WOOD GROUP MUSTANG

Refining 101

Prepared for PESA
May 2015

Safety & Assurance | Relationships | Social Responsibility | People | Innovation | Financial Responsibility | Integrity

What is Crude Oil?

…Black Gold

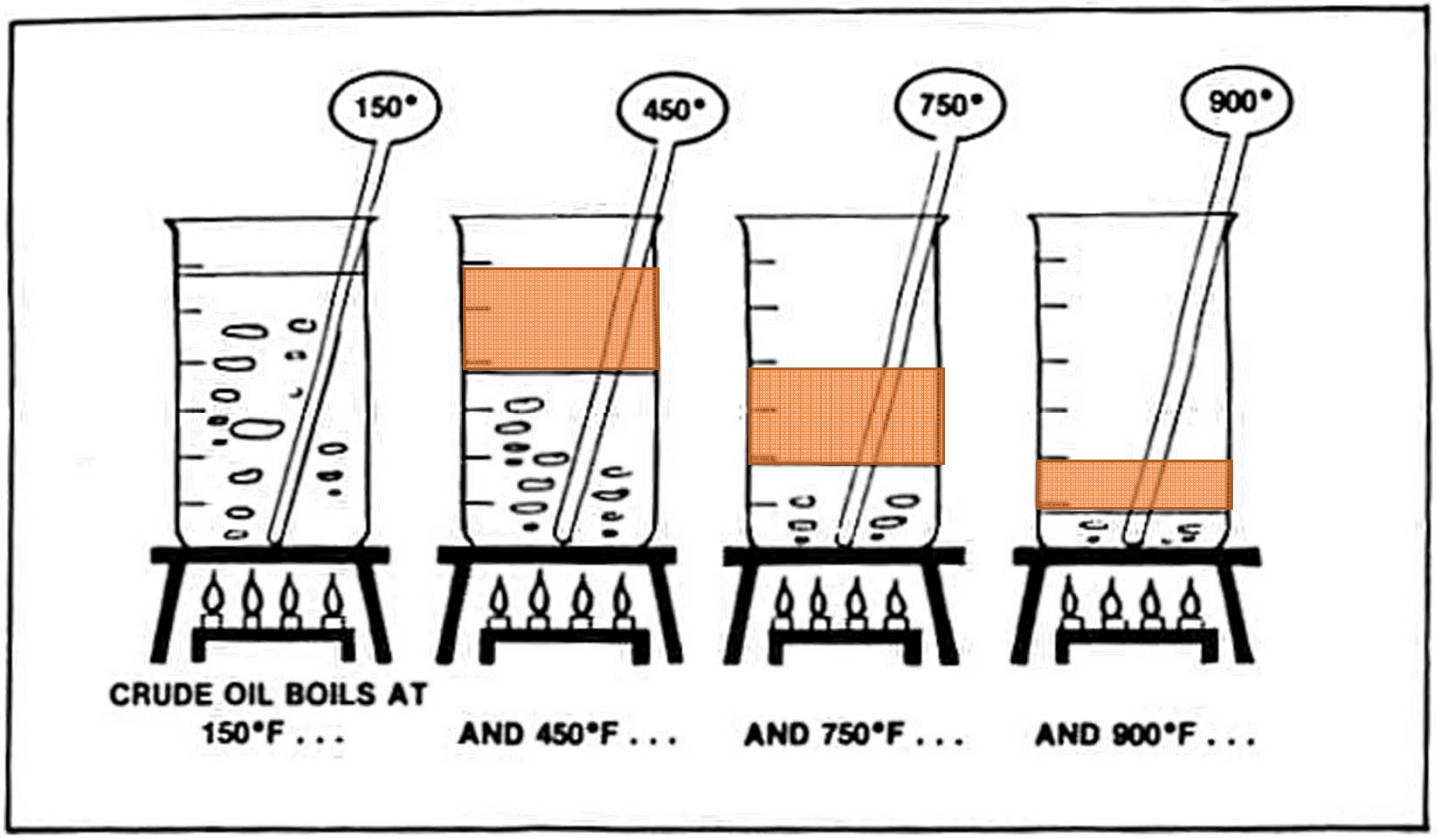
….Texas Tea

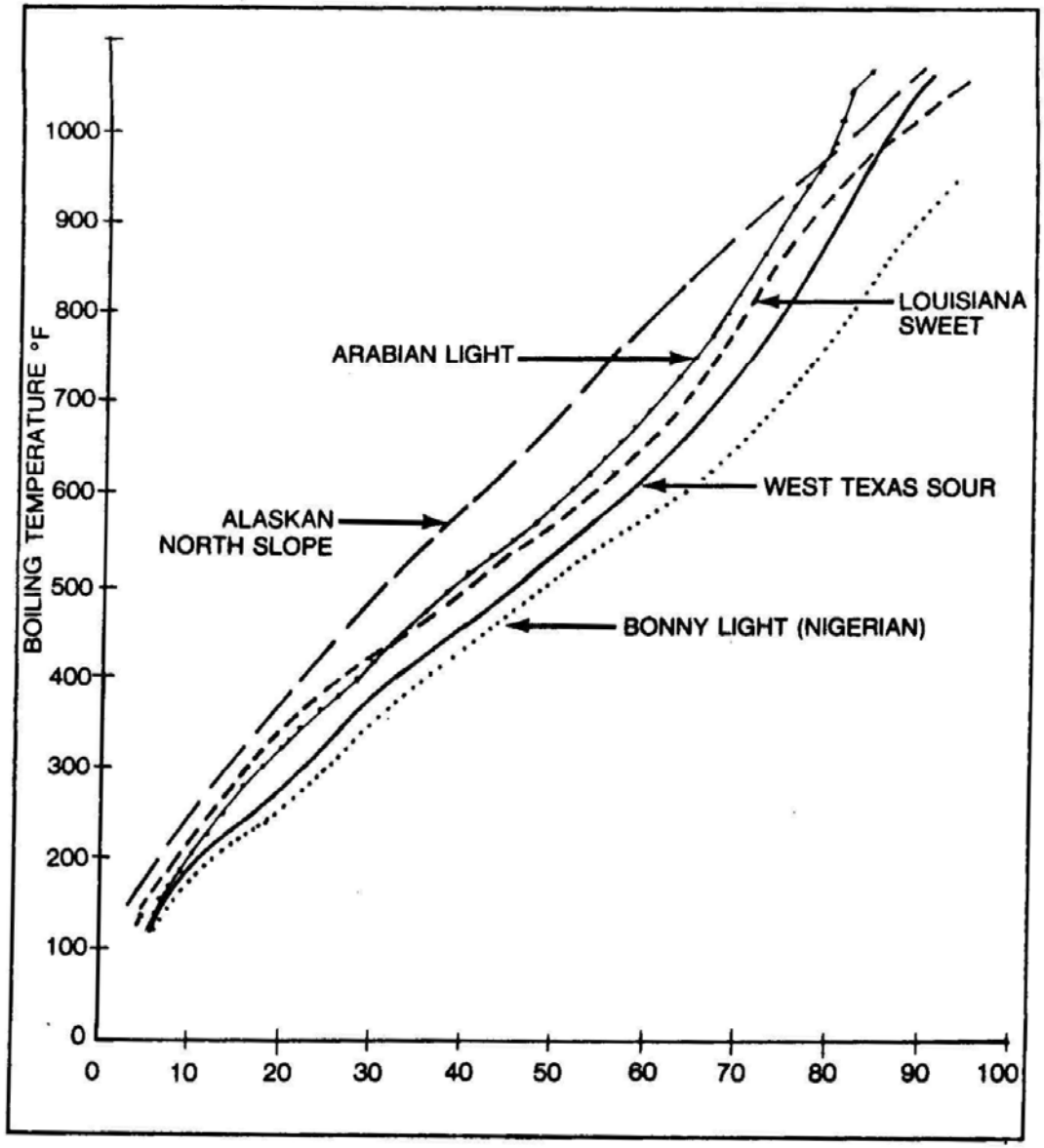


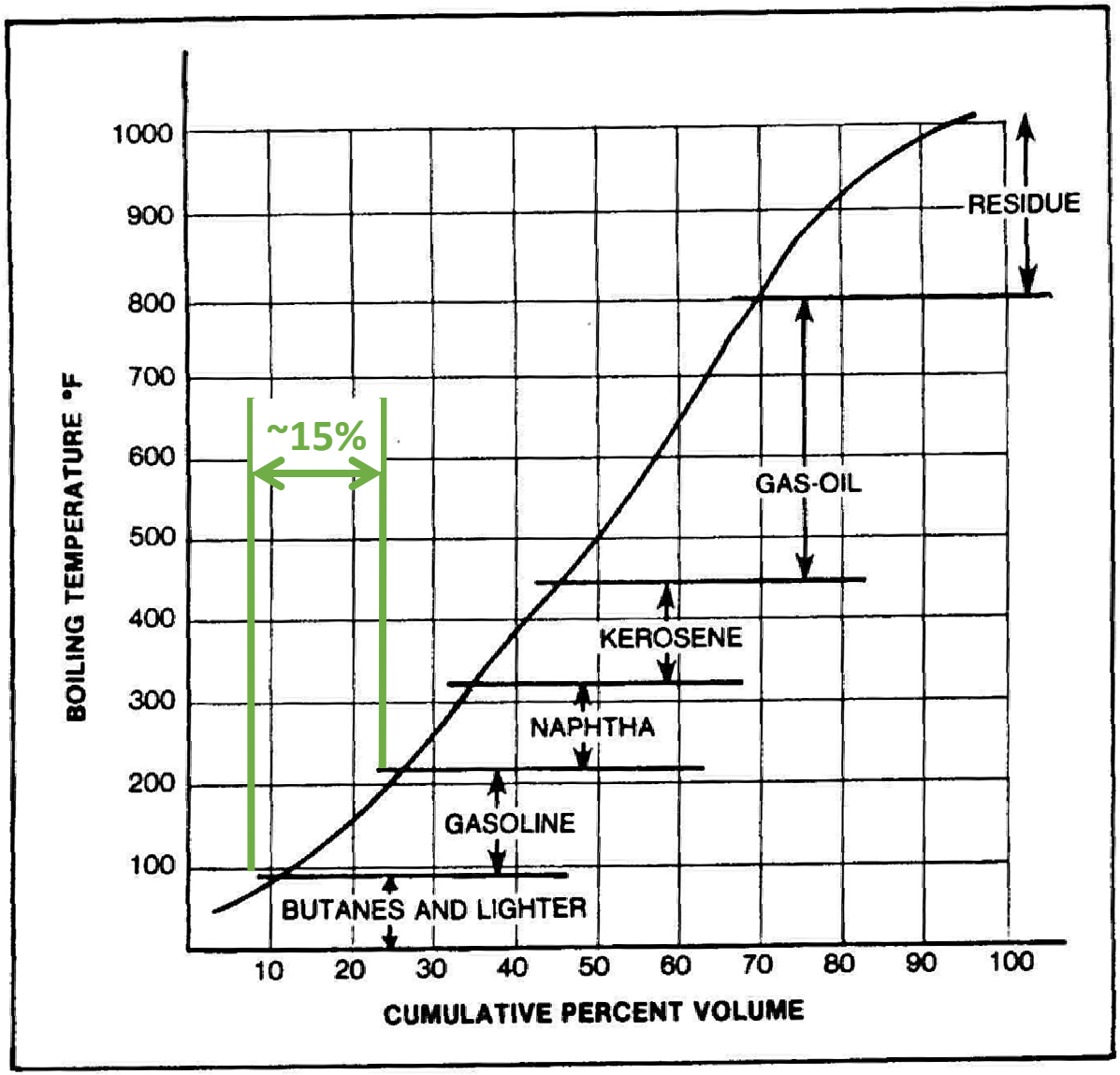
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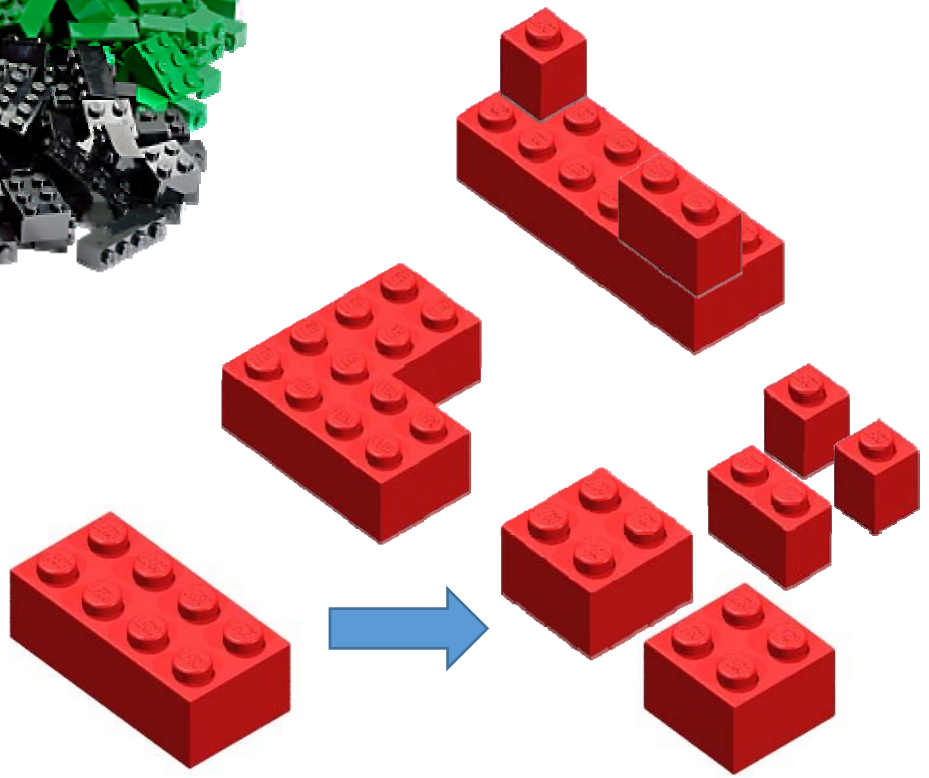



BOILING TEMPERATURE °F
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
ARABIAN LIGHT
LOUISIANA SWEET
ALASKAN NORTH SLOPE
WEST TEXAS SOUR
BONNY LIGHT (NIGERIAN)


BOILING TEMPERATURE °F
1000
900
800
700
600
500
400
300
200
100
~15%
RESIDUE
GAS-OIL
KEROSENE
NAPHTHA
GASOLINE
BUTANES AND LIGHTER
10
20
30
40
50
60
70
80
90
100
CUMULATIVE PERCENT VOLUME

