Hydrocarbon processing

Refinery configurations

English version based on the presentation of Szalmásné Dr. Pécsvári Gabriella, held in 2014

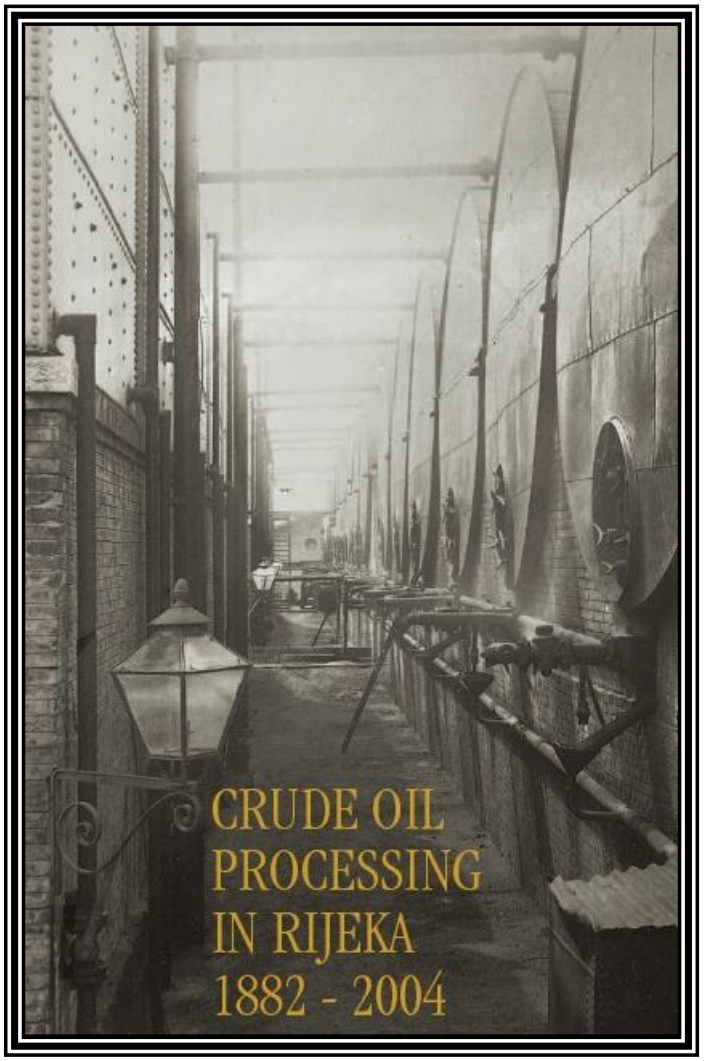
MOL Kurzus

Milestones in Technical Development & Short History

Market demand

19th Century: The rising demand for oil was motivated in particular for lighting paraffin lamps.

Refinery structure. Simple**, batch distillation type**.



Milestones in Technical Development & Short History

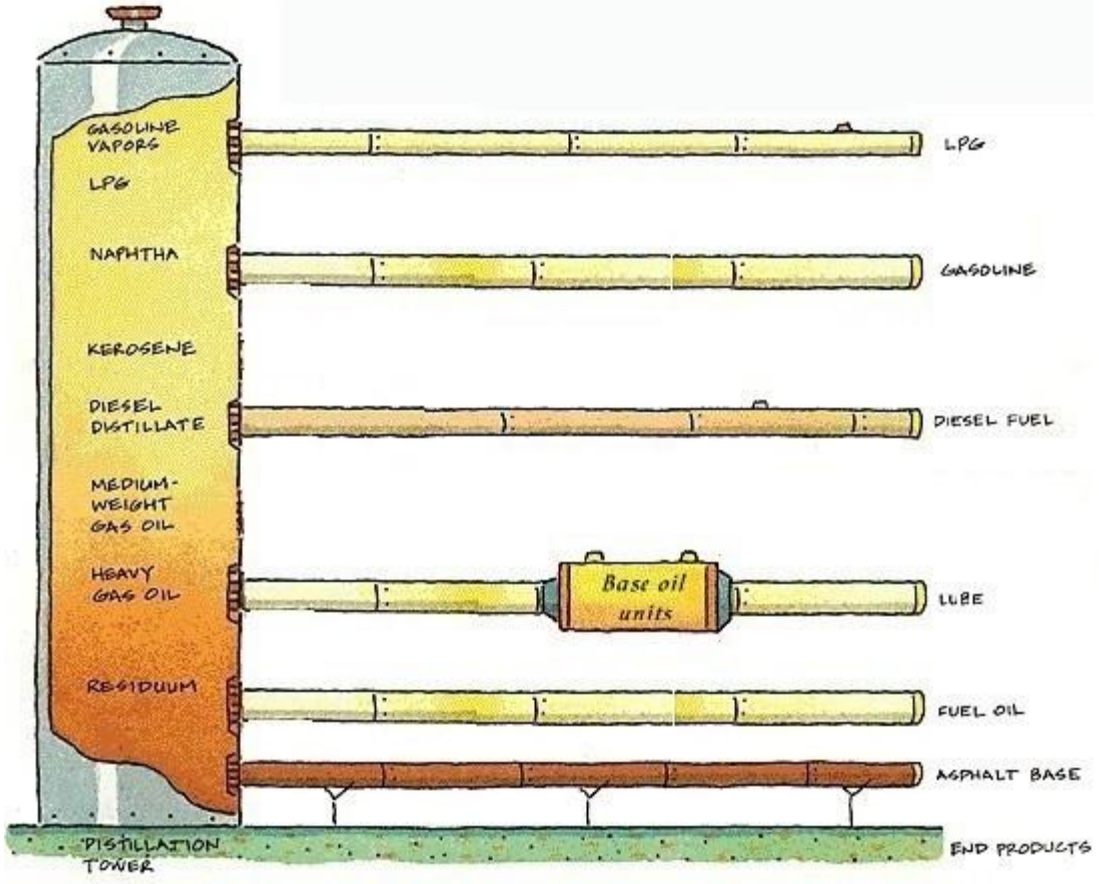
Mather photograph

Photo courtesy Drake Well Museum

Milestones in Technical Development & Short History

Early refining Technology (pre-war-era)

Motor fuels and fuel oil production in **Topping** refineries with gasoline, diesel, base oil and bitumen production Hight gasoline octane is only achievable with octane booster additives. Products are corrosive due to sulphur content.

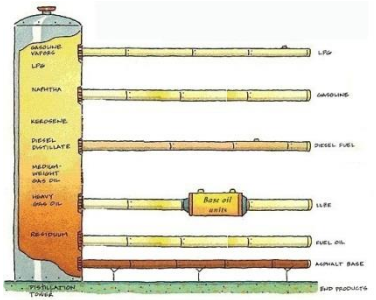


Hungarian fuel qualities in the „ancient times”

