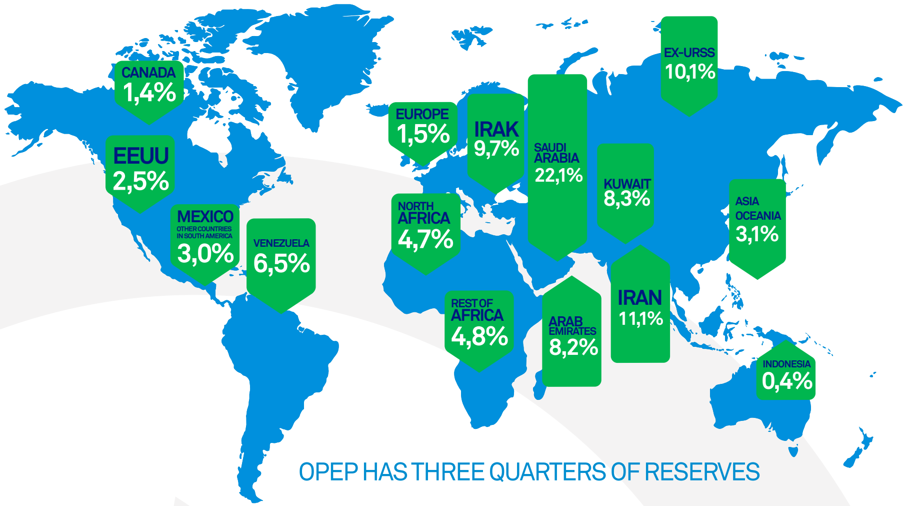
AEA ENERGY

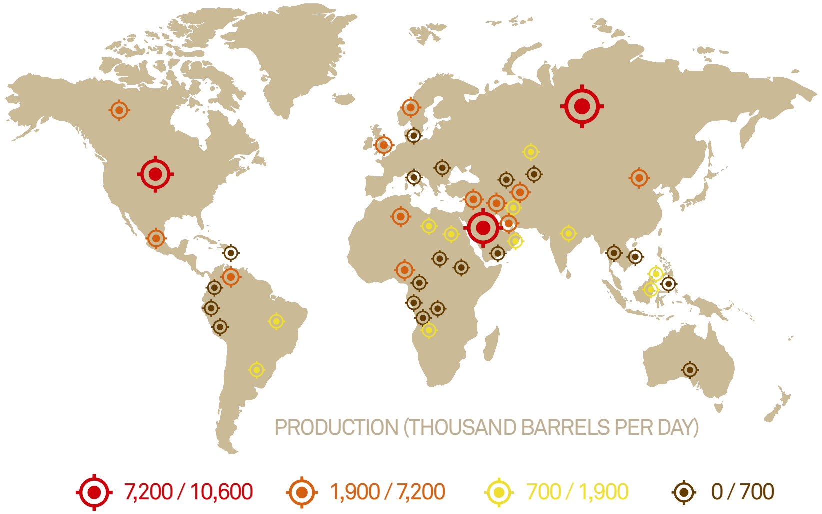
A new generation of tools for refineries

MARKETING DOCUMENTATION /2014

CONTEXT

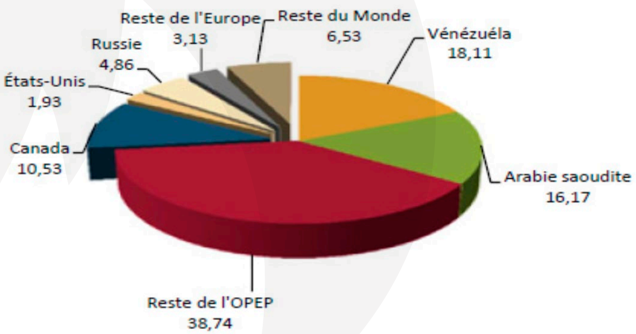
Crude oil production is ensured for the 60 upcoming years

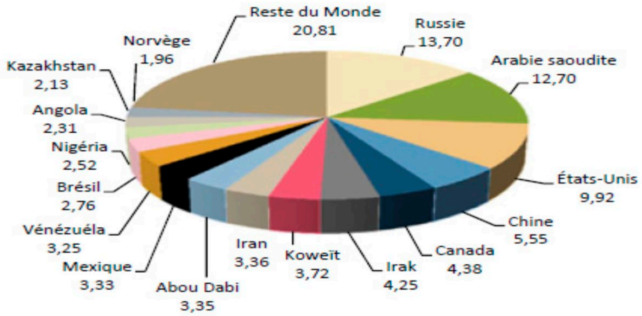




On the 1st of January 2014, proven crude oil worldwide reserves have stabilized themselves at 224 billion tons (+ 0,3 %), which represents approximately 60 years of production at the current rate.

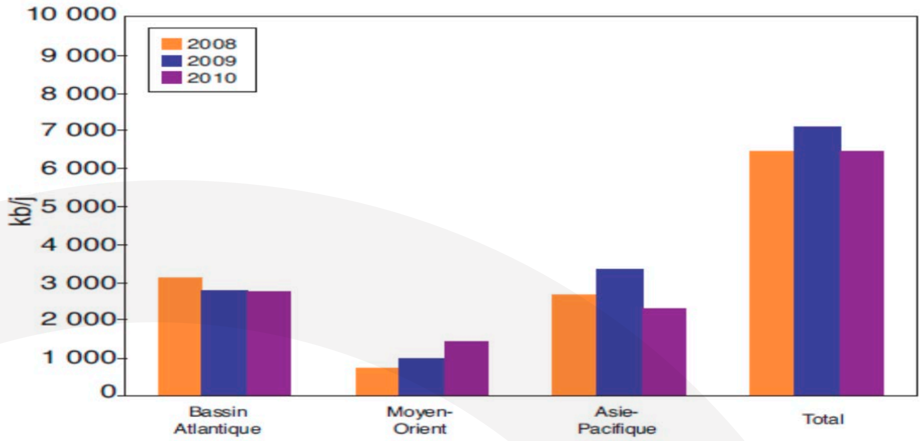
Worldwide oil production has reached 3,75 billion tons in 2013, representing a slight growth over the year (+ 0,8 %). The production of the twelve OPEC country members has receded by 2,2 %, bringing it to 1,53 billion tons.

