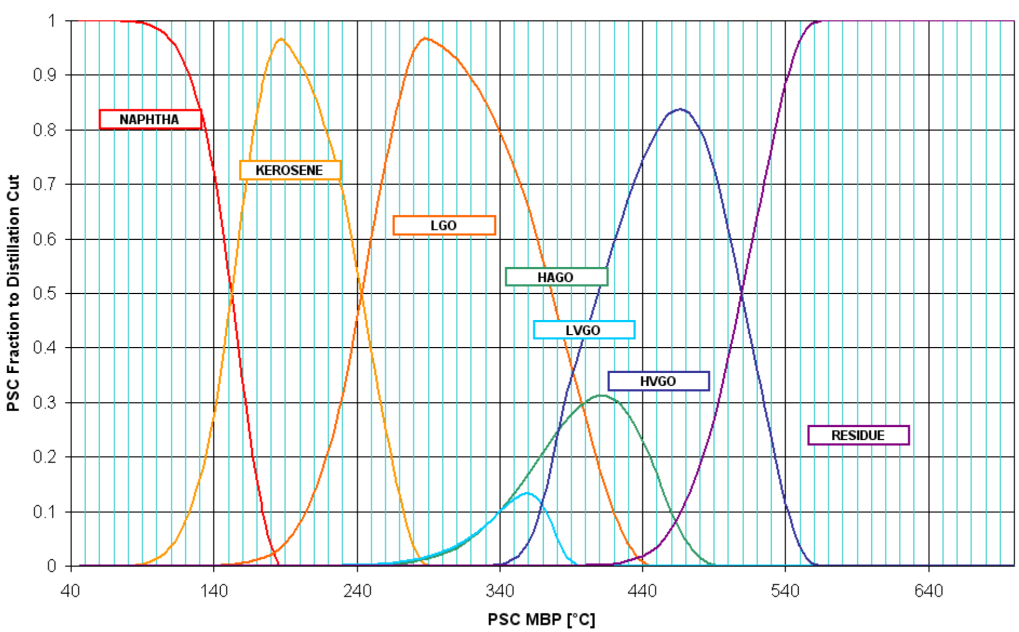
In case of new units, plant simulation models must be fine-tuned to reproduce the commercial yields and performance granted by plant Licensor.

Accounting for real fractionation

Detailed crude characterisation permits to embed directly in the LP model processes and activities usually realised externally like:

- Calculate oil mixes and fractions
- Simulate distillation units (with efficiency)
- Characterise Process units feedstock and effluents.