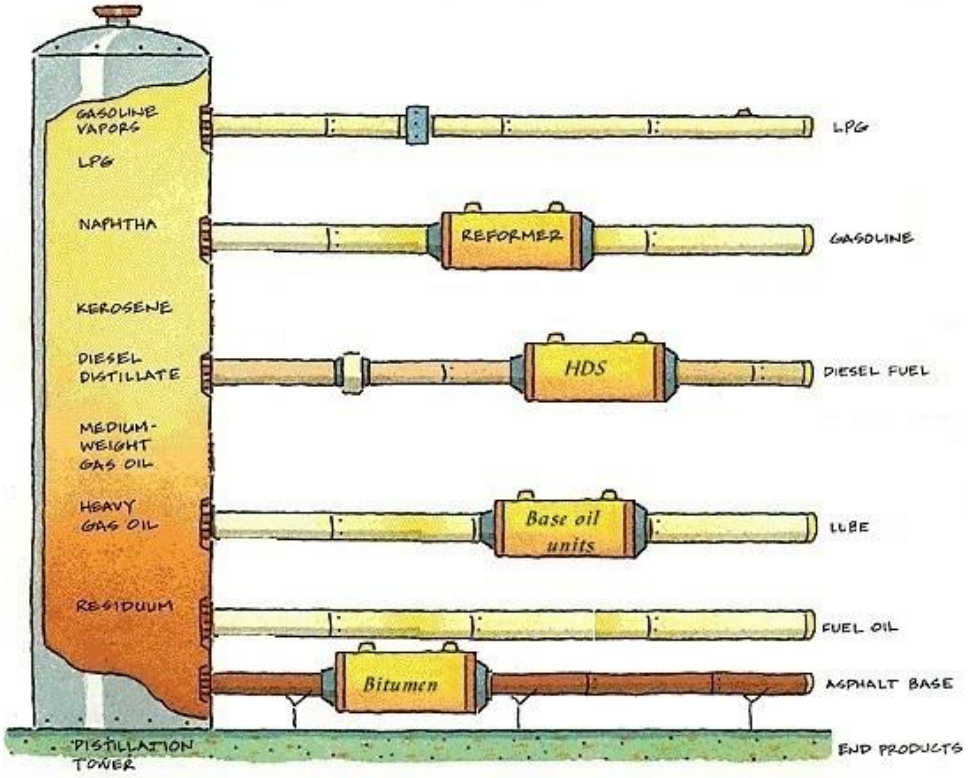
Year	1950
	Gasoline
Octane number ,min	70
Sulphur content, max.	-
Distillation	
IBP, max	52 °C
E100, min	20%
FBP, max	196°C
lead content	kb. 0,5 cm^3/l

Milestones in Technical Development & Short History

Hydroskimming refinery: motor fuel, heating oil and ” black products” (fuel oil, base oil and bitumen)



Increasing demand of quantity and <u>quality,</u> engine developments: much more complex refinery is required (octane number enhancement, desulphurisation)



Quality improving technologies

1. <u>Applicability improvement of the products:</u>

Gasoline: octane number improvement and light compounds supply

- Catalytic reforming
- Isomerisation
- Alkylation
- ETBE production

Base oil Base oil and paraffin production technologies

Bitumen Bitumen blowing and modification

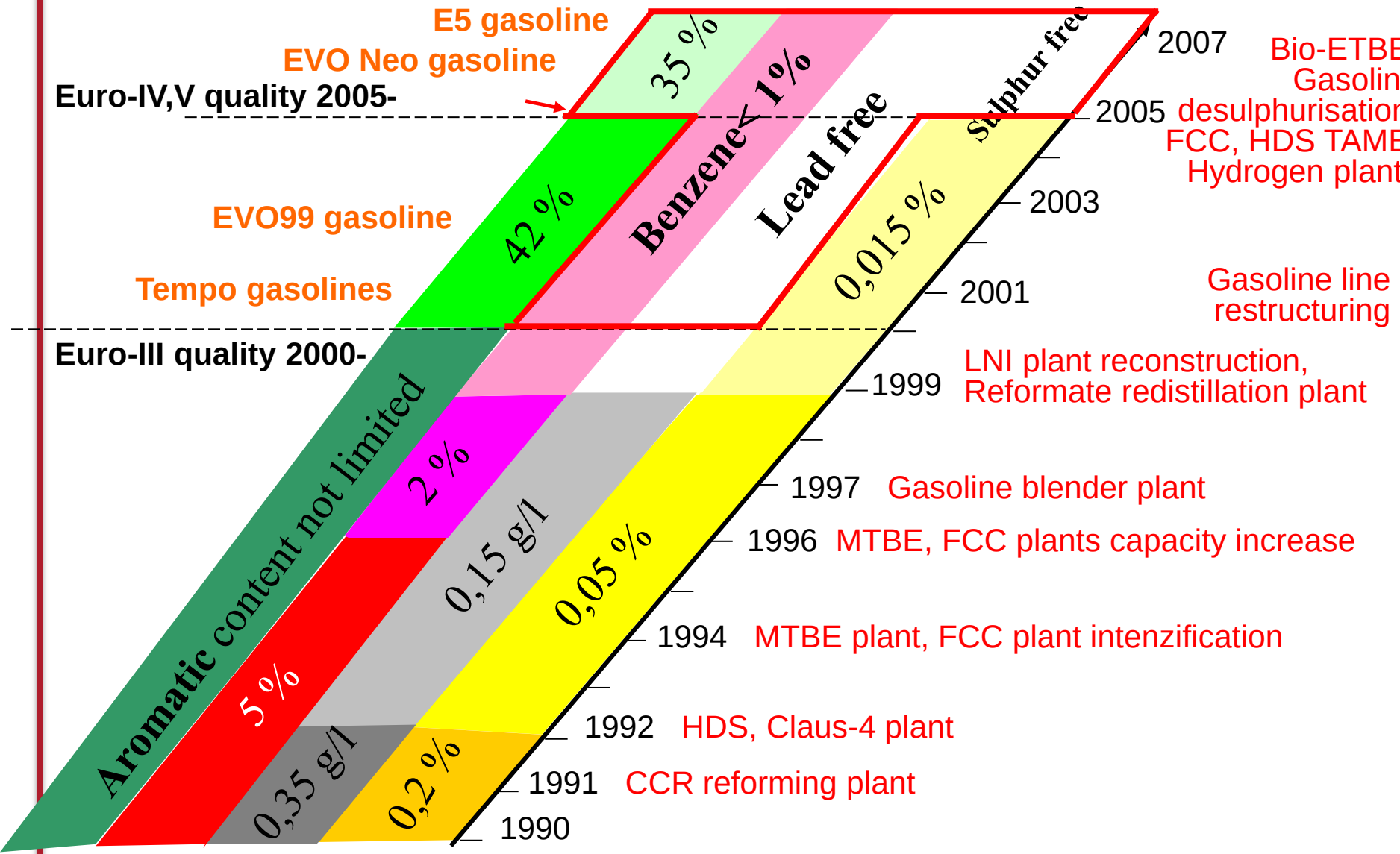
2. Products must meet more strict environmental protection and emission requirements

