PETROBRAS' Delayed Coking Unit: a new concept

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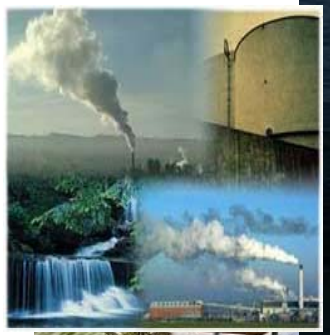
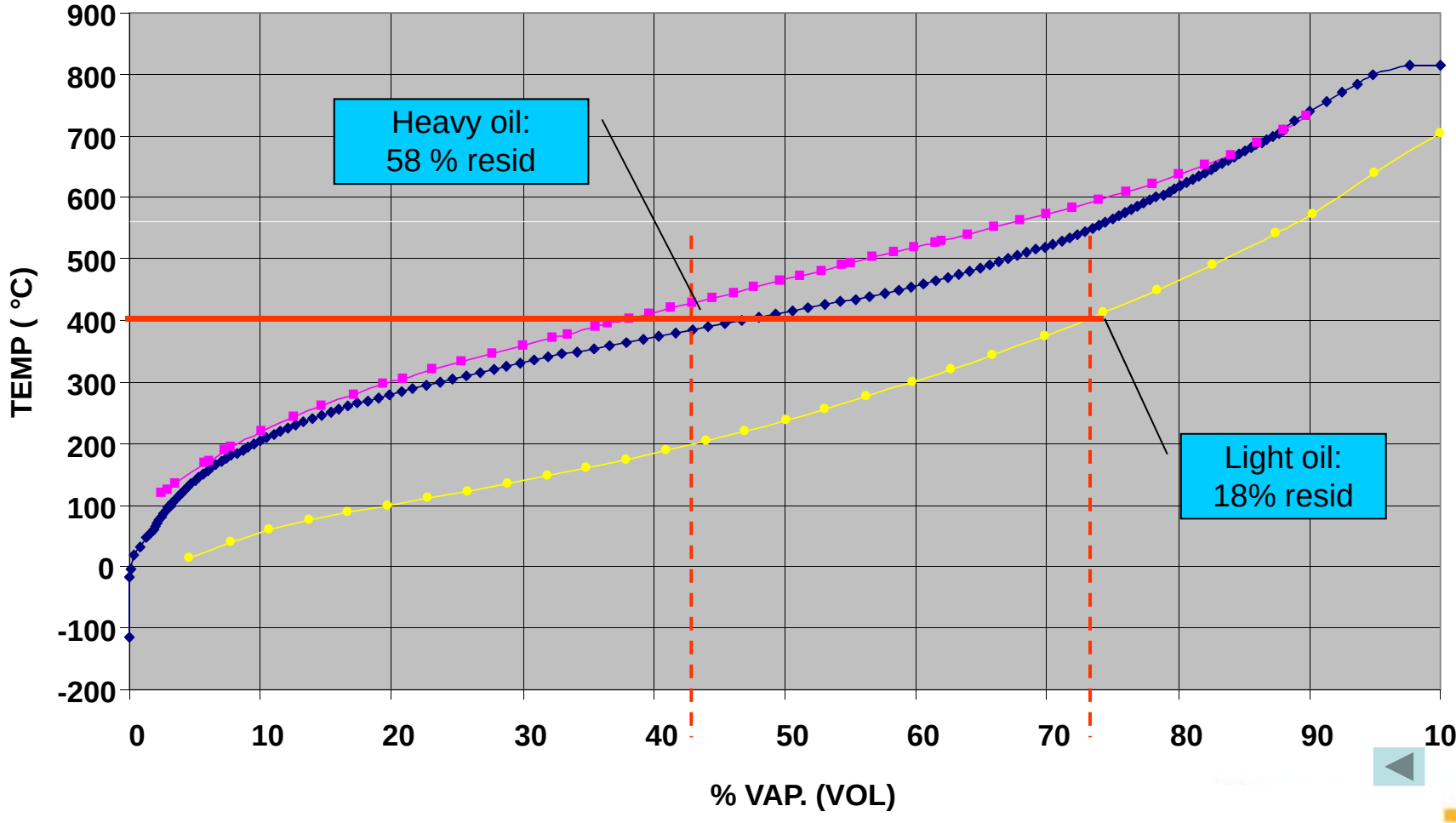
Current Refining Scenario

- Increase in processing capacity of heavy oil and national oil.
- New profile of oil products demand.
- Demand for high quality products.
- Growth of environmental concerns.
- Growth of biofuel demand.