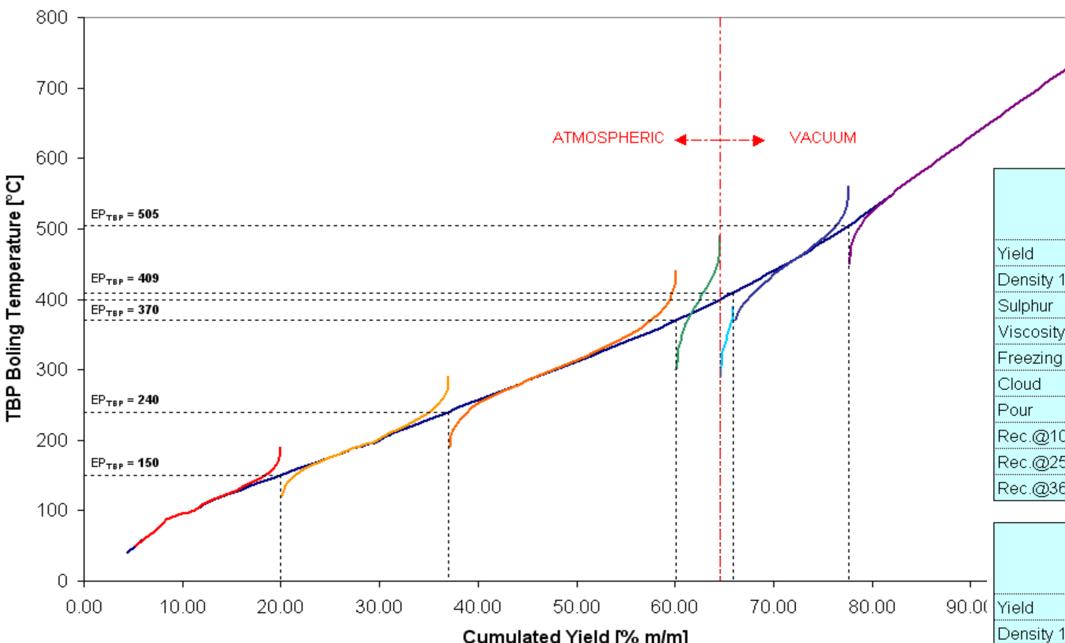




Actual distillation results

Ignoring this effect introduces quality estimations errors affecting the optimal solution (overestimating refinery result).

Biggest effects are on viscosity, cold properties and distillation values



RECUTTING WITHOUT FRACTIONATION INDEXES

		NAPHTHA	KERO	LGO	HAGO	LVGO	HVGO	RESIDUE
Yield	% m/m	19.55	17.12	23.05	4.53	1.30	11.72	22.37
Density 15/4	Kg/dm^3	0.695	0.792	0.850	0.892	0.899	0.917	1.013
Sulphur	% m/m	0.053	0.208	1.244	2.057	1.982	2.371	5.189
Viscosity@50°C	cst	0.41	1.04	3.33	10.2	14.6	35.6	33229
Freezing	°C		-51.9	-8.1				
Cloud	°C		-49.1	-3.6	21.2	25.8	34.2	
Pour	°C		-51	-6.4	16.5	20.4	32	
Rec.@100	% v/v	56						
Rec.@250	% v/v		100	0	0	0		
Rec.@360	% v/v			100	0	0		

RECUTTING WITH FRACTIONATION INDEXES

		NAPHTHA	KERO	LGO	HAGO	LVGO	HVGO	RESIDUE
Yield	% m/m	19.55	17.12	23.05	4.53	1.30	11.72	22.37
Density 15/4	Kg/dm^3	0.696	0.792	0.851	0.893	0.872	0.916	1.012
Sulphur	% m/m	0.059	0.242	1.247	2.005	1.746	2.395	5.166
Viscosity@50°C	cst	0.41	1.05	3.4	11.8	5.5	32.6	29931
Freezing	°C		-48	-7.2				
Cloud	°C		-45.1	-0.6	23.7	8.2	33.8	
Pour	°C		-48.6	-5.3	18.8	6.6	31.4	
Rec.@100	% v/v	52						
Rec.@250	% v/v		99	4	0	0		
Rec.@360	% v/v			93	21	96		

Changes in the range 10-20 %
Changes beyond 20 %

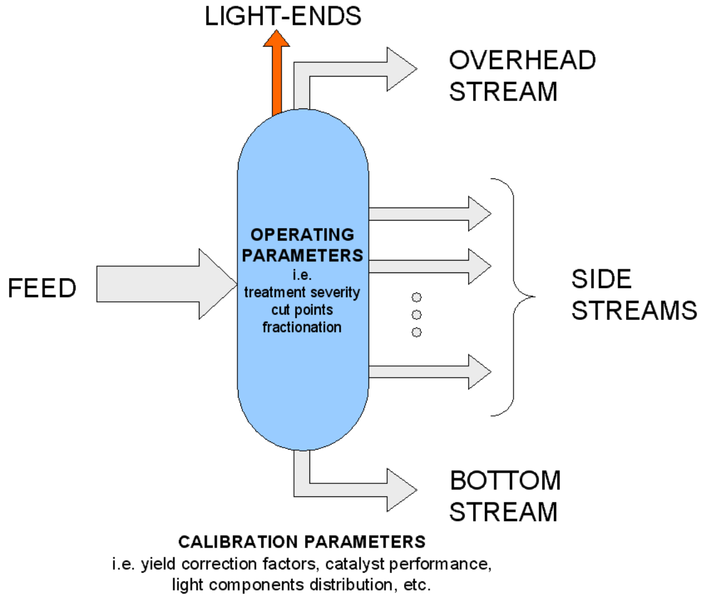
Other processes

Traditional LP tools use different approaches to estimate the yield and quality of Hydro treatment and Conversion processes:

- Sub models (base-delta modelling technique)
- Exchange data with external simulation packages

SIMRAF™ Plant Simulation Models use proprietary correlations based on plant feedstock and characteristic operating variables.