Gasoline

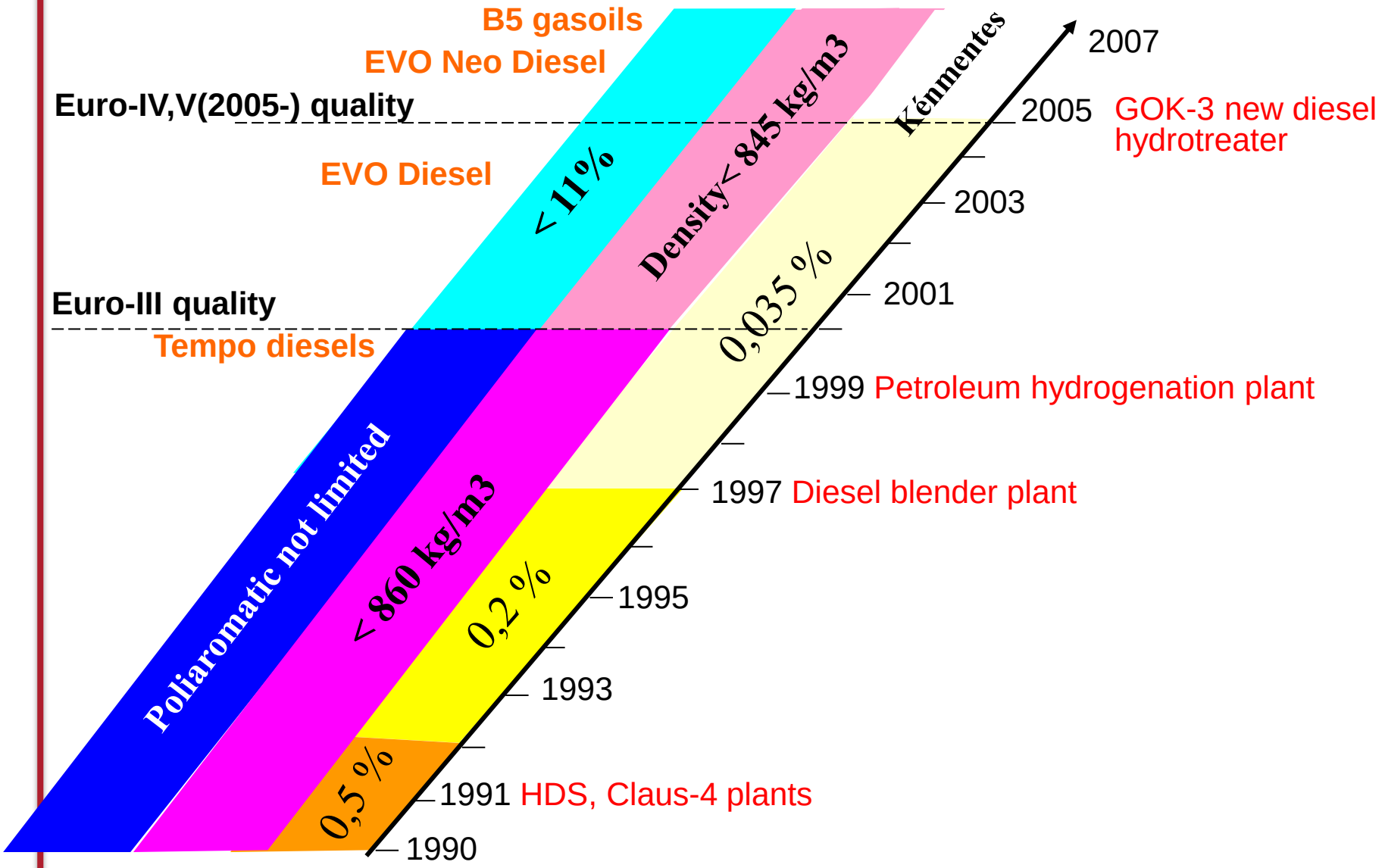
Diesel

→ Desulphurisation technologies

Product quality improvement in DR – gasoline line



Product quality improvement in DR – diesel line



Milestones in Technical Development & Short History

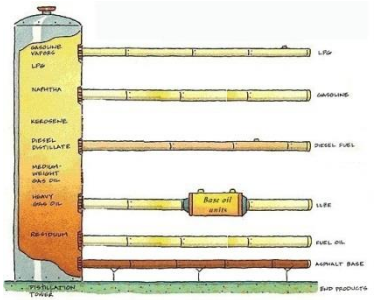
Cracking type refinery: motor fuels and heating oil production (gasoline, diesel, base oils and bitumen)

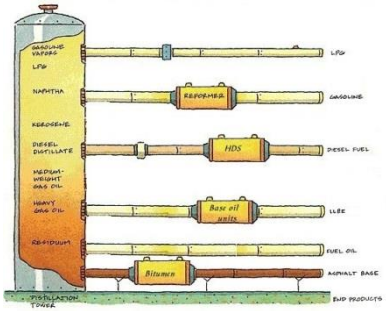
Increasing demand of quantity and <u>quality,</u> engine developments: much more complex refinery is required

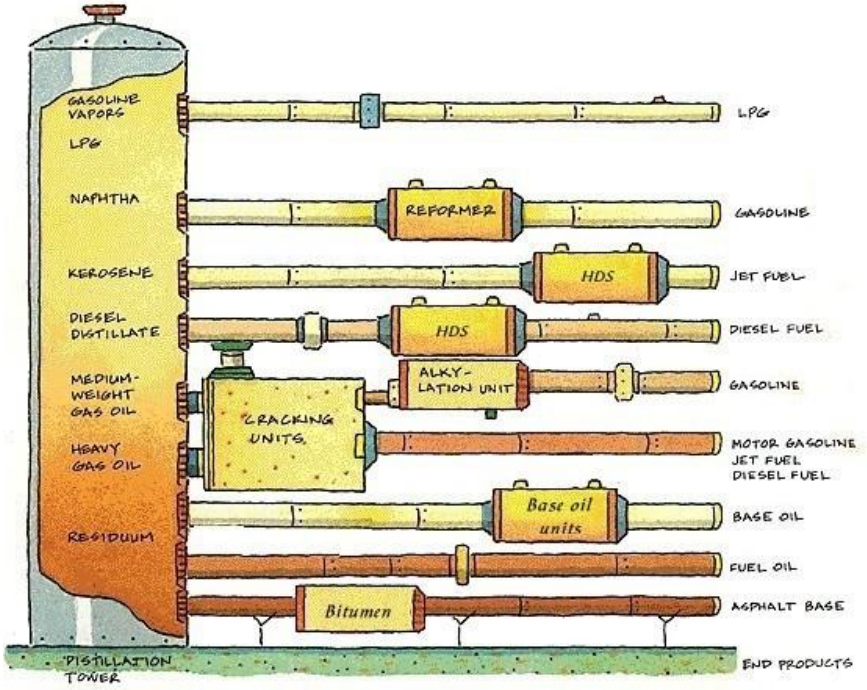
Crude oil price boom – specific yields from crude must be increased

Conversion and bottom upgrading technologies

High complexity refinery:

