



Petroleum Refining



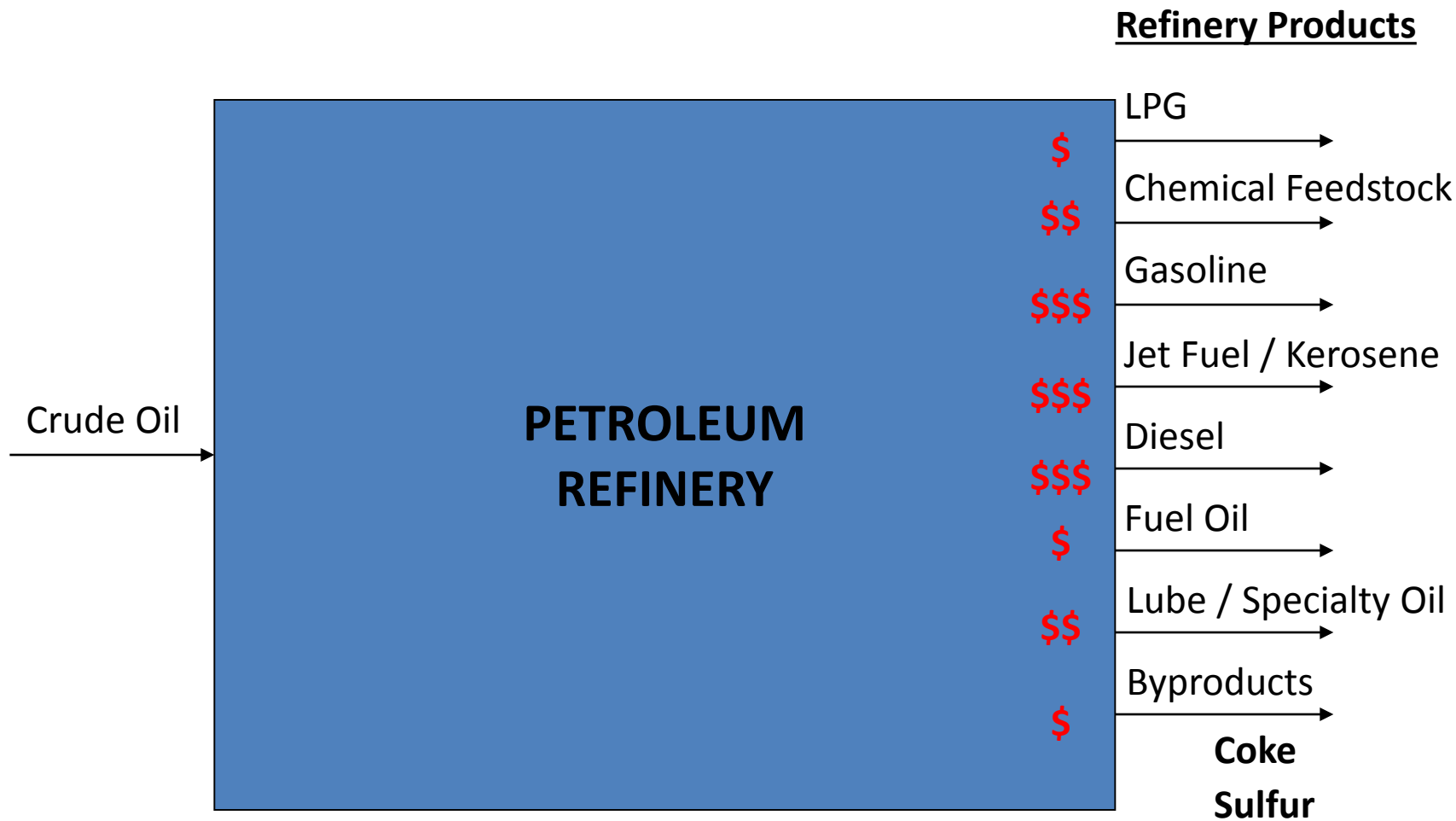
- **Handbook Of Petroleum Refining Processes**, Robert A. Meyers, ed.
- **Petroleum Refining Technology and Economics**, James H. Gary, et al.

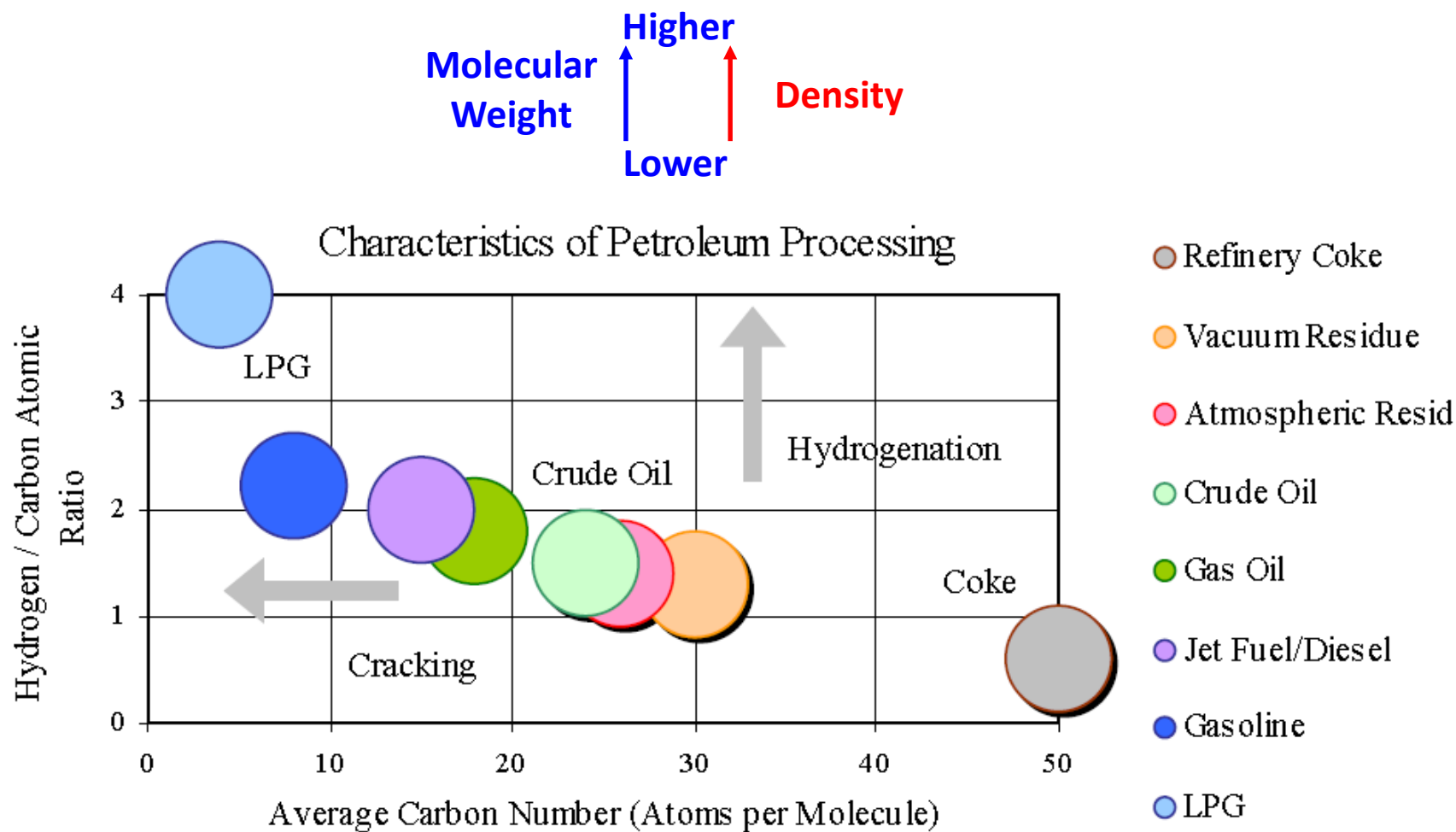


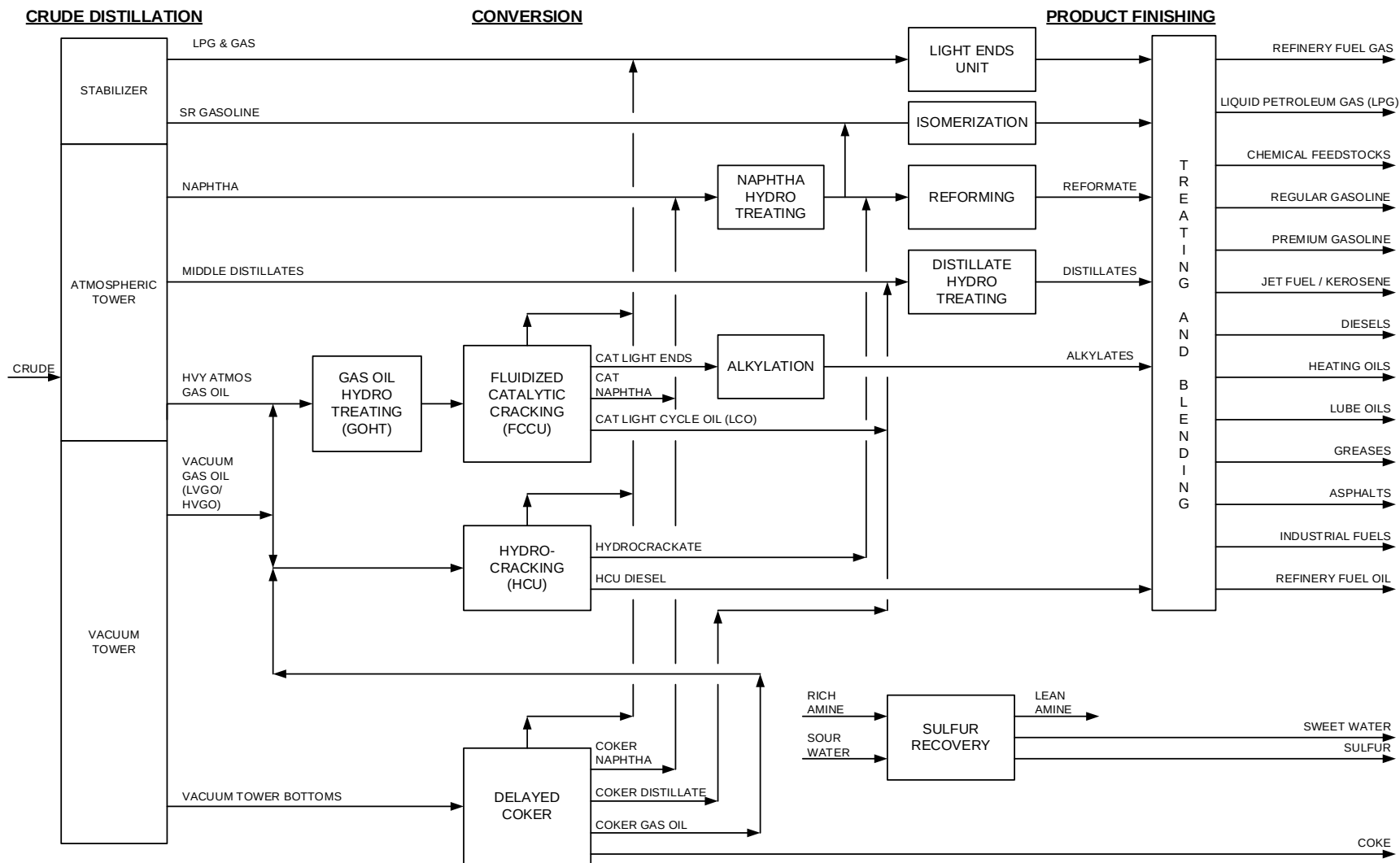
- **INPUT:** Process Multiple Crude Compositions At Minimum Cost
- **OUTPUT:** Produce Slate Of Products That Provide The Most Profit For Current Market Conditions
- **CONVERSION:** Utilize Processes That Upgrade Value Of Petroleum Components
- **FULL CONVERSION REFINERY**
 - Change Less Valuable Fractions Into Higher Value Transportation Fuels
 - Process Heavier, Cheaper Crude Oil
 - Convert ~90% Of Crude Oil Into Fuels And Products

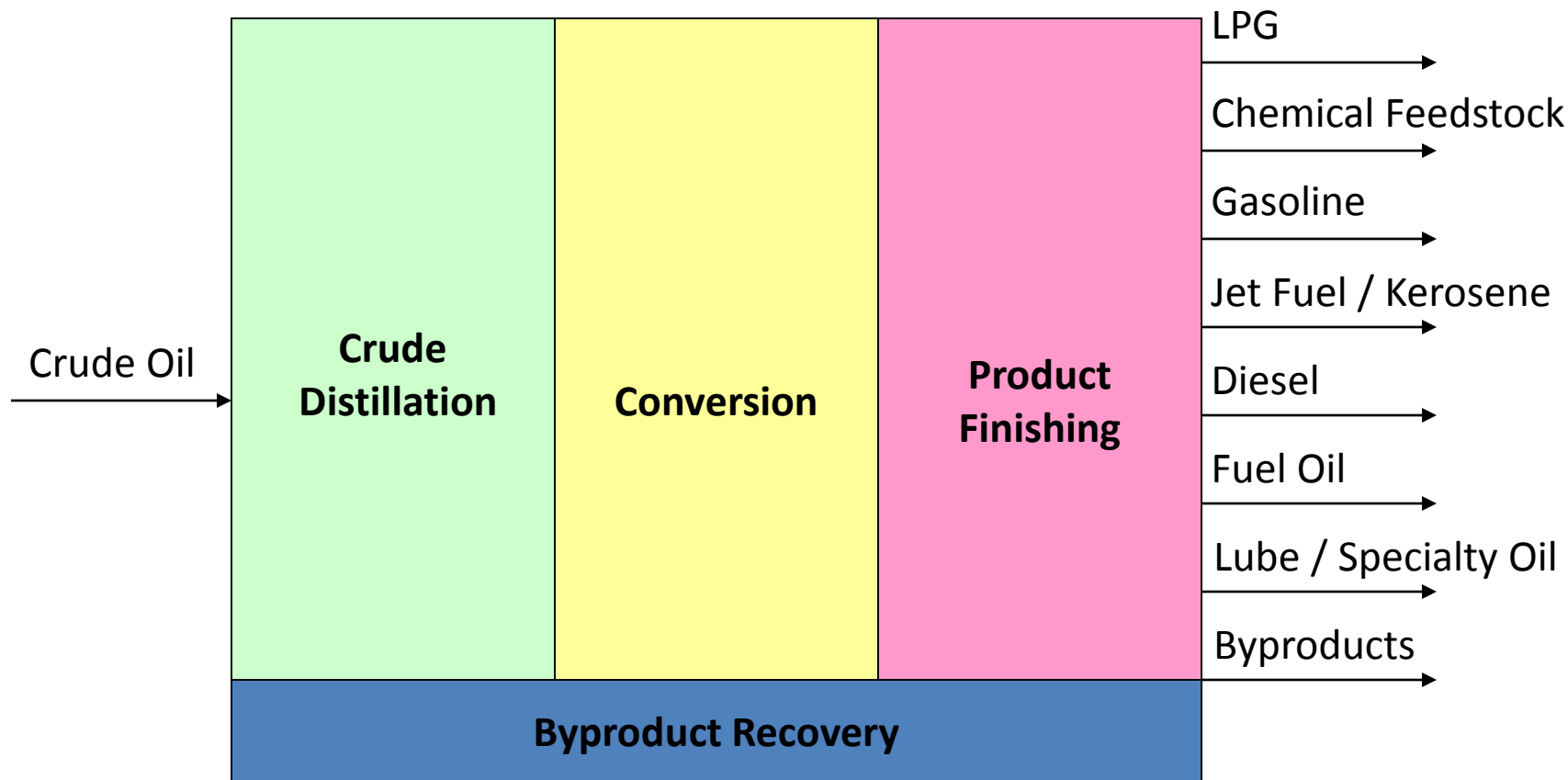


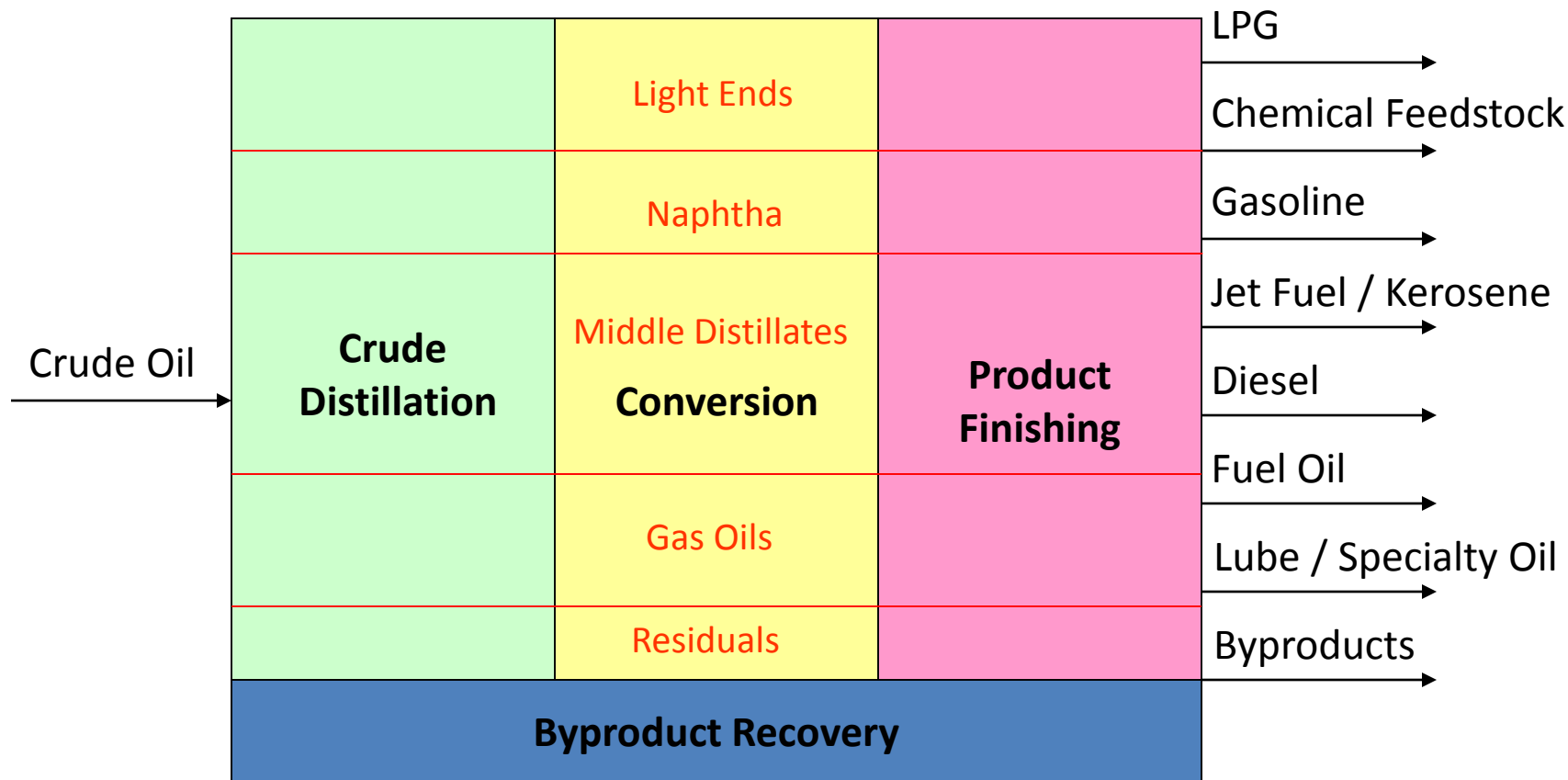
Petroleum Refinery Products













Refinery Value Yield

1 BARREL



CRUDE
\$60 / BBL (BRENT)