- Fine-tuneable to predict real performance.
- Need few input data
- Available processes are:
  - Distillation (primary and successive)
  - Hydrotreatments
  - Thermal Conversions
  - Catalytic Conversions
  - Lubricants



Auxiliary systems

The LP model balances the production and the consumption of the utilities required for process units operation.

The investment for auxiliary systems can be a big part of whole project cost.

The LP model ought to:

- Manage meaningful utilities (Fuel, Power, Steam, Cooling, Hydrogen Networks) and relative consumption
- Handle the burning of alternative fuels internally produced (fuel gas, fuel oil) or imported (natural gas)
- Model auxiliary plants and related capacity constraints
- Balance fuels and utilities networks
- Model utility purchase and sale

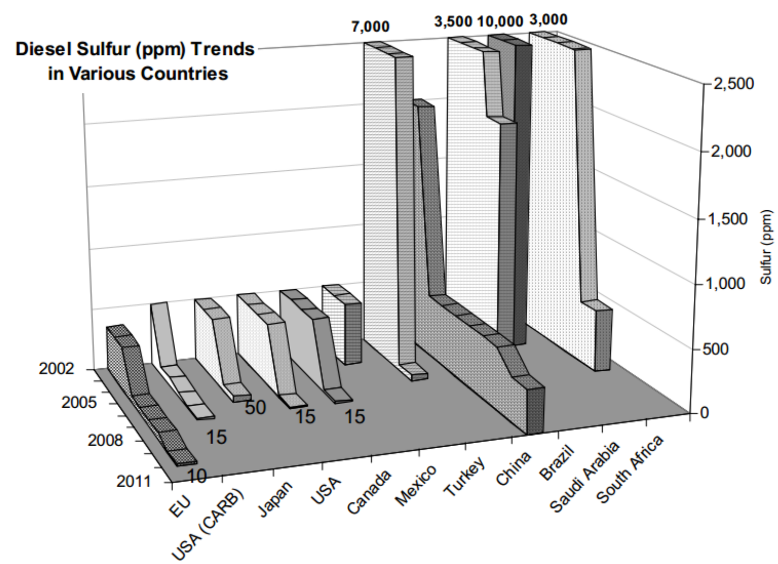
Modelling blending operation

Modelling of blending operation is very important since it affects the choice of process licenses as well as refinery operation:

- Consider meaningful key quality specifications
- Consider quality composition bounds (ex. Oxygenates)
- Exclude unreasonable or not applicable options