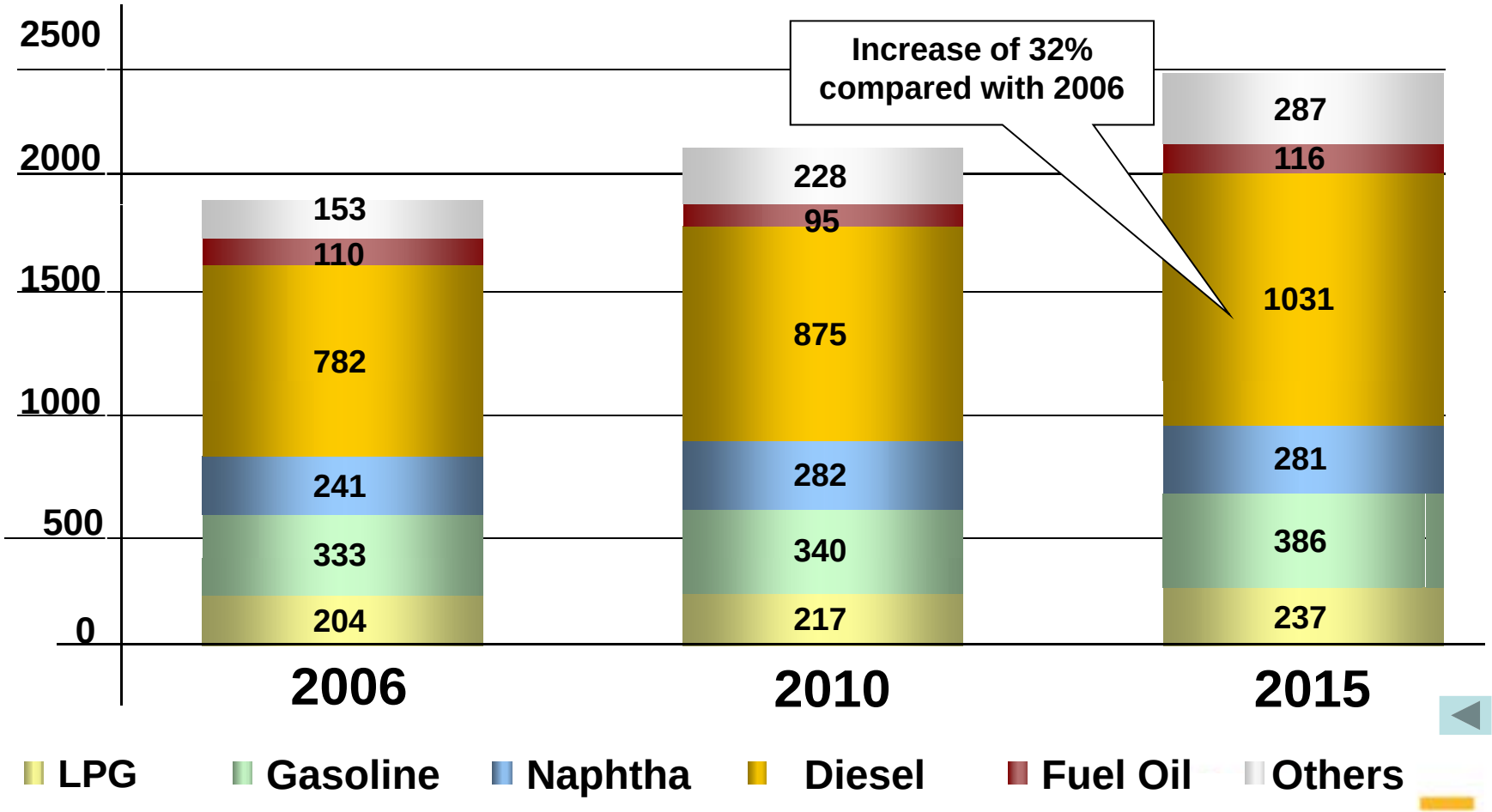


Typical Petroleum Distillation Curve



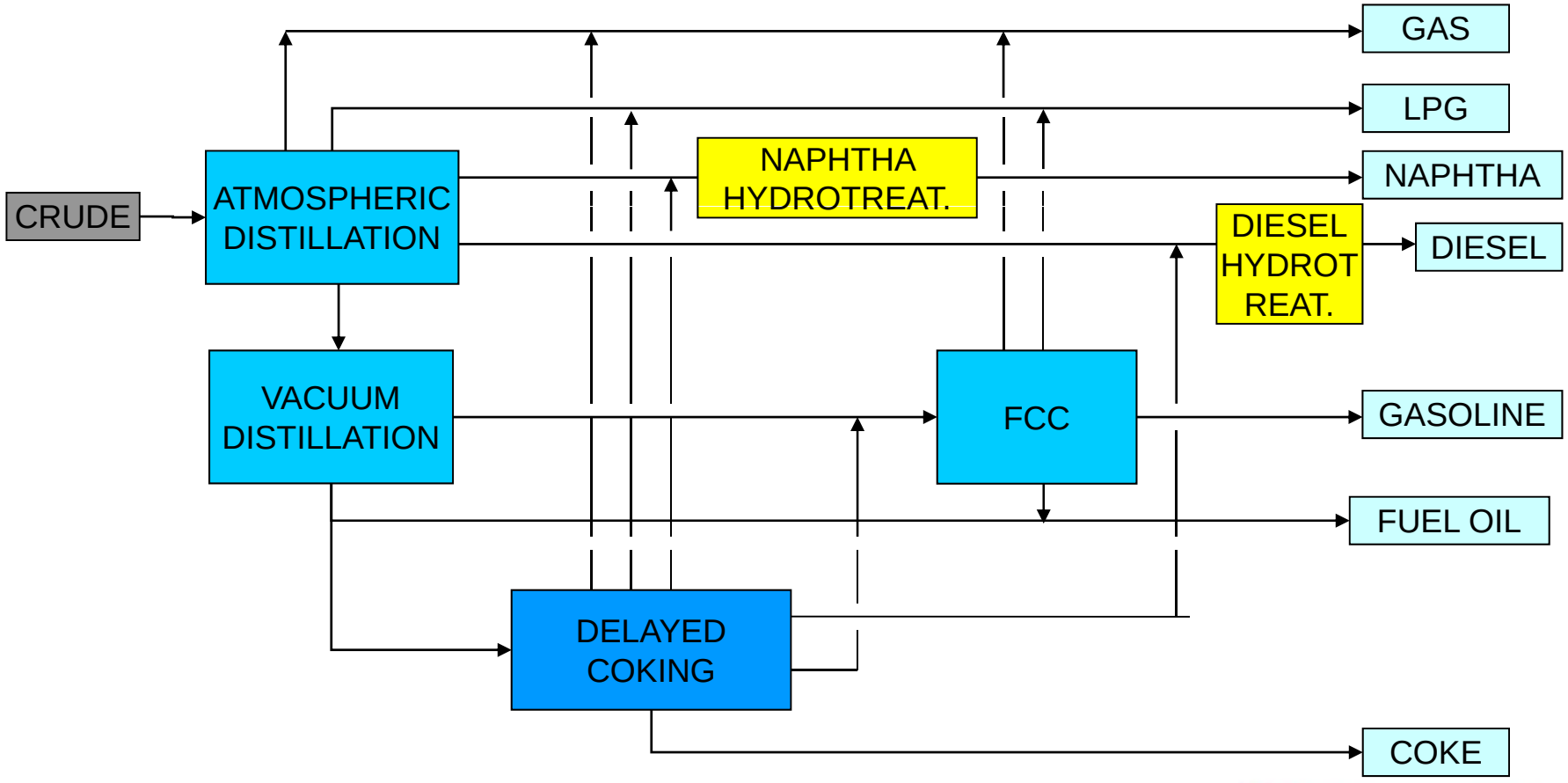
Product Demand

Internal Market / Brazil (1000 bpd)