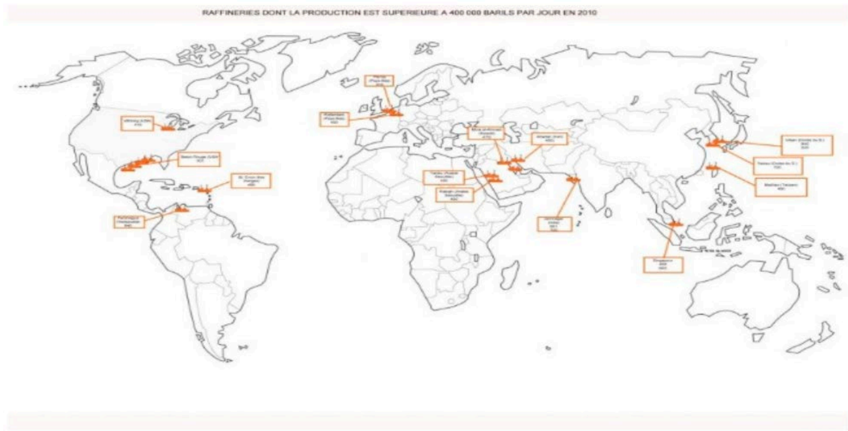




CONTEXT

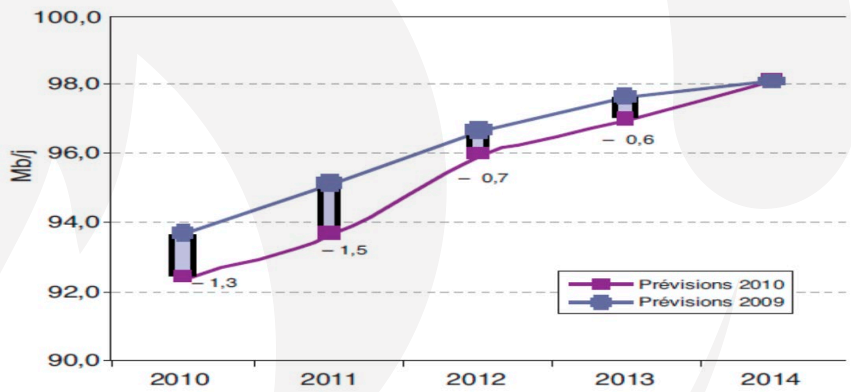
Global refinery overcapacity should be maintained

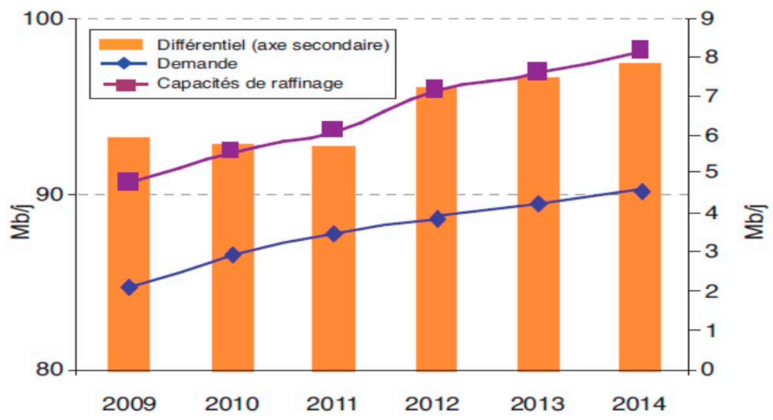




Regional analysis shows very contrasted situations depending on intensity in demand.
In the OECD countries, especially on north American and European markets, where demand tends to decline on the long term, overcapacities should continue to increase.

Globally, refinery overcapacities will still continue several years considering additional capacities, operational medium term capacities as well as projections for oil demand.





CONTEXT

Petroleum refinery processes are set to evolve

- The petroleum refinery industry is submitted to several constraints, obliging oil operators to modify their production orientations. Quality requirements for end products are increasingly strong.
- Exploited crude oil types are broadened; including to heavy oils and unconventional oils (e.g.: tar sand, shale oil)
- Economic pressures lead to the maximum valuation of each barrel at a lower cost, notably at a lower energy cost.

IN CONCLUSION

Increasingly heavy investments:

The refinery of Ras Tanura (Jubail) in Saudi Arabia, with a refinery capacity of 400 000 barrels per day, co-financed by Saudi Aramco and Total, costs approximately 10 billion dollars.

Operating costs to optimize:

In France in 2008, a refinery uses, for its own functioning, around 7% of the crude oil she treats, against 4 to 5% only in the 1980s. In the United States, where profound conversions of heavy oil are more developed, this percentage attains 11 to 13% on the same date.

CONTEXT

Crude oil : diversity is very important

There are hundreds of sorts of crude oil around the world.

The most important are:

- the Brent, the reference crude oil in Europe
- the WTI (West Texan Intermediate), that of North and South America
- the Dubaï Light, that of Asia

The different crude oils are usually distinguished by their density (measured in API degrees) and their sulfur content.

Each crude oil has unique chemical and molecular characteristics.

Three big families are distinguished according to their chemical composition :

1. Paraffinic
2. Naphthenic
3. Aromatic

The **Crude Oil Assay** is a chemical evaluation of raw materials present in crude oil, performed by specialized laboratories.

REFINERIES

Distinction is made according to their complexity

There are approximately **850 refineries in the world.**

They can be classified according to the installed units, which are more or less complex:

1. **The simple refinery** performs atmospheric distillation and also contains product quality enhancing units: catalytic reforming and hydrodesulfuration.

2. **The catalytic cracking configuration** contains, in addition to the basic scheme, a vacuum distillation unit, a fluid catalytic cracking unit (FCC), and a viscosity breaking unit.

3. **The hydrocracking configuration** contains, in addition to the basic scheme, a vacuum distillation unit, an hydrocracking unit, and eventually a coking unit.

4. **The complex refinery with hydroconversion and IGCC** contains a fluid catalytic cracking unit and additional profound conversion capacities (fluid catalytic cracking of residues and/or IGCC).

5. **The refinery specialized** in the production of lubricants and asphalt commodities. It notably contains a vacuum distillation unit.

REFINERIES

The reasons behind performance differences per refinery

- Refineries have very different performances depending on the nature of units and the refining processes used (cf. opposite figure)

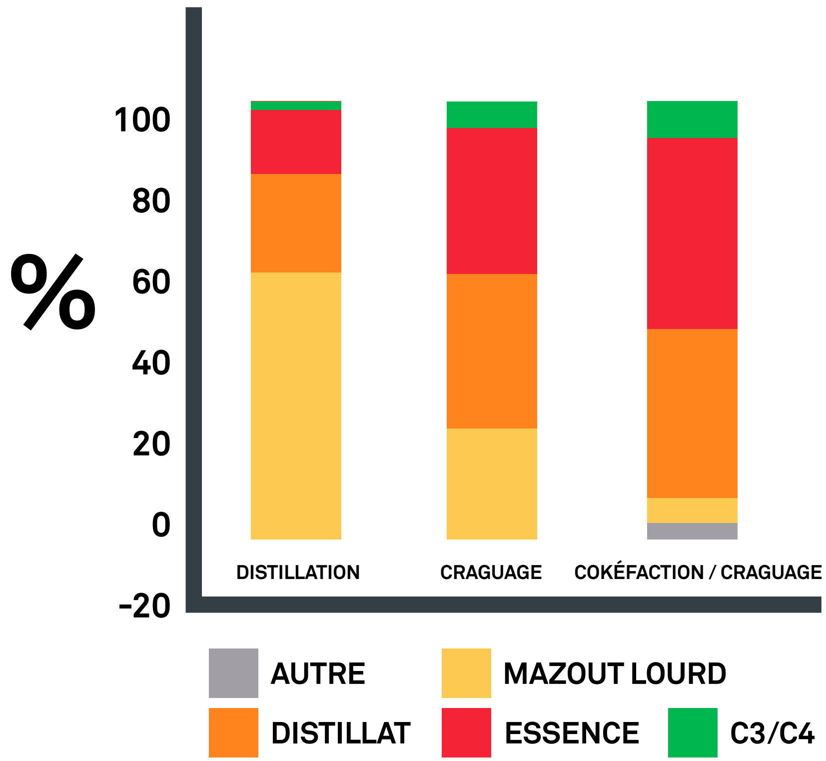
- Each refinery is different because of its age, the technology it uses and the modifications made over time, but certain generalizations are nevertheless possible.

