

Refining Processes



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Refineries are designed around certain crude oil qualities, primarily in terms of gravity (density) and sulfur content

Gravity (density)

- The lighter (less dense) the crude the more desirable components it naturally contains
 - Refineries have less chemical work to do
 - Less sophisticated refineries are needed
- Measured in units called degrees API
 - Light crude is generally above 35 degrees API
 - Medium crude is generally 27-35 degrees API
 - Heavy crude is generally below 27 degrees API
- Examples
 - Tar – Gravity of about 8
 - Motor Oil – Gravity of about 40

Refineries are designed around certain crude oil qualities, primarily in terms of gravity (density) and sulfur content

Sulfur content

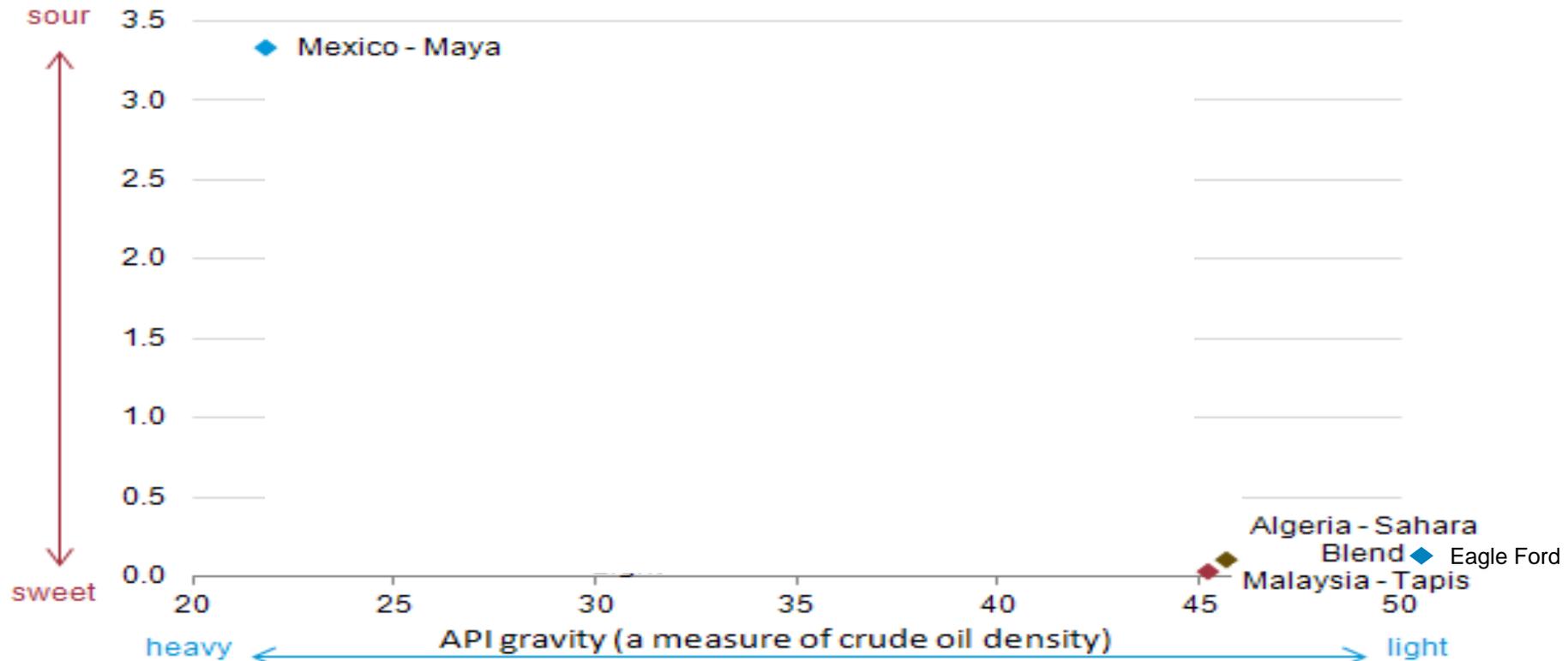
- Sulfur poisons the catalysts used in refinery chemical processes/automobile catalytic converters
- When burned, it forms sulfur dioxide – sulfuric acid
 - Corrodes engines/boilers
 - Causes acid rain
- Measured in weight percent
 - Sweet crude is generally below 1.0%
 - Sour crude is generally above 1.0%