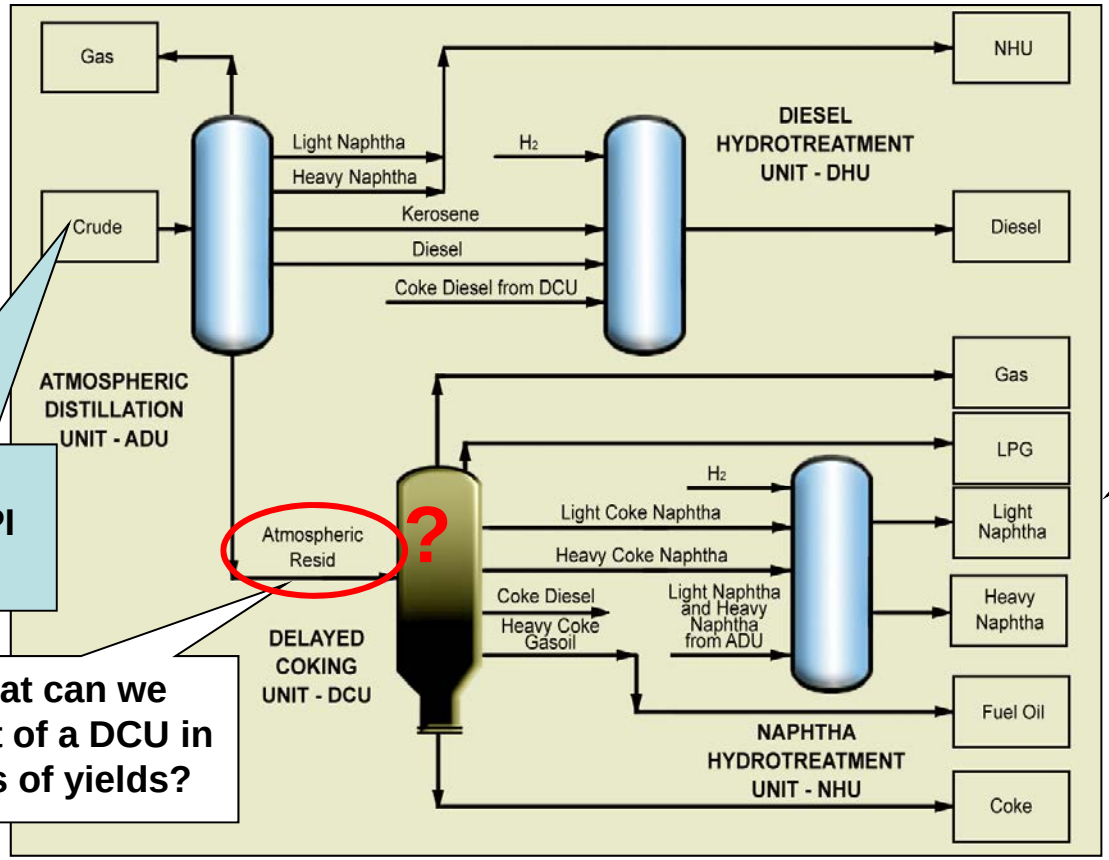
Typical refining scheme

Target to gasoline market and low fuel oil production



Refining scheme

Target to diesel market and low investment



- Marlim 16º API
- Carabobo 16º API
(synthetic crude)

What can we expect of a DCU in terms of yields?

Scheme of Abreu e Lima Refinery (230,000 bpd)

Flexibility for future installation of Vacuum Unit and Hydrocracking Unit to attend the market

Pilot Unit Informations

Patent: PI 0603024-6A (Petrobras)

Feed Streams

Properties	VR	AR	HVGO
RCR, %wt	15.0	7.3	0.59
ºAPI	9.5	14.3	18.4
Sulfur, %wt	0.74	0.67	0.54

Operating Conditions

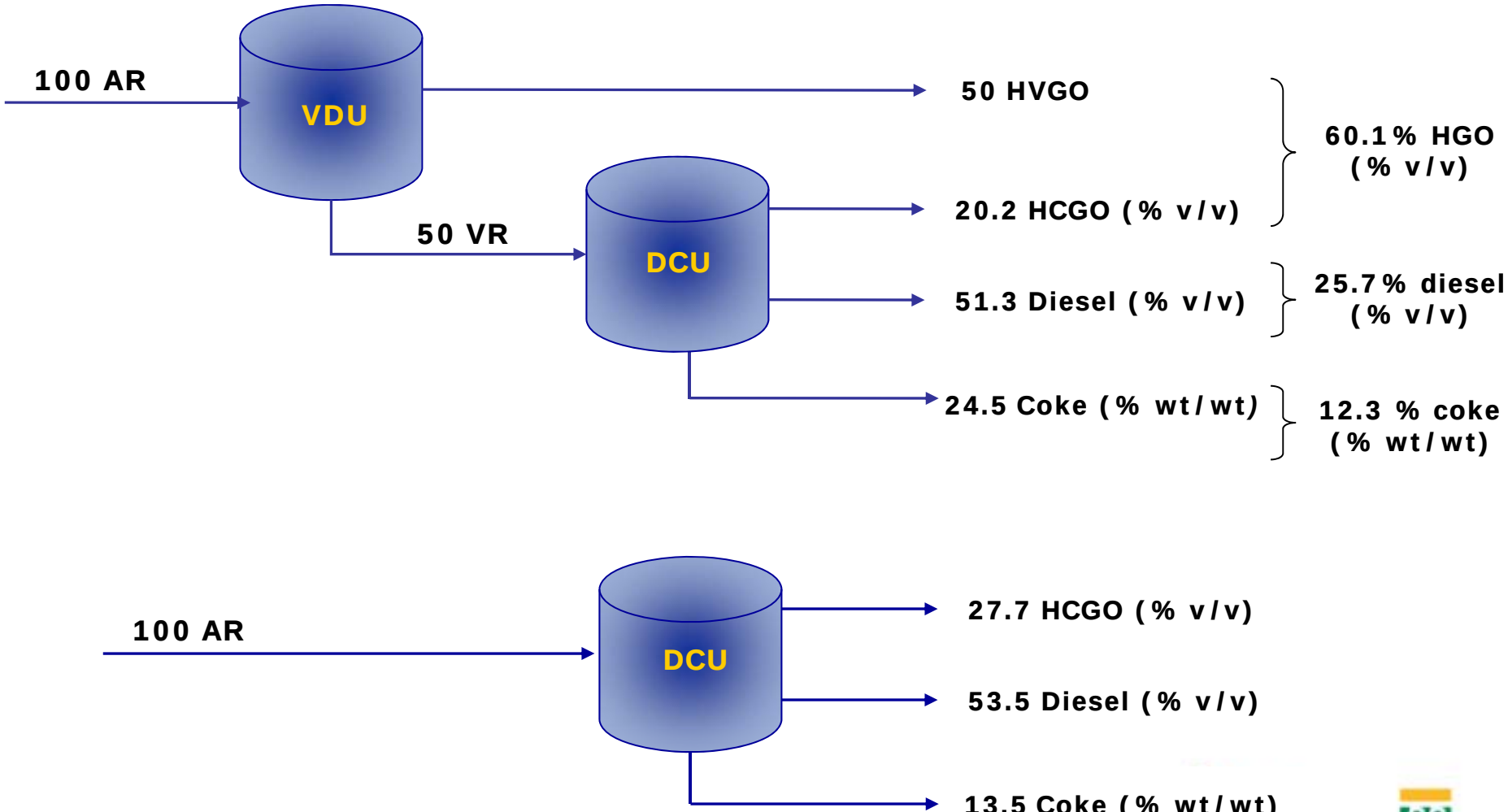
Heater outlet temperature,°C	500
Coke Drum pressure, kgf/cm^2 g	2.0