1 BARREL



GASOLINE
\$87 / BBL
JET FUEL
\$90 / BBL
DIESEL
\$92 / BBL



Refinery Volume Yield

**1 BARREL
CRUDE**

=

**1.1 BARREL
PRODUCT**





Crude Oil



- Crude Oil Is A Complex Mixture Of Hydrocarbons Generated By Nature
- Light Crudes Have Lower Boiling Point Components With More Value As Products
- Sweet Crudes Have Lower Sulfur Concentrations
 - Less Expensive Materials Of Construction
 - Less Sulfur Handling Requirements
- Light, Sweet Crudes Are Becoming More Scarce And More Expensive



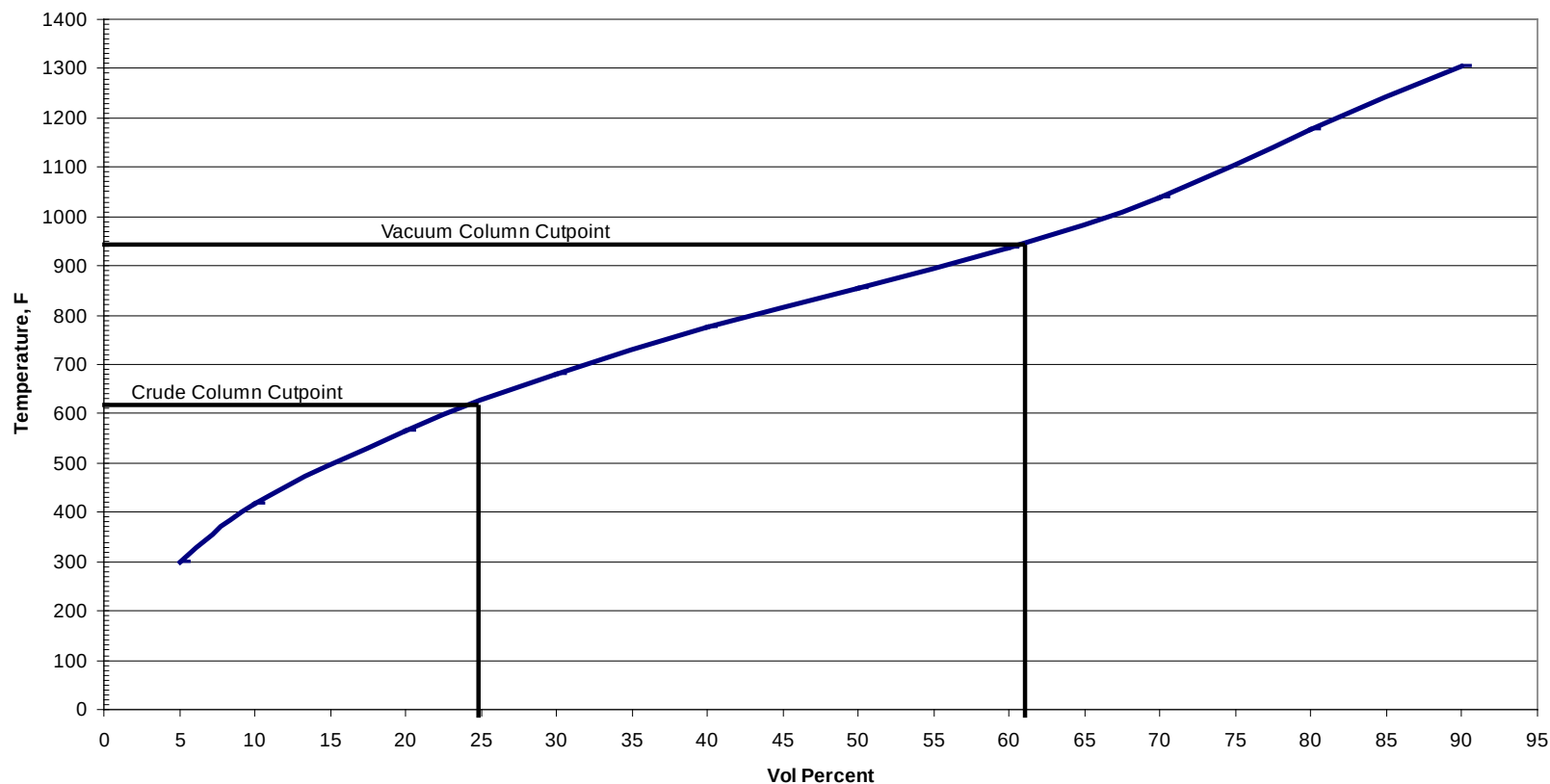
- Heavier Crudes Have Higher Boiling Point Components With Less Value As Products
- Heavier Crudes Require More Refinery Process Steps To Convert To Lower Boiling Point Components Of Higher Value
- Sour Crudes Have Higher Sulfur Concentrations
 - More Expensive Materials Of Construction
 - More Sulfur Handling Requirements
- Heavy, Sour Crudes Are More Available And Less Expensive Than Light, Sweet Crudes



- **Crude Assay** Is Used To Define Specific Properties That Impact Refining
- Crude Oil Properties Include:
 - Boiling Point Curve
 - API Gravity
 - Sulfur Content
 - Nitrogen Content
 - Metals (Nickel/Vanadium)
 - Conradson Carbon Residue (CCR)
 - PONA Analysis
(Paraffins/Olefins/Naphthenes/Aromatics)
 - Viscosity Curve



Crude Oil Boiling Point Curve

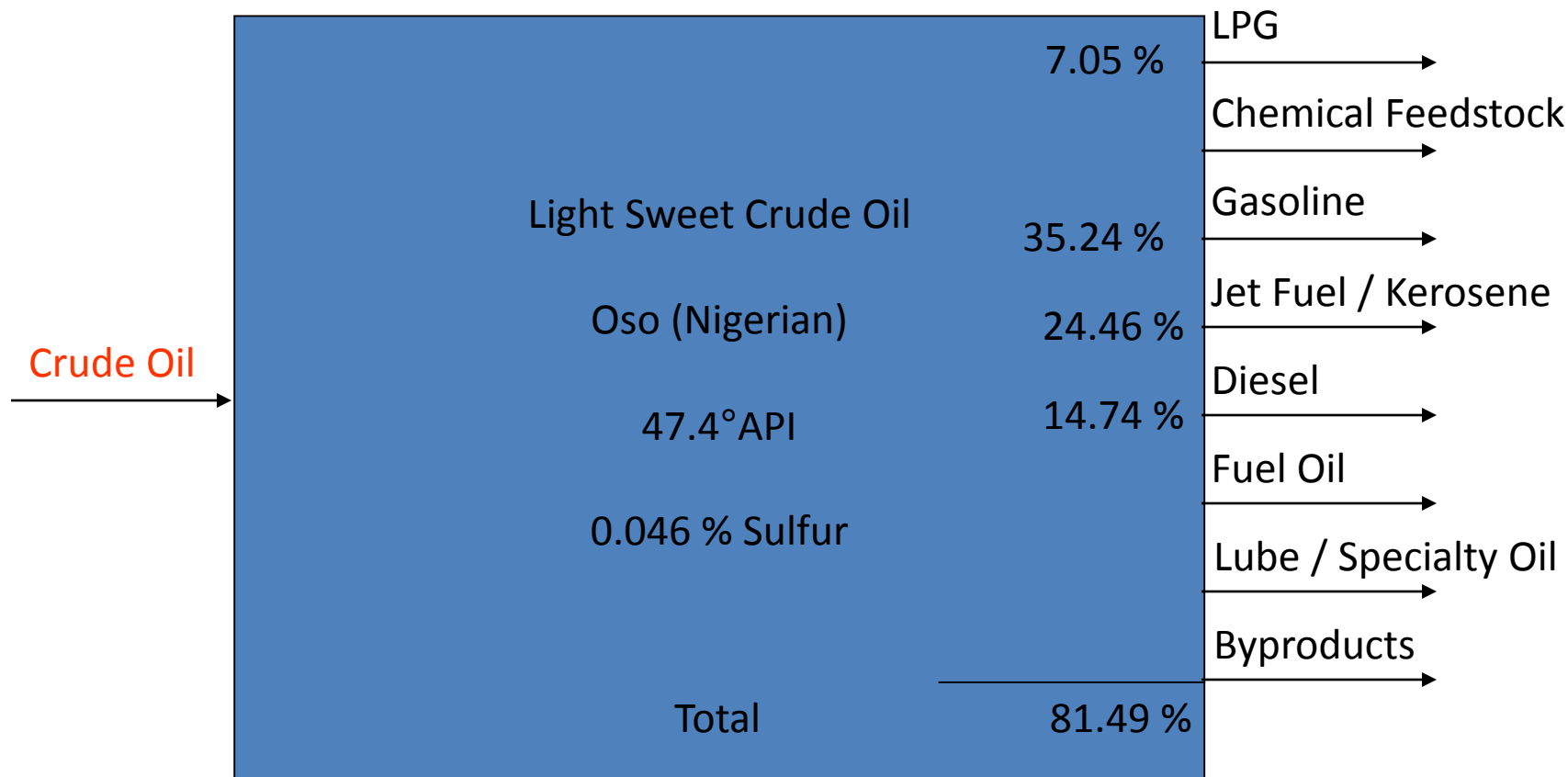




- API Gravity Is A Measure Of Crude Oil Density
- Higher API Gravity = Lower Density
- Lower API Gravity = Higher Density
- **Light Crudes** Are Greater Than 40° API
- **Medium Crudes** Are 20° To 40° API
- **Heavy Crudes** Are Less Than 20° API