Conversion vs. Separation





Conversion vs. Separation

Generally, heavy crude is not as valuable as lighter crude

Goal: Make more gasoline/diesel via conversion

Conversion (reaction) vs. Separation

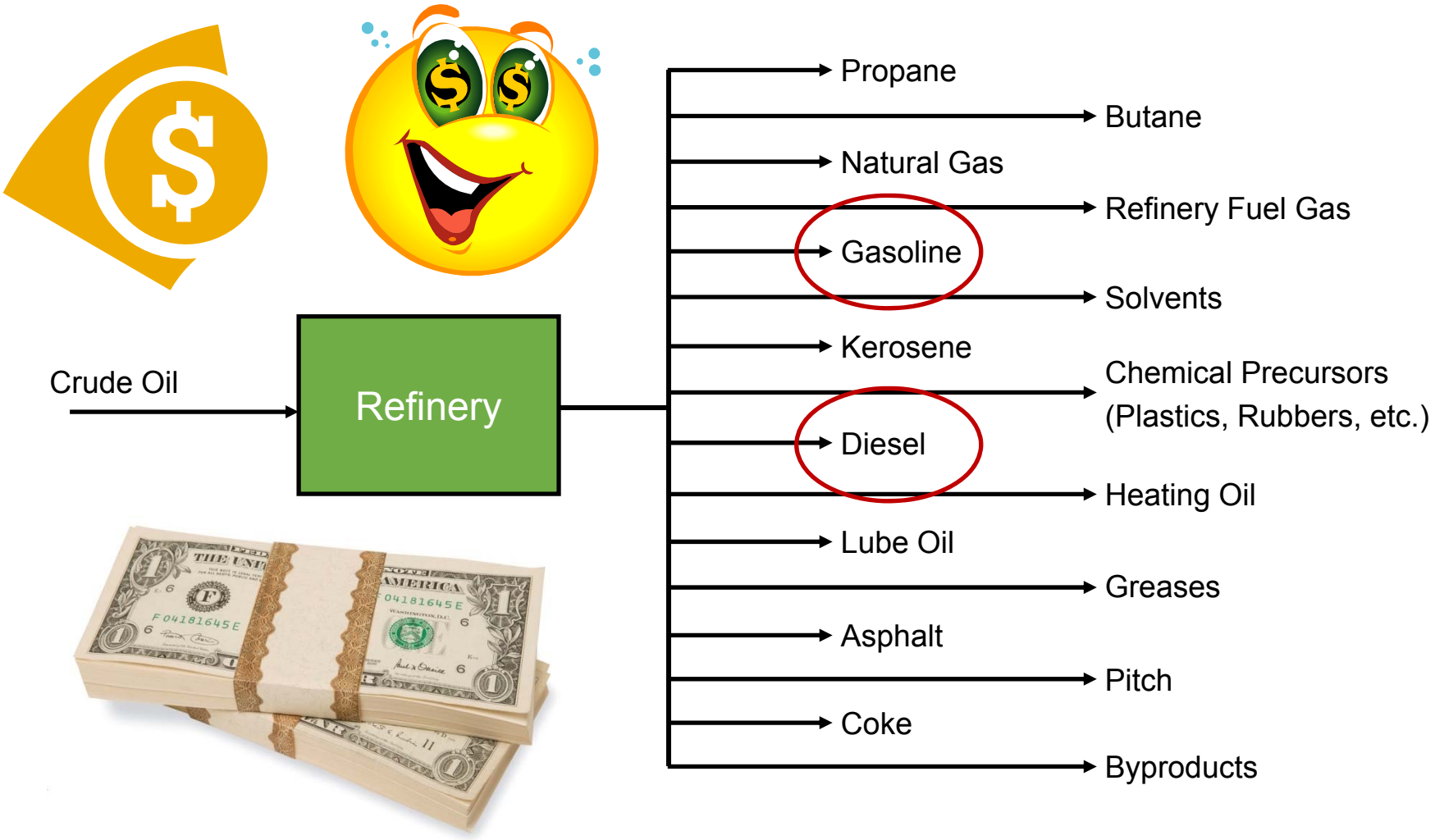
% gasoline/diesel without conversion – ~50%

% gasoline/diesel with conversion – ~90%

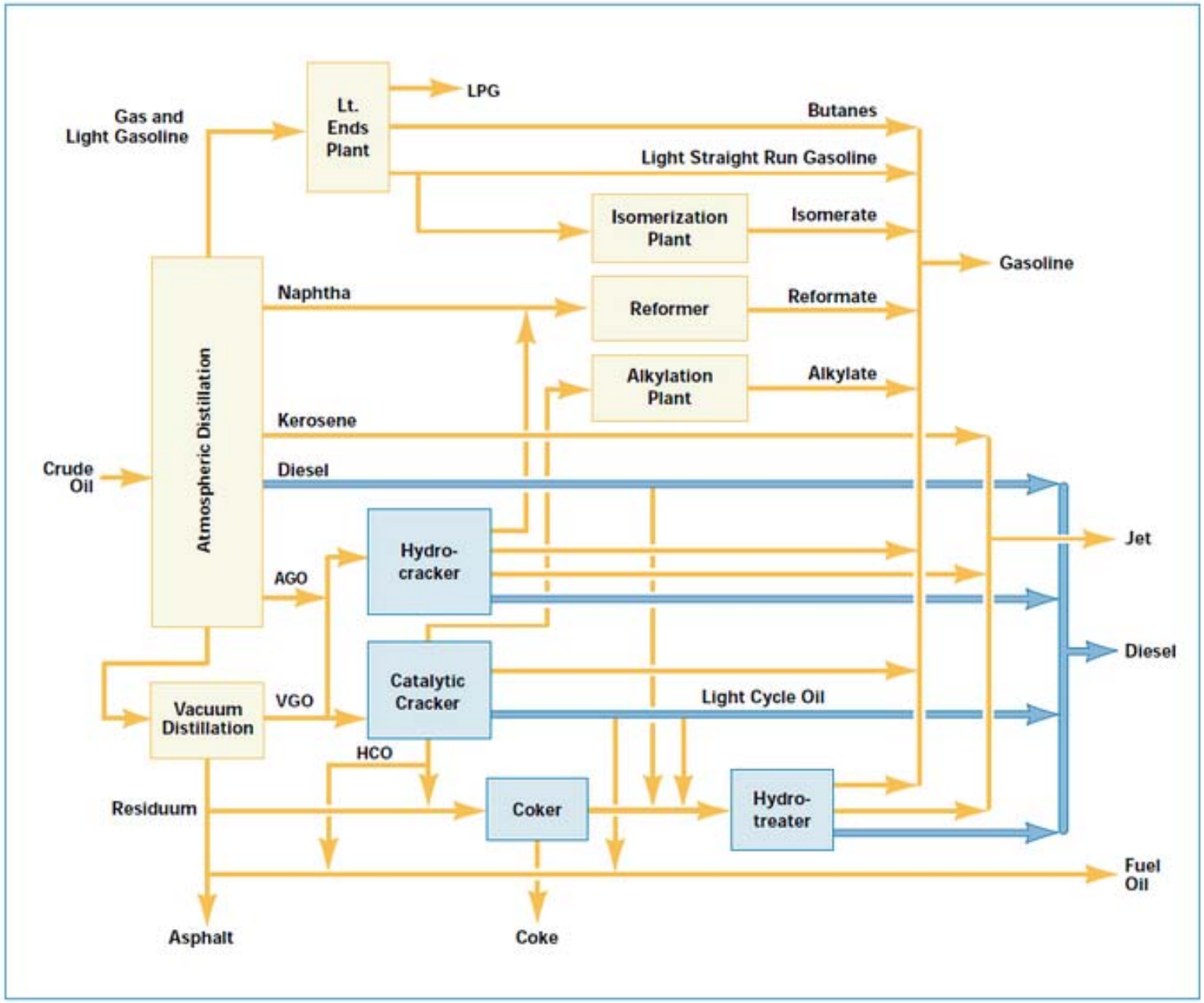
Separation Units	Conversion Units
Crude	FCC
Vacuum	Coker
Gas Concentration	Hydrocracker
	Isomerization
	Reformer
	Alkylation