- The installation of an additional conversion capacity increases the performance on the production of clean products and reduces the production of heavy fuel oil.

- However, it also results in an increase of energy consumptions and therefore of exploitation costs.

- The refineries' configuration is also dictated by products' demand in each region.

Performance comparison per type of refinery «Heavy crude oil Example »



REFINERIES

End products obtention processes are increasingly complex

Along time, refining units evolve to enable deep conversions :

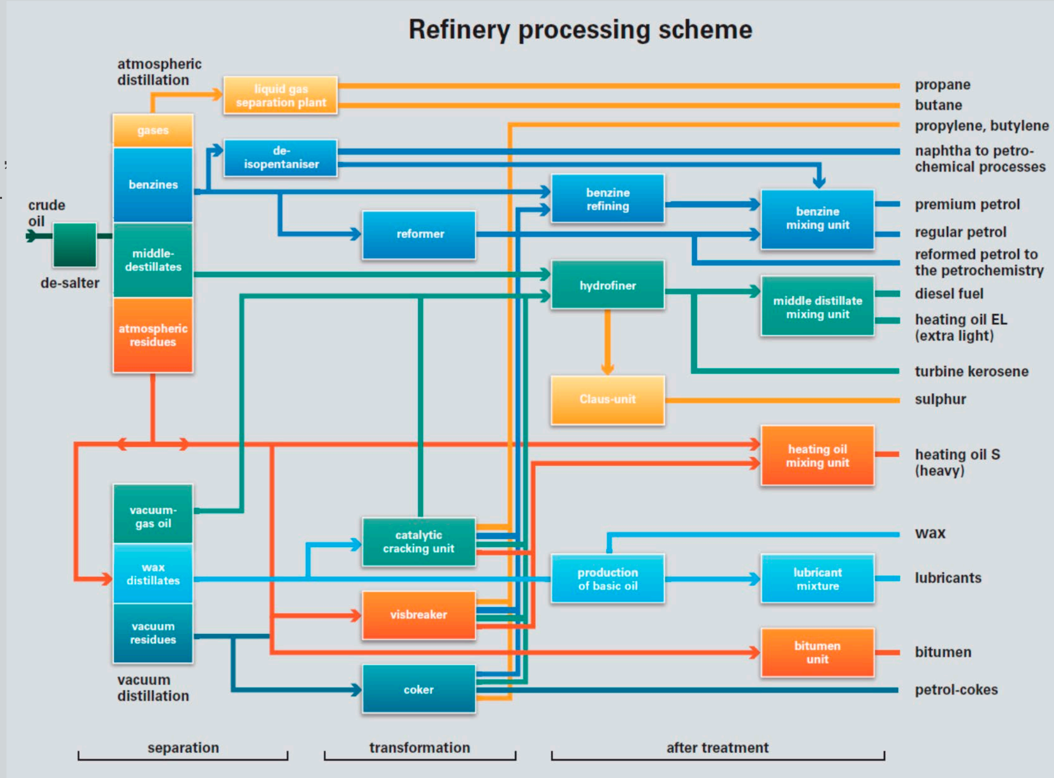
1960 A refinery's main role is to fraction crude oil in gasolines, gas-oils and heavy fuel oils. Since no intermediary complex process is used, this refining consumes little energy.

1980 1990 The aim is to increase the utilization rate (ratio between the treated crude oil and the distillation capacity). This rate increases from 70 to 80% on average.

2000 Exploited hydrocarbons are heavier and request more transformations to obtain light and medium products.

Currently, the world demand in petroleum products is composed as follows:

- **40%** for light products (fuels)
- **40%** for medium products (fuel oil, gas-oil)
- **20%** for heavy products



THE MARKET

Refining margins are low

Refining operates between two markets:
that of crude oil and that of petroleum end products:

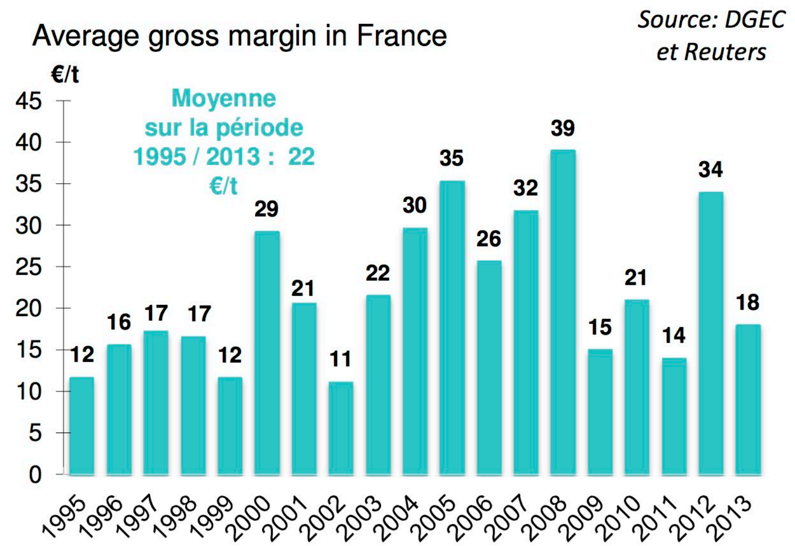
• The currently high prices of crude oil are due to the equilibrium between a constrained offer and a demand led by the economical growth of India and China.

• End product markets may evolve differently depending on the products' family (gasoline, oil-gas, heavy fuel oils...) and/or their consumption area (North America, South-East Asia, Northern Europe...).

Refining's gross margin is the difference between the refined products' market value and crude oil's purcha-sing price.

In France, this margin is low :

- 18 euros per crude oil ton on average
- To be compared to the 30 euros per ton for both fixed and variable costs



In Europe, consumption related to transport requires important evolutions of production tools to adapt to the market:

- Increase in sulfur rate in imported crudes
- Reduction of production surpluses for gasoline and heavy fuel oils
- Increase in oil-gas production
- Adaptation to increasingly rigorous specifica tions for fuels

For example, the refinery in Normandy has rebalanced its productions for the benefit of diesel. Investments have enabled to reduce annual distillation capacity, to increase the size of the distillate hydrocracker (DHC) and improve energy efficiency whilst reducing CO2 emissions.