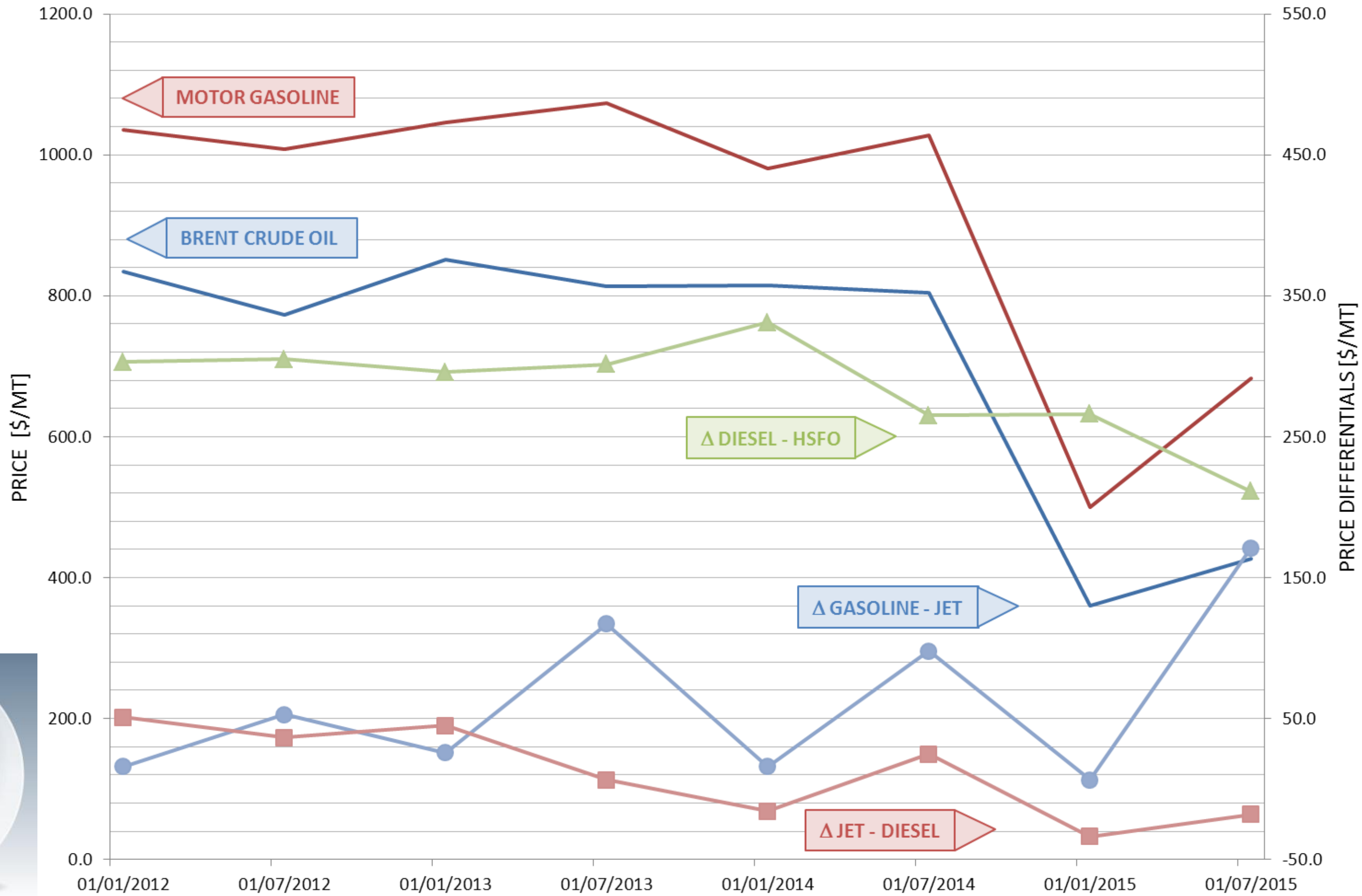
SIMRAF™ predicts mix properties applying for each specification the proper blending rule (linearization indexes and volume factors).

		H. Naphtha		L. Naphtha		Unleaded		Unlead. Plus	
SPECIFICATION	UNIT	Min	Max	Min	Max	Min	Max	Min	Max
Antiknok additives TEL/TML		Clear		Clear		Clear		Clear	
Density	kg/dm^3	0.660	0.730	0.630	0.660	0.715	0.770	0.715	0.770
Sulphur	ppm		500		300		10		10
Paraffines	%v	65.0		87.0					
Aromatics	%v		12.0		4.0		35.0		35.0
Benzene	%v						1		1
Olefins	%v						18		18
MON	_					85		88	
RON	_					95		98	
RVP	kPa		85			65	80	65	80
Recovered@70°C (summer)	%v					20	48	20	48
Recovered@70°C (winter)	%v					22	50	22	50
Recovered@100°C	%v					46	71	46	71
Recovered@125°C	%v	50		95					
Recovered@150°C	%v					75		75	
Recovered@180°C	%v	95				90		90	
NAFT+AROM	%v				13				
Vapour Lock Index	_					750	950	750	950