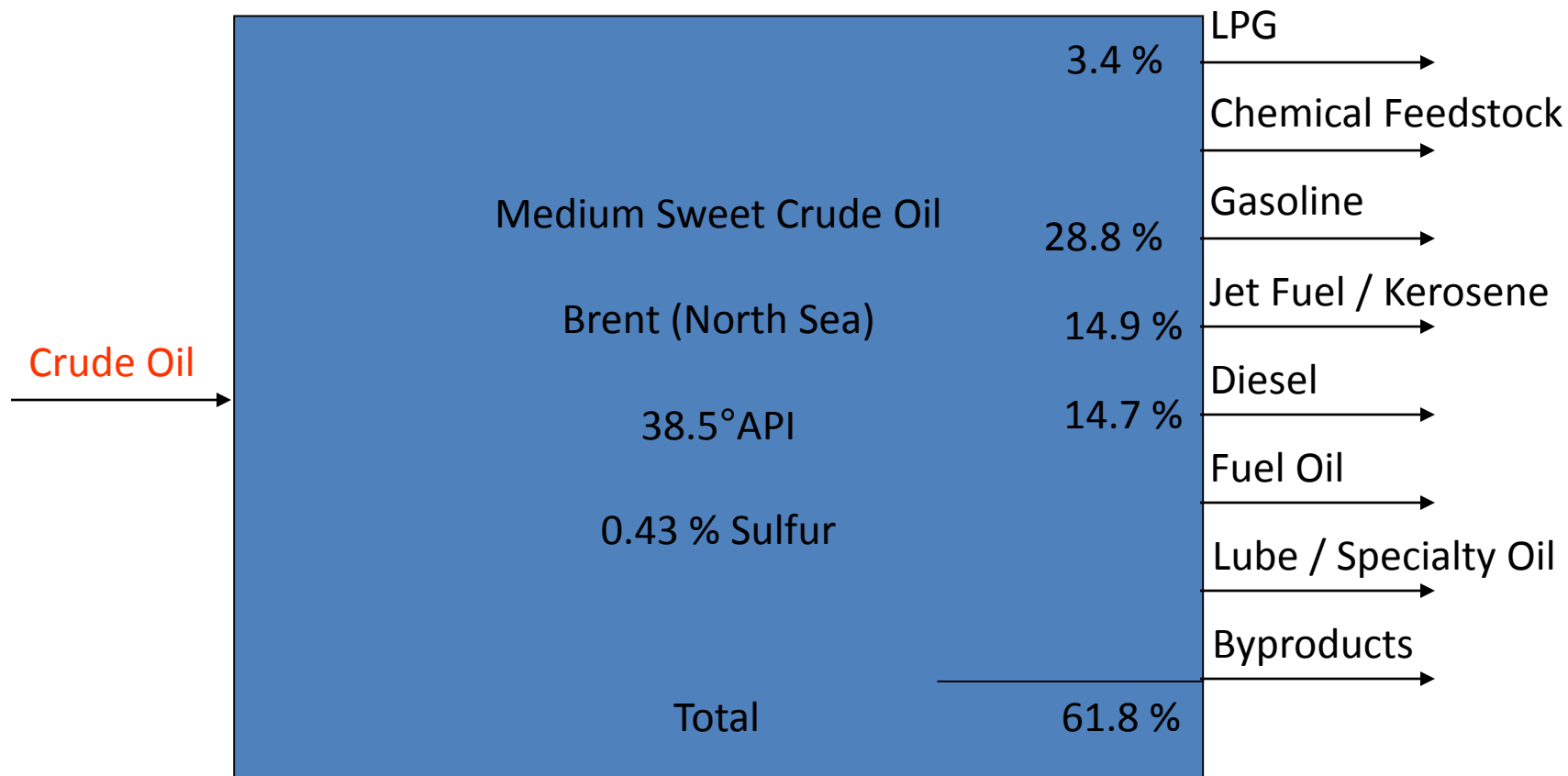


Light Sweet Crude



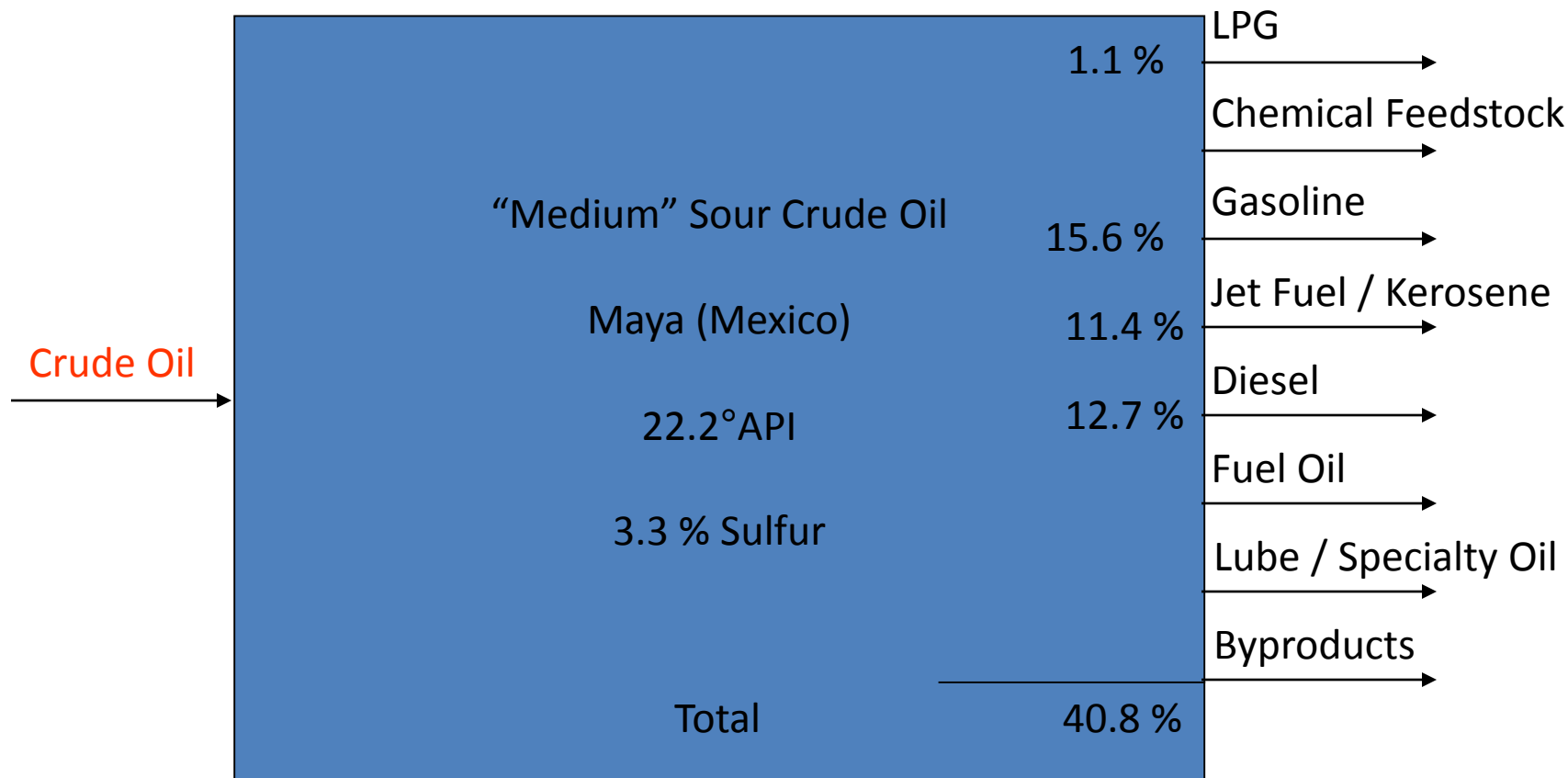


Medium Sweet Crude



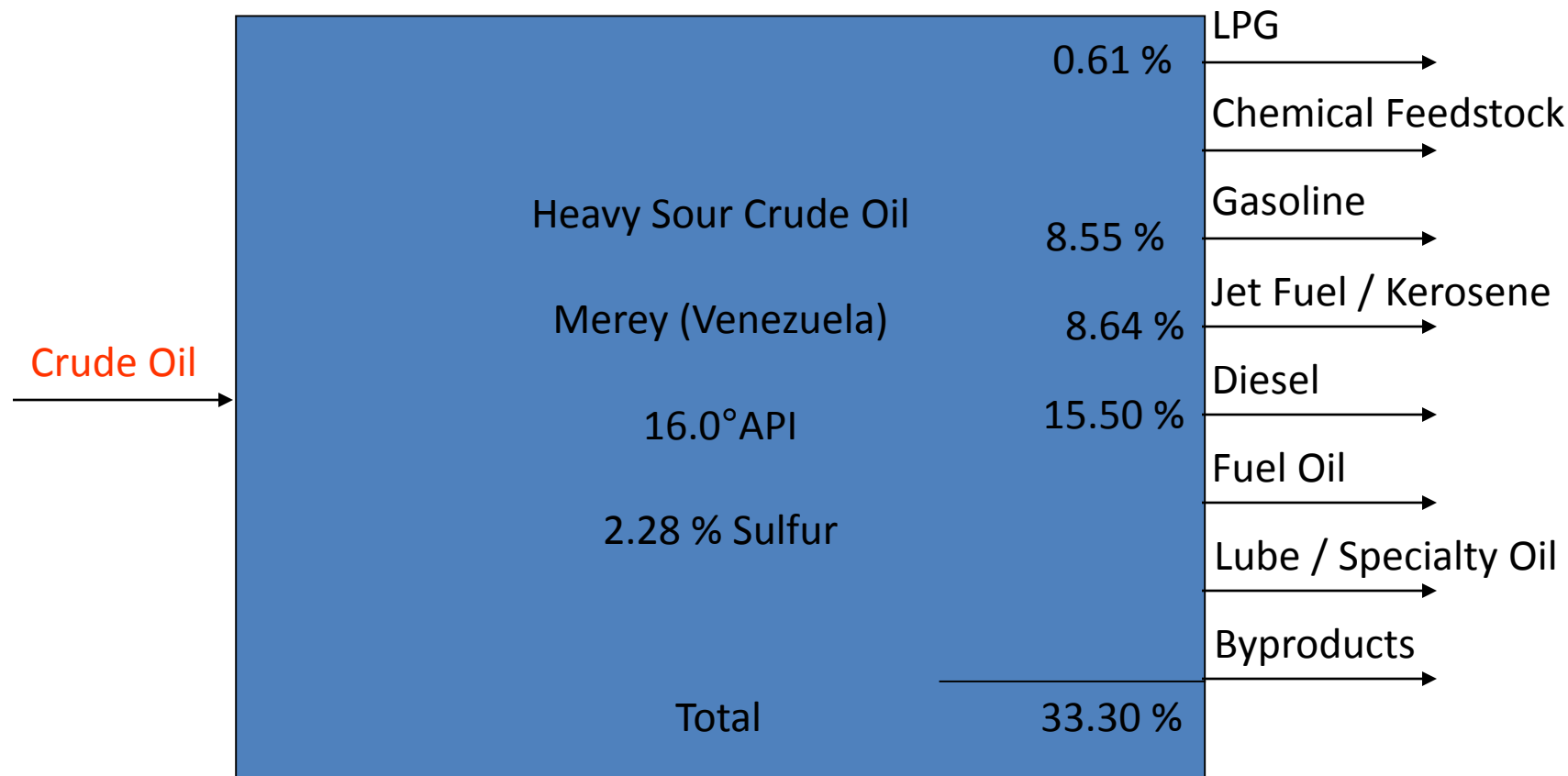


Medium Sour Crude





Heavy Sour Crude

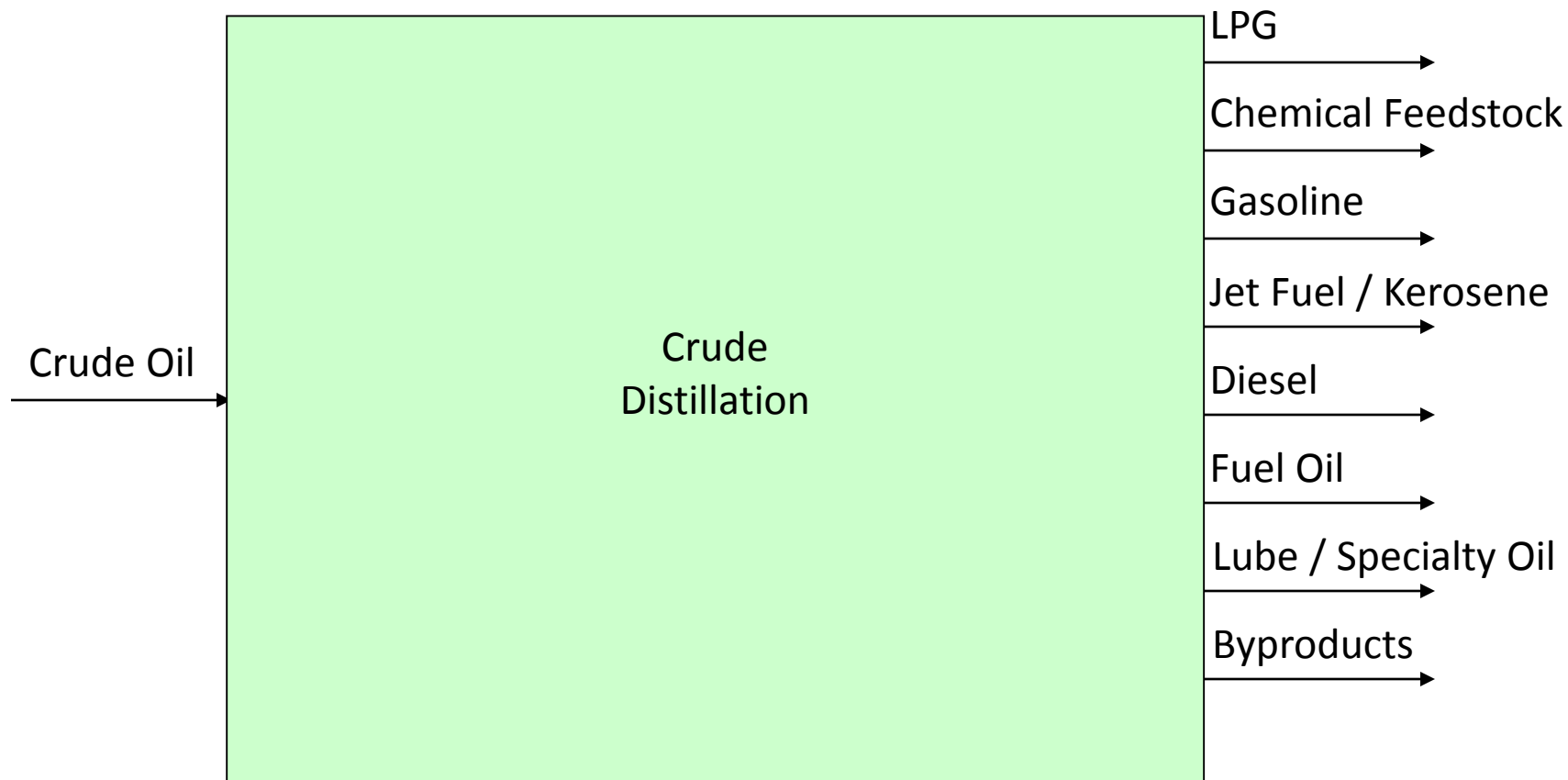




Crude Distillation



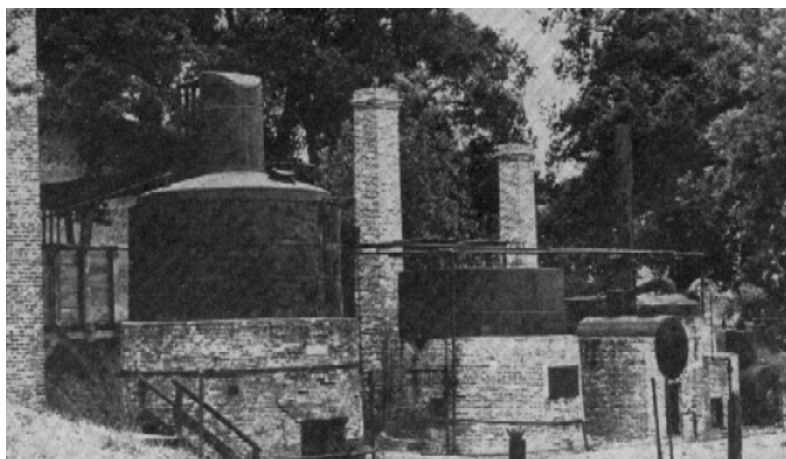
Crude Distillation



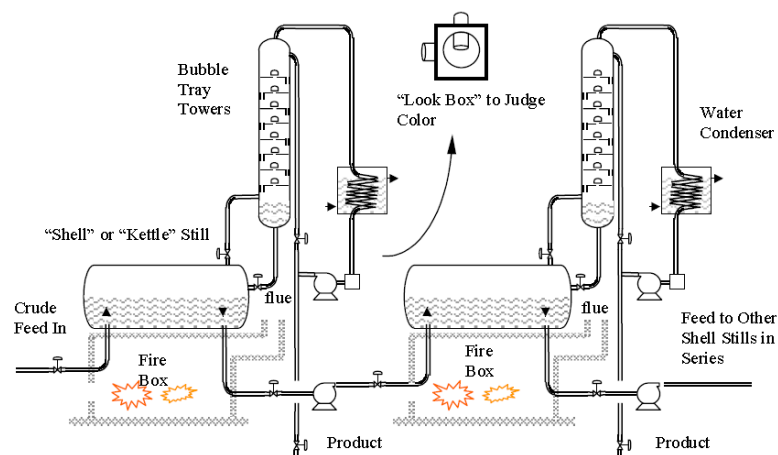
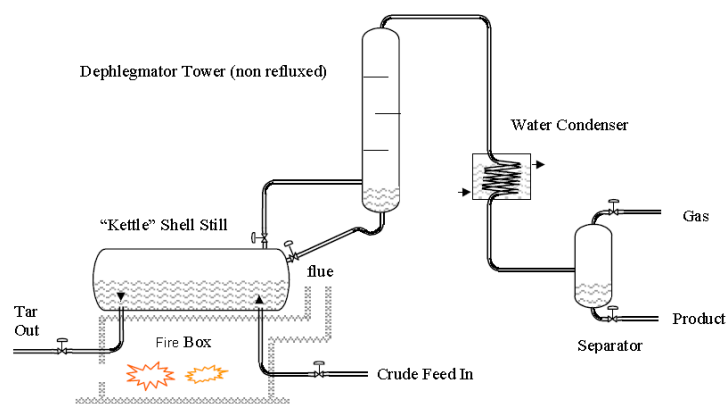
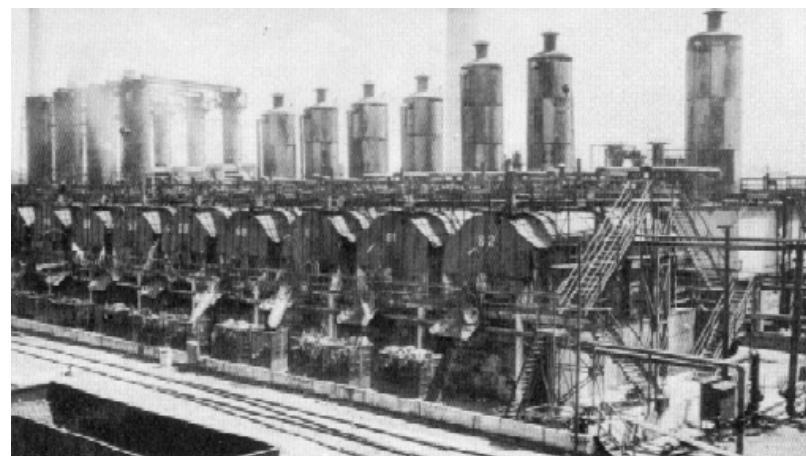