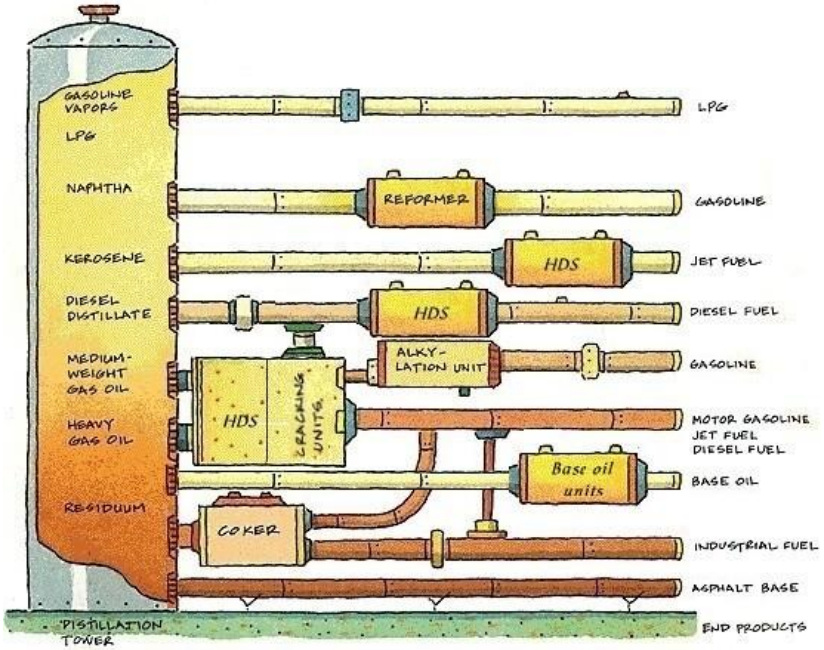


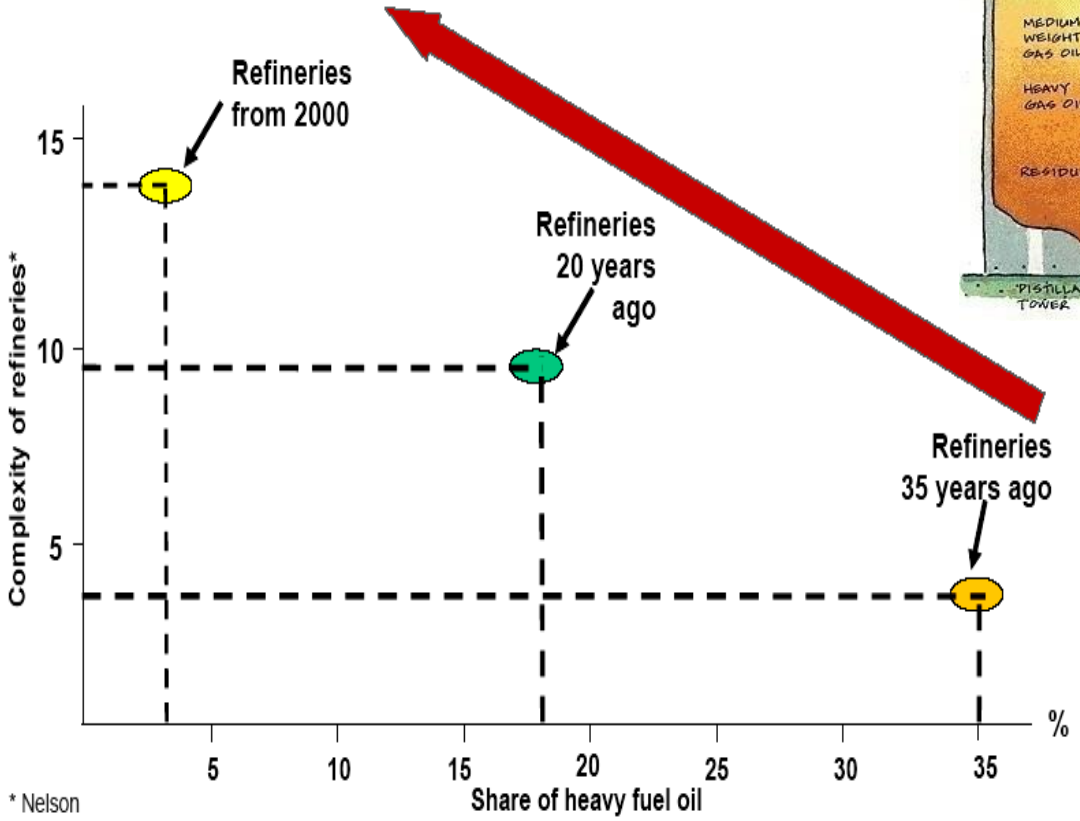




Main Development Direction of Refineries from 1995

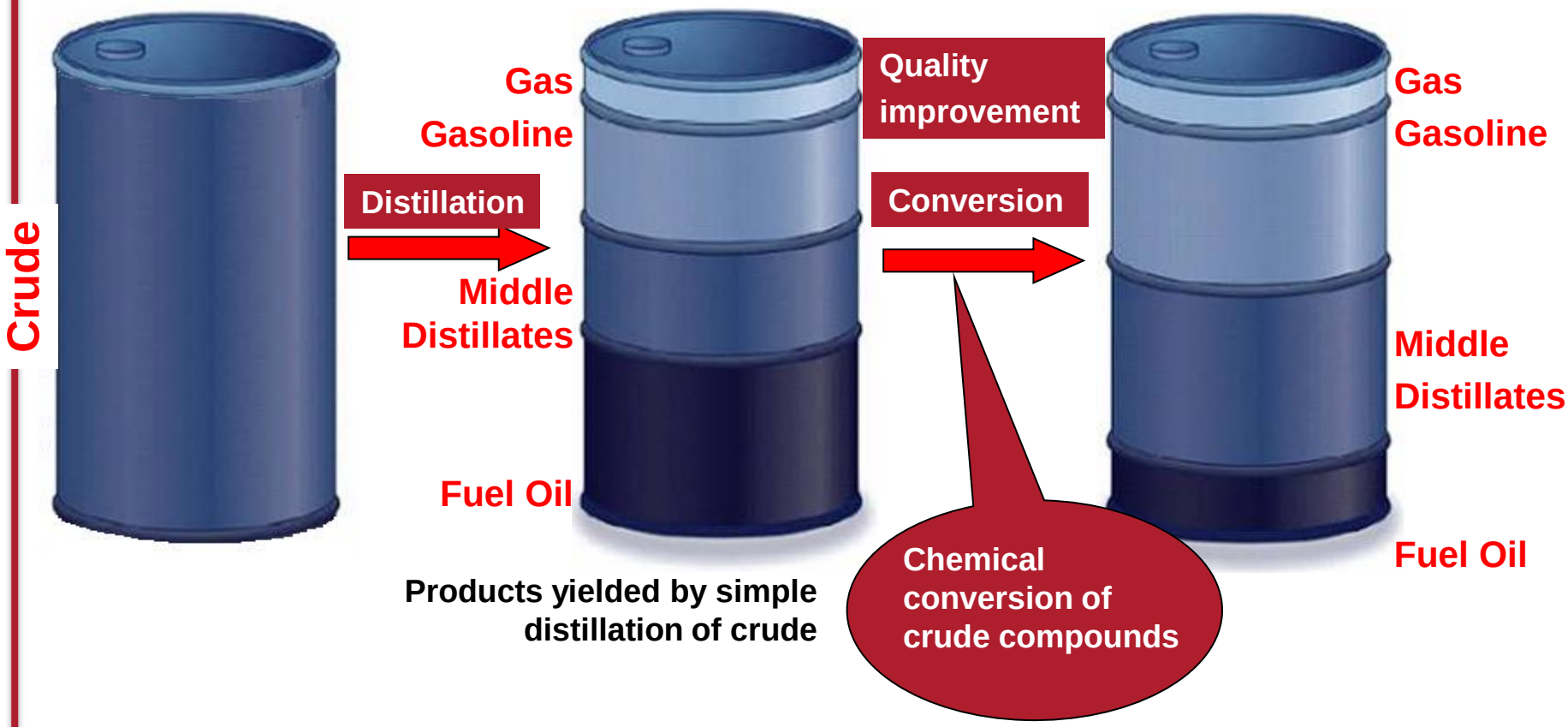
Residue upgrade process





Purpose of Refining

Production of product-structure according to market demand on an economical way



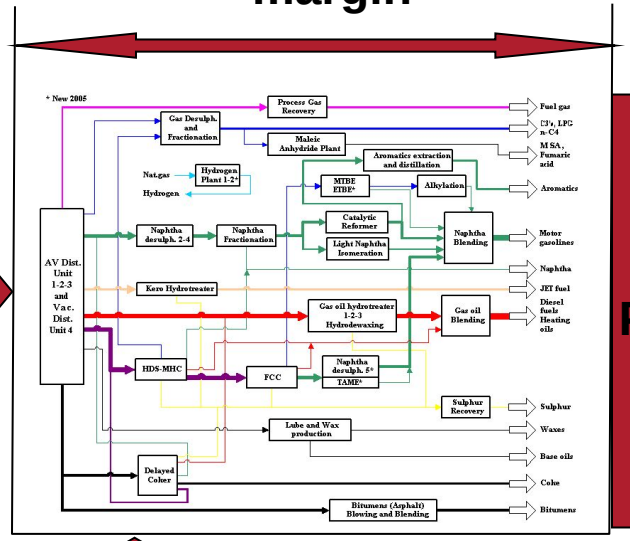
The whole procedure is called „Refining"