Yields

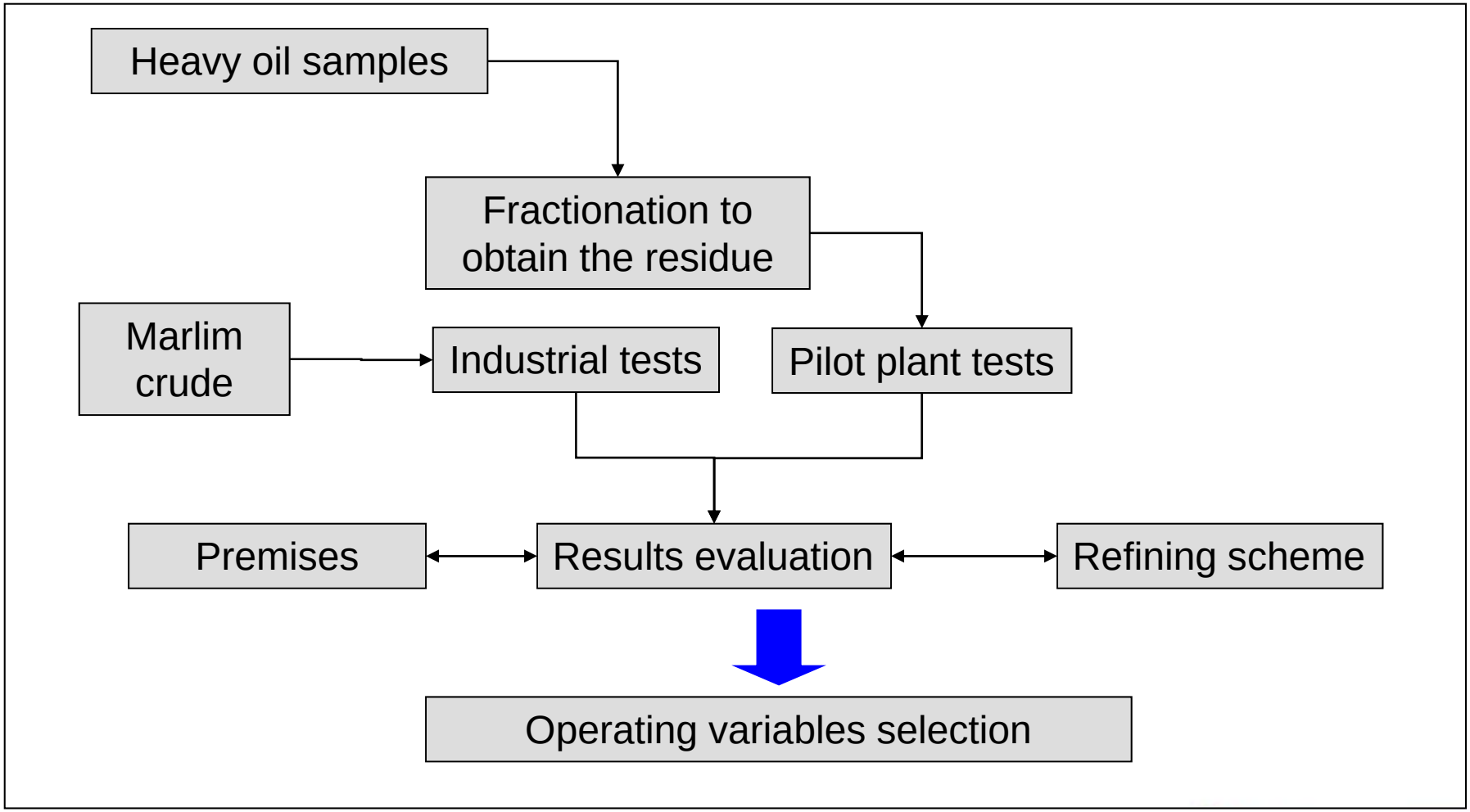
Products	VR	VR + 20% HVGO	AR
Diesel, %v	51.3	52.2	53.5
HCGO, %v	20.2	23.2	27.7
Coke, %wt	24.5	20.3	13.5

Pilot Unit Informations

Patent: PI 0603024-6A (Petrobras)



Operating Variables Selection



Operating Variables

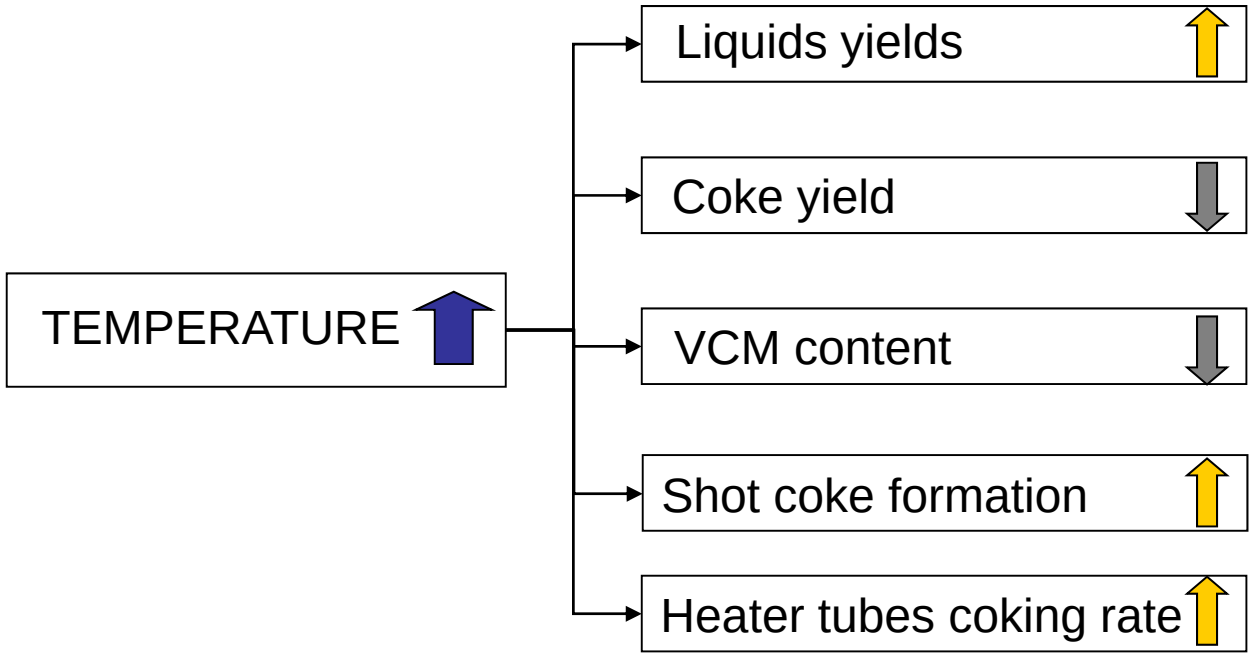
Coke Drum Pressure

PRESSURE ↑

- Heavy gasoil yield ↓
- Middle distillates and coke yields ↑
- Heavy gasoil quality ↑
- Shot coke formation ↓
- Coke drum diameter ↓
- Gas Compressor power ↓