History Of Crude Distillation

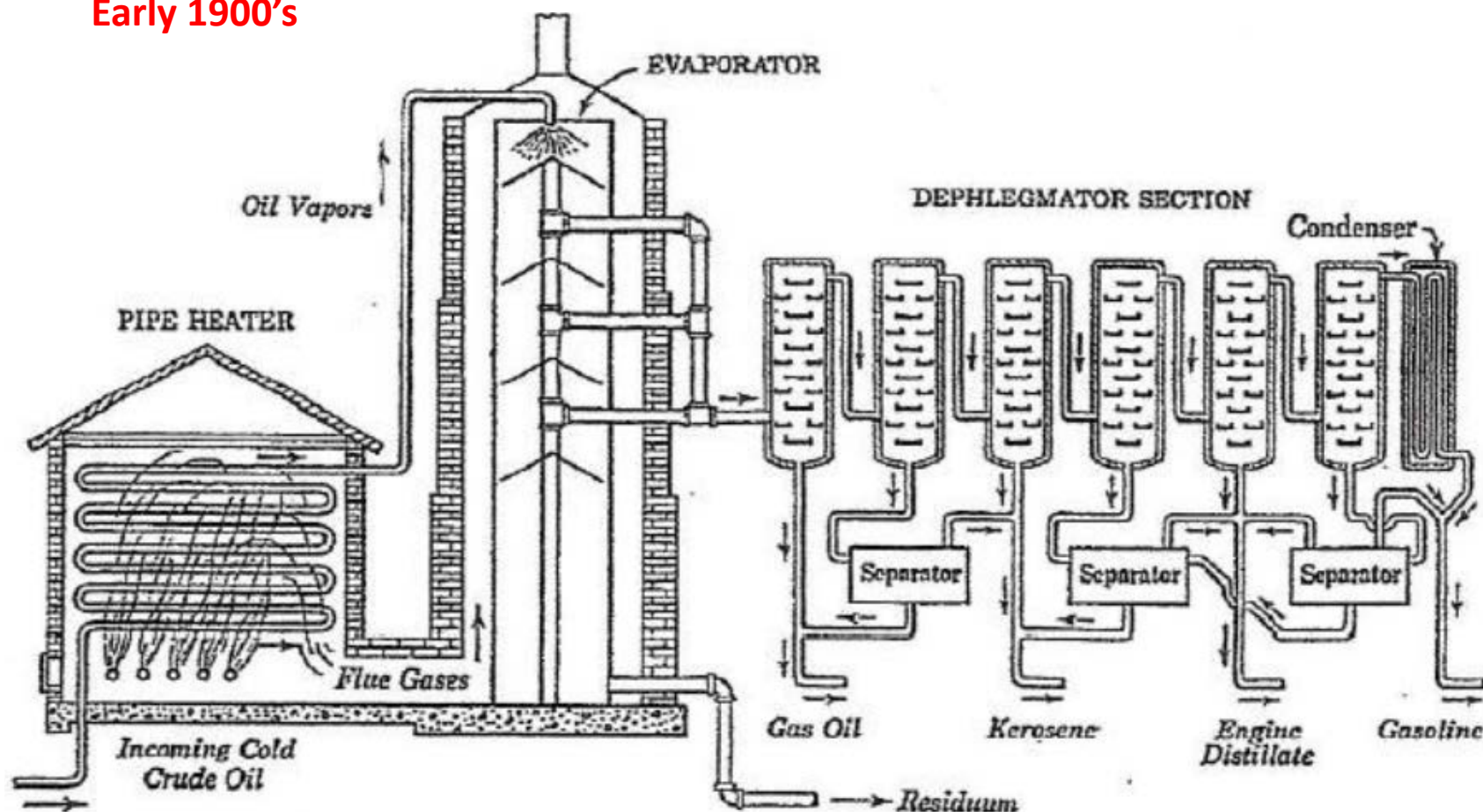
Batch Still Late 1800's



Continuous Bench Still Early 1900's



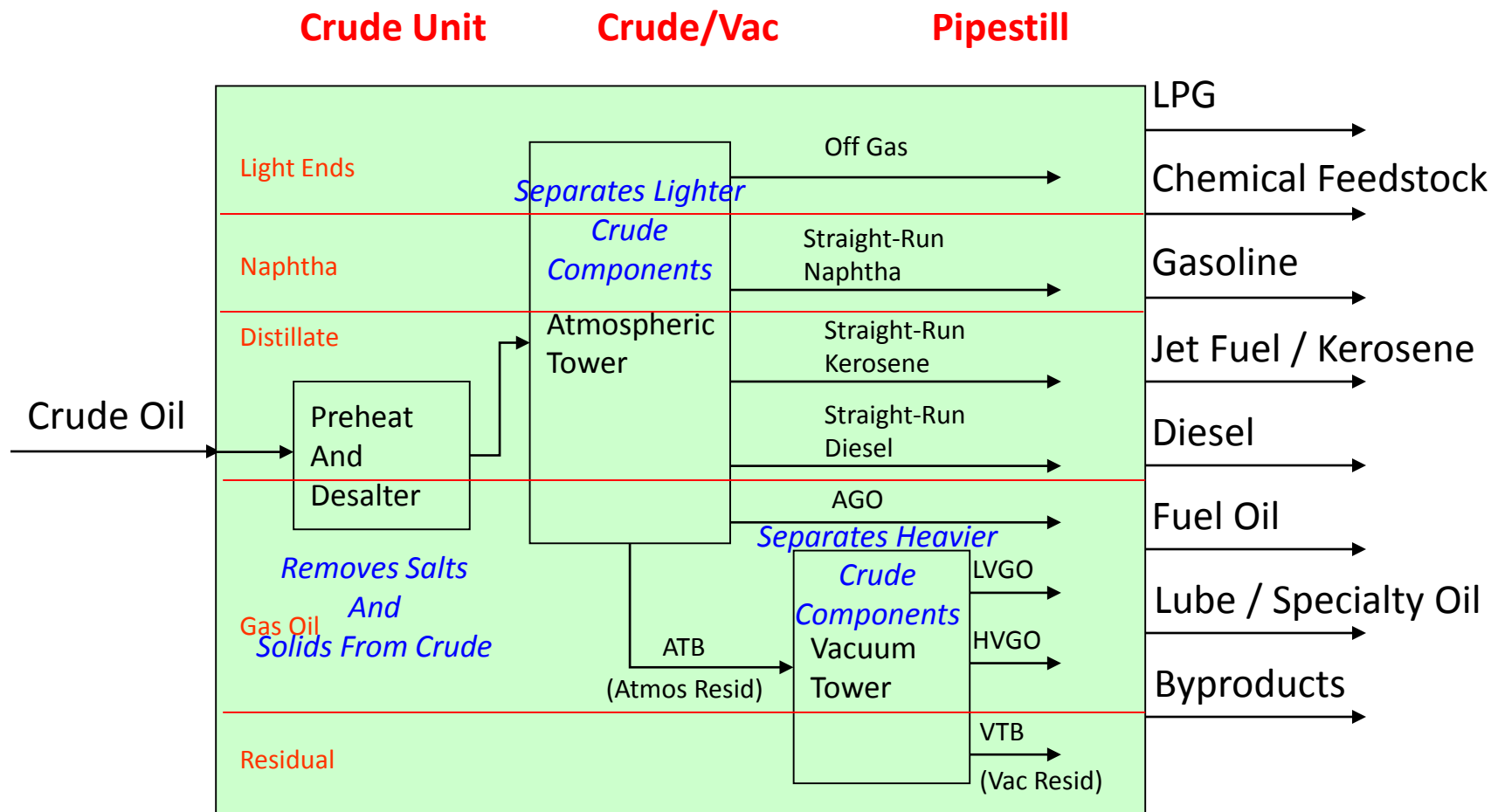
Pipe Continuous Still Early 1900's



Trumble Process

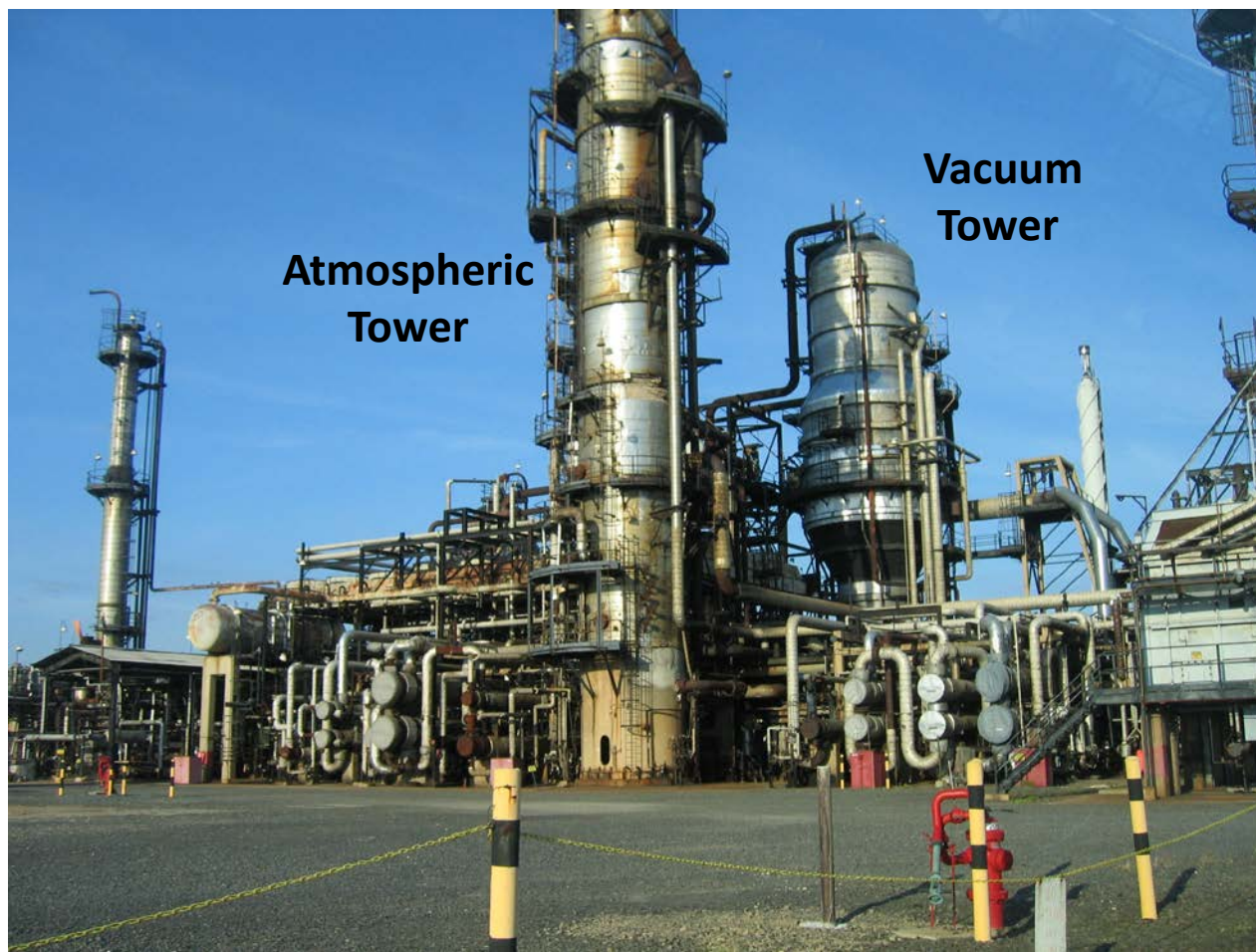


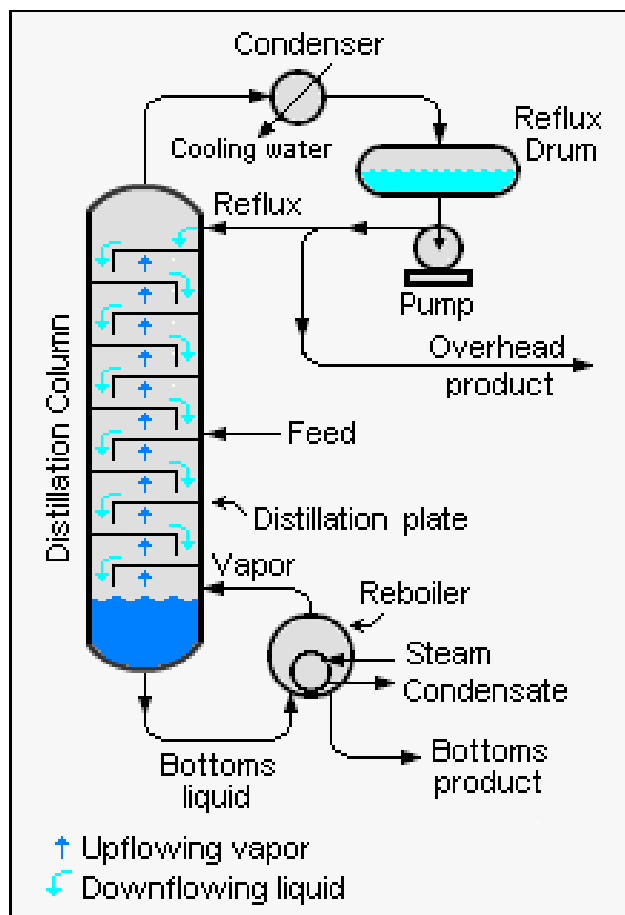
Crude Distillation





Crude Distillation



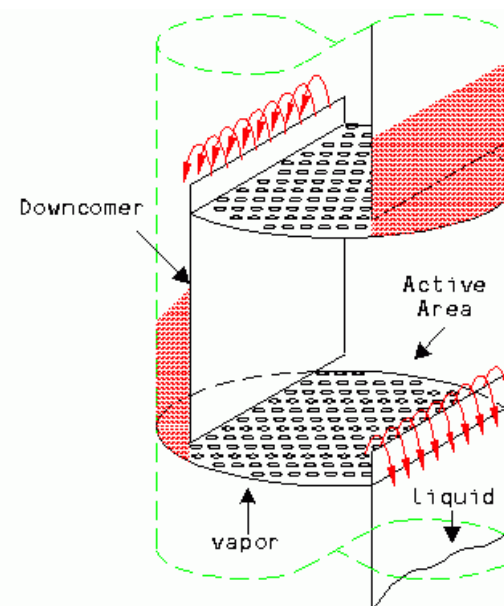


**Lower Boiling
Temperature**

**Lower
Molecular Weight**

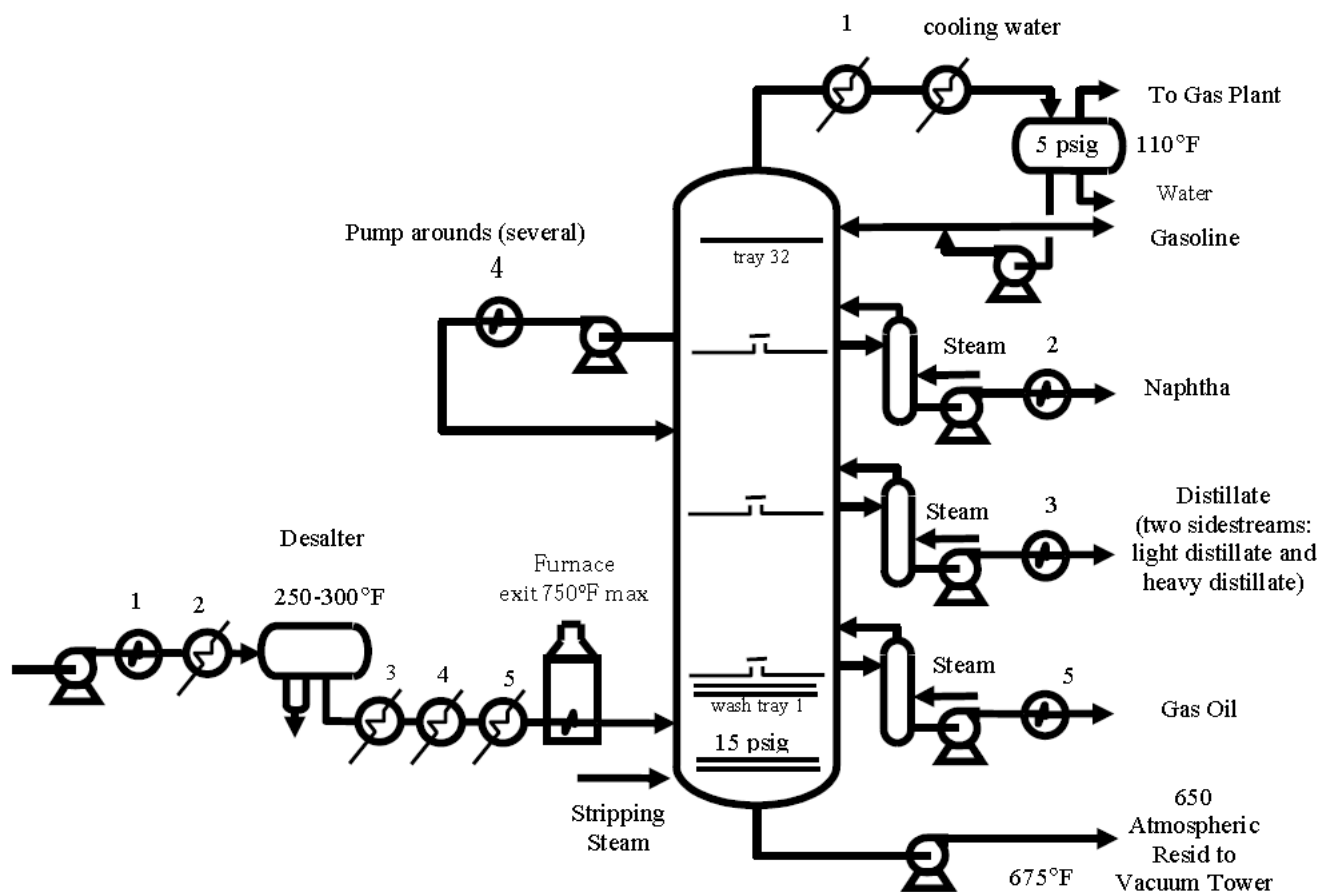
**Higher Boiling
Temperature**

**Higher
Molecular Weight**



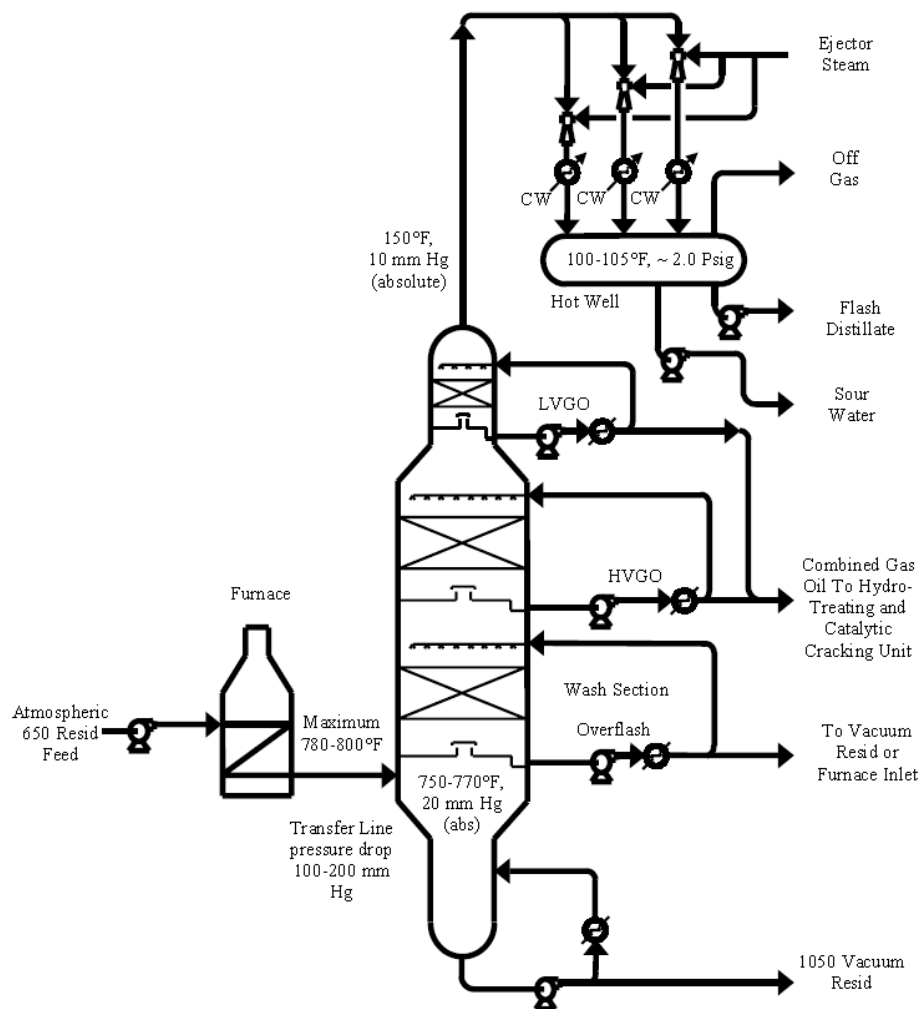