Refinery margin

margin

Resources

/cost/



Products

/income/

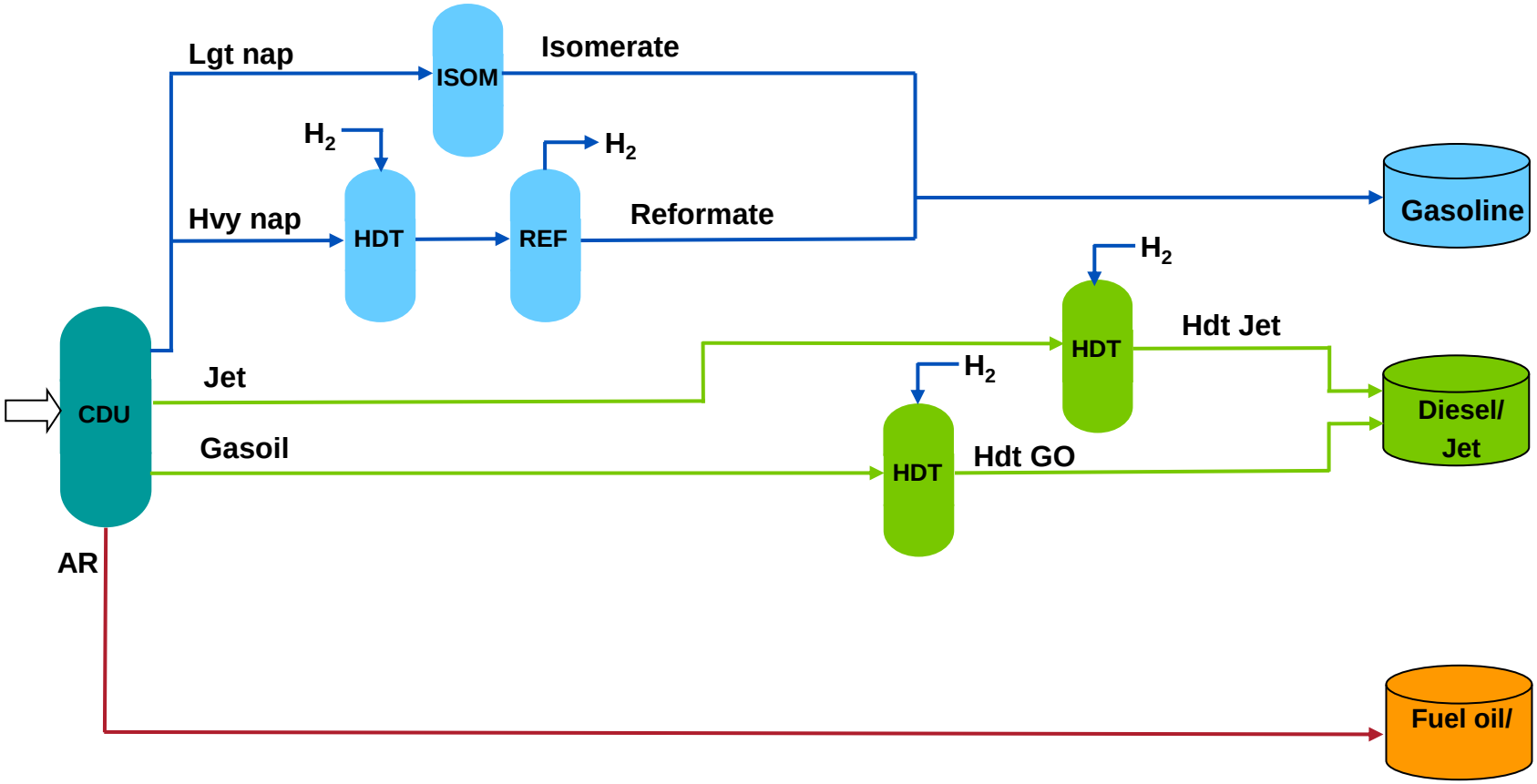
Operational cost

- **Energy usage (steam, electricity, cooling water, gas)**
- **Other used materials (catalysts, chemicals, additives)**
- **Maintenance**
- **Human resources**

$$\Sigma \text{ out} - \Sigma \text{ in} \geq 0$$

Refinery configurations - I

Hydroskimming refinery

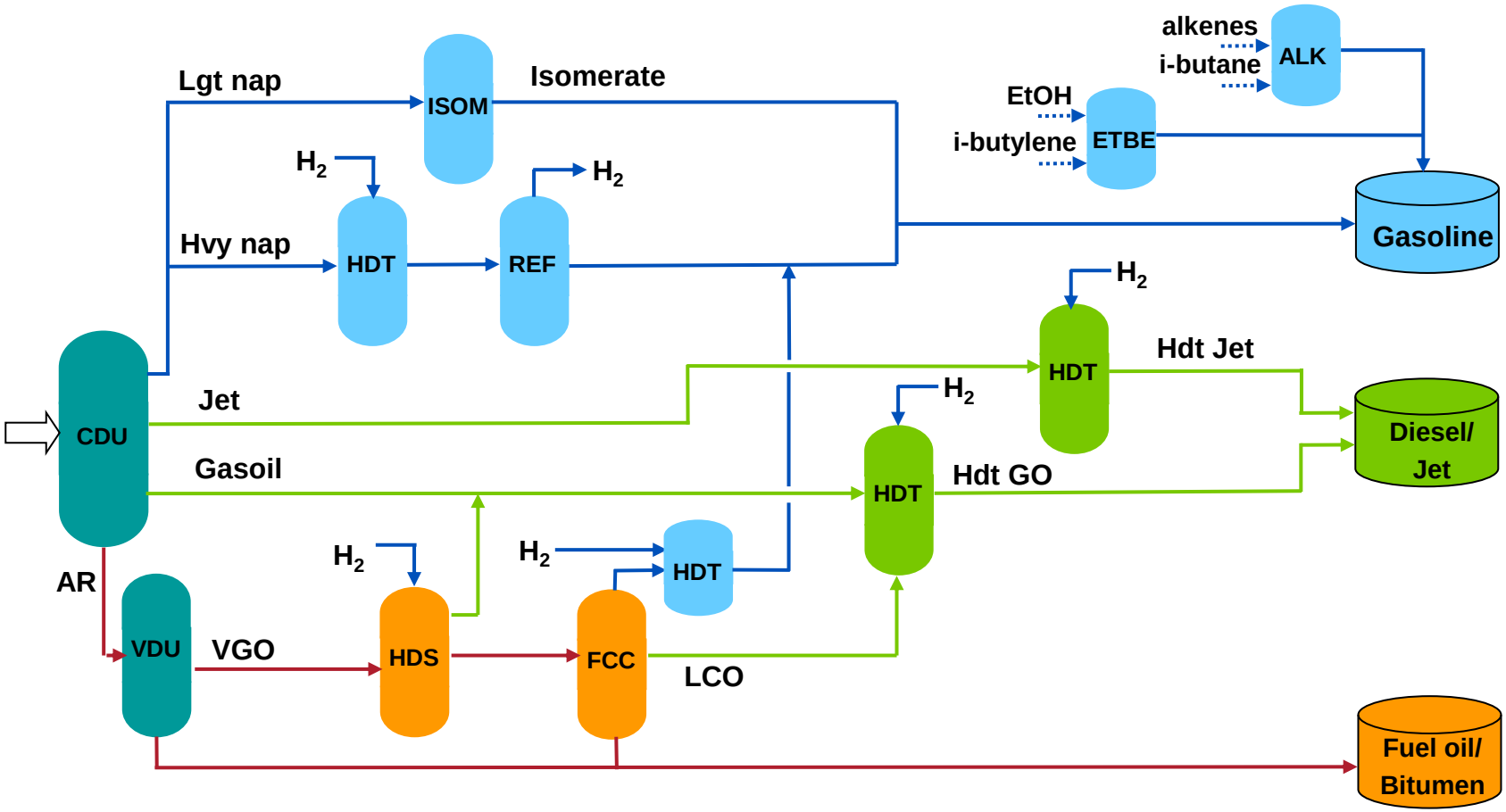


Refinery configurations - I

	Hydroskimming		
	Crude A	**Crude B**	**Crude C**
Products	**Yield, %**	**Yield, %**	**Yield, %**
LPG	0,6	1,2	1,8
C3=	0,0	0,0	0
Benzene rich cut	0,2	0,7	1,1
Virgin Naphtha	0,8	3,8	5,5
Mogas	3,7	10,9	16,3
Sum gasoline	**4,7**	**15,5**	**22,9**
JET	2,8	6,1	11,3
Diesel Fuel	6,5	12,5	18,8
Heating Oil	1,3	4,8	3,4
Sum Middle Distillates	**10,5**	**23,4**	**33,5**
Fuel Oil 1%	1,2	4,5	3,0
LCO+FCCslurry	0,0	0,0	0,0
Fuel Oil 3,5%	**78,2**	**51,0**	**34,4**
Bitumen	4,1	2,7	1,8
Coke	0,0	0,0	0,0
Sulphur	0,1	0,2	0,3
Sum product	99,4	98,5	97,7
loss + own cons.	0,6	1,5	2,3
crude oil prize (USD/t)	504,0	544,0	580,0
Gross margin (USD/t)	**-56,0**	**-11,0**	**11,0**
(fuel oil 400USD/t)			
Gross margin (USD/t)	-17	14	28
(fuel oil 450USD/t)			