Market scenarios

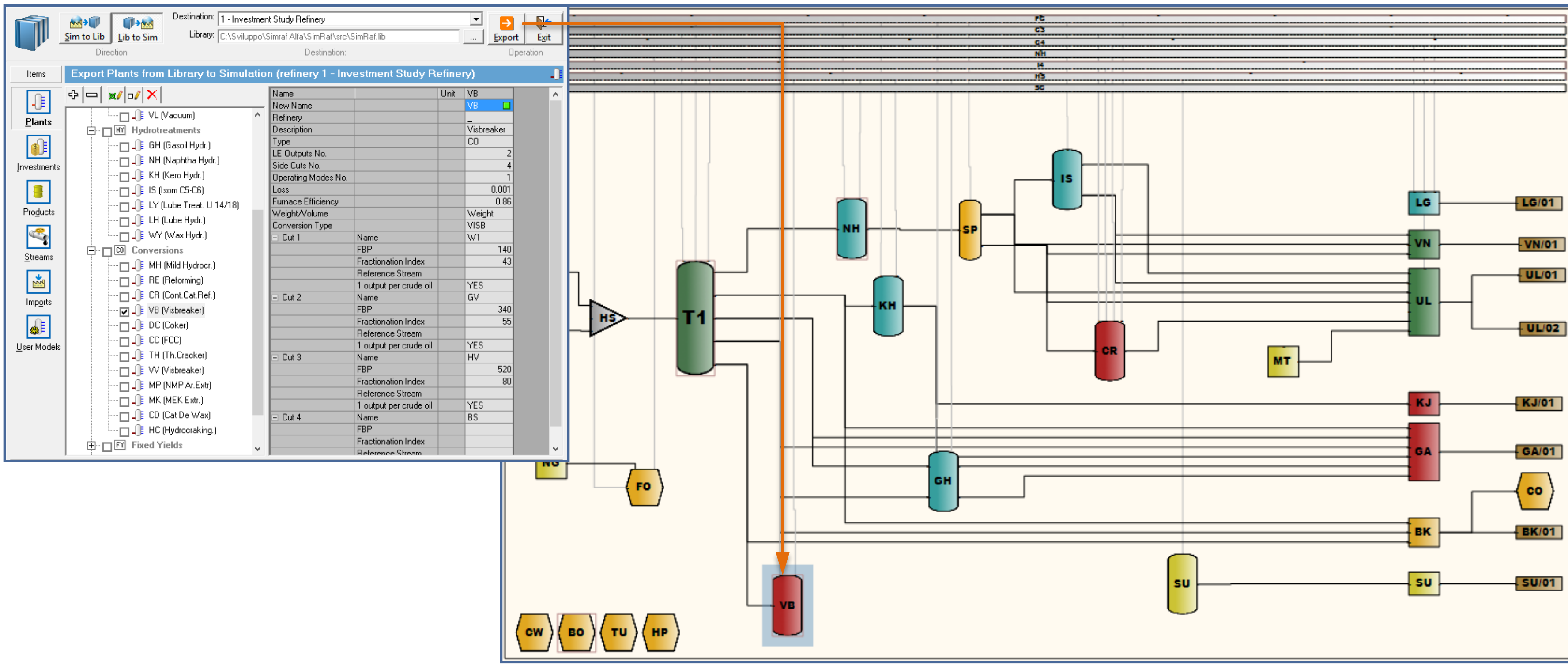
The proper definition of commercial scenarios (product prices and market demand) is fundamental to assure a realistic forecast of investment return.



Building Refinery Scheme

Simulation objects (Plants, Products, Streams, Investment data) are easily added, customized and connected to build the processing scheme.

As soon as a feedstock is connected the plant is calculated and results are available for the matrix generation process.



Investment data management

CAPEX data must be part of the optimization process and should account for:

- Plant capacity: scale factors (non linear behaviour)
- Inflation: actualization methods (e.g. Nelson Farrar)
- Localisation: corrections for specific local requirements
- Offsite and utilities: additional interventions induced by the new unit.
- Financial Costs: function of Interest rate and depreciation period.

SIMRAF™ offers specific features for CAPEX elaboration and actualization.

actualization

	Unit	MY
Description		Mild Hydrocr.
Plant type		CO
Year		1991
Investment	$	97,000,000.0
Capacity	ton/day	4300
K	_	0.61
Effective capacity	ton/day	4000
Effective year		2013
Localization	_	1.1
Offsites	_	1
Utilities	_	1.1
Nelson-Farrar Delta	_	1.99138
Effective investment	$	223,641,300.0

modelling

	Unit	VA	VB	TH	MH
Type		DI	CO	CO	CO
Description		Vacuum	Visbreaker	Th.Cracker	Mild Hydrocr.
Template					
Recursion		YES	YES	YES	YES
Capacity	ton/day	8000	2500	2000	4000
Stream days per year	days	330	330	330	330
Capital cost	$	80,730,750.0	46,856,880.0	40,985,230.0	223,641,300.0
Interest rate	%	6.0	6.0	6.0	6.0
Amortization period	year	10.0	10.0	10.0	10.0
Scale factor	_	0.61	0.6	0.6	0.61
Specific cost	$/ton	4.2	7.7	8.4	23.0

Fixed and variable investments

SIMRAF™ handles the non-linear the correlation between Capacity and CAPEX with a recursive process which adjusts the specific investment cost.