Atmospheric Tower





Vacuum Tower

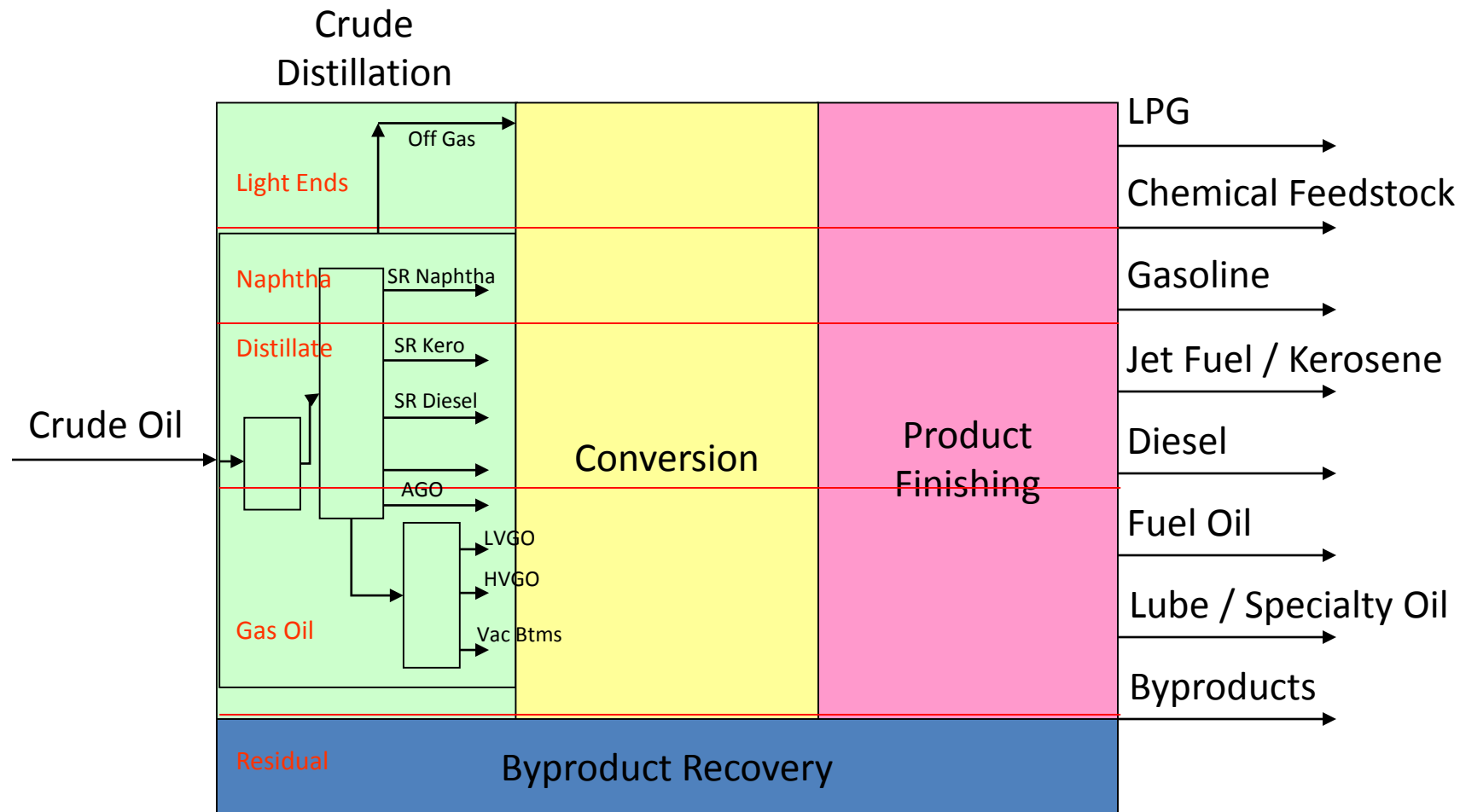


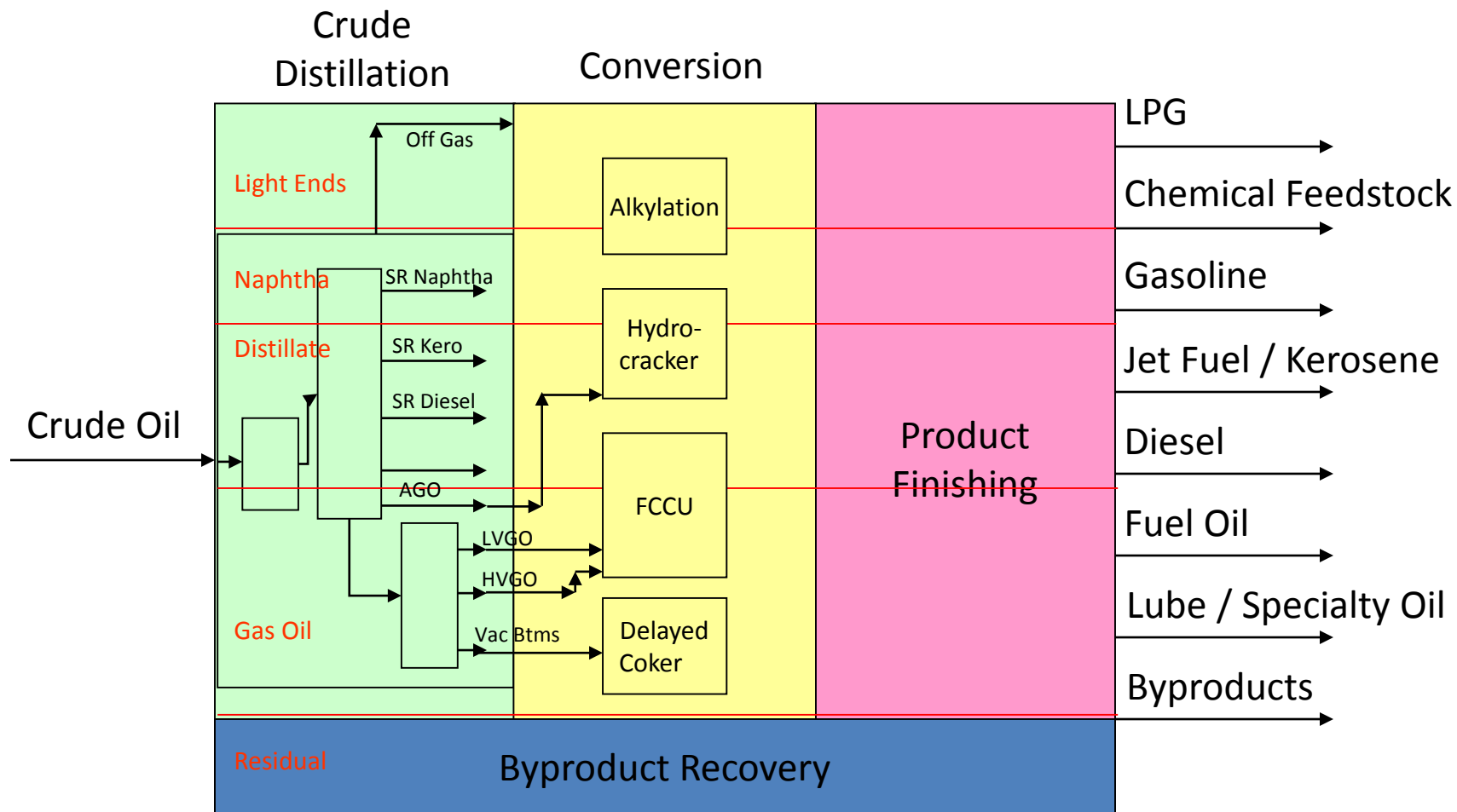


Conversion



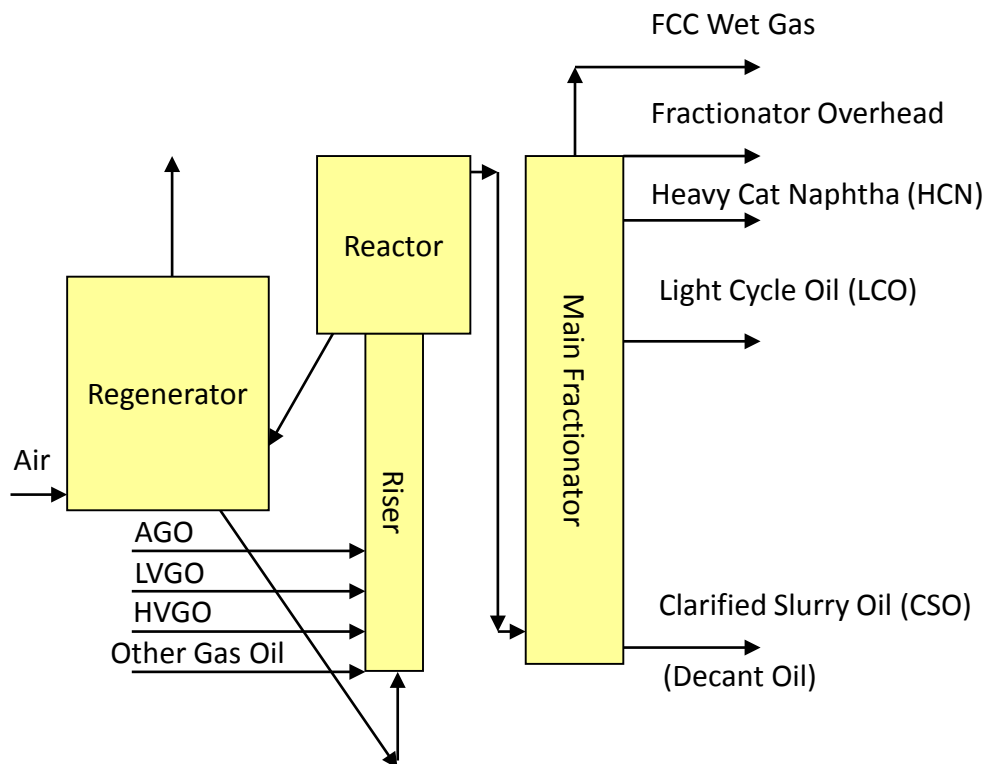
Crude Distillation







Fluidized Catalytic Cracking (FCC) Reaction - Regeneration

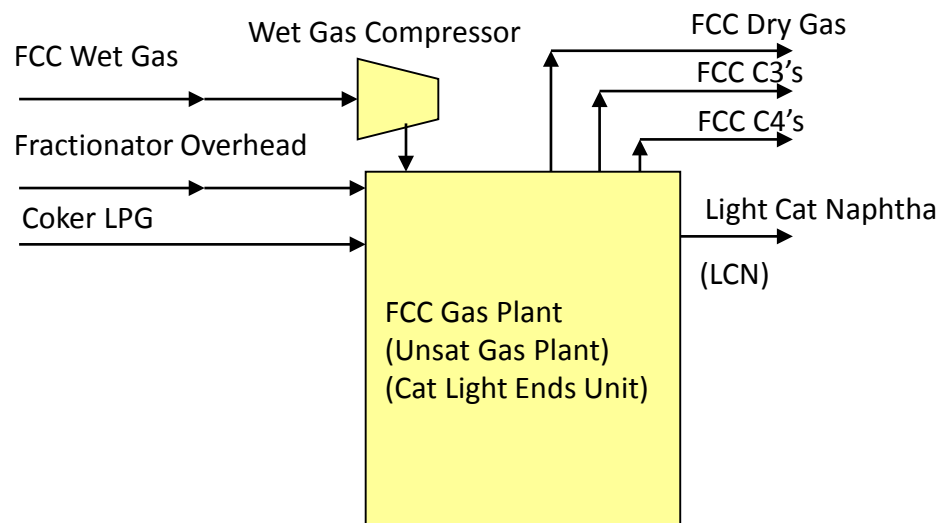




Reactor

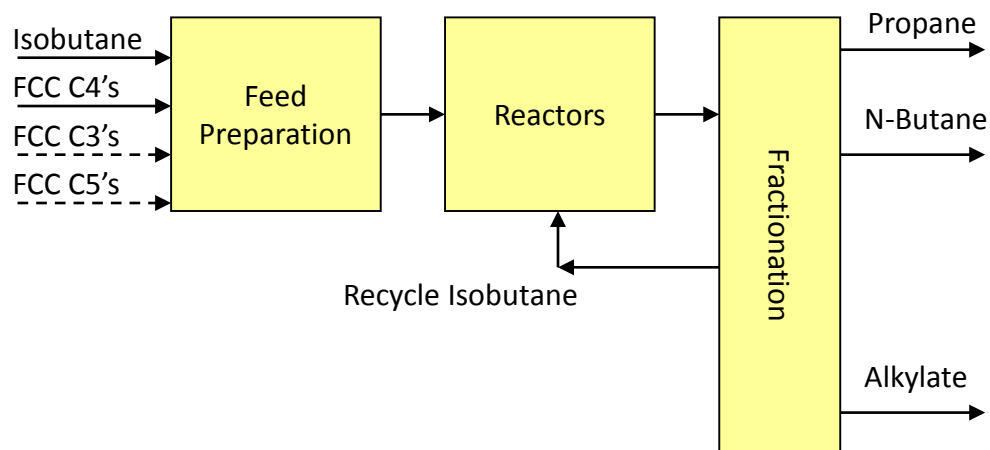
Regenerator

Main Fractionator



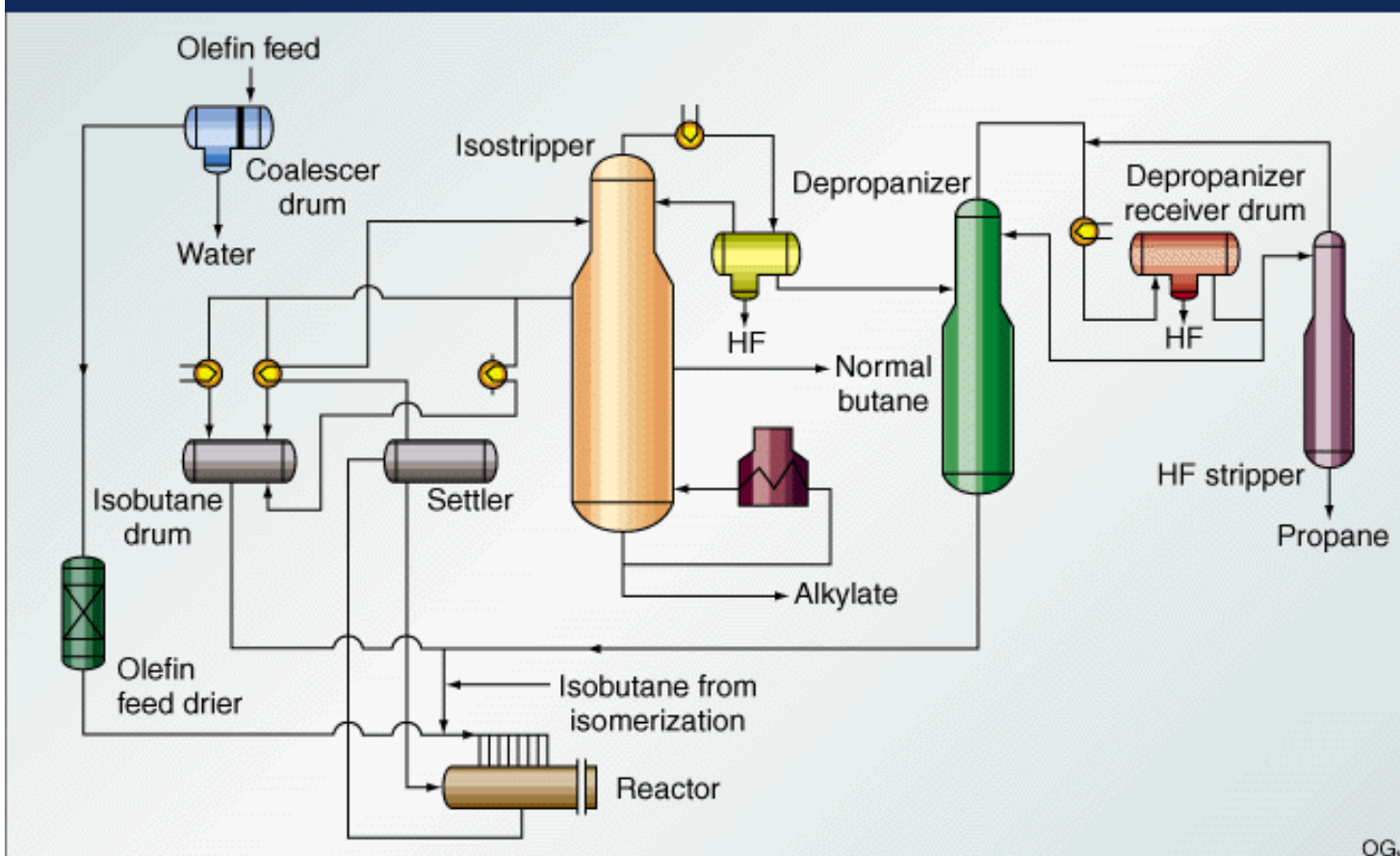
FCC C3's
P/P Olefins
C3 Olefins
Refinery Grade Propylene

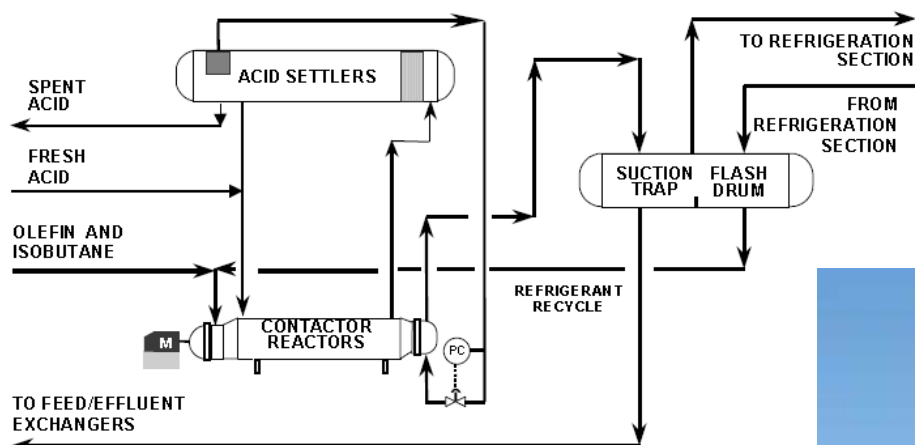
FCC C4's
B/B Olefins
C4 Olefins
Refinery Butylenes