Refinery configurations - II

Hydroskimming + FCC refinery



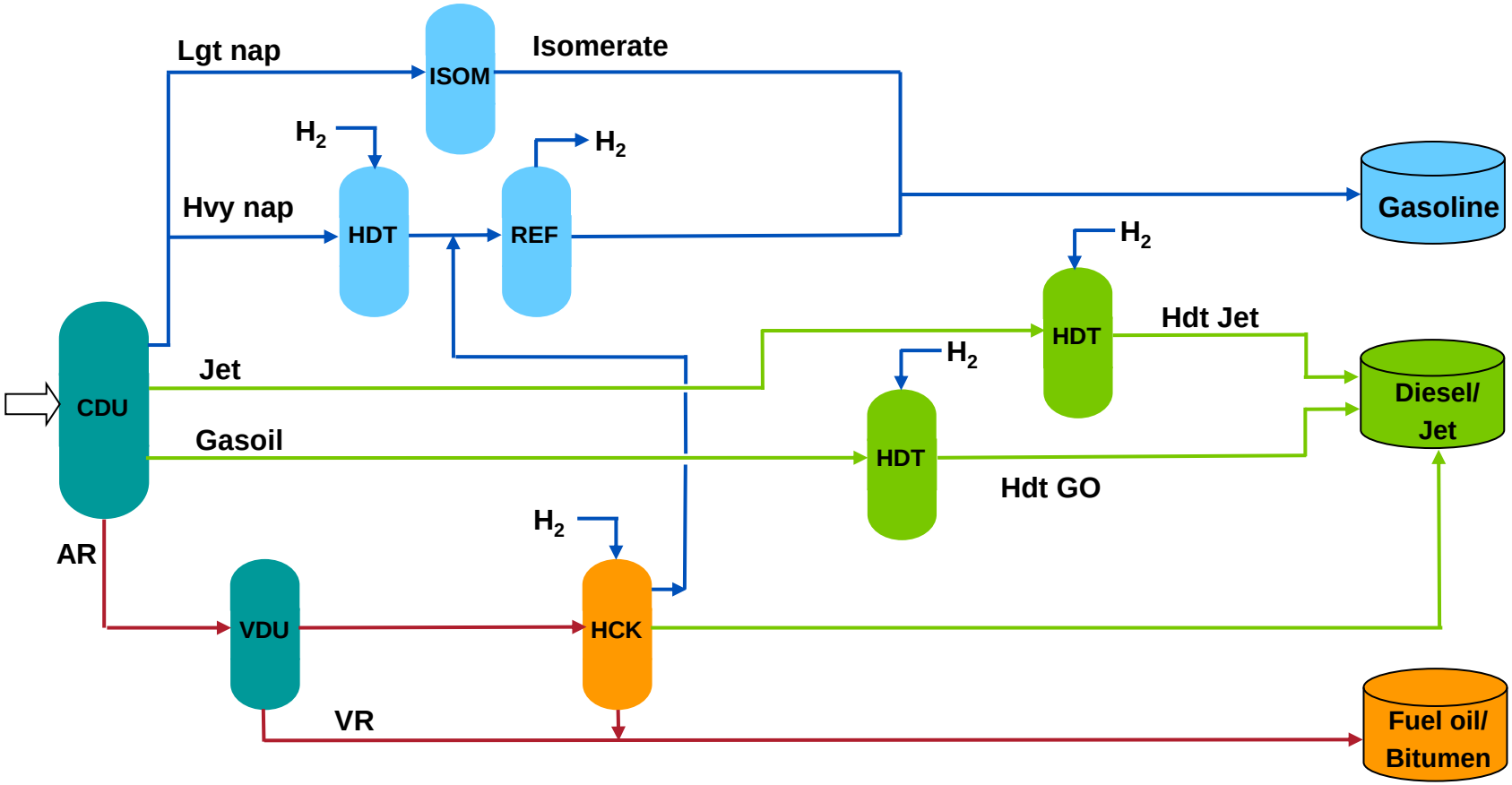
Refinery configurations - II

- **Hydroskimming + FCC refinery**

	Hydroskimming			Hydroskimming + FCC		
	Crude A	Crude B	Crude C	Crude A	Crude B	Crude C
Products	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**
LPG	0,6	1,2	1,8	3,0	4,9	4,1
C3=	0,0	0,0	0	0,7	1,2	1,016726
Benzene rich cut	0,2	0,7	1,1	0,3	0,8	1,1
Virgin Naphtha	0,8	3,8	5,5	1,1	4,2	5,8
Mogas	3,7	10,9	16,3	13,4	26,1	26,2
Sum gasoline	**4,7**	**15,5**	**22,9**	**14,8**	**31,2**	**33,2**
JET	2,8	6,1	11,3	2,8	6,1	11,3
Diesel Fuel	6,5	12,5	18,8	24,3	29,7	29,1
Heating Oil	1,3	4,8	3,4	1,0	1,4	1,2
Sum Middle Distillates	**10,5**	**23,4**	**33,5**	**28,1**	**37,2**	**41,6**
Fuel Oil 1%	1,2	4,5	3,0	0,2	0,3	0,2
LCO+FCCslurry	0,0	0,0	0,0	0,8	1,2	0,8
Fuel Oil 3,5%	**78,2**	**51,0**	**34,4**	**44,9**	**17,9**	**12,2**
Bitumen	4,1	2,7	1,8	2,4	0,9	0,6
Coke	0,0	0,0	0,0	0,0	0,0	0,0
Sulphur	0,1	0,2	0,3	0,5	0,7	0,6
Sum product	99,4	98,5	97,7	95,3	95,6	94,4
loss + own cons.	0,6	1,5	2,3	4,7	4,4	5,6
crude oil prize (USD/t)	504,0	544,0	580,0	504,0	544,0	580,0
Gross margin (USD/t)	**-56,0**	**-11,0**	**11,0**	**23,0**	**83,0**	**67,0**