Operating Variables

Heater Temperature



Operating Variables

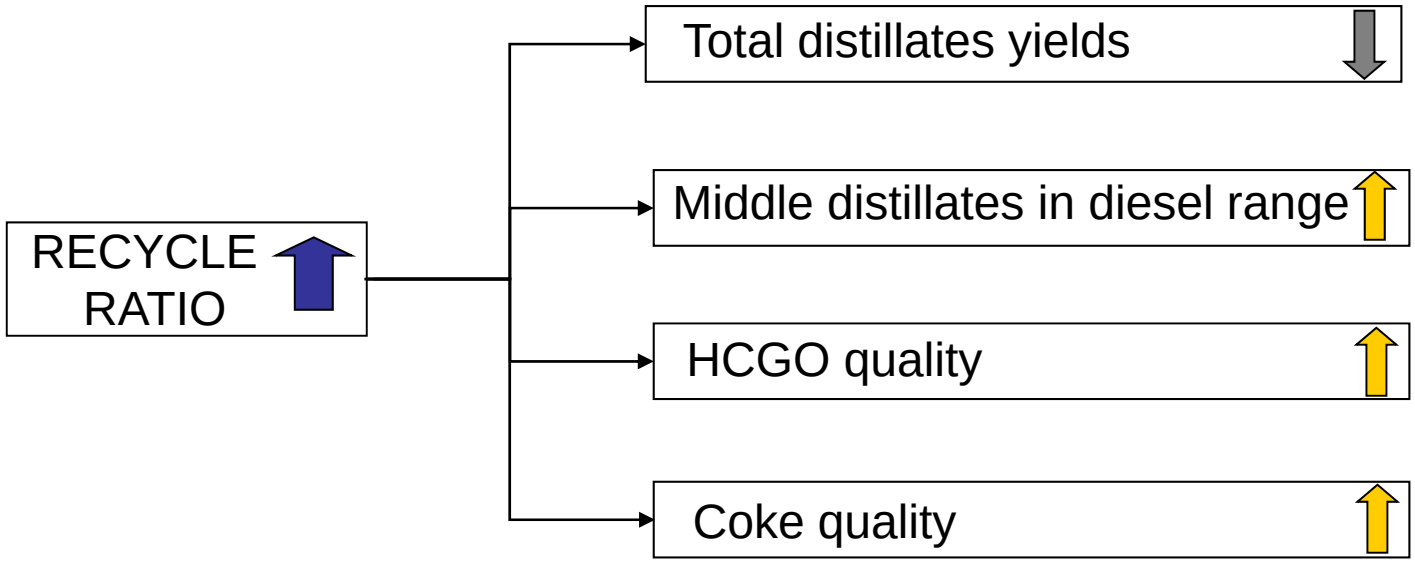
Recycle Ratio

RECYCLE	Heavy liquid fraction due to feedstock´s cracking.
	High boiling point and high carbon residue compared with other coker distillates.
	When recycle is incorporated into fresh feed, this fraction is cracked one more time while passing through furnace and drum.
	When recycle isn't incorporated into fresh feed, it is taken back with HGO, increasing the production of HGO and worsening its quality.

The recycle ratio is defined by the temperature control in the Fractionator bottom.