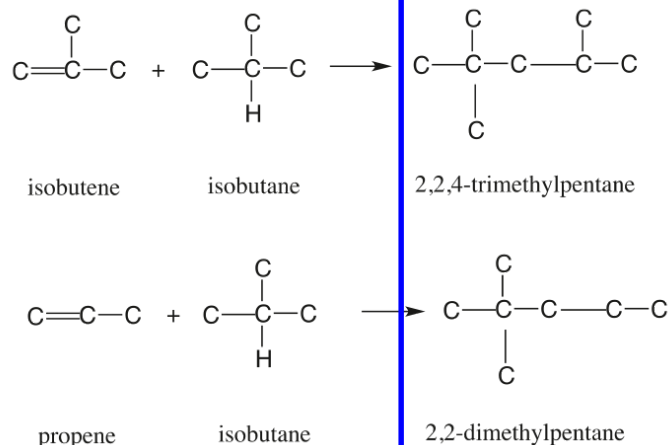


ALKYLATION-UNIT FLOW DIAGRAM





Alkylates

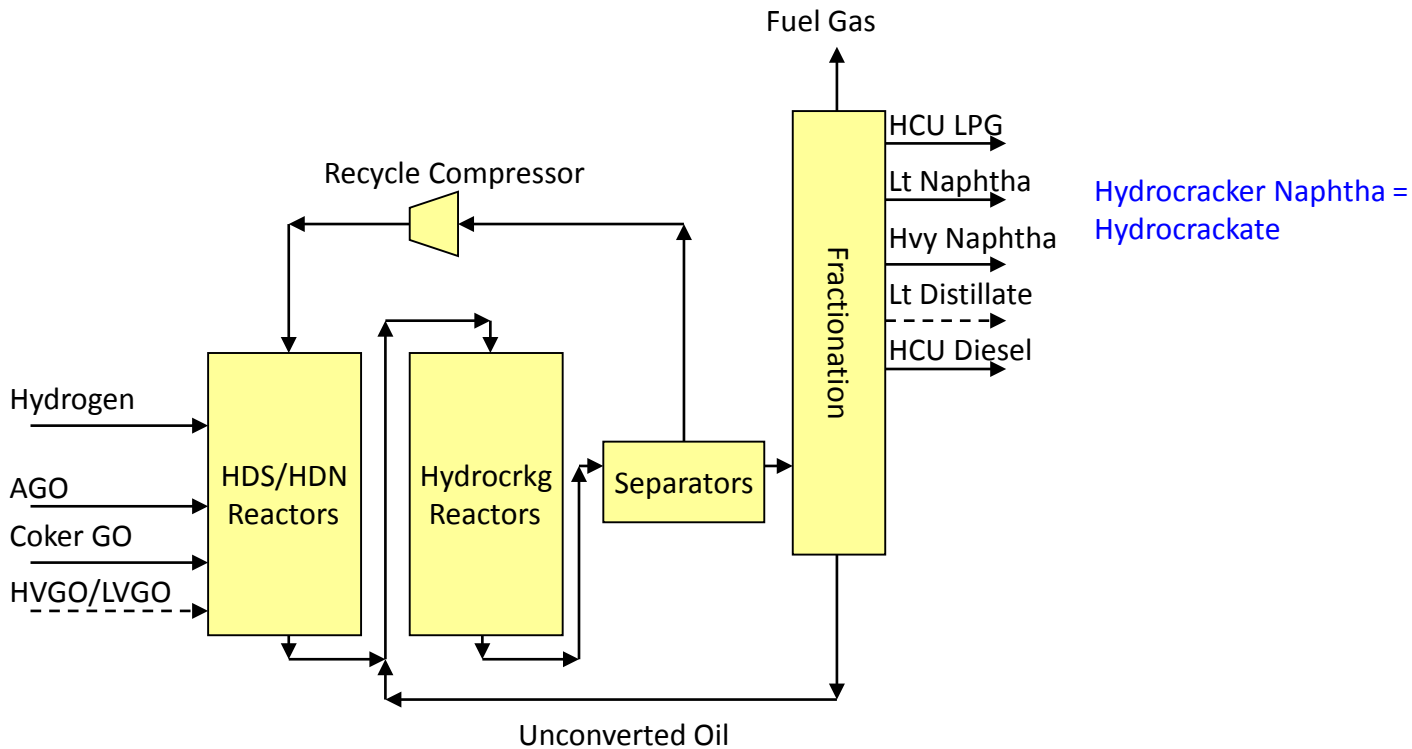


DuPont STRATCO



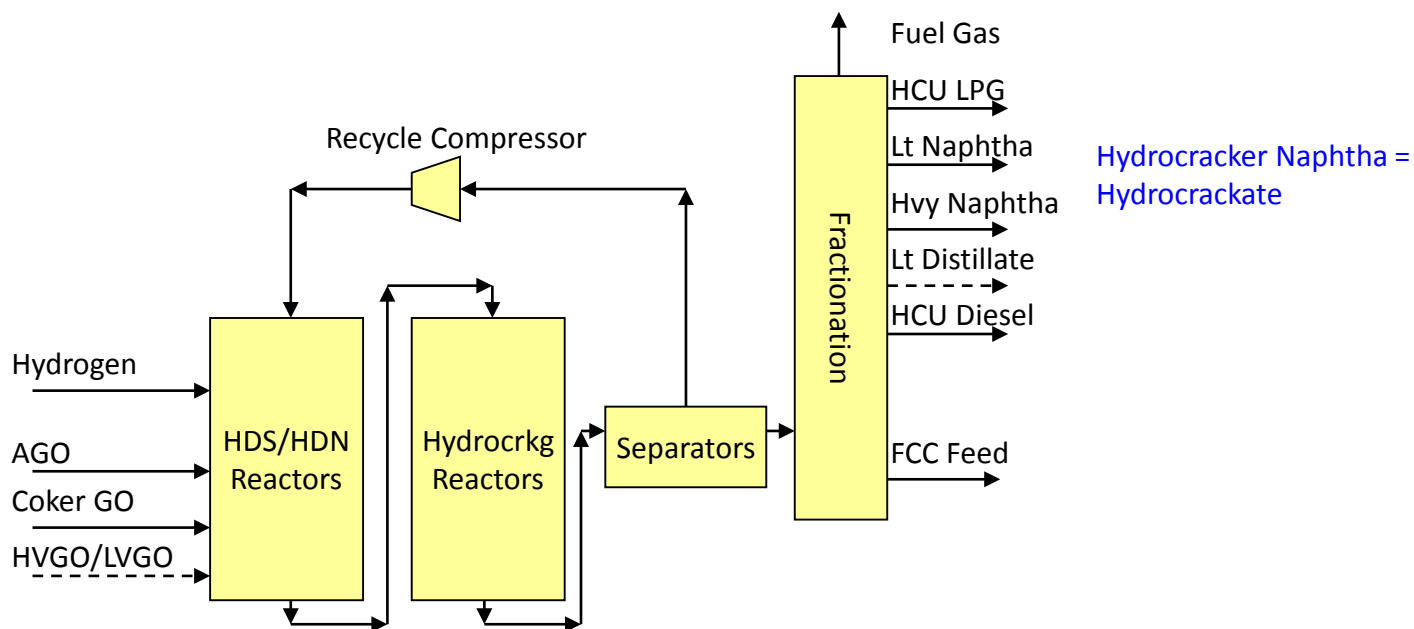
Full Conversion Hydrocracking

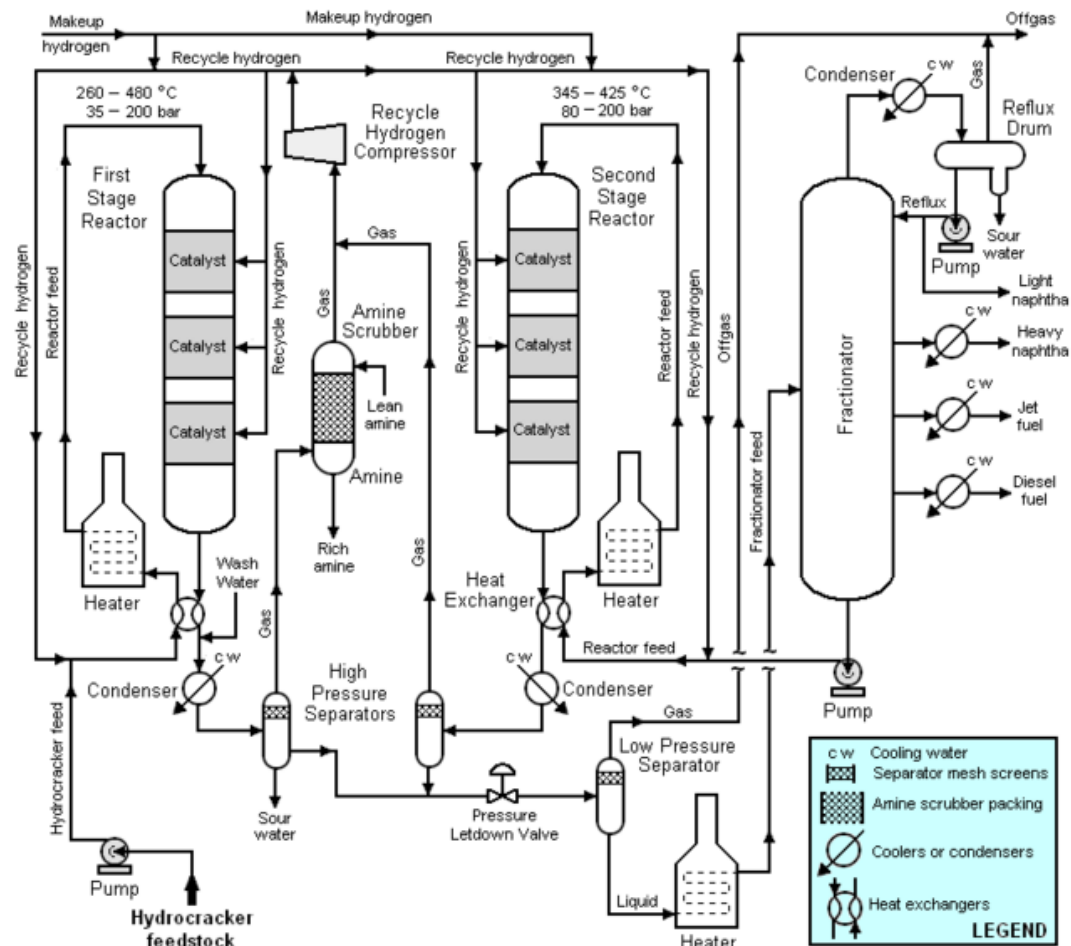
Full Conversion





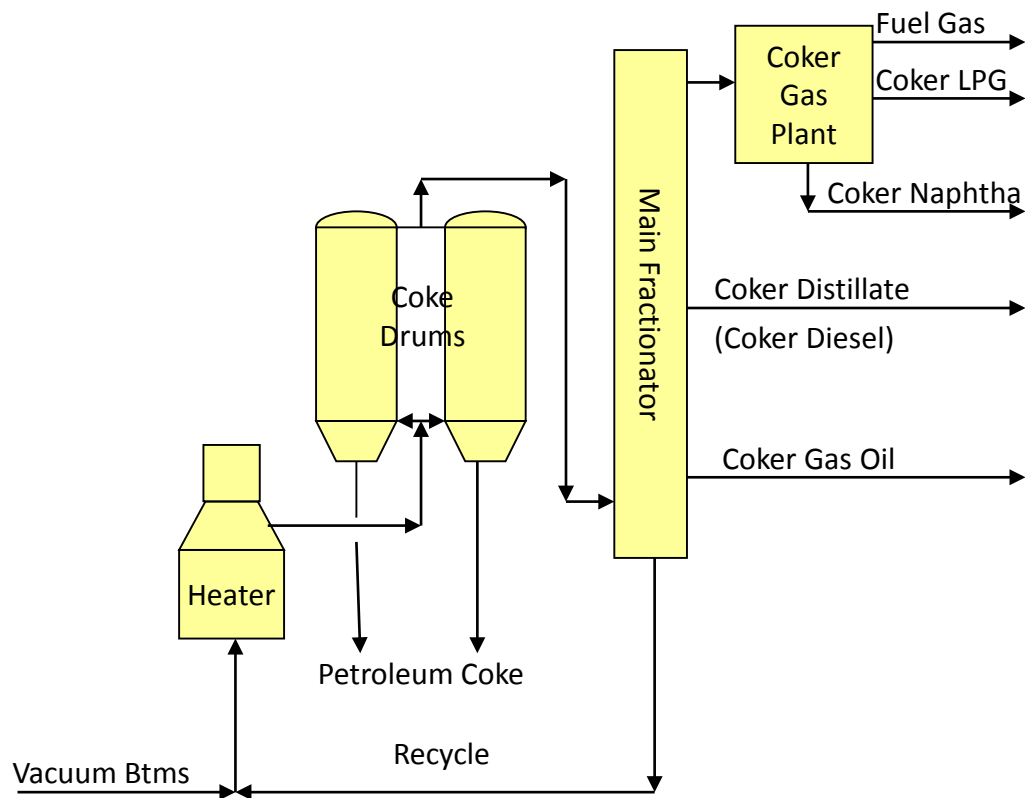
Partial Conversion







Delayed Coking





Delayed Coking

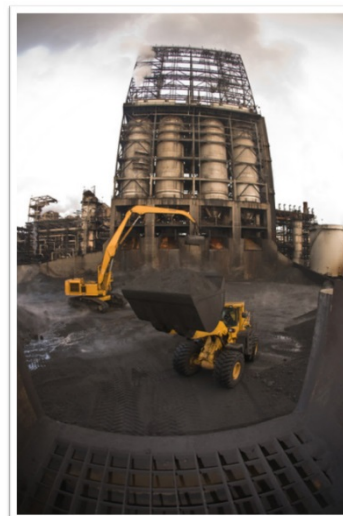
Feed Heaters



**Derricks For
Cutting Water**

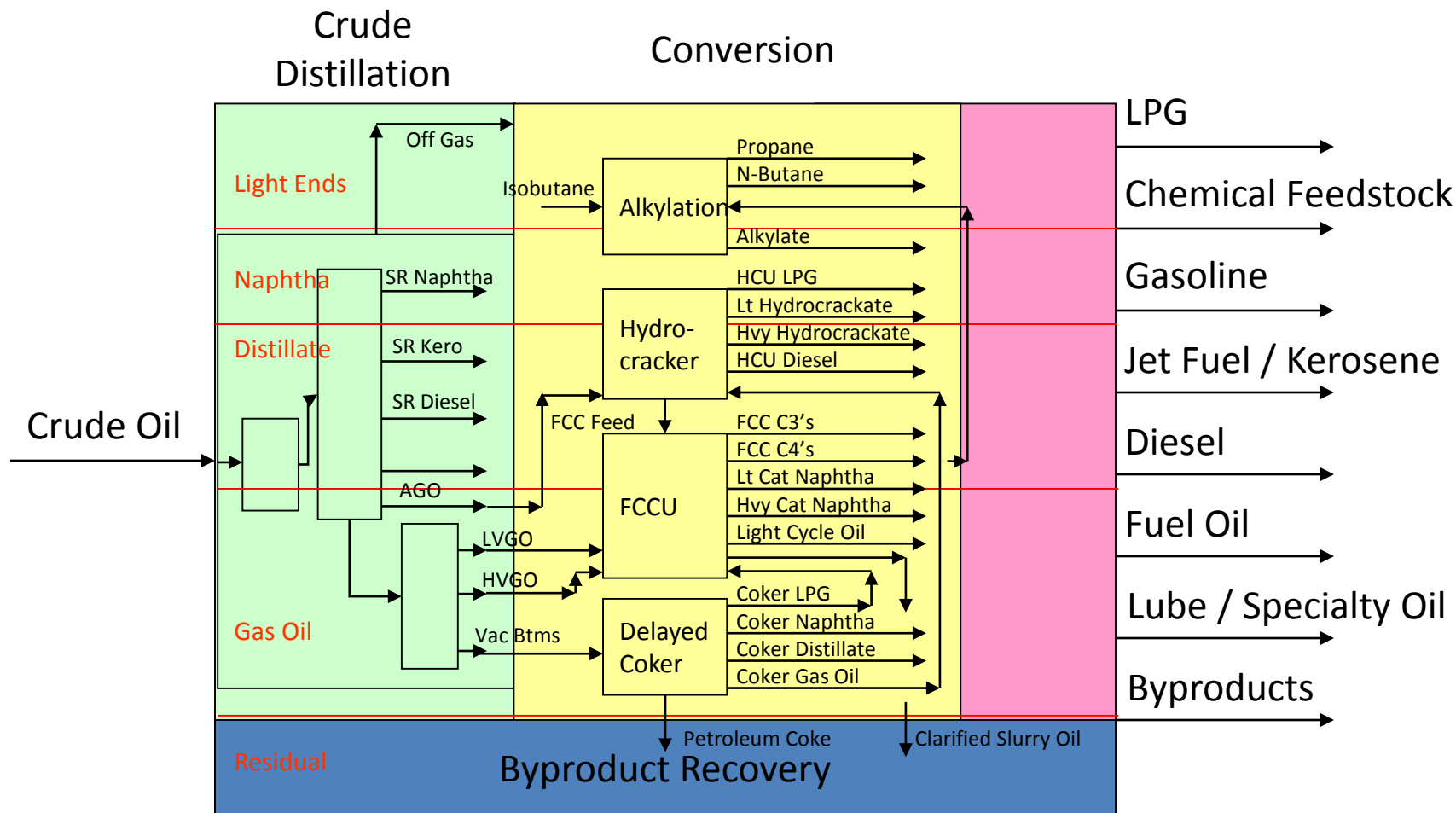
Coke Drums

Coke Pit





Conversion Overview





Product Finishing

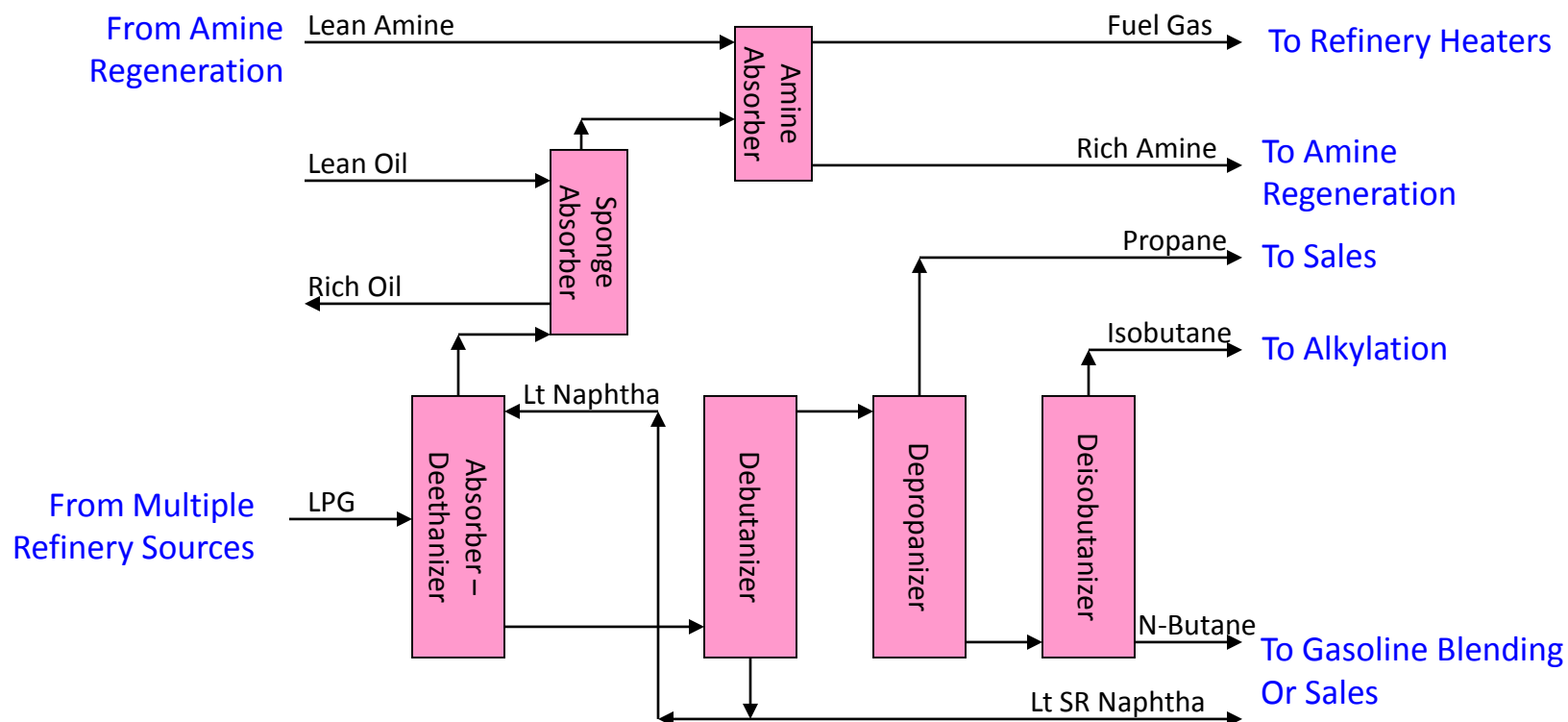


- **Light Ends** – Fuel Gas
- **Naphtha** – Gasoline
- **Distillates** – Kerosene, Jet Fuel, Diesel
- **Gas Oils** – Pre-/Post- Hydrotreating Before Converting to Gasoline (FCCU) Or Diesel (Hydrocracking)



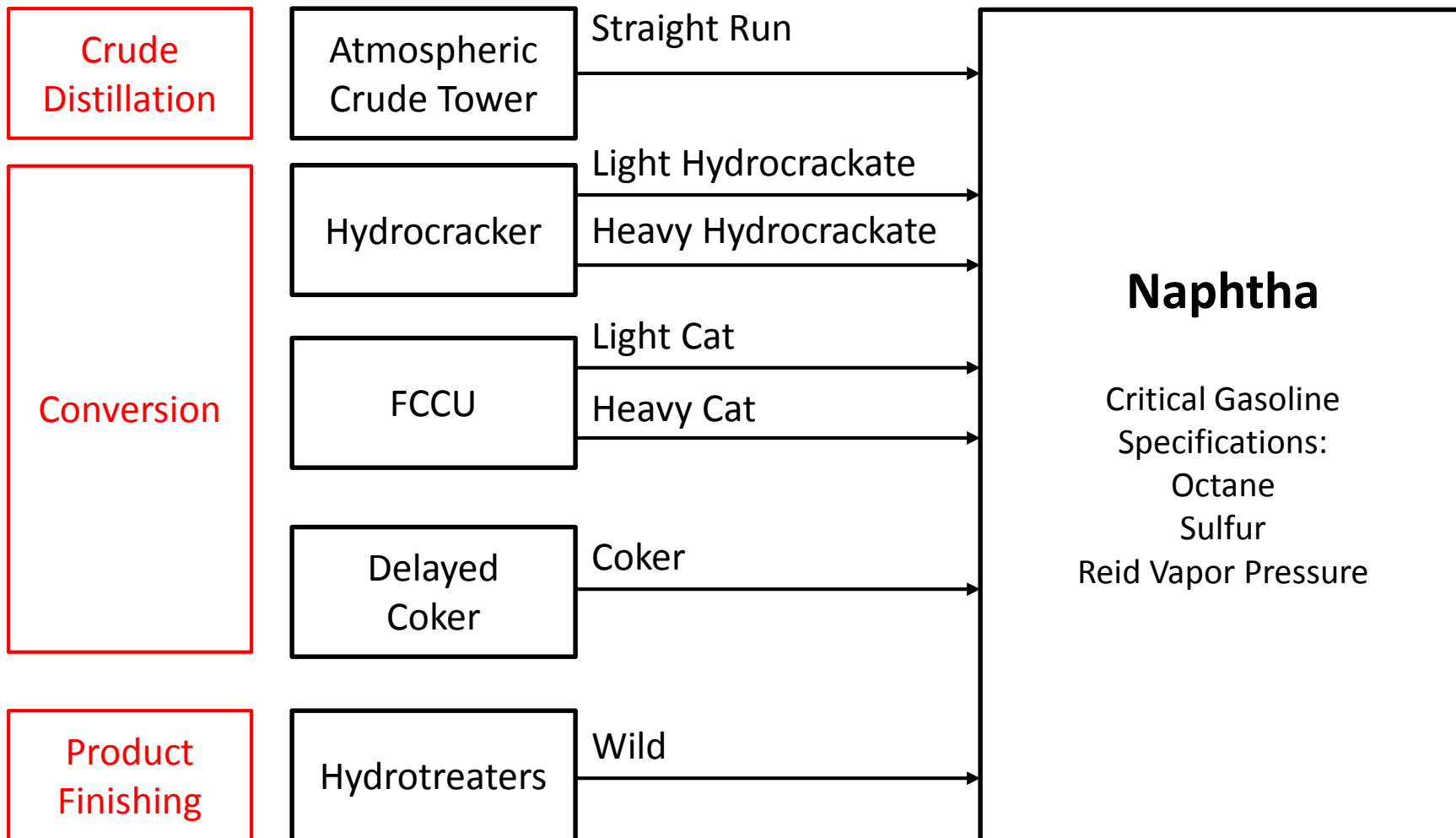
Light Ends Processing

Saturate Gas Plant





Naphtha Processing



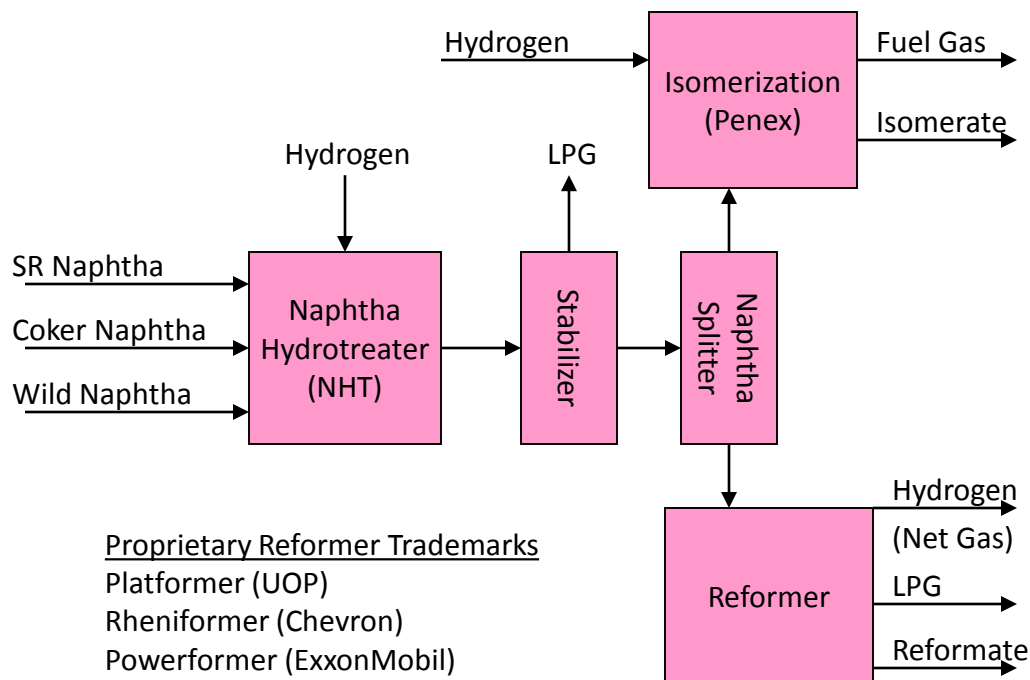


Naphtha Processing

	Octane	Sulfur	RVP
<u>SR Naphtha</u> →	Low	High	High