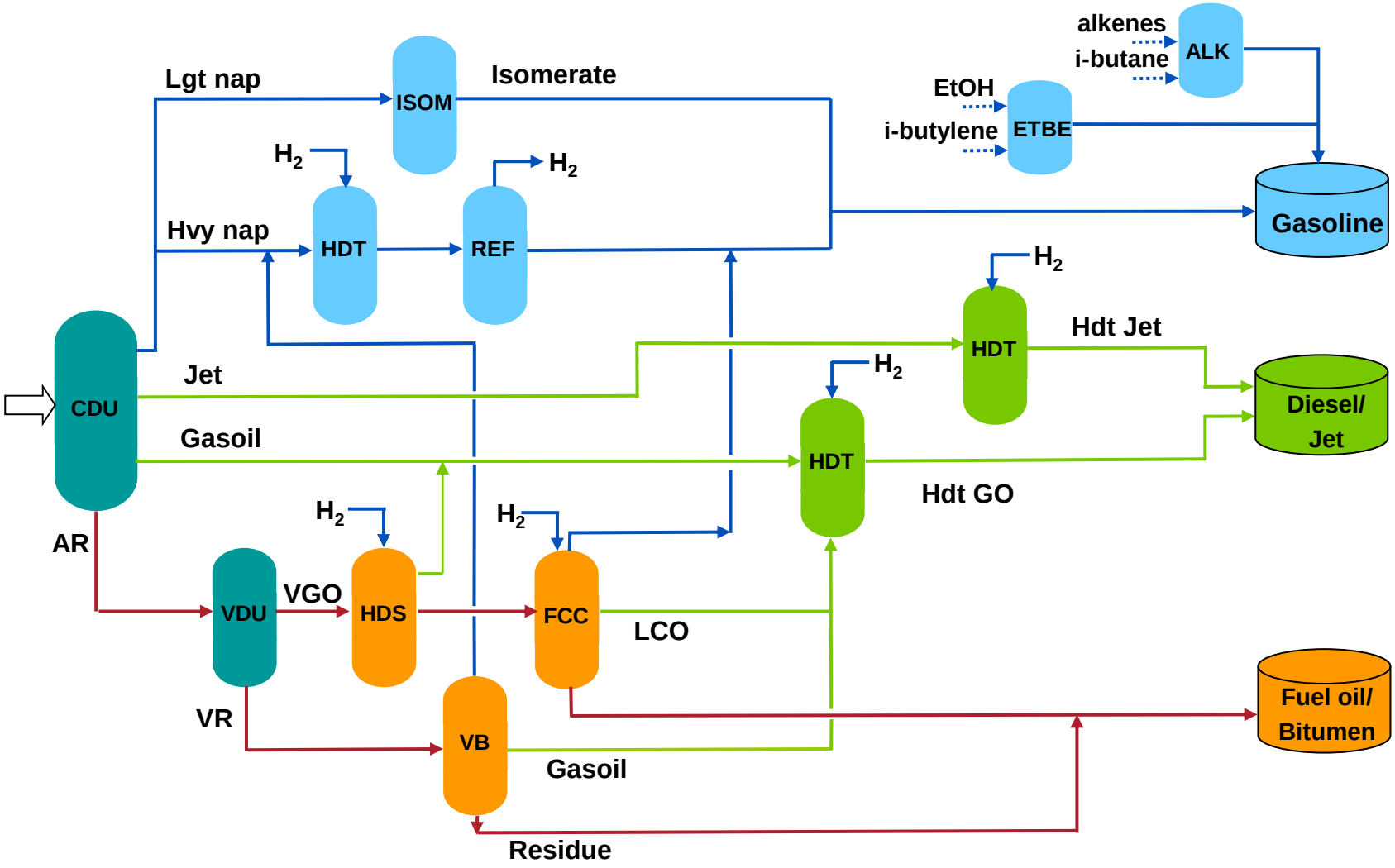
Refinery configurations - III

Hydroskimming + HCK refinery



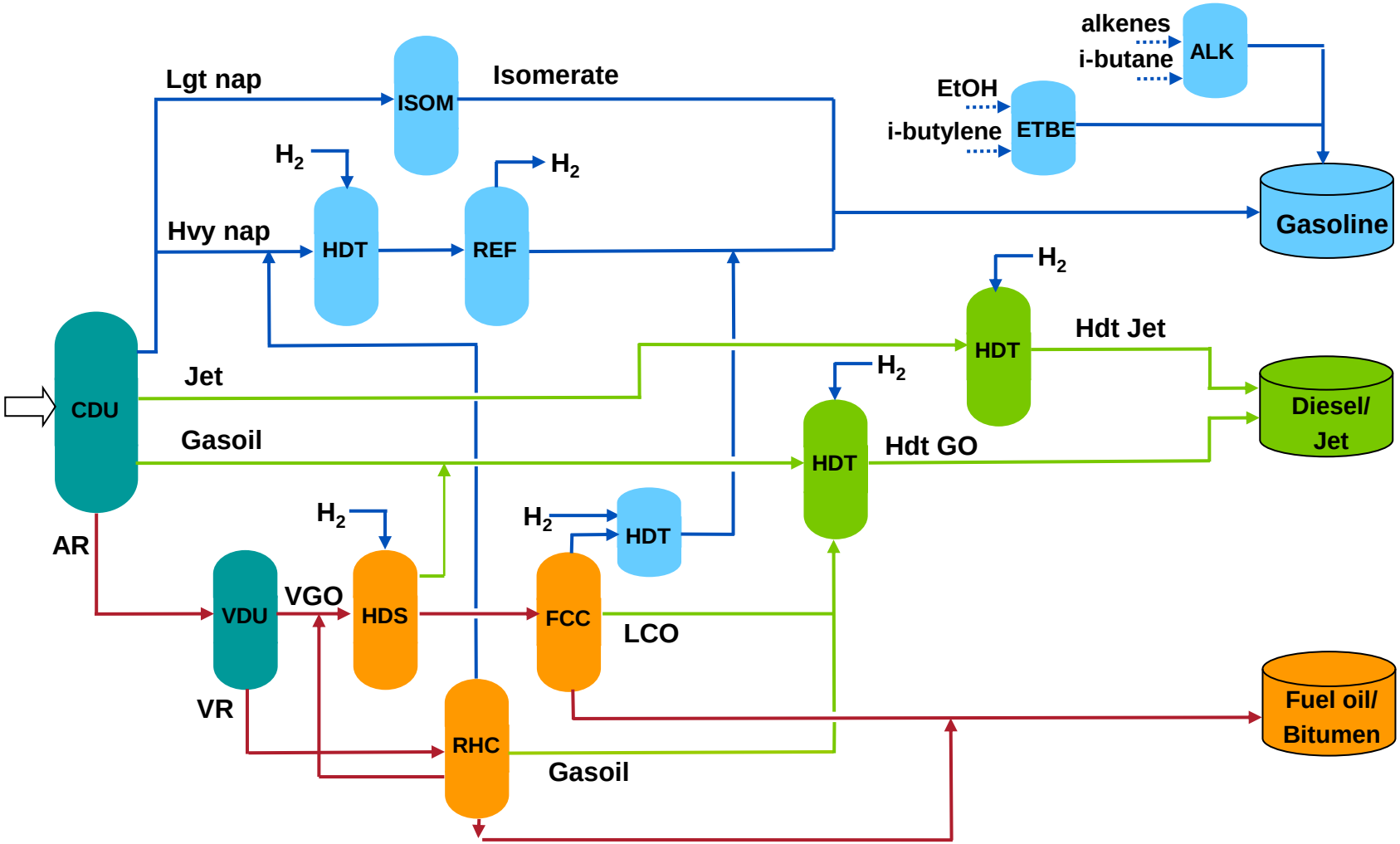
Refinery configurations - IV

Hydroskimming + FCC + VB refinery



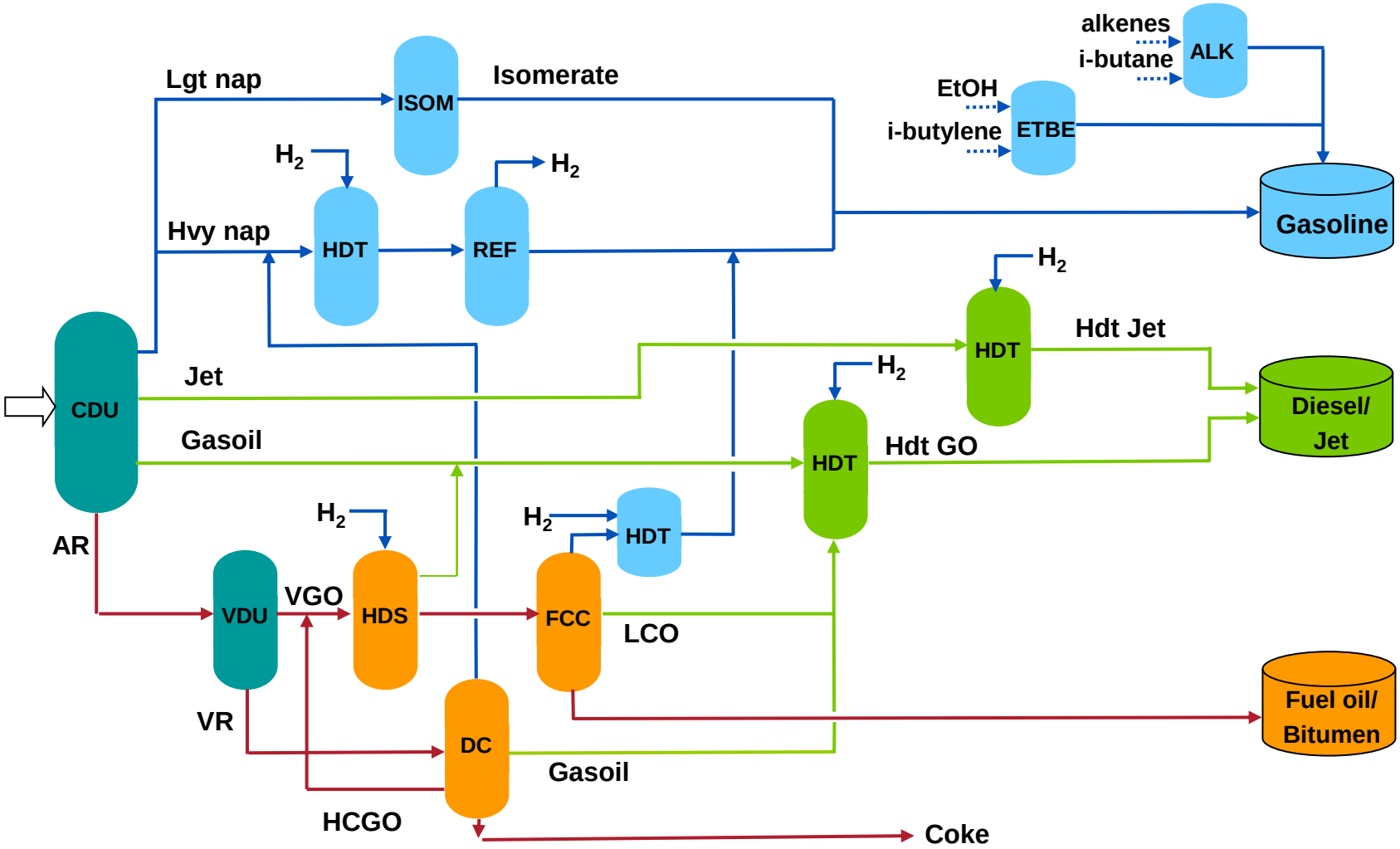
Refinery configurations - V

Hydroskimming + FCC + RHC refinery



Refinery configurations - VI

Hydroskimming + FCC + DC refinery



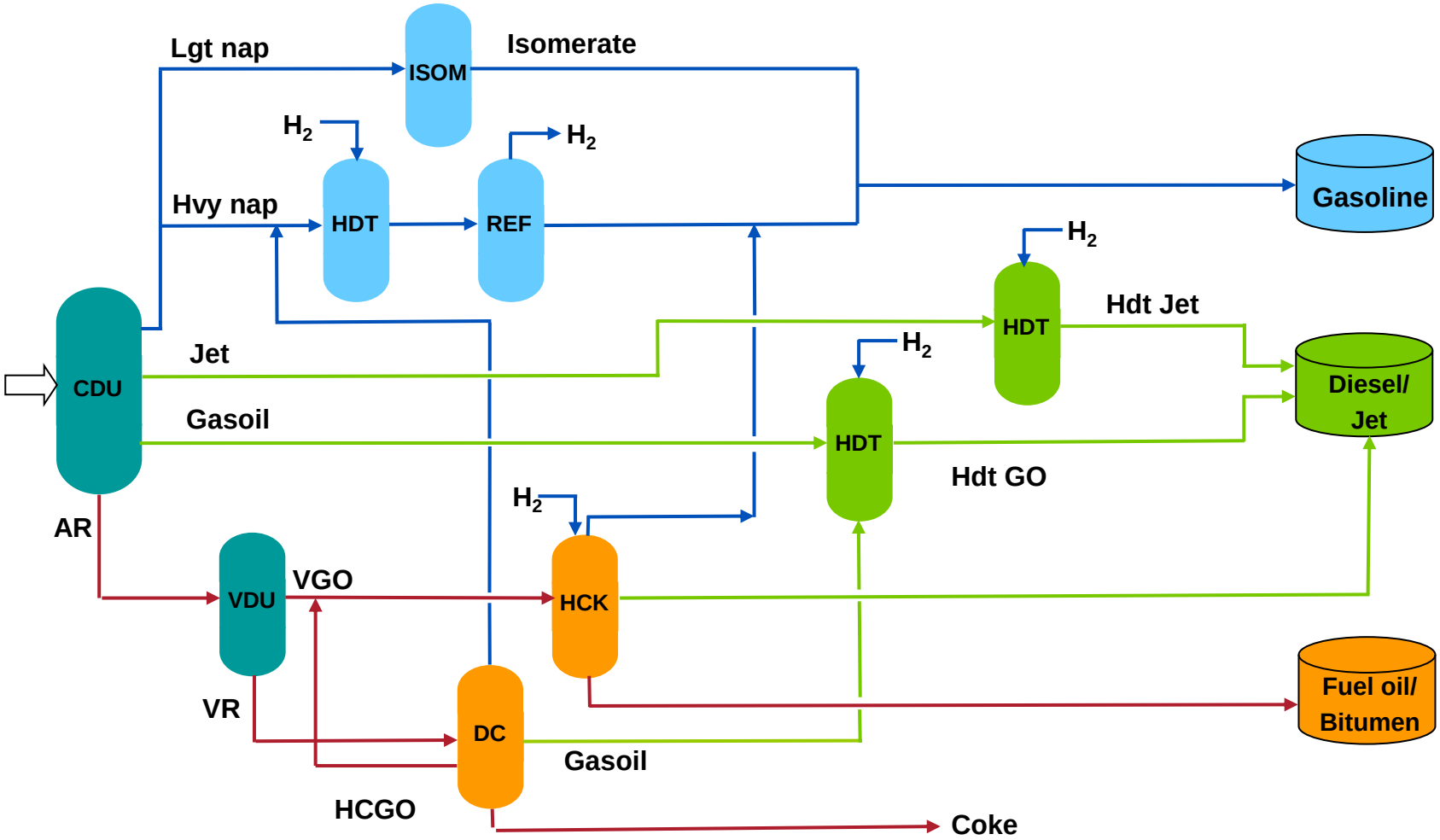
Refinery configurations - VI

Hydroskimming + FCC + DC refinery

	Hydroskimming			Hydroskimming + FCC			Hydroskimming + FCC+ DC		
	Crude A	Crude B	Crude C	Crude A	Crude B	Crude C	Crude A	Crude B	Crude C
Products	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**	**Yield, %**
LPG	0,6	1,2	1,8	3,0	4,9	4,1	6,8	6,5	5,1
C3=	0,0	0,0	0	0,7	1,2	1,016726	1,7	1,6	1,3
Benzene rich cut	0,2	0,7	1,1	0,3	0,8	1,1	0,3	0,8	1,2
Virgin Naphtha	0,8	3,8	5,5	1,1	4,2	5,8	1,4	4,4	5,9
Mogas	3,7	10,9	16,3	13,4	26,1	26,2	21,1	29,2	28,3
Sum gasoline	**4,7**	**15,5**	**22,9**	**14,8**	**31,2**	**33,2**	**22,8**	**34,4**	**35,4**