Refining 101



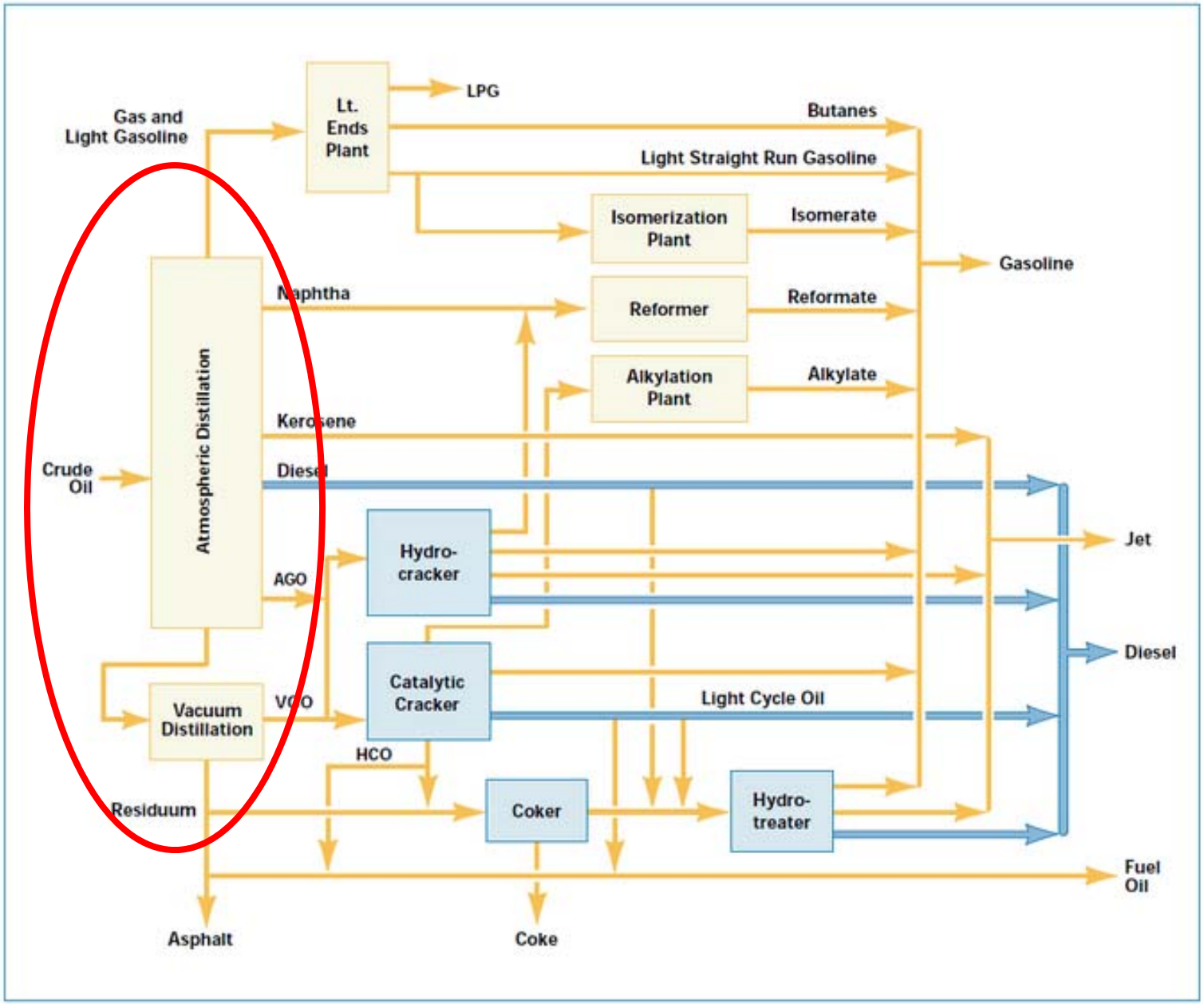
Refinery Block Flow Diagram



Units in a Refinery

- Crude Unit
- Vacuum Unit
- Hydrotreating/cracking Unit
- Fluid Catalytic Cracker Unit
- Delayed Coker Unit
- Gasoline Upgrading Units