<u>Coker Naphtha</u> →	Medium	Very High	High
<u>Wild Naphtha</u> →	Very Low	Very High	Very High
<u>Lt Hydrocrackate</u> →	Medium	Very Low	High
<u>Hvy Hydrocrackate</u> →	Medium	Very Low	Low
<u>Lt Cat Naphtha</u> →	High	Medium	Medium
<u>Hvy Cat Naphtha</u> →	High	High	Low
<u>Alkylate</u> →	Very High	None	Low



SR/Coker/Wild



Stabilize – Reduce RVP

Reform – Boost Heavy SR Octane

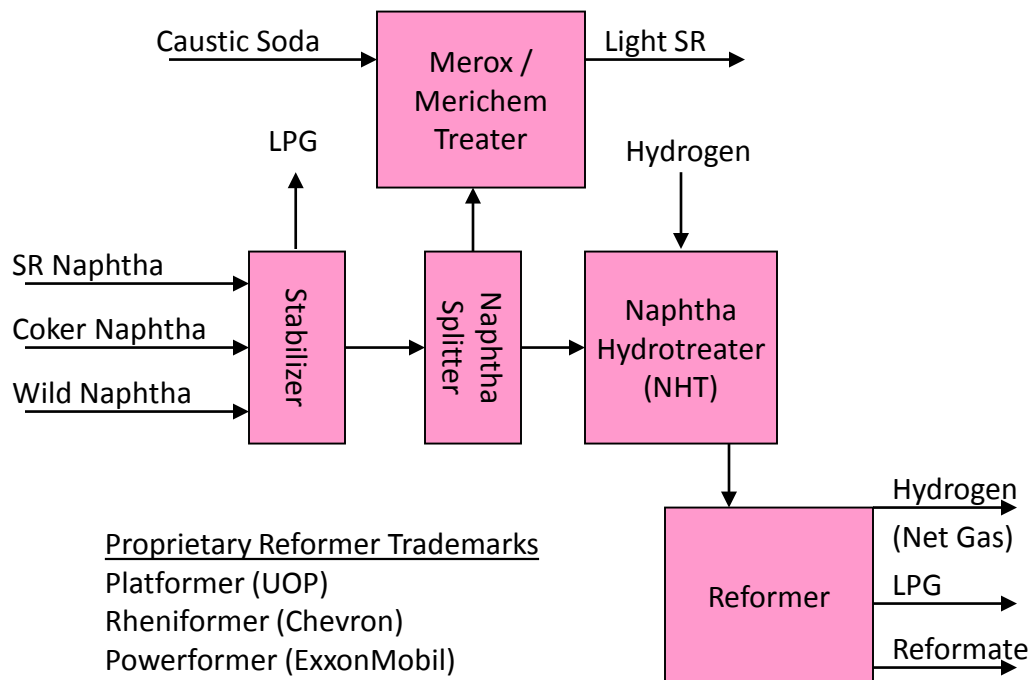
Hydrotreat – Remove Sulfur and Olefins

Isomerize – Boost Light SR Octane

Split – Separate Light And Heavy SR



SR/Coker/Wild



Stabilize – Reduce RVP

Reform – Boost Heavy SR Octane

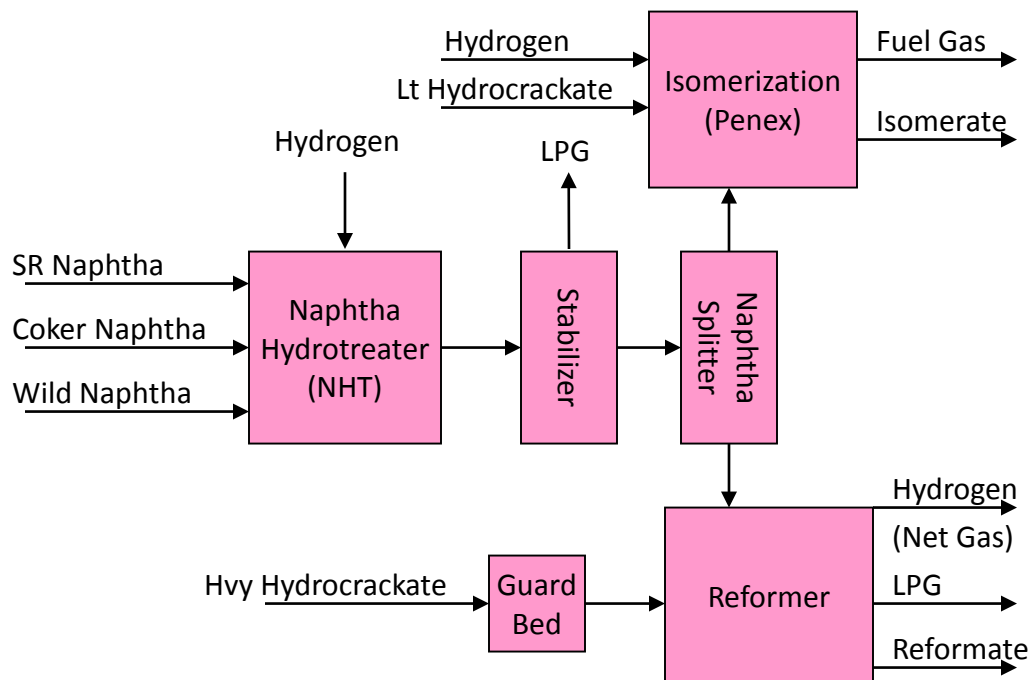
Hydrotreat – Remove Sulfur and Olefins

Isomerize – Boost Light SR Octane

Split – Separate Light And Heavy SR



SR/Coker/Wild



Stabilize – Reduce RVP

Reform – Boost Heavy SR Octane

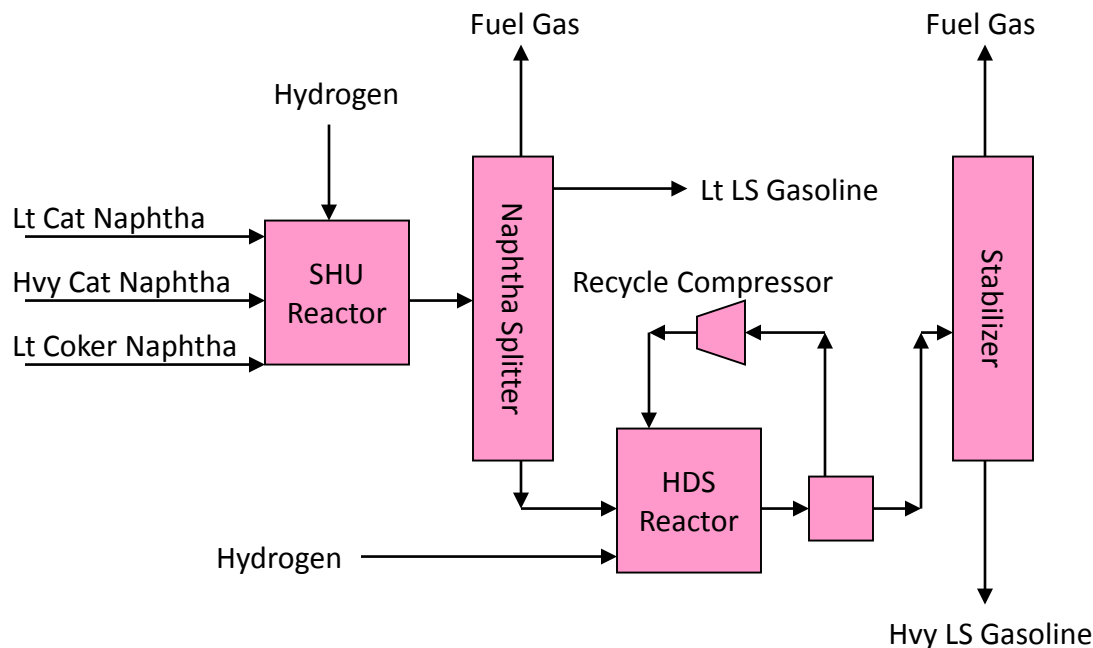
Hydrotreat – Remove Sulfur and Olefins

Isomerize – Boost Light SR Octane

Split – Separate Light And Heavy SR



Lt Cat/Hvy Cat/Lt Coker



Remove Diolefins (Gum-Formers)