And there are other crude characteristics that make them more or less desirable and affect their relative prices

- Metals content- Nickel/Vanadium act as catalyst poisons as does sulfur
- TAN (Total Acid Number) - acid content that can lead to equipment corrosion, may require special metals to be used in construction
- Naphthenic vs paraffinic - chemical components that yield less desirable products

Crude oils have a wide variety of qualities

Density and sulfur content of selected crude oils
sulfur content (percentage)

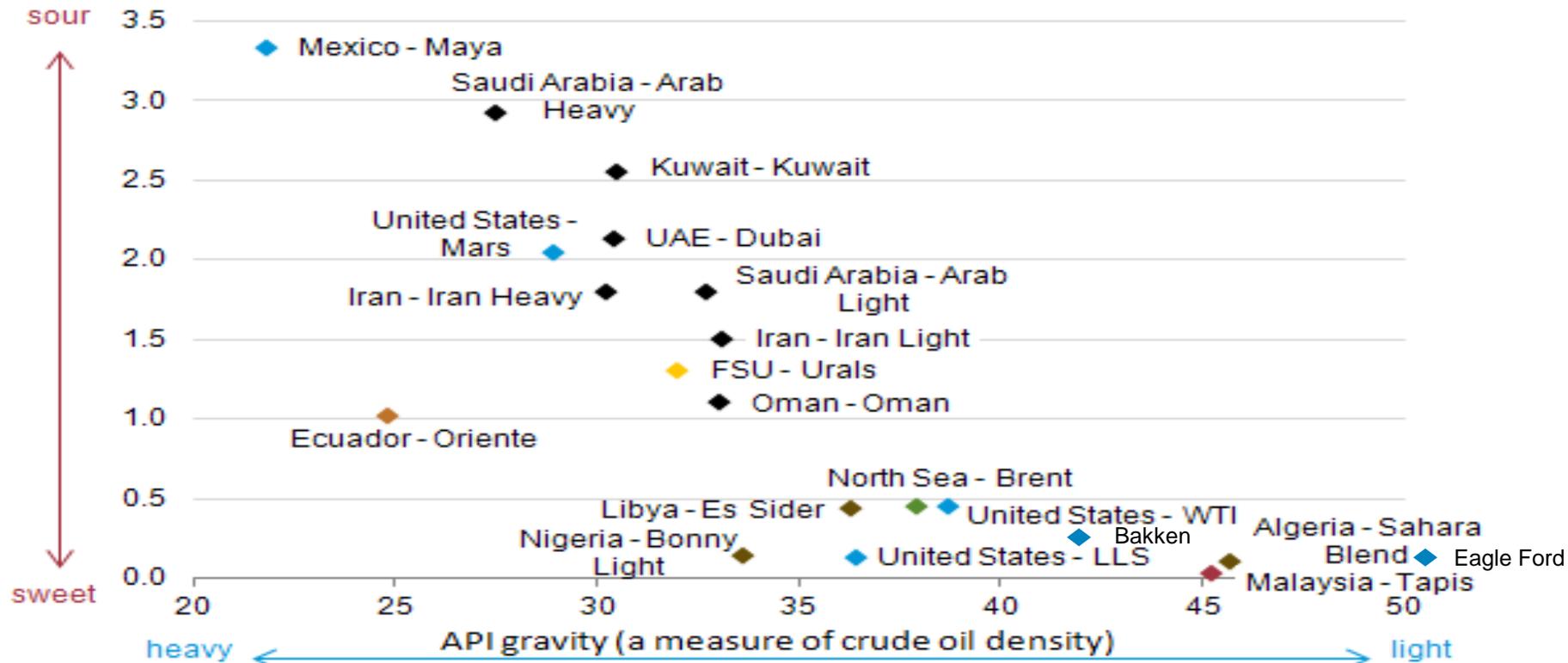


Source: U.S. Energy Information Administration, based on Energy Intelligence Group—International Crude Oil Market Handbook.