AEA ENERGY

Presentation

AEA ENERGY is a integrated modelling, simulation and optimization solution. **AEA ENERGY** is dedicated to the refining sector and its related trades. **AEA ENERGY** is adapted:

01

To engineering firms to maximize projects' returns on investment (plants new builds and upgrades)

02

To refiners to maximize their refining finan-cial margins on a daily basis

03

To oils traders to best value each crude oil cargo

04

To Plants owners, to get supply chain management decision support

Since 5 years, GreenAlyze's simulation algorithms are used on various projects:

Opportunity and feasibility studies, revamping studies, operational diagnosis and refinery	Crude oil valuation	Estimation of investments (CAPEX / OPEX),	Environmental studies (Pre-EIA).

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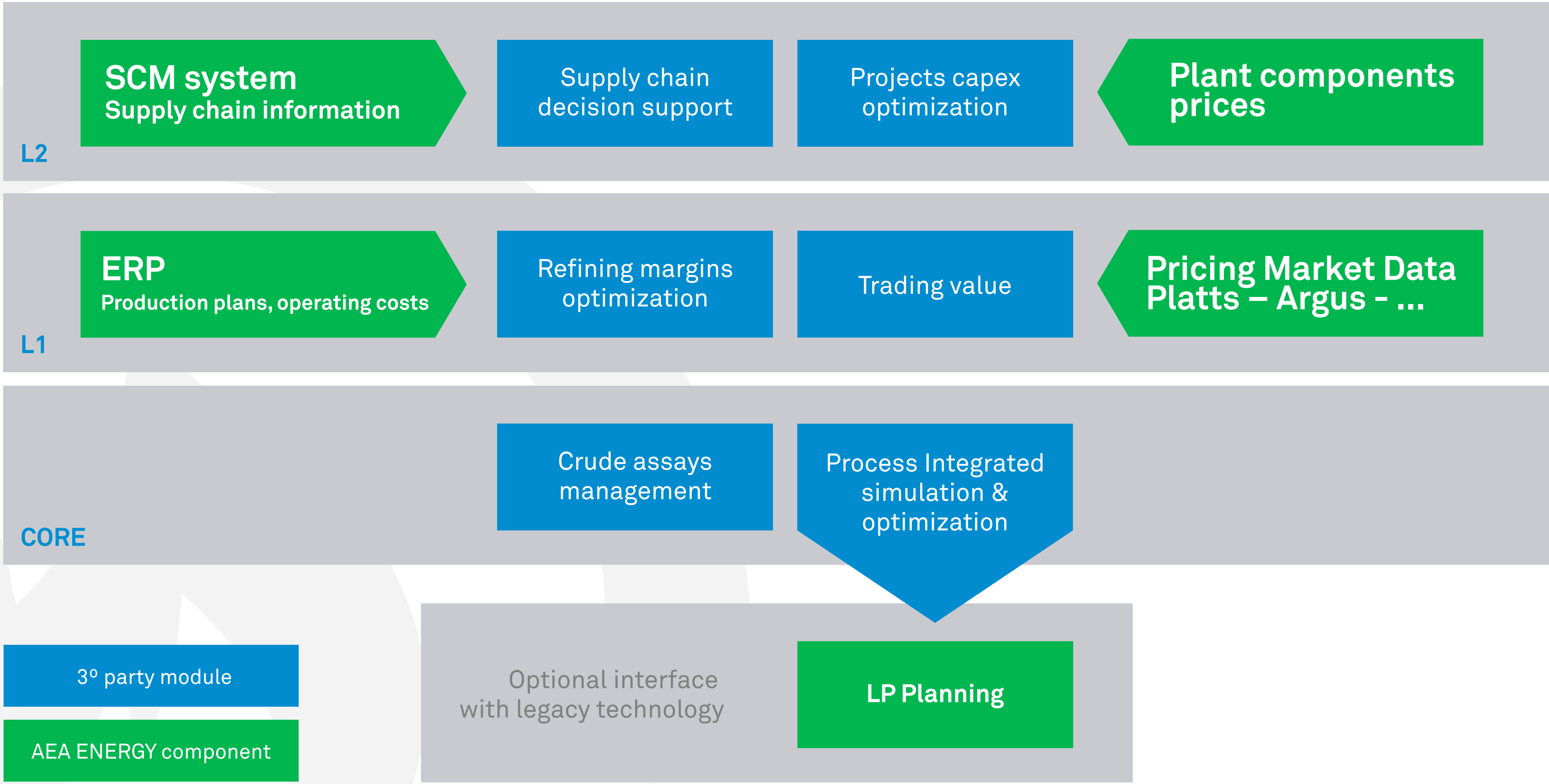
An integrated approach



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Modules' detail (1/3)

Modelling, Simulation & Optimization

Configuration of the refining scheme and intermediary flows, and of the end products' specifications.

Edition of balances of materials, energy and refinery uses (global, per units, per big products : Gas, LPG, Gasoline, Jet / Kerosen, Diesel, Heavy Fuel Oil),

- Including oil units' process models : atmospheric and vacuum distilla tion, catalytic reforming, catalytic cracking, hydrocracking, hydrotreat ments, final products mixture,...
- These process models are interactive and integrated with the balance of materials.

Edition of the environmental balance, of the balance of contami-nants' emissions (SO_2, NO_x, CO, COV,...)
and emitted CO_2 balance.

Cost of emitted CO_2

- Tax impact and Carbon value
- Carbon and hydrogen balances

Interface with a set of « crude assays » and a « CAM Crude Assay Manager » formatting these crude assays to supply the refinery (CAM and GreenAlyze integration)

In optimizing mode, it enables to maximize the refining margin or Variable costs margin for an existing refinery or a project, by opera-ting on chosen variables (crude oil choice, refinery configuration and product routing between units, treatment units' operating and conversion conditions...)