Operating Variables

Recycle Ratio

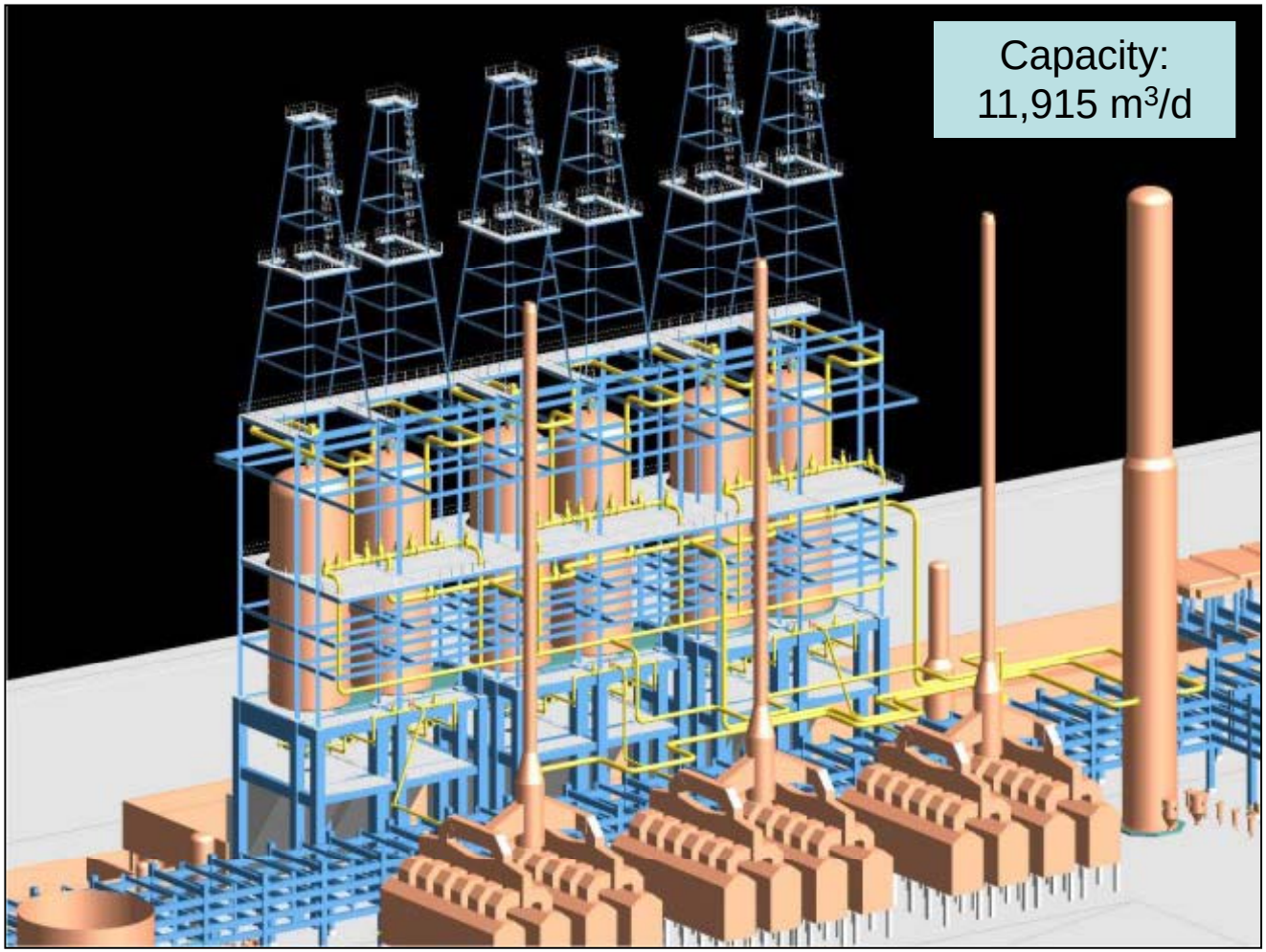


Operating Variables Definition

- ✓ High Recicle Ratio: > 20% v/v;
- ✓ High Coke Drum Pressure: 2.0 kgf/cm^2 g;
- ✓ High Heater outlet temperature: > 500°C

These conditions meet the main goal of maximizing diesel production and minimizing fuel oil production.

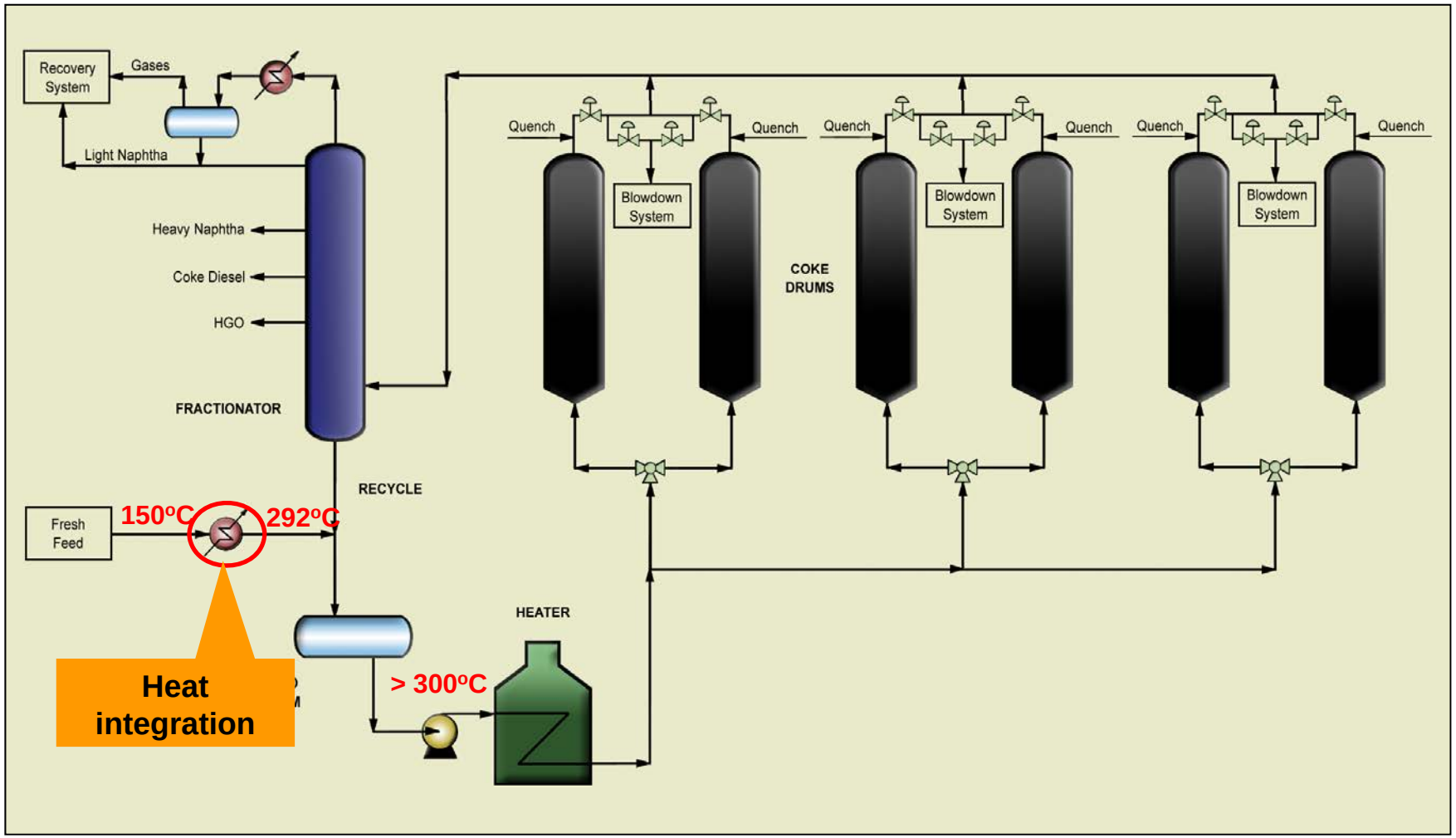
New Petrobras' DCU to Abreu e Lima Refinery