This approach is used to put in competition alternative processes or licenses under different market scenarios

Similarly to other fixed costs, fixed investments are used to calculate the Refinery result.

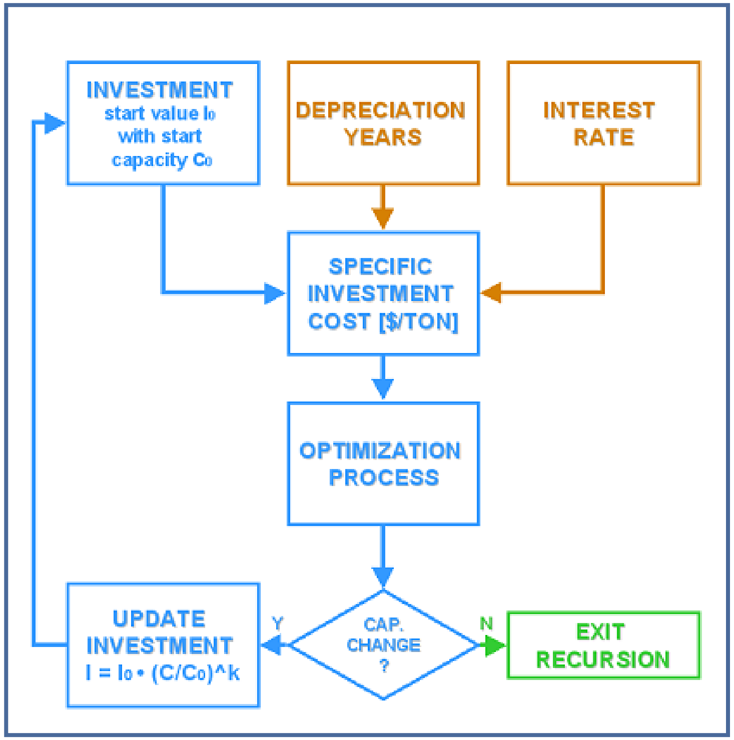
*** Economic function value: 380,134,972.3

*** Investments after optimization:

REF	PLANT	INV.ID.	ACTIVITY	CONV.	PREV.VALUE	CURR.VALUE	TOLER.	T.TYPE	PREV.COEFF	CURR.COEFF
1	VA	0001	117CAü.WVA		2029979.00	2029979.00	5.000	[%]	4.6032	4.6032
1	VB	0002	117CAü.WVB		982990.10	982990.10	5.000	[%]	7.1945	7.1945
1	TH	0003	117CAü.WTH		1018595.00	1018595.00	5.000	[%]	7.0928	7.0928
1	MH	0004	117CAü.WMH		1260513.00	1260513.00	5.000	[%]	23.4372	23.4372
1	CC	0005	117CAü.WCC		859.02	859.02	5.000	[%]	249.8419	249.8419
1	DC	0006	117CAü.WDC		--	.00	5.000	[%]	--	--
1	SU	0007	117CAü.WSU		53543.43	53543.43	5.000	[%]	59.3851	59.3851
1	AL	0008	117CAü.WAL		--	.00	5.000	[%]	--	--

***
*** RECURSION TERMINATED: investment costs recursion converged
***

*** Recursion computation terminated at 29/09/2015 10:09:45



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Technical and Economic Results

SIMRAF™ automatically extracts from the solution the information required for further technical and financial in-depth analysis.