Notes: Points on the graph are labeled by country and benchmark name and are color coded to correspond with regions in the map below. The graph does not indicate price or volume output values. United States-Mars is an offshore drilling site in the Gulf of Mexico. WTI = West Texas Intermediate; LLS = Louisiana Light Sweet; FSU = Former Soviet Union; UAE = United Arab Emirates.

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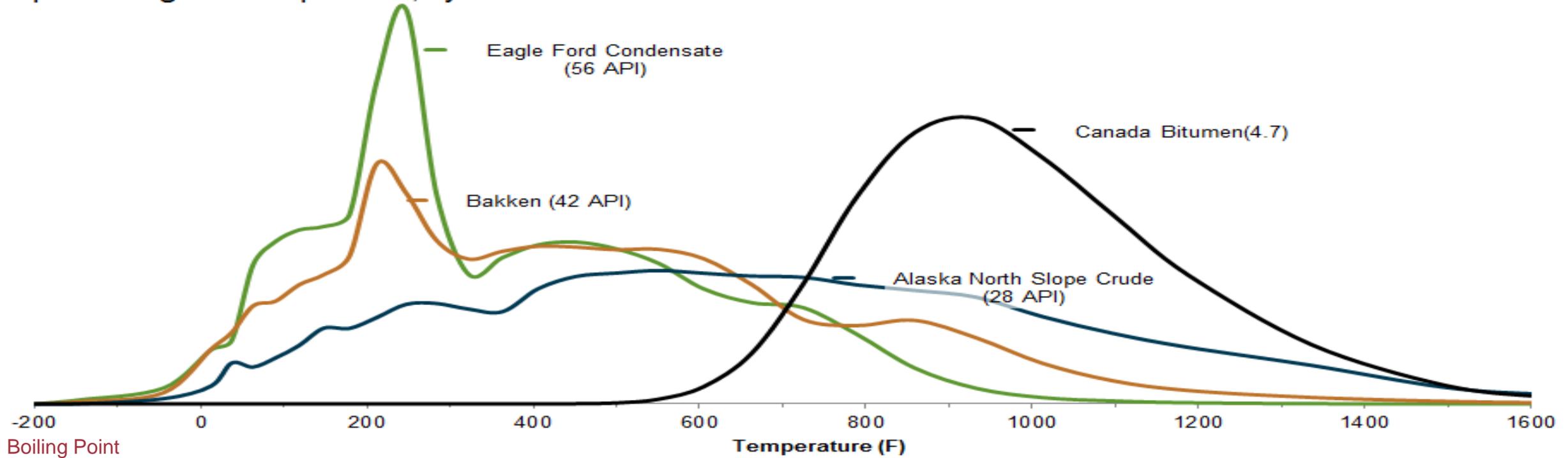


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Crude oils exhibit a wide variation in the size and distribution of hydrocarbon molecules