Remove Mercaptans (Sulfur)

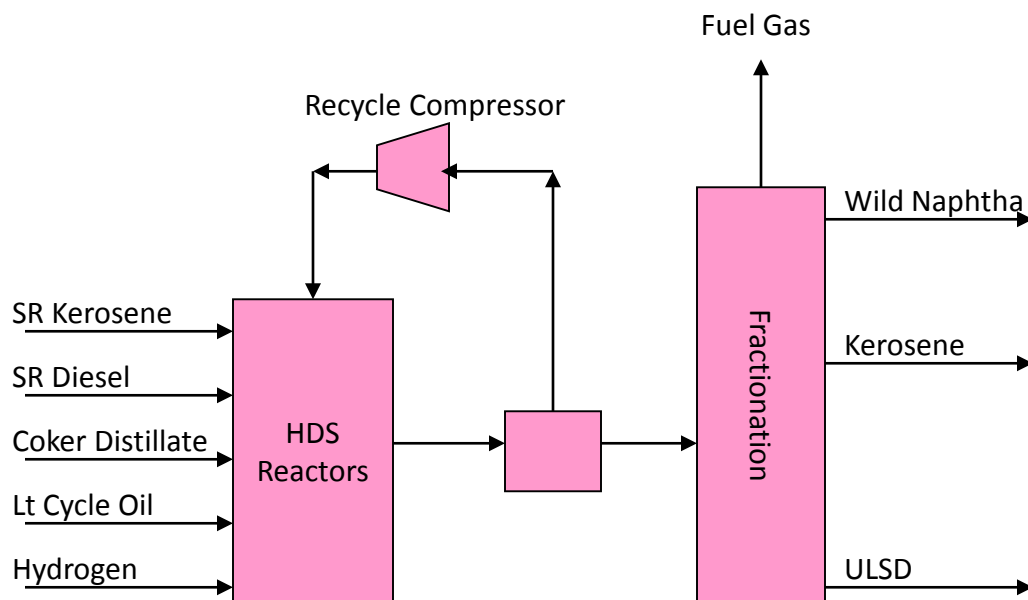
Split to Maximize Light Cat Naphtha Octane

Hydrotreat But Minimize Olefin Saturation

Stabilize To Decrease Gasoline RVP

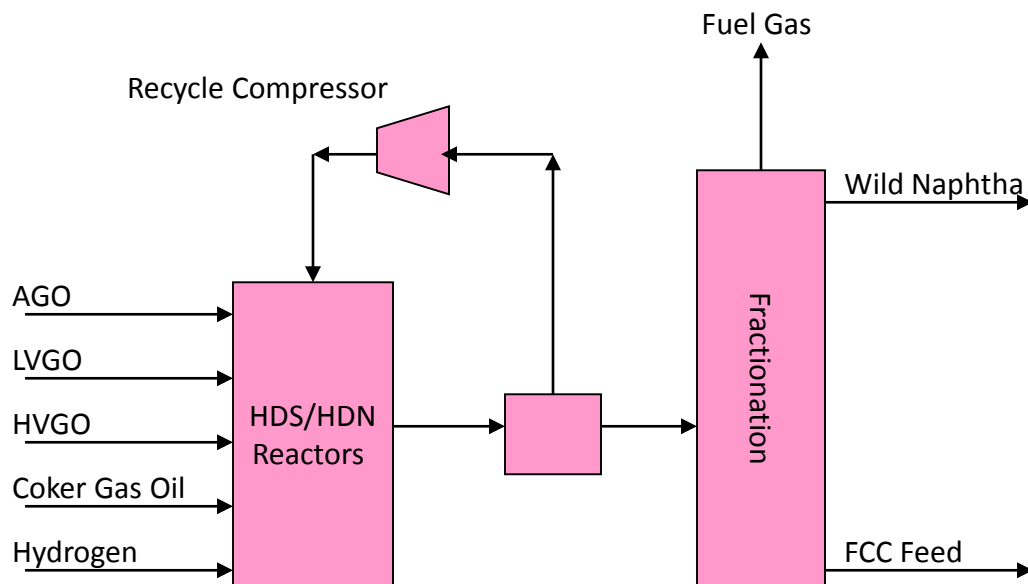


Distillate Hydrotreater (DHT)





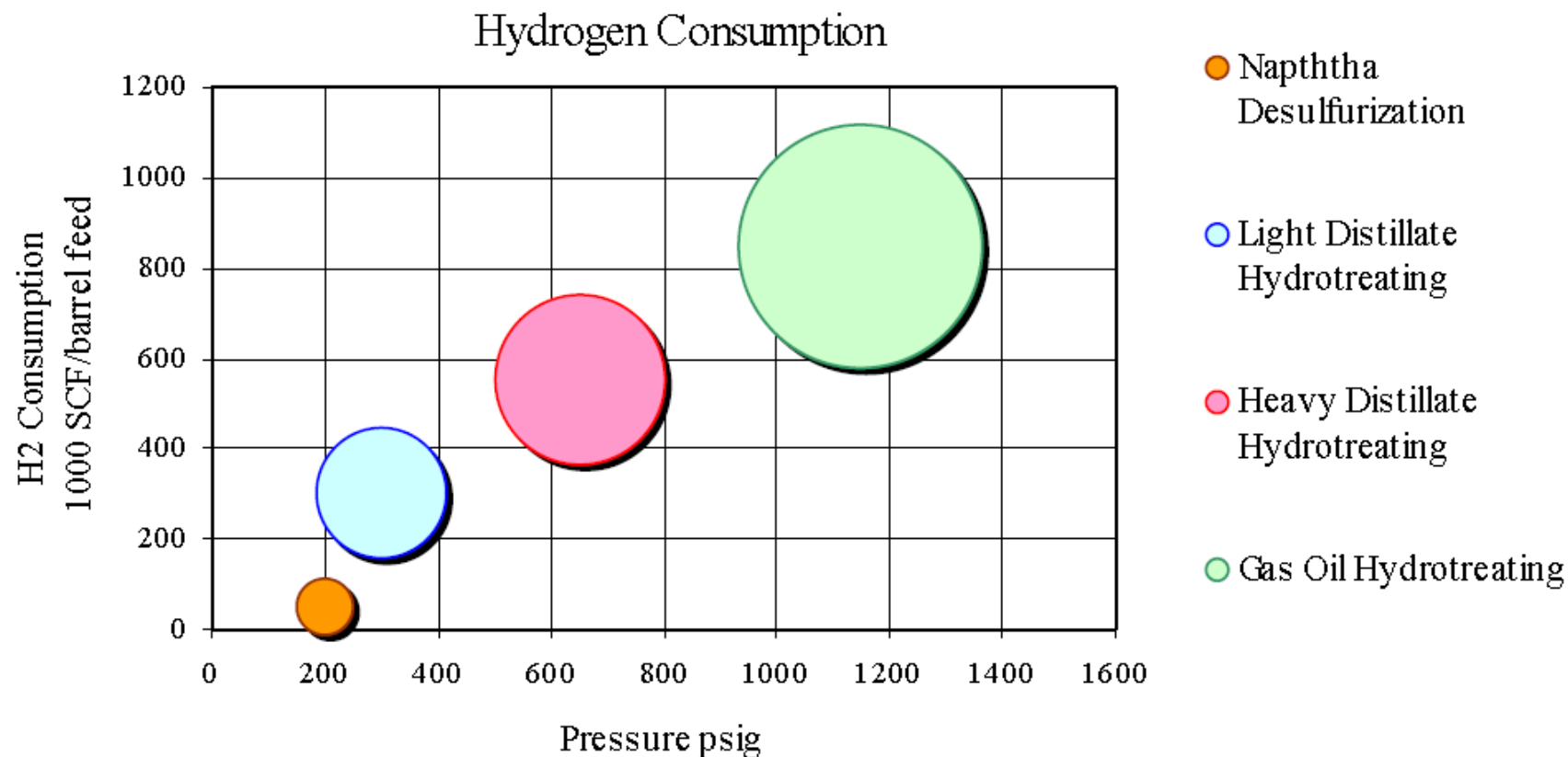
Gas Oil Hydrotreater (GOHT)



Hydrotreating Gas Oil Before FCCU Avoids Hydrotreating Separate FCCU Products



Hydrotreating H₂ Consumption

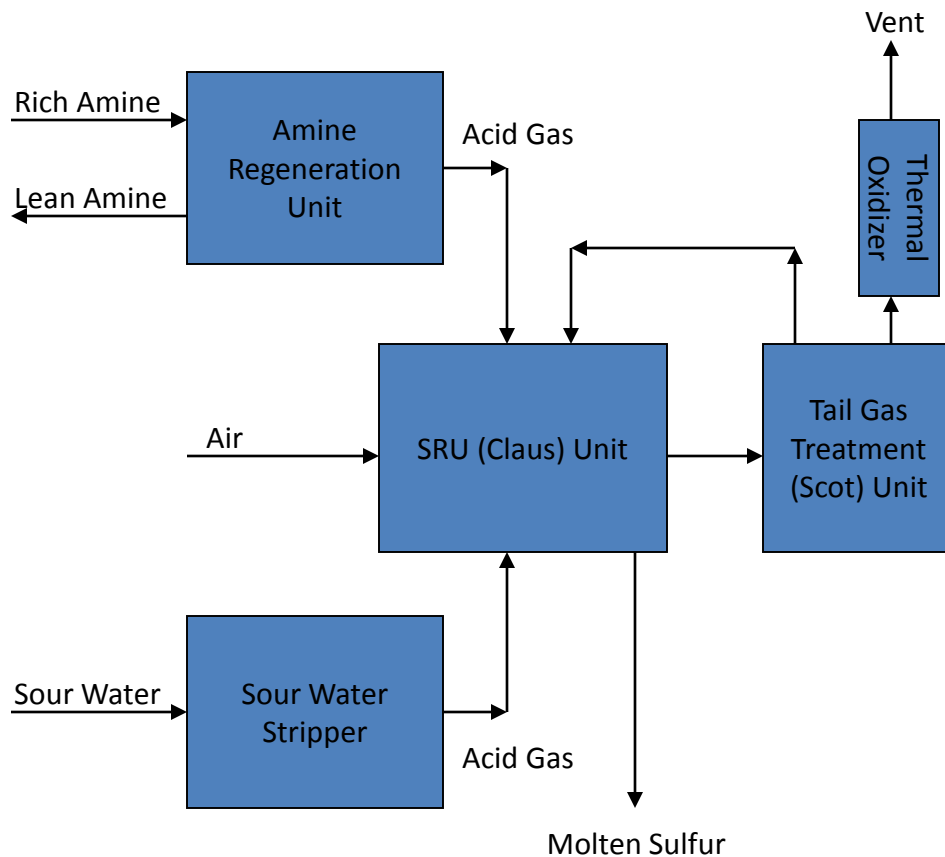




Byproduct Recovery

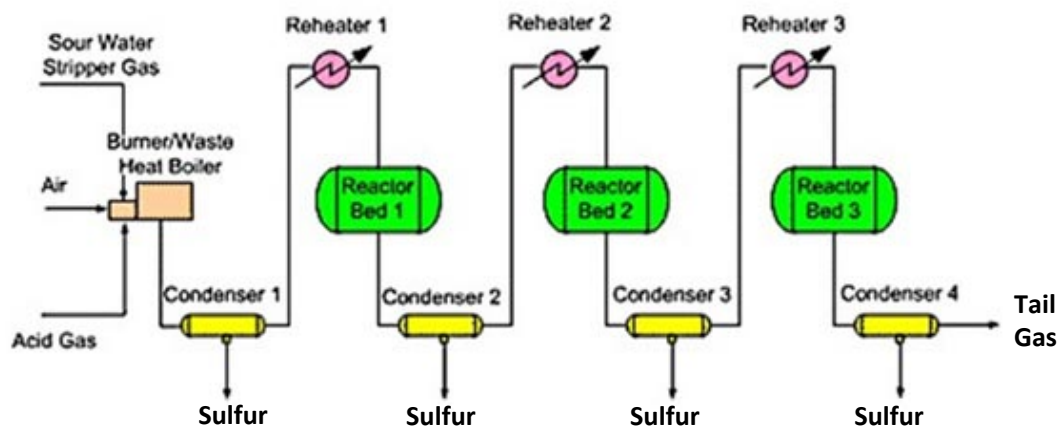


Sulfur Recovery Complex





Claus Sulfur Unit



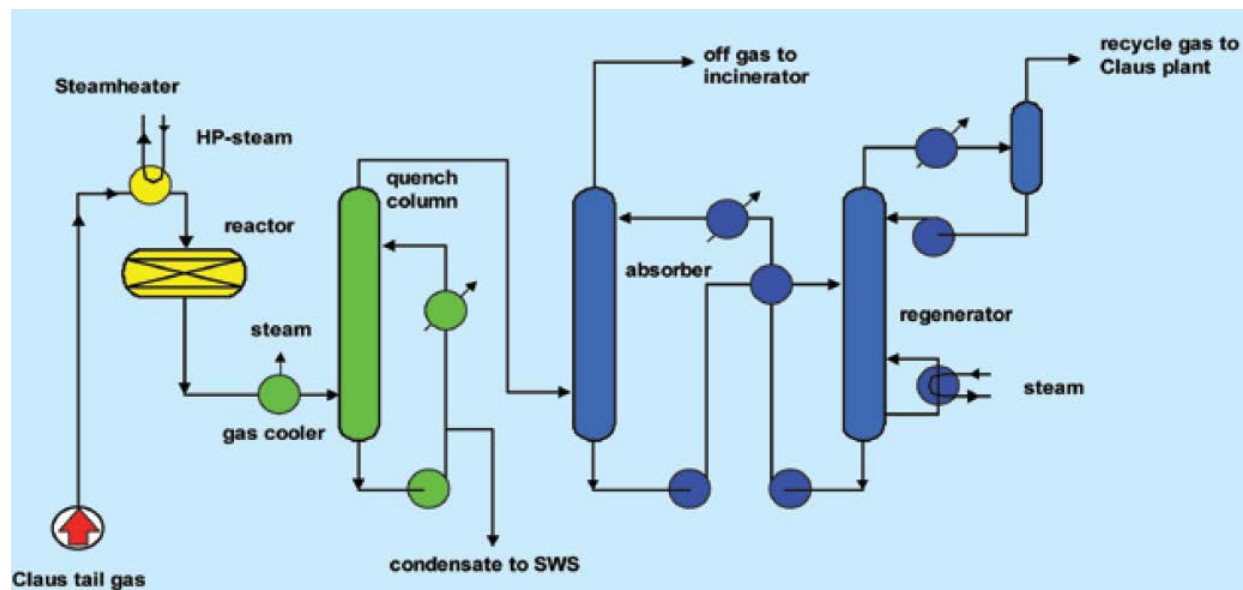
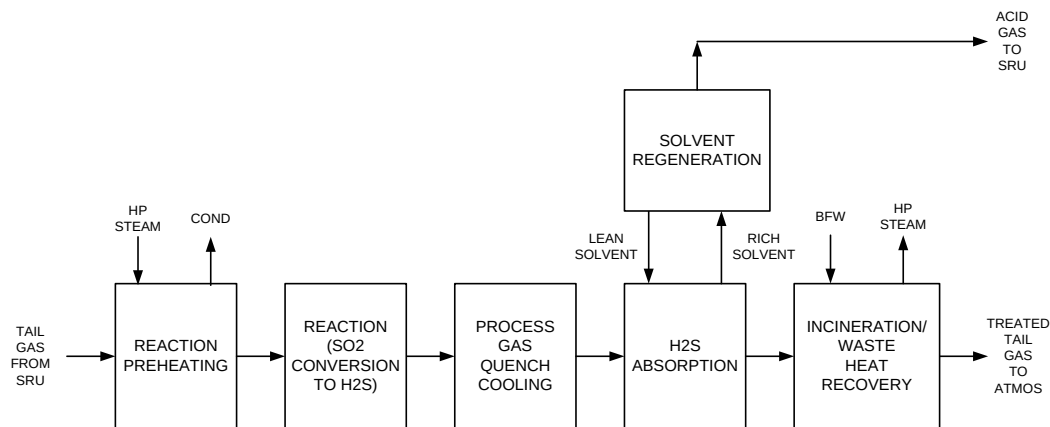


US Patent No. 3,963,44

Ford, Bacon & Davis, LLC



Tail Gas Treatment





- Petroleum Refinery Converts Crude Oil To Fuels and Chemical Feedstocks
- Molecules In Crude Oil Are Converted To High Value Products Through Refinery Conversion And Product Finishing Steps
- Removing Sulfur From Refinery Products Is Critical in Meeting Environmental Requirements (Tier 3 = 10 ppmw)