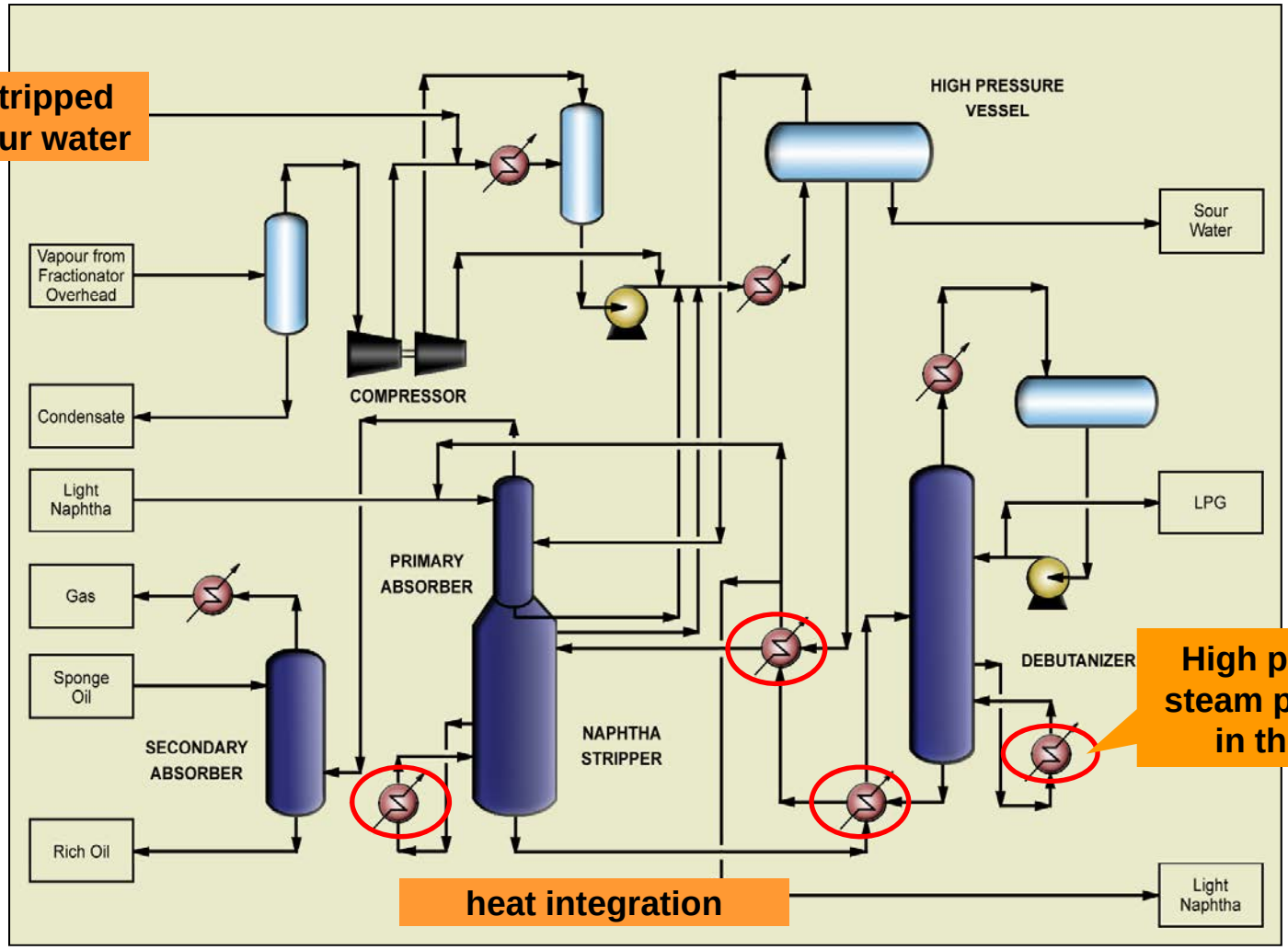
Driving Forces for New DCU

- Maximizing diesel production.
- Minimizing fuel oil production.
- Minimizing investment cost;
- Minimizing water consumption;
- Minimizing emissions;
- Increase safety and operational continuity.

Reaction and Fractionation Sections



Gas Recovery Section



Fractionation and Gas Recovery Sections

➢The designed process scheme meets environmental and operational requirements:

- ✓energy recovery optimization;
- ✓ operational stability;
- ✓ minimum fresh water consumption;
- ✓ flexibility to process:
  - external streams;
  - off spec products.

Fractionation and Gas Recovery Sections

- Heat integration studies based on:
  - ✓ tools and softwares like PETROBRAS simulators and others using “pinch technology” concept;
  - ✓ PETROBRAS experience in DCU project and operation.
- Upsets due to coke drum batch operation controlled by:
  - ✓ project criteria to minimize impacts at Fractionation and Gas Recovery Sections;
  - ✓ instrumentation and advanced control tools.

Fractionation and Gas Recovery Sections

- Environmental impact reduced by:
  - ✓ minimizing fresh water consumption.
  - ✓ actions to meet minimum emissions: closed pump-out system, maximum number of PSV relief aligned to internal DCU systems, etc.
  - ✓ processing off-spec products and external streams, minimizing refinery residues generation.

Fractionation and Gas Recovery Sections

➢ Maximum use of air coolers instead of cooling water exchangers:

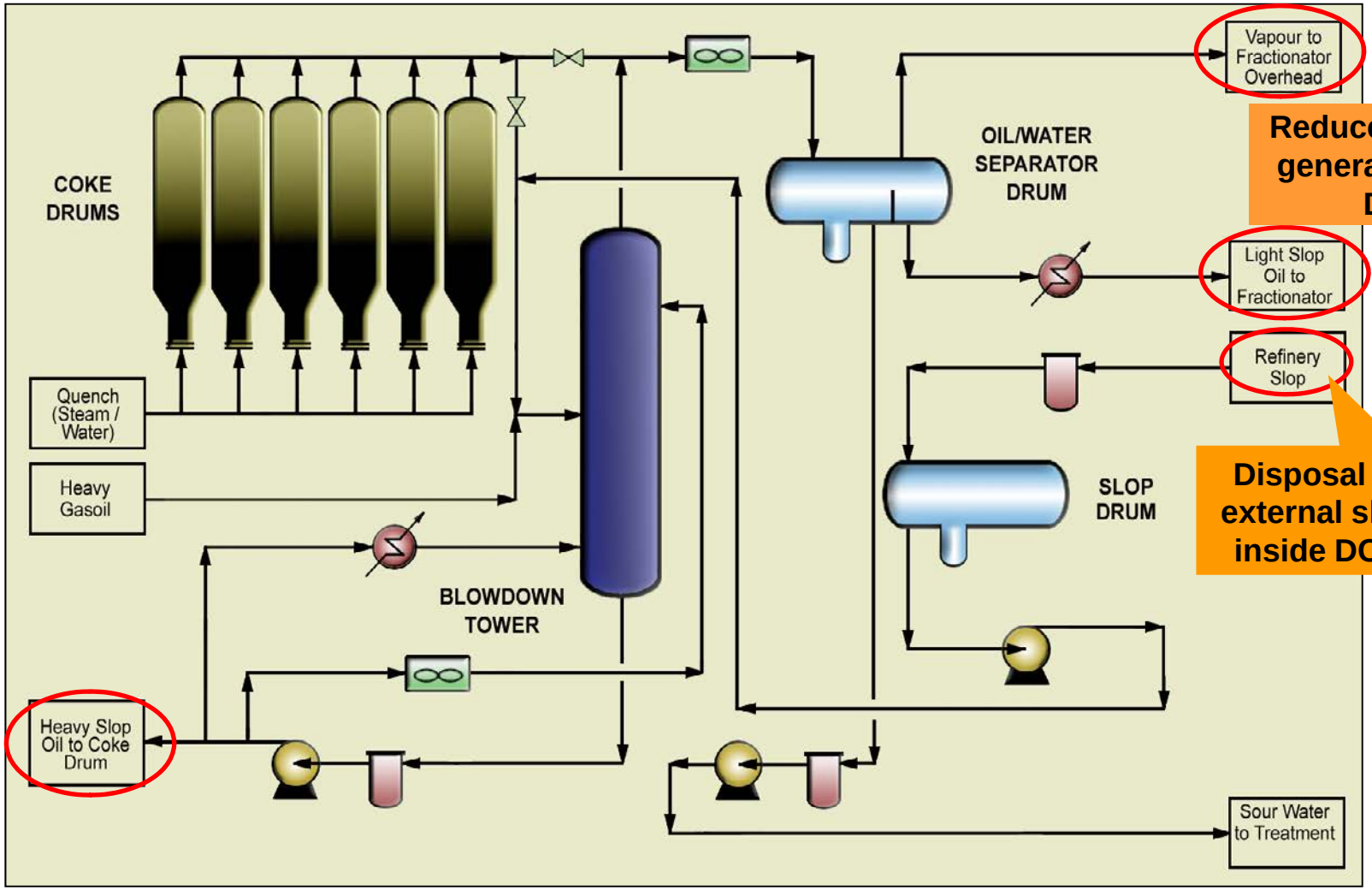
Heat exchangers	% DUTY	
	OTHERS	New DCU
Using cooling water	51.7	23.0
Air coolers	25.3	45.9
Using process streams	23.0	31.1