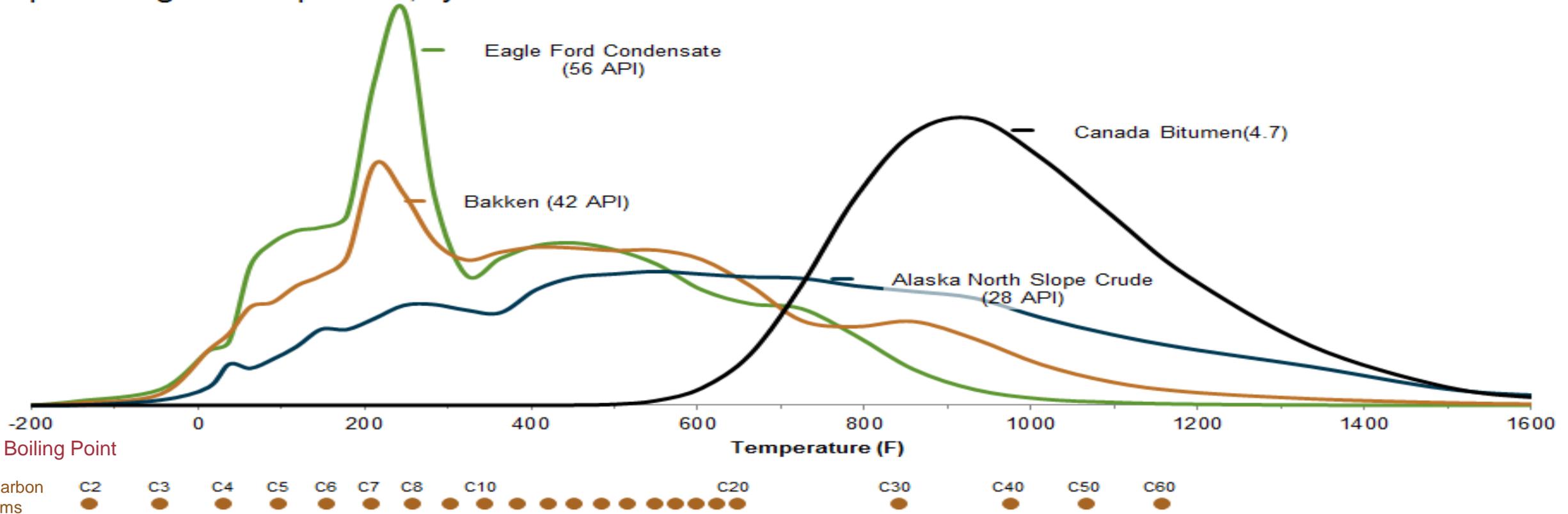
percentage of composition, by volume



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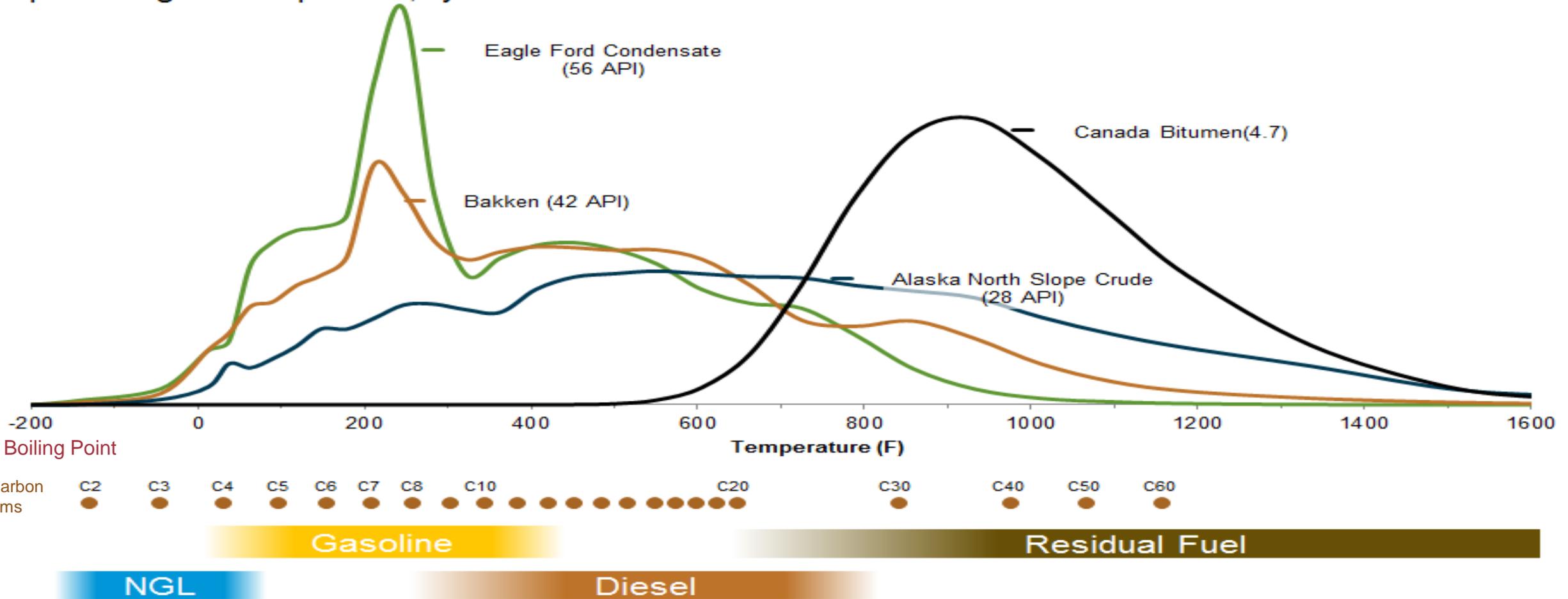
Crude oils exhibit a wide variation in the size and distribution of hydrocarbon molecules