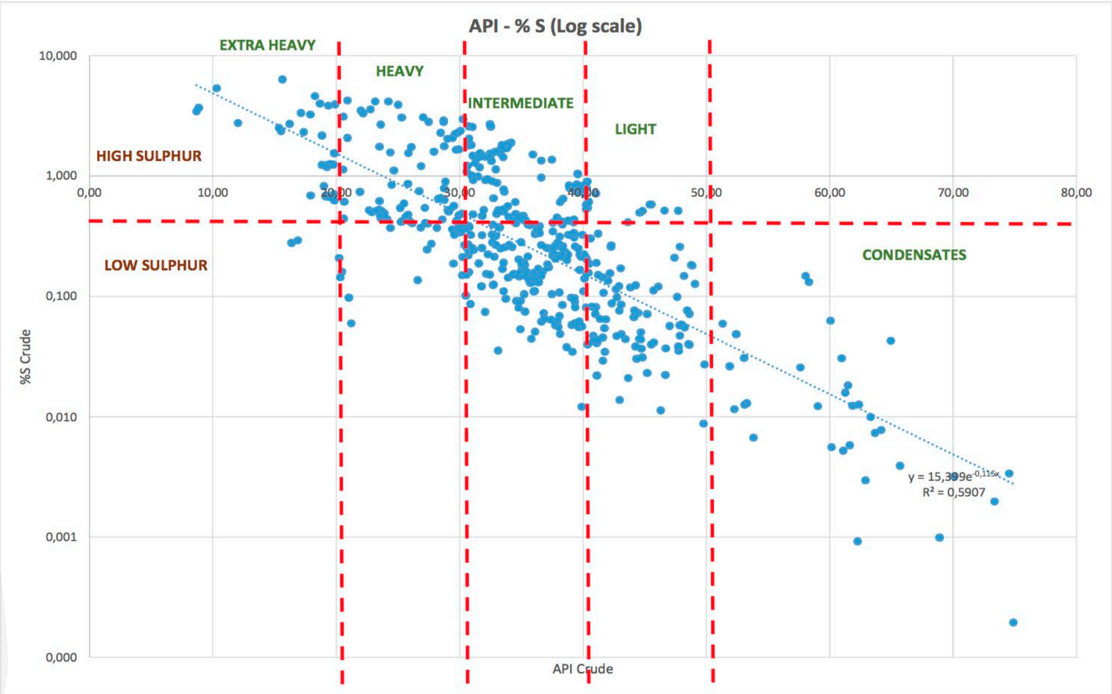
- Evaluation and optimization of energetic schemes: combustibles' balance, energy and utilities production balance. (co- generation).

CAM (Crude Assay Management)

Currently, a database of 500 crude oils contains their characteristics (Crude Assay : molecular composition and petroleum properties).

They are modeled and formatted to be directly utilizable in the GreenAlyze refinery simulator.

The tool includes both the methodology and the process enabling the user to enter new crude oils in the database or to update the ones existing.



Example of a crude oils database:
Density characteristics (° API) and %S

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Modules' detail (3/3)

CAPEX - Project Value

Preliminary evaluation of Oil & Gas investment projects Example : refinery, Upgrader, Gas and train treatment LNG, Central Processing Facility),

The configuration has been simulated including the preliminary evaluation of investments (CAPEX estimate), the evaluation of the economic and financial balance of the project, the financing plan and cash flows, as well as the project's profitability calculation (NPV Net Present Value, IRR Internal rate of return, Payback period criteria).

Trading Value

Valuation of each crude oil or crude oil fractions (atmospheric residuum, VGO fraction,...) in each refinery configuration ("netback value").

Can be used along 2 axes :

« buy side » : chose the "opportunity" crude oil or the mix of crude oils which maximizes the margin of a refinery to supply, « sell side » : discover the value of different crude oils available for different markets and different refiners – potential customers).

Interfaced with databases of prices updated in real time(PLATTS, ARGUS), it enable to identify the arbitration opportunities in real time (differential between the market price and the netback value), by considering freight rates (worldscale) between regional markets.

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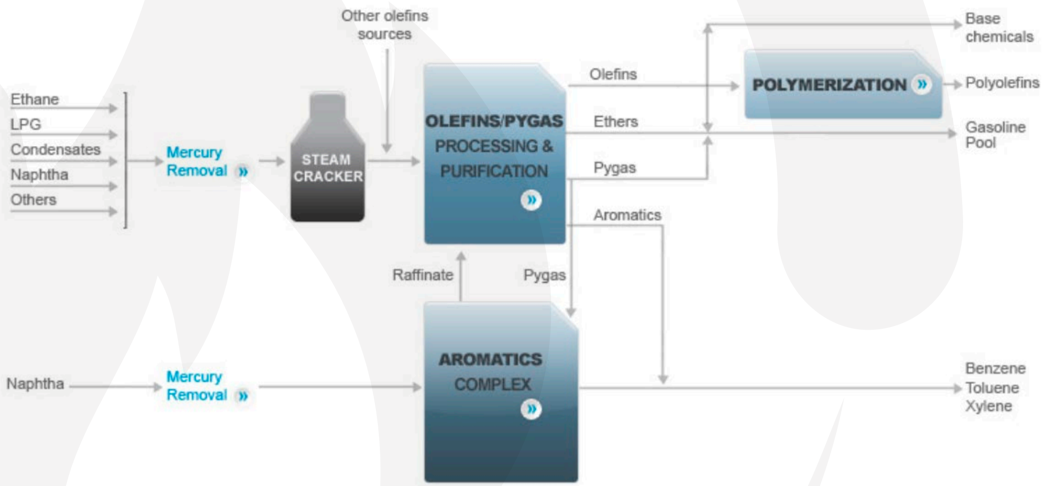
Other functions (1/2)

The simulator for the Petrochemical sector

A complementary Petrochemical simulator is interfaced with the Refining and the crude oils database (CAM).
It enables the autonomous simulation of a petrochemical complex or the representation and valuation an integrated petrochemical complex when associated to a refining simulator – petrochemical (with all economies of scale and integration associated to these refining-petrochemical-energy complexes.



The petrochemical simulator models the principal petrochemical units, represented in poles :

- Steam cracking and olefin production,
- Production of the associated polyolefin,
- Aromatic Complex, optimizing the fractioning and the synthesis of intermediary aromatics (BTX Benzene Toluene, Xylenes) and Styrenes,
- Synthesis gas (SYNGAS CO + H2) from the SMR (Steam Methane Reforming) or gasification, for the production of petrochemical and fertilizer raw materials (Ammoniac, Methanol, Urea and derivatives), or liquid fuels of 2ª / 3ª generation (GTL, CTL, BTL Gas To Liquid, Coal To Liquid, Biomass To Liquid) by Fischer Tropsch processes.

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Other functions (2/2)

The UPSTREAM simulator

It enables an autonomous simulation of a petrol and gas production system, or associated to the refining simulator to represent and value a complex integrated Upstream – Upgrader in the case of extra heavy oil petroleum production (EHO extra heavy oils– syncrudes).

It models the principal production systems implicated:

- Petrol and gas production from the production wells (clusters)
- The system of transport (pipelines vs containers - monophasic gases / liquids / multiphasic gases)
- The CPF Central Processing Facility (Gas, Liquids, Mixes) with the separation of production water according to the evolution of production parameters (GOR, WOR)
- The UPGRADER of EHO, DEHO (Extra Heavy Oil, Diluted Extra Heavy Oil),
- The treatment (acid gas, dew point H20 et HC) and the separation of natural gas (NGL C2, LPG, Condensates).
- GNL treatments (gas treatment, liquefaction)

It integrates the following functionalities :

- Development and production planning (EP Early Production, Plateau, decline) with the evolutions (oils/gas production, evolution of production parameters over time GOR, WOR).
- Quantity and Quality of the production, materials and energy balance
- CAPEX of the production system(class 5 and class 4 : UPGRADER).
- Economic balance and production valuation.

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A new solution to step out of linear programming methods

The petrochemistry sector has been a pioneer in the use of tools based on simplex algorithms in the 1950s (Search for optimum in linear functions introduces by Georges Dantzig).