Refinery Block Flow Diagram – Crude/Vac Units



Crude Unit



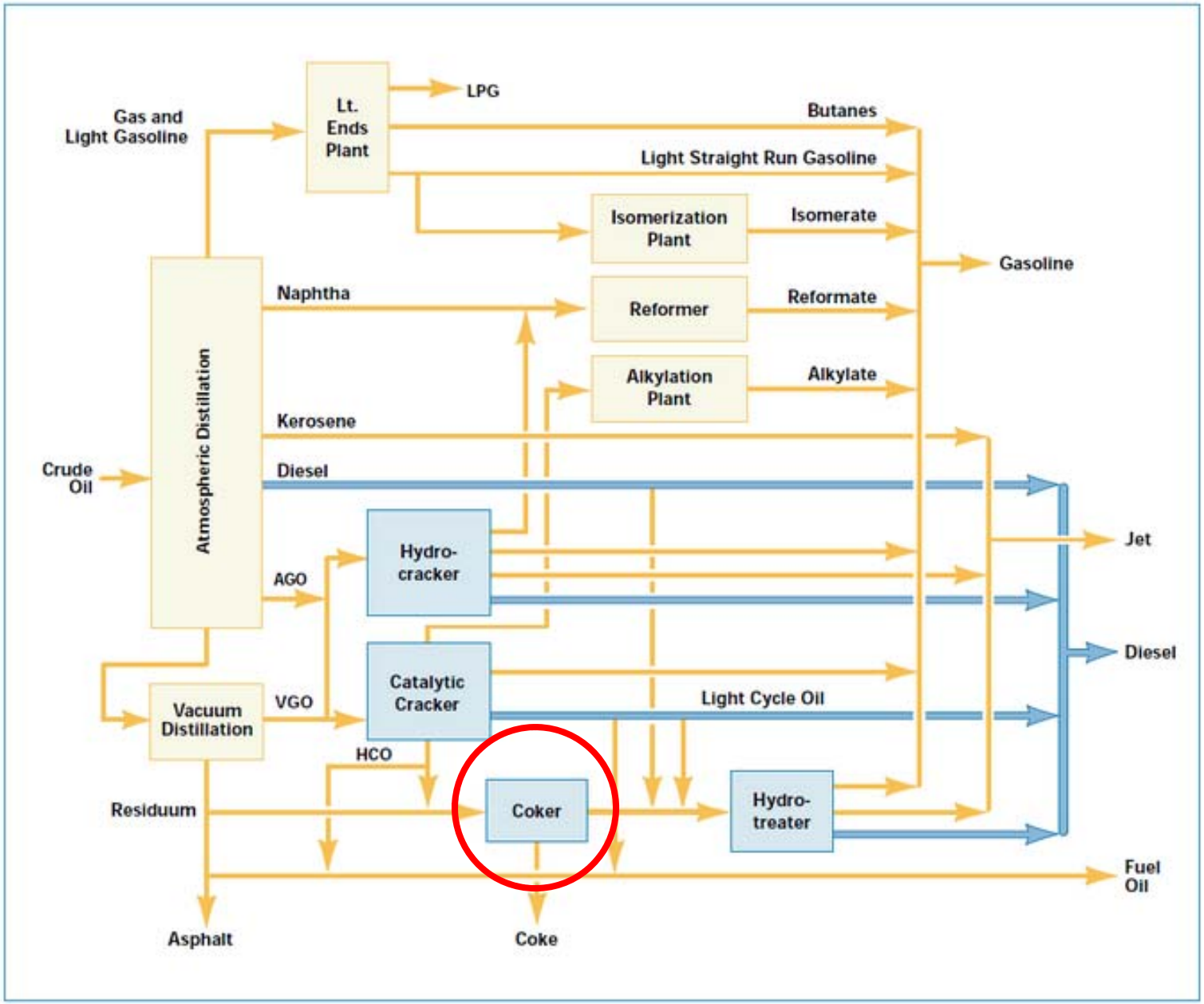
Vacuum Unit







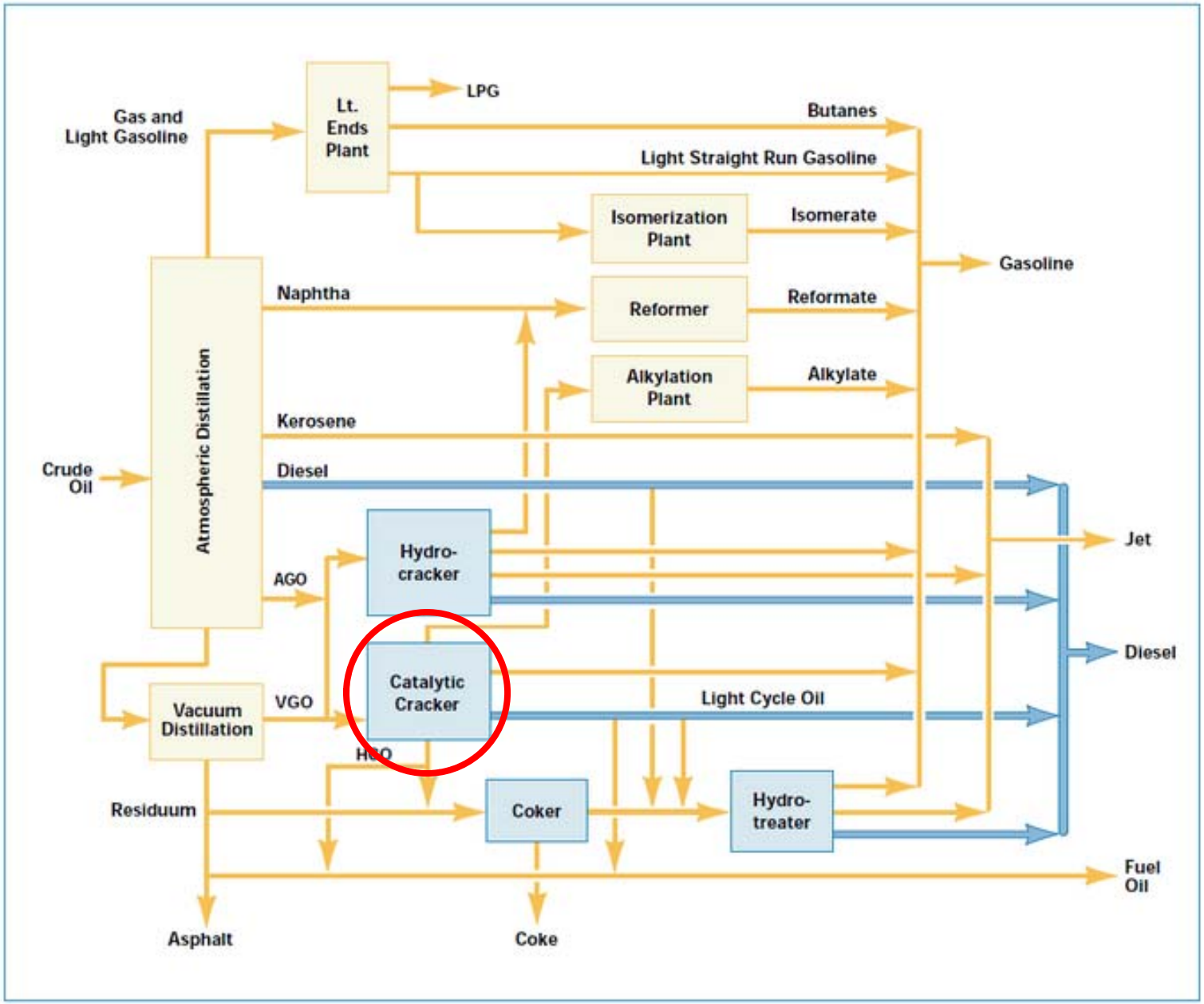
Refinery Block Flow Diagram – Coker



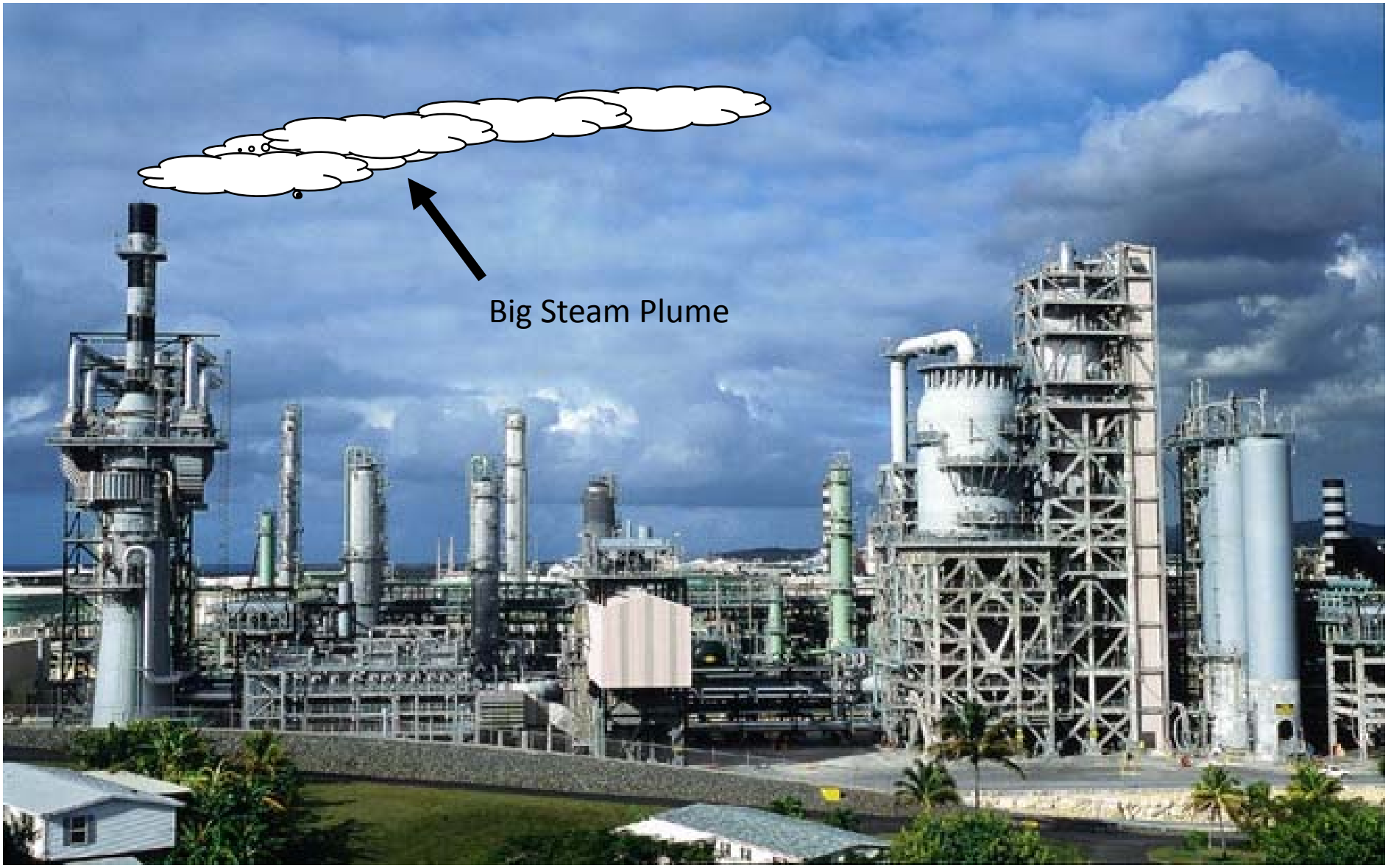
Delayed Coker



Refinery Block Flow Diagram – FCC



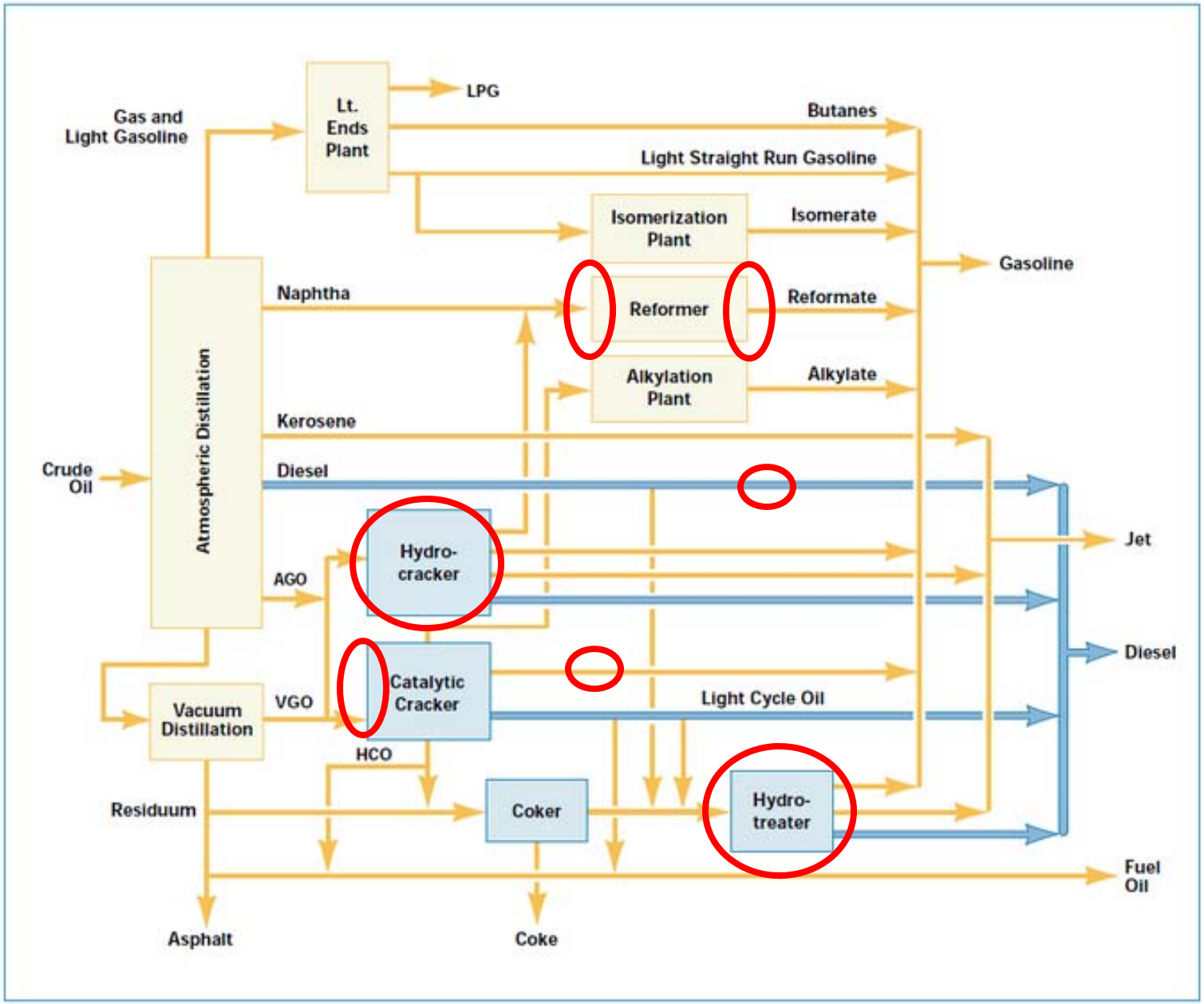
Fluid Catalytic Cracker - FCC







Refinery Block Flow Diagram – Hydrotreaters



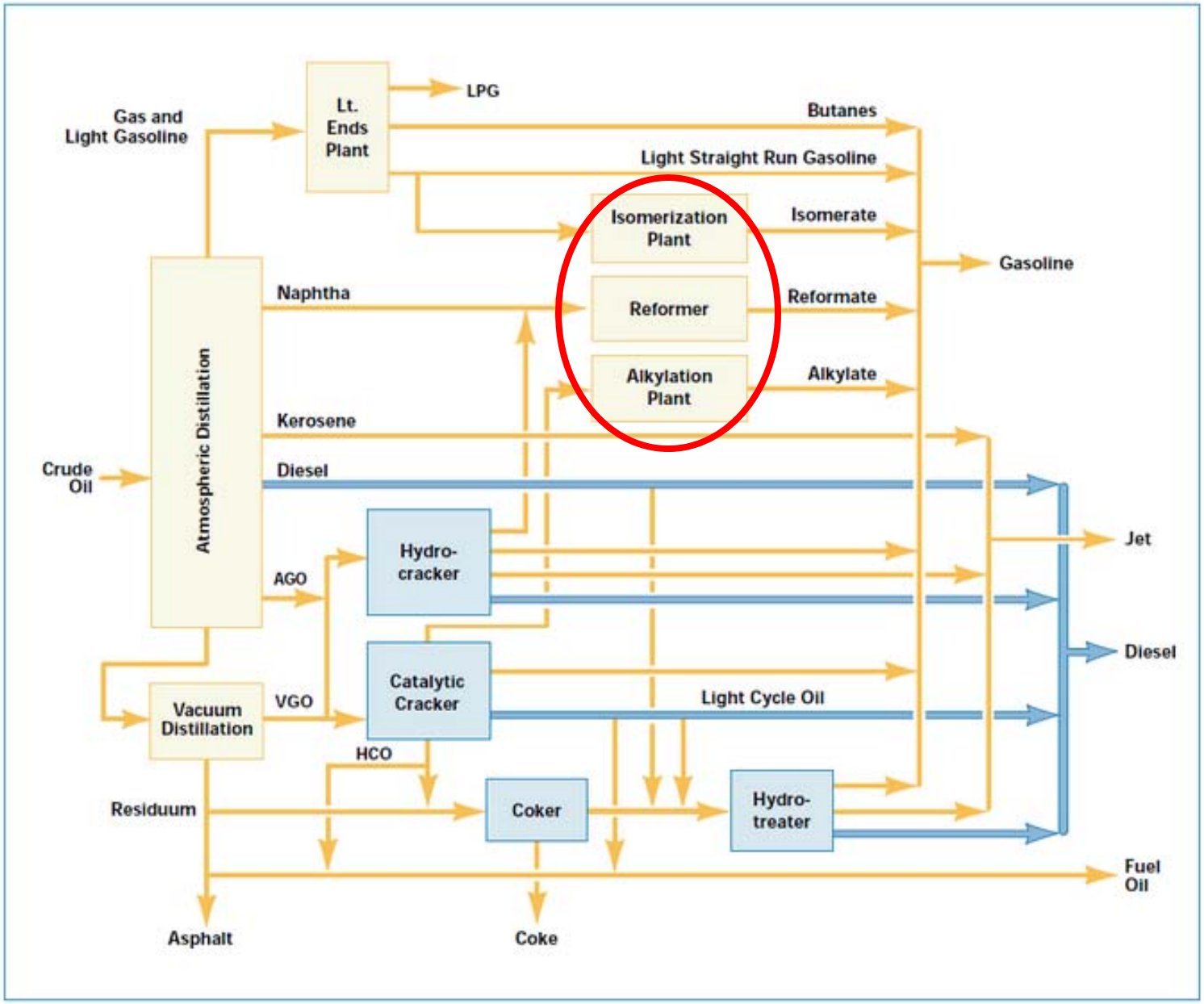
Hydrotreater