percentage of composition, by volume

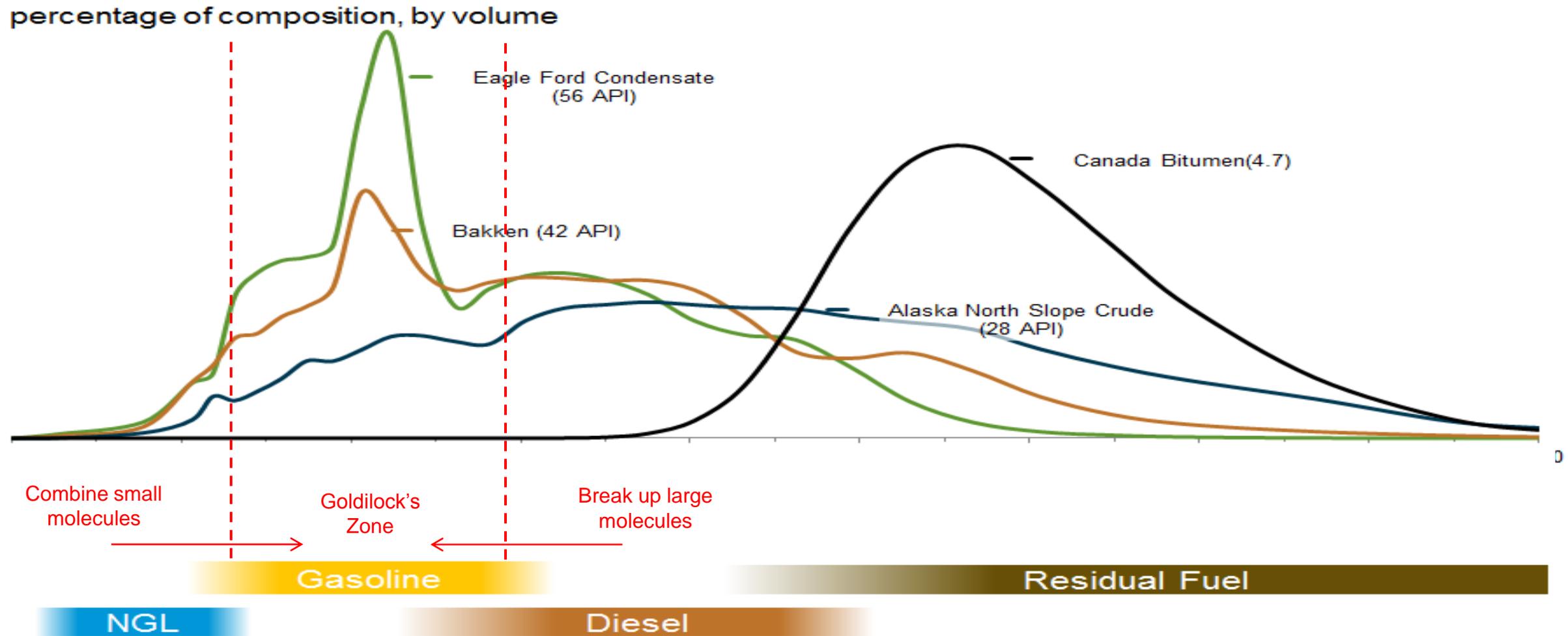


Crude oils exhibit a wide variation in the size and distribution of hydrocarbon molecules