FEED ORIGIN			TR_A	VA_A	VB_A	VA_A	VB_A	T1_A
FEED	UNIT	Feed Pool	TT..TR	VDAHVA	HVAHVB	VDALVA	HVALVB	HGALT1
Quantity	ton	1260512.4	123174.6	15120.7	3438.5	930652.9	182515.2	5610.5
Initial Boiling Point - TBP	°C		370	370	340	370	340	360
Final Boiling Point - TBP	°C		580	535	520	535	520	370
Initial Boiling Point - Real	°C			352	285	351	284	[illegible]
Final Boiling Point - Real	°C			575	586	570	593	
Density	kg/dm3	0.9398	1.0300	0.9446	0.9747	0.9262	0.9564	[illegible]
Molecular weight	Kg/mol			379.63		479.03		[illegible]
Refraction Index @20°C	_							[illegible]
Sulphur	%w	2.3715	0.3000	3.3001	4.4242	2.5057	2.9850	[illegible]
Viscosity @50°C	cst	57.86	10000.00	65.25	80.49	36.04	82.54	[illegible]
Viscosity @100°C	cst	8.95		11.55	10.26	7.89	10.41	[illegible]
Viscosity Index	_	40.2		93.4		107.1		[illegible]
Bromine Number	g/100g	4.2	5.0	0.0	25.0	0.0	25.0	
Flash point	°C		120.0	86.6	180.2	86.6	180.2	[illegible]
Total Nitrogen	ppm	792.8	50.0	806.6	2151.5	774.1	1382.6	[illegible]
Basic Nitrogen	ppm	211.7	20.0	206.9	350.0	210.3	350.0	[illegible]
Aniline Point	°C			78.42		81.69		[illegible]
Cetane Index	_							[illegible]

ECONOMIC RESULTS	UNIT	VALUE
Sales	$	3,773,252,970.5
Purchases	$	3,317,403,803.4
Variable Costs	$	19,135,922.9
Personnel	$	52,058,820.0
Maintenance	$	62,470,580.0
Insurance + Property Taxes	$	26,029,410.0
Overheads	$	29,152,940.0
Interest on working capital	$	12,365,400.0
Total Production Costs	$	3,518,616,876.3
Interest on Investments Debt	$	69,276,059.8
Fixed Depreciation	$	25,540,000.0
Valued Depreciation	$	41,642,093.5
Total Costs	$	3,655,075,029.6
Taxable income	$	118,177,940.9
Income Tax	$	29,544,485.2
Net Income	$	88,633,455.7
Capital Costs	$	416,420,934.7
Cash Flow	$	155,815,549.1
Pay Out Period	year	2.7
DCFRR - IRR	%	35.6
NPV	$	730,395,070.9

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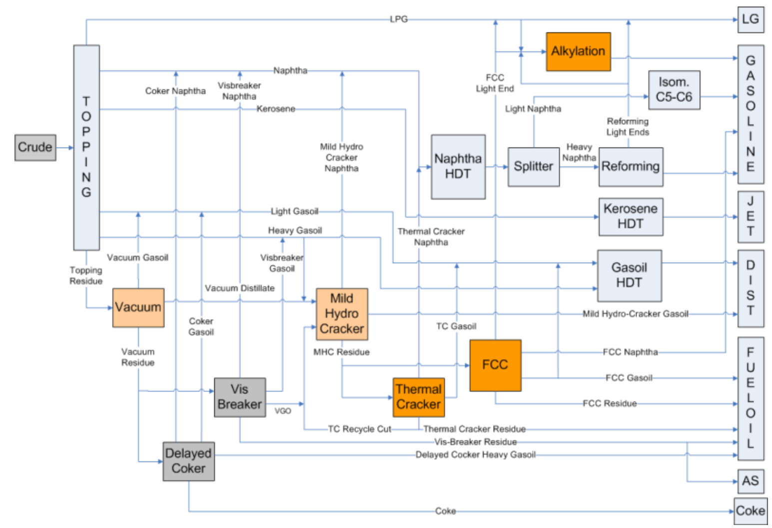
CONCLUSION

- Feasibility Study worth to be executed rigorously; technical and commercial details must be carefully analysed before proceeding further.
- The uncertainness of future scenarios suggests to select resilient schemes with fair results in any scenario (which are not necessarily the most profitable ones).
- LP permits to simulate alternative schemes in many scenarios and is particularly adequate to support the execution of the study.
- Coupling Plant Simulation and LP in the same environment SIMRAF™ is particularly adequate to execute this task with relevant added-value compared to traditional LP tools.



THANK YOU!