Sulfur Plant



Refinery Block Flow Diagram – Gasoline Upgrading



Gasoline and Diesel Pools

Gasoline Pool

- Octane
- Environmental specs
  - Regional, rural/urban
- Specs
  - Octane
  - Vap pressure
  - Olefins
  - Benzene
  - Aromatics
  - Sulfur
- Blending

Diesel Pool

- On road (ULSD) / Off road
- Specs
  - Cetane – auto-ignite property
  - Flash point
  - Cold props – cloud/pour point
- Blending
  - Straight Run (SR) diesel - moderate sulfur, no olefins
  - FCC LCO - high sulfur, olefins, aromatics
  - Coker diesel - high sulfur, olefins, aromatics, silicon
  - Hydrocracker diesel - low sulfur, low olefins, low aromatics

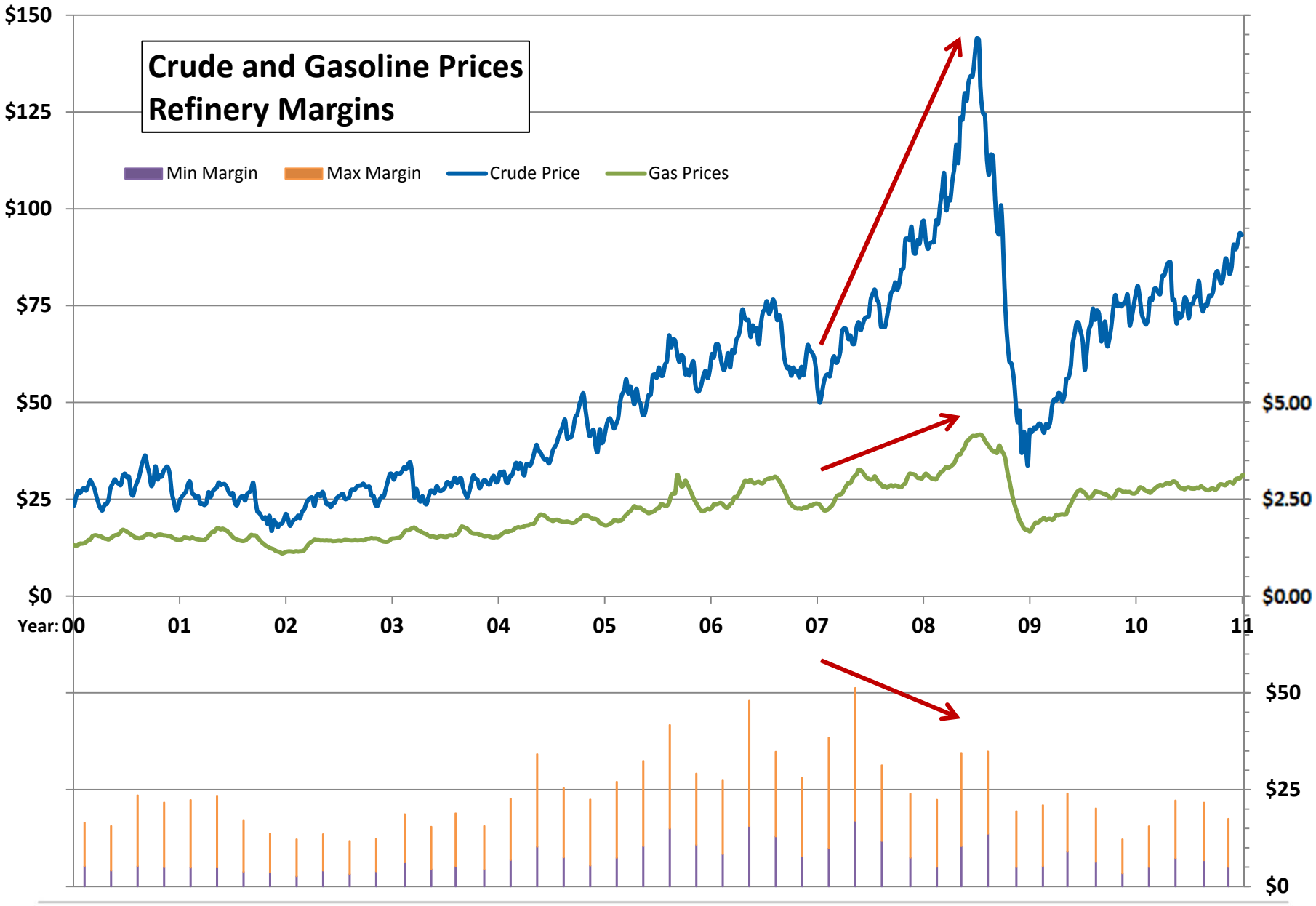
GASOLINE BLENDING	
Source	**% of pool**
Alkylate	13
Coker Naphtha	1
Hydrocracked Naphtha	2
FCC Naphtha	36
Isomerate	6
LSR Naphtha	3
Butanes	5
Reformate	34
Total	100

Refining Economics

Reality: Refiners only make $5-15 per barrel of oil processed.

The Reality of Refining:

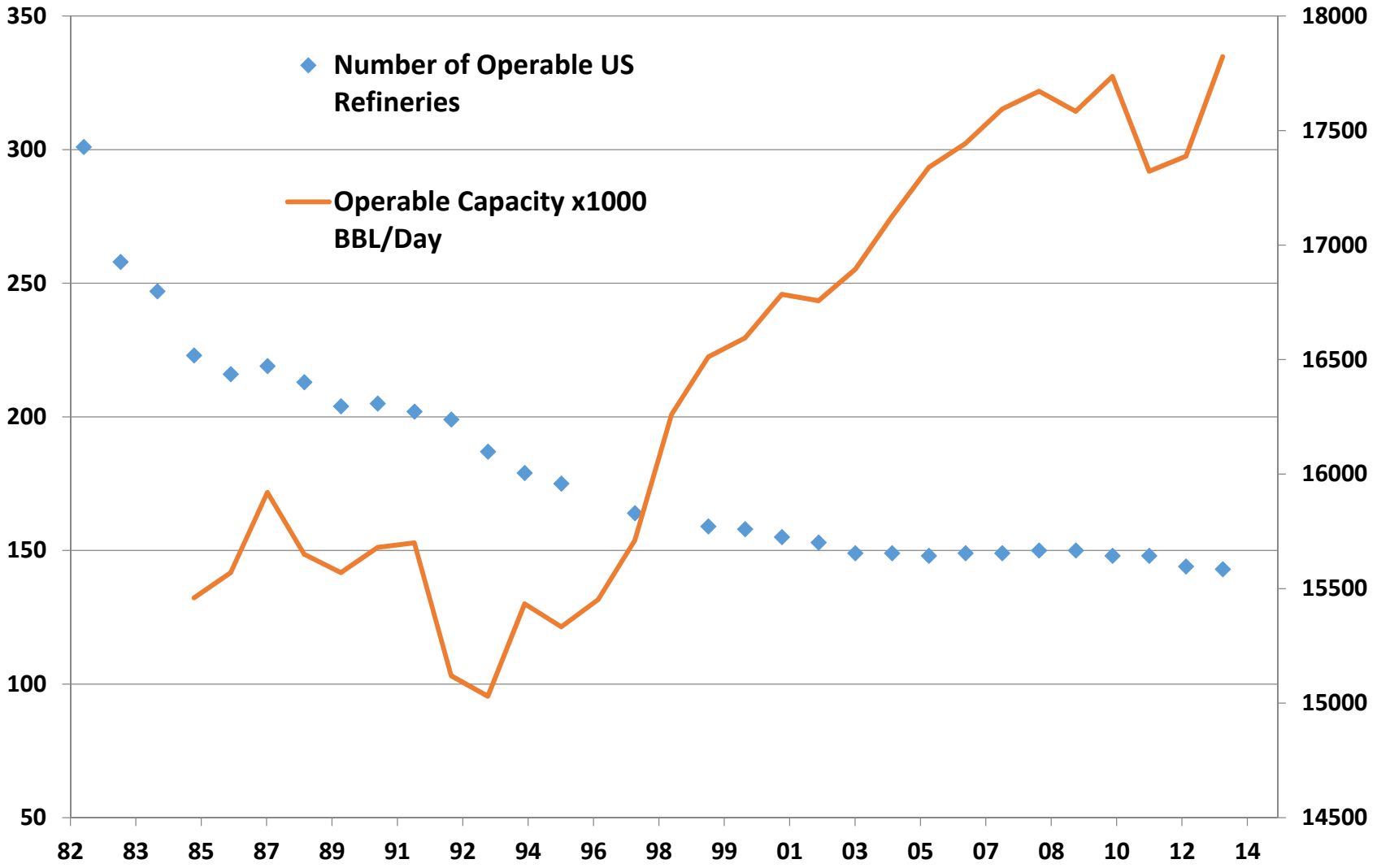
1) PROCESSING COSTS (it costs a ton of $$$ to build all that processing equipment)
2) VOLUME (one barrel of crude does not equal one barrel of gasoline)
3) FEEDSTOCK PROPERTIES (you have to be able to get crudes you can process)
4) MARKETS (refiners are at the mercy of crude prices AND gasoline prices)
5) GEOGRAPHY (refineries are tied to their own regions by feed and product supply lines)
6) SEASONALITY (gasoline and diesel are seasonal products)


Crude and Gasoline Prices
Refinery Margins
Min Margin
Max Margin
Crude Price
Gas Prices
$150
$125
$100
$75
$50
$25
$0
$5.00
$2.50
$0.00
Year: 00
01
02
03
04
05
06
07
08
09
10
11
$50
$25
$0

U.S. Refineries



Refining Capacity vs. Refineries



Trends in Refinery Upgrades / Revamps

- Environmental
  - Benzene reduction – EPA MSAT II mandate
  - Air quality Projects – SO_X and NO_X in FCC and fired heater flue gas
  - Carbon capture / CO_2 reduction
  - EPA Tier III for further sulfur reduction in gasoline
- Reduce product sulfur content
  - Grassroots hydrotreating units
  - Revamp existing units with more catalyst volume
  - Sulfur Recovery Unit (SRU) capacity
  - Hydrogen generation capacity or buy it over the fence
- Crude quality and capacity upgrades
  - Grassroots conversion units – cokers / hydrocrackers
  - Metallurgical upgrades
  - Pump upgrades for higher viscosity / rate
  - Desalter upgrades
  - Efficiency upgrades


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Top Refiners US and Worldwide

Refinery Throughput
Barrels/Day (Jan 2014 – OGJ)

1	Valero Energy	12	2,096,500	11.8%
2	Phillips66	12	2,060,200	11.6%
3	Exxon Mobil	7	2,043,500	11.5%
4	Marathon Oil	8	1,714,000	9.6%
5	Chevron	5	955,000	5.4%
6	Royal Dutch Shell	8	901,000	5.1%
7	Citgo / PDVSA	4	849,400	4.8%
8	BP PLC	5	795,900	4.5%
9	Motiva Enterprises	3	772,000	4.3%
10	Flint Hills (Koch)	3	714,400	4.0%
11	Tesoro	6	564,300	3.2%
12	Sunoco	2	505,000	2.8%
13	Saudi Aramco	3	410,000	2.3%
14	EnCana Corp.	2	276,000	1.5%
15	LyondellBasell	1	268,000	1.5%
Top 15 Total		**78**	**14,153,200**	**79.4%**
Total American		**139**	**17,824,000**	**100%**

1	Exxon Mobil	5,589,000	6.3%
2	Royal Dutch Shell	4,109,239	4.7%
3	Sinopec	3,971,000	4.5%
4	BP PLC	2,858,964	3.2%
5	Saudi Aramco	2,851,500	3.2%
6	Valero Energy	2,776,500	3.2%
7	Petroleos de Venezuela SA	2,678,000	3.0%
8	China Nat'l Petroleum Corp.	2,675,000	3.0%
9	Chevron Corp	2,539,600	2.9%
10	Phillips66	2,514,200	2.9%
11	Total SA	2,304,326	2.6%
12	Petroleo Brasileiro SA	1,997,000	2.3%
13	Marathon Petroleum Co. LP	1,714,000	1.9%
14	Petroleos Mexicanos	1,703,000	1.9%
15	Nat'l Iranion Oil Co.	1,451,000	1.6%
16	JX Nippon Oil & Energy Corp.	1,423,200	1.6%
17	Rosneft	1,293,000	1.5%
18	OAO Lukoil	1,217,000	1.4%
19	SK Innovation	1,115,000	1.3%
20	Repsol YPF SA	1,105,500	1.3%
21	Kuwait Nat'l Petroleum Co.	1,085,000	1.2%
22	Pertamina	993,000	1.1%
23	Agip Petroli SpA	904,000	1.0%
24	Flint Hills Resources	714,400	0.8%
25	Sunoco Inc.	505,000	0.6%
Total refining capacity of top 25 woldwide:		**52,087,429**	**59.2%**
Total world capacity in 645 refineries:		**88,029,000**	**100%**

The Changing Global Refining Landscape

Percentage of Worldwide Capacity

	2000	2007	2010	2013
North America	26.5%	24.4%	22.8%	22.5%
South/Central America	7.8%	7.2%	7.3%	6.4%
Europe & Eurasia	28.1%	27.6%	26.7%	25.2%
Middle East	7.9%	8.3%	8.6%	9.3%
Africa	3.2%	3.3%	3.6%	3.7%
China	6.1%	8.7%	11.0%	13.3%
India	2.7%	3.4%	4.0%	4.5%
Japan	6.0%	5.3%	4.9%	4.3%
Other Asia Pacific / Australia	11.7%	11.8%	11.0%	10.9%

References

- US EIA: www.eia.gov
- BP Energy Outlook 2013: www.bp.com
- Wikipedia: en.wikipedia.org - Oil Refinery
- The Oil Drum: Global Refining Capacity
- Oil and Gas Journal: www.ogj.com
- Petroleum Refining for the Non-Technical Person; William Leffler
- American Fuel and Petrochemical Manufacturers: www.afpm.org
- Various Wood Group Mustang projects