JET	2,8	6,1	11,3	2,8	6,1	11,3	2,8	6,1	11,3
Diesel Fuel	6,5	12,5	18,8	24,3	29,7	29,1	38,7	35,4	33,0
Heating Oil	1,3	4,8	3,4	1,0	1,4	1,2	1,7	1,7	1,3
Sum Middle Distillates	**10,5**	**23,4**	**33,5**	**28,1**	**37,2**	**41,6**	**43,2**	**43,2**	**45,7**
Fuel Oil 1%	1,2	4,5	3,0	0,2	0,3	0,2	0,3	0,3	0,2
LCO+FCCslurry	0,0	0,0	0,0	0,8	1,2	0,8	1,4	1,5	1,0
Fuel Oil 3,5%	**78,2**	**51,0**	**34,4**	**44,9**	**17,9**	**12,2**	**0,0**	**0,0**	**0,0**
Bitumen	4,1	2,7	1,8	2,4	0,9	0,6	0,0	0,0	0,0
Coke	0,0	0,0	0,0	0,0	0,0	0,0	9,5	3,8	2,6
Sulphur	0,1	0,2	0,3	0,5	0,7	0,6	1,0	0,9	0,8
Sum product	99,4	98,5	97,7	95,3	95,6	94,4	86,6	92,1	92,0
loss + own cons.	0,6	1,5	2,3	4,7	4,4	5,6	13,4	7,9	8,0
crude oil prize (USD/t)	504,0	544,0	580,0	504,0	544,0	580,0	504,0	544,0	580,0
Gross margin (USD/t)	**-56,0**	**-11,0**	**11,0**	**23,0**	**83,0**	**67,0**	**49,0**	**94,0**	**74,0**

Refinery configurations - VII

Hydroskimming + HCK + DC refinery



Integration of Hydrocracking Unit into the Danube Refinery