Half a century later, these solutions still represent the state of the art.

These tools have been improved to take into account the limits of this method, for example by integrating recursive concepts such the SLP (Successive Linear Programming) to integrate multiple grade mixtures with intermediary steps.

But the result is an increase in tools' complexity, increasingly long processing delays, a complete opacity of optimization engines and above all the impossibility to know if the obtained result is really optimum.

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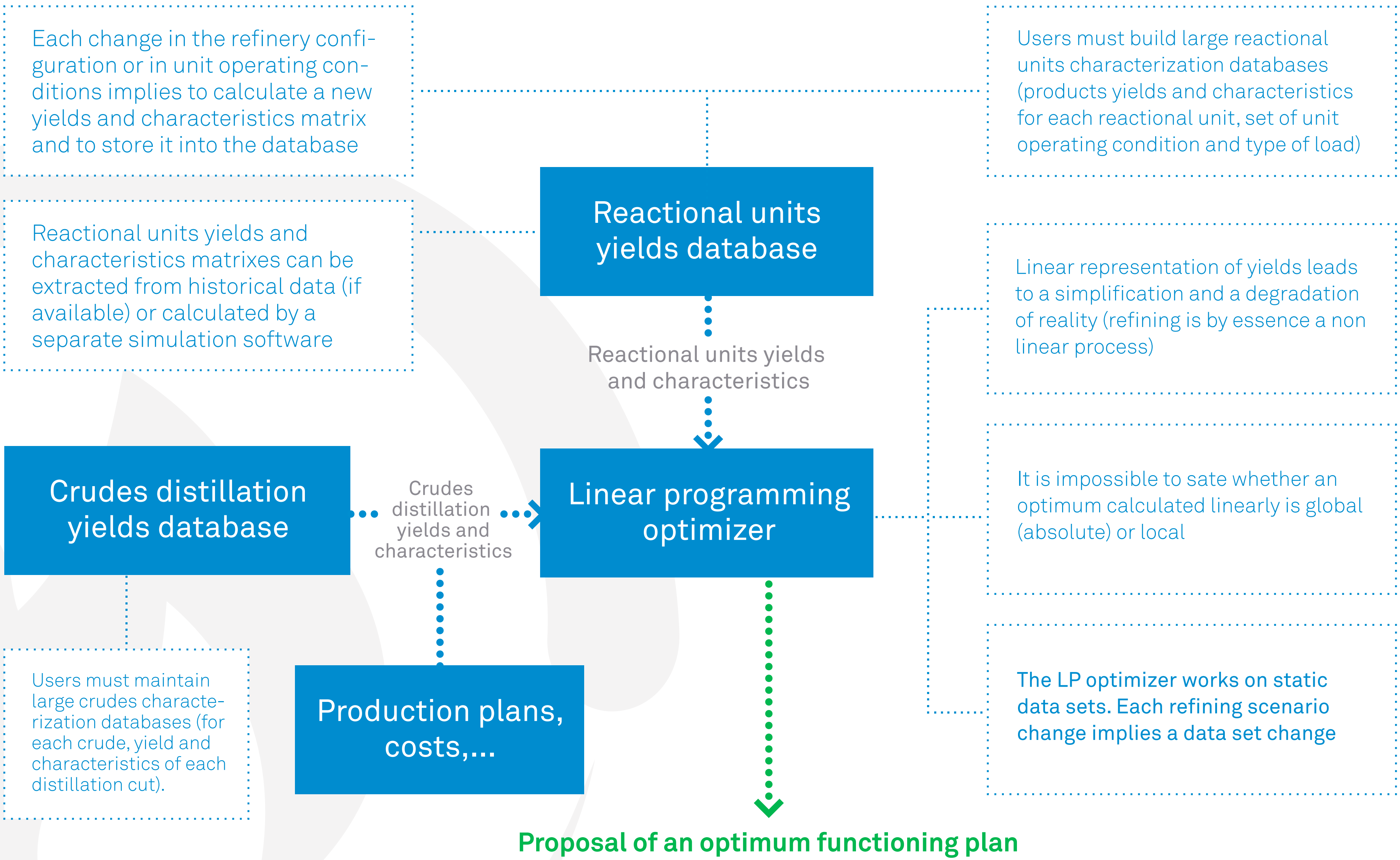
Limits of these historical solutions



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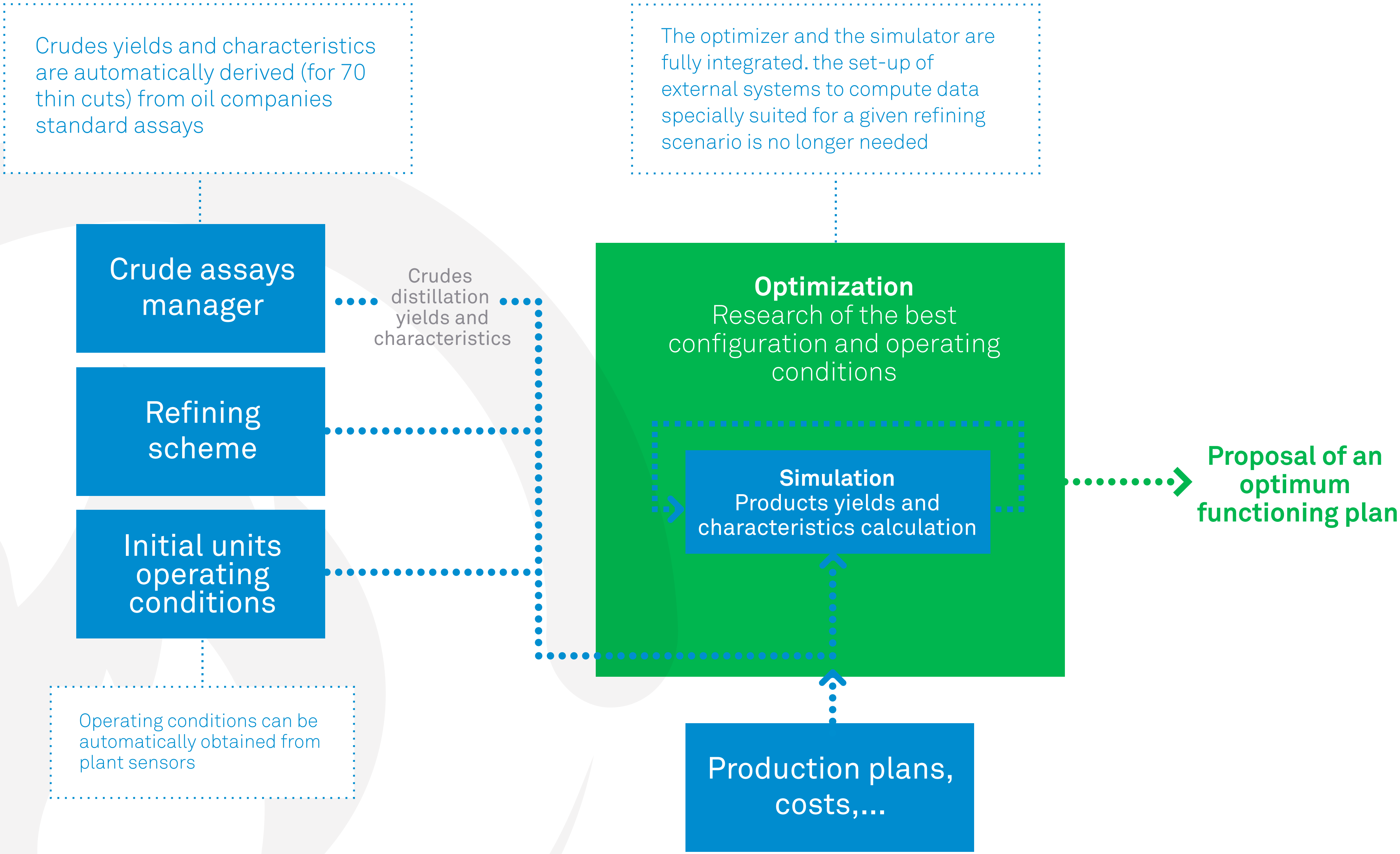
The integrated model's functionning