maximized air cooler use instead of cooling water

heat integration

➢ Use of stripped sour water to wash compressor gases.

Closed Blowdown System



Reduced residue generation from DCU

Disposal of external slop inside DCU

Closed Blowdown System

- Main goals
  - ✓ Receiving coke drum effluent from steam purge and water quench steps.
  - ✓ Recovering steam and hydrocarbon vapors as sour water, gas and slop oil streams to be processed in DCU:
    - minimizing residue generation.

- Main design and operation issues:
  - ✓ Formation of water/oil emulsion phase.
  - ✓ Separation of hydrocarbon streams in order to enable the best routing inside DCU.

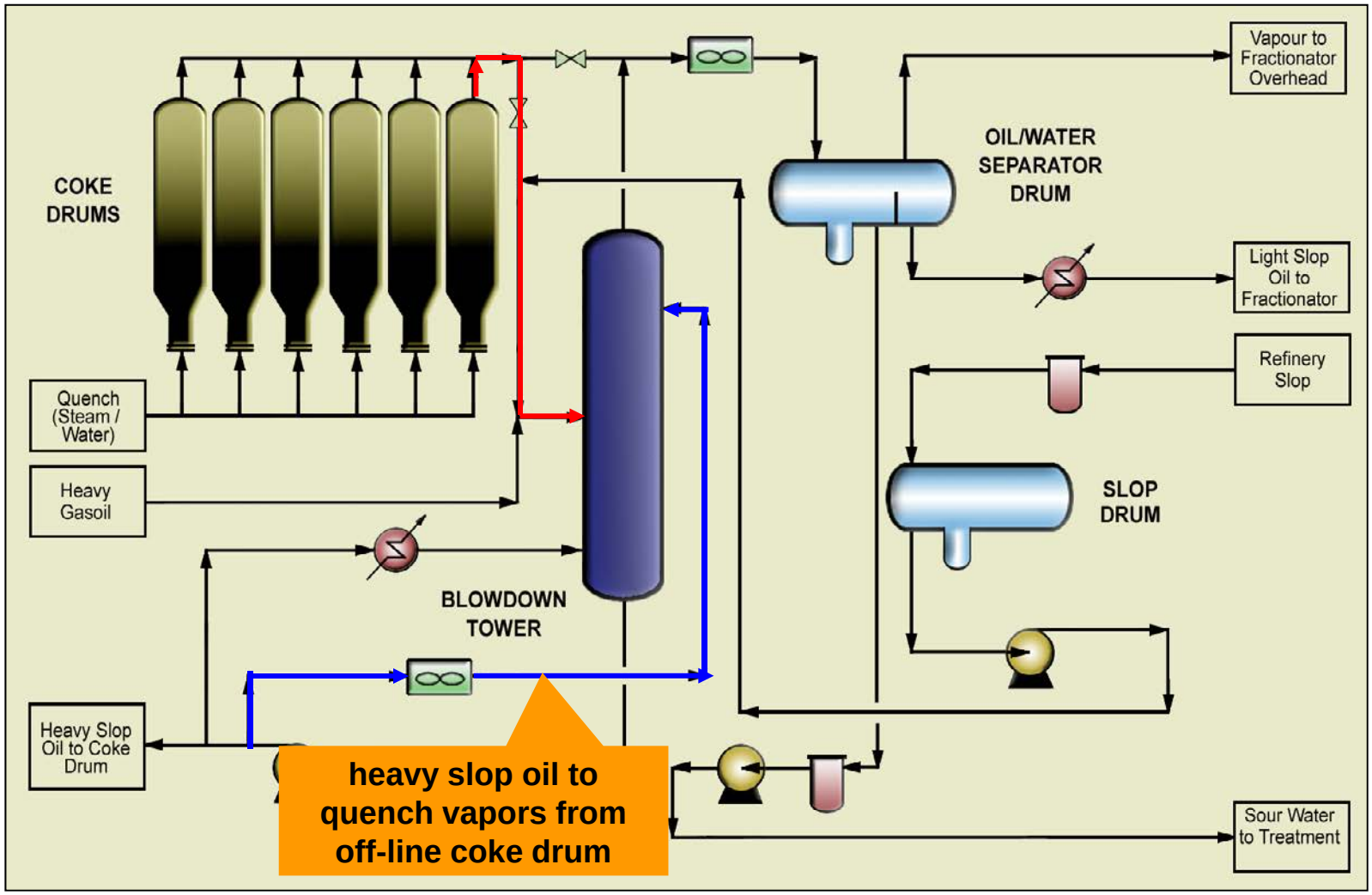
Closed Blowdown System

- Desing improvements
  - ✓ Defined pressure and temperature profile in order to improve heavy and light slop oil fractionation:
    - better reuse of these streams in DCU, recovering them as distillate products.
  - ✓ Blowdown designed to damp fluctuation of light and heavy slop oil production:
    - minimum upset at Fractionator operation.
  - ✓ Disposal of refinery residue in the Blowdown.

Closed Blowdown System

- Desing improvements
  - ✓ Operating temperature that minimizes emulsion formation:
    - significant reduction of mechanical damage risk caused by severe water vaporization inside Fractionator and coke drum overhead line.
  - ✓ Off-line coke drum effluent quenched mainly by the heavy slop oil recovered in this system:
    - reduction of residue generation.
  - ✓ Maximized air cooler use.

Closed Blowdown System



Conclusions

- The new Petrobras' Delayed Coking Unit considers:
  - ✓ Operating conditions in order to maximize diesel production.
  - ✓ Operational stability by the use of advanced control tools.
  - ✓ Strong heat integration, reducing utilities consumption.
  - ✓ Reduced slop and waste generation.
  - ✓ Flexibility to process refinery residue and off-spec products.