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The gains regards to historical models

- A precise, intuitive and extremely efficient chemical model :
  - The model's update is performed rapidly
  - Simulation algorithms of all unit types have been validated by an independent expert committee and by comparisons with real cases

- The modelling per independent units is reactive:
  - A unit's shutdown does not block the simulator

- The possibility to calculate a functioning plan per day rather than per month:
  - The integration of the optimizer and of the simulator enables the elaboration of a daily functioning plan taking into account the units' real characteristics (maintenance, ...)

- A reduced optimization team :
  - The global workload enables to reduce the planning team to a single person

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Units which can be modelled and simulated

Physical units which do not perform molecular transformation:

- ADU (Atmospheric Distillation Unit)
- VDU (Vacuum Distillation Unit)
- SDA (Solvent Deasphalting)
- SGP (Saturated Gas Plant)
- UGP (Unsaturated Gas Plant)

Units which convert residues:

- VB (Viscosity breaker): thermic cracking
- DC (Delayed Coking)
- AR-DS (AR Hydrodesulfuration)
- HCK-RESID (Residue Hydrocracking)
- RFCC (Residue Fluid Catalytic Cracking)

Specific units:

- AMIN-CLAUS (Treats H_2S -> S2, S4, S6)
- NH3-Stripper (Treats NH_3)
- H2-BAL (Hydrogen balance)
- H2P-SMR (Hydrogen production unit, for complex refineries) : Stoichiometric

Reactional units which perform molecular transformation (cracking) Either by treating the gas or naphtha fraction:

- ISOM (Isomerization)
- **CATREF (Catalytic Reforming)**
- NHDT (Naphtha Hydro Treatment)
- ALKYL (Alkylation) – Stoichiometric
- MTBE (Etherification) – Stoichiometric
- OLIGO (Oligomerization) – Stoichiometric

Or by treating heavier distillates (200º to 560º) :

- KERO-HDS (Kero Hydrodesulfuration)
- GO-HDS (GO Hydrodesulfuration)
- **FCC (Fluid Catalytic Cracking)**
- VGO-HT (VGO Hydro treatment)
- VGH-HCK (VGO Hydrocracking)

The tanks :

RFG POOL (for the refinery's internal consumptions)

- LPG POOL (Propane, butane, LPG)
- NAPHTHA POOL
- MOGAS POOL
- Intermediary pools

AEA ENERGY

Example of usage by an engineering team: a real upgrader case

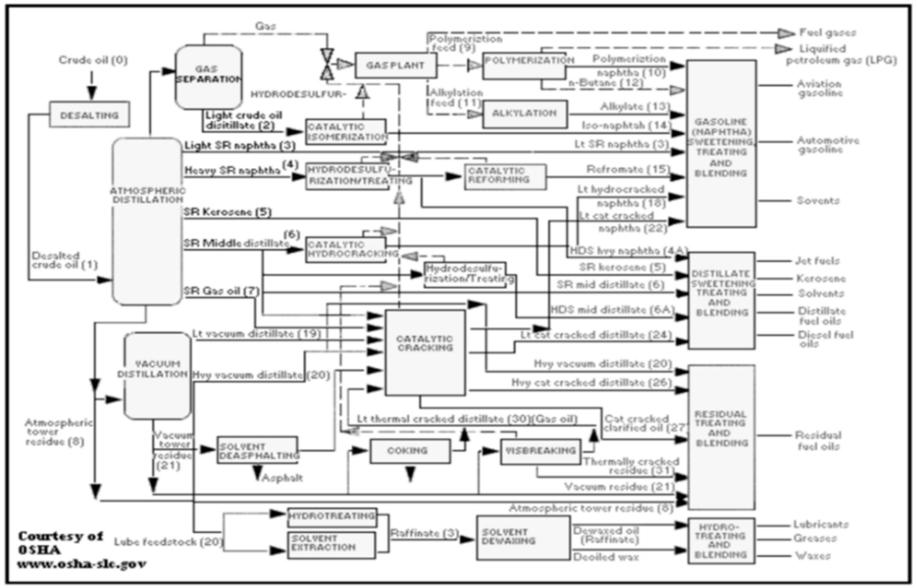
In the context of a large refinery upgrader project, AEA ENERGY is used by an engineering team to identify the solution able to deliver the highest return on investment.

To do so, the following elements have been implemented in AEA ENERGY:

- A set of 28 crude oils.
- The modelling of different solutions based on 26 simulated units (existing and additional).

The following methodology has been used by the engineering team :

- Define the different possible evolutions
  - 3 axes have been chosen with dimensioning variants
- Model all these solutions in AEA ENERGY
- Simulate the functioning of each target refinery configuration and search for the optimum functioning with the set of crude oils
- Compare obtained results to related investments (out of the AEA ENERGY solution)
- Select the best scenario and further qualify the choice with complementary simulations



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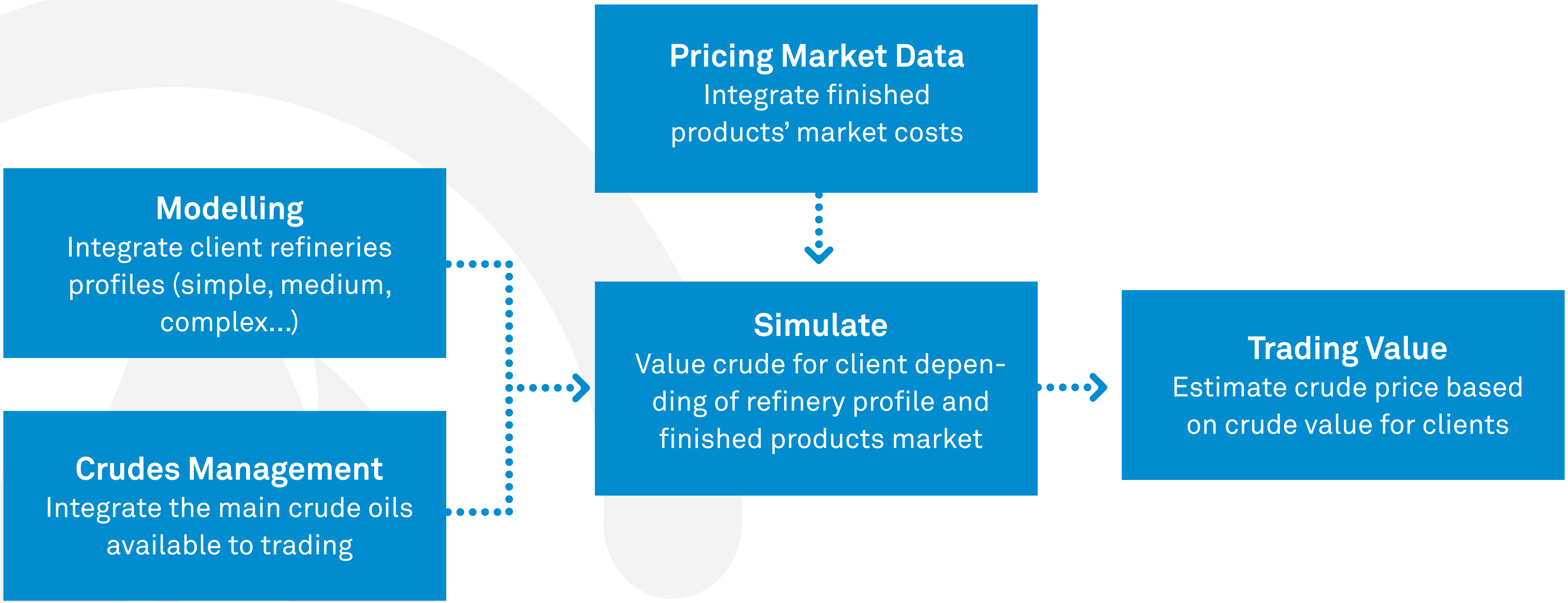
Example of usage of the modules for a trader



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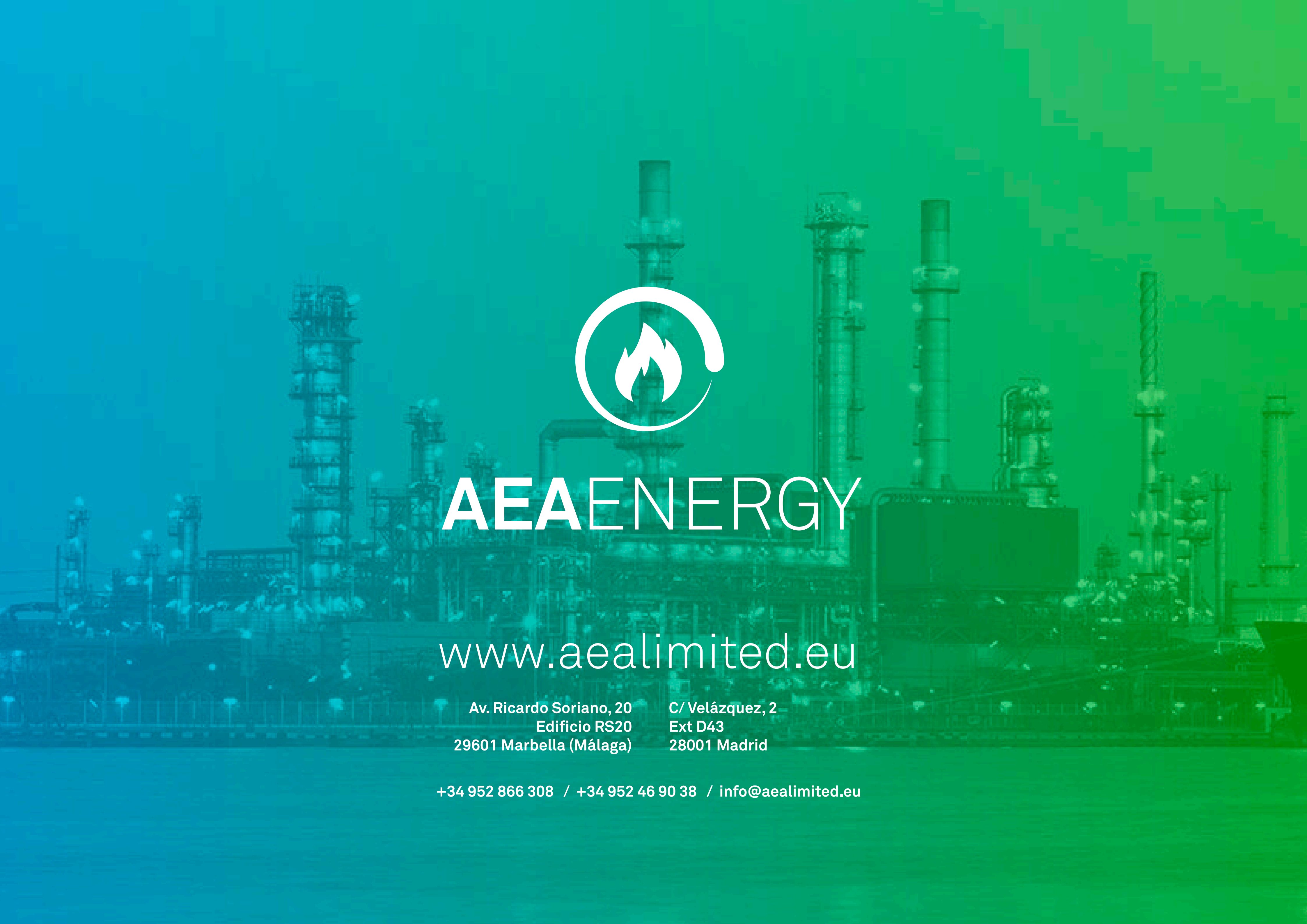
The competition is mature but complex, costly and not very evolutive

Competitors	Figures available about the company (*)	Operating places	Target Industries
AspenTech	150 000 end-users in over 1.750 companies	Worldwide	Oil & gas, chemical, engineering & construction, pharmaceutical, food, beverage, and consumer packaged goods companies
Honeywell	Is part of Fortune 100 132 000 employees	Worldwide	Many lines of business
Invensys (recently Schneider Electric)	180 countries 16 500 employees Works with 23 of the top 25 petroleum companies Enables 18% of the world's crude oil refining	Worldwide	Oil refinery industry, power station, mining companies, appliance manufacturers
Haverly	Exists since 1962 1st in refinery planning & optimization	Worldwide	Oil industry
KBC	Exists for 30 years 70 countries	Worldwide	Oil industry (Upstream/Midstream/Downstream)
Prometheus	Exists for 25 years	Italy and Mediterranean countries	Private oil sector



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