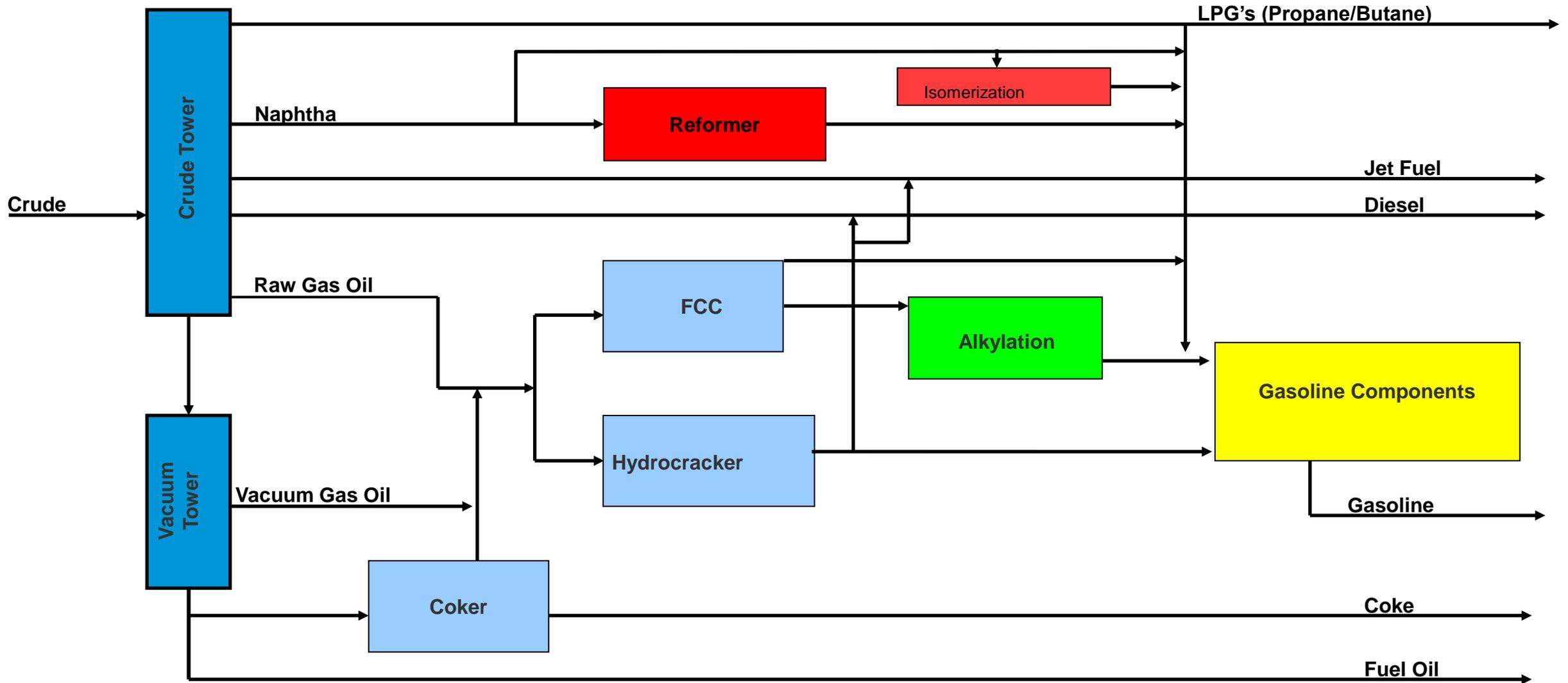
percentage of composition, by volume



Crude oils exhibit a wide variation in the size and distribution of hydrocarbon molecules



Refining processes



Refinery processes typically fall into one of three categories

- Distillation- separate molecules
- Conversion - change molecules
- De-sulfurization – remove sulfur

Refinery processes: Distillation

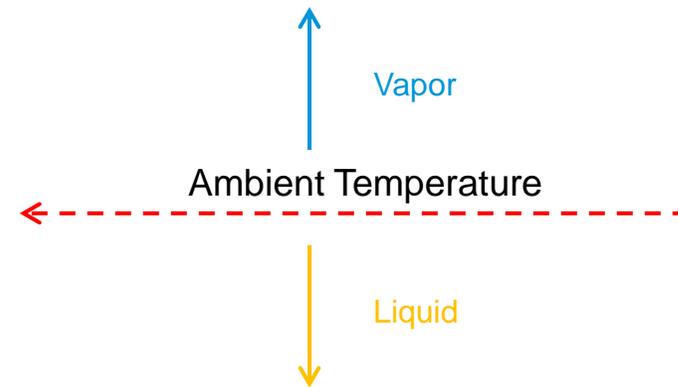
- Separation of components by boiling point. Does not change the chemical nature of the components
- First process in refining. Separates crude oil into groups of components to be directed to other processes.
- Used throughout refining for separation and/or purification.

Distillation is the process of separating a mixture of components according to their differences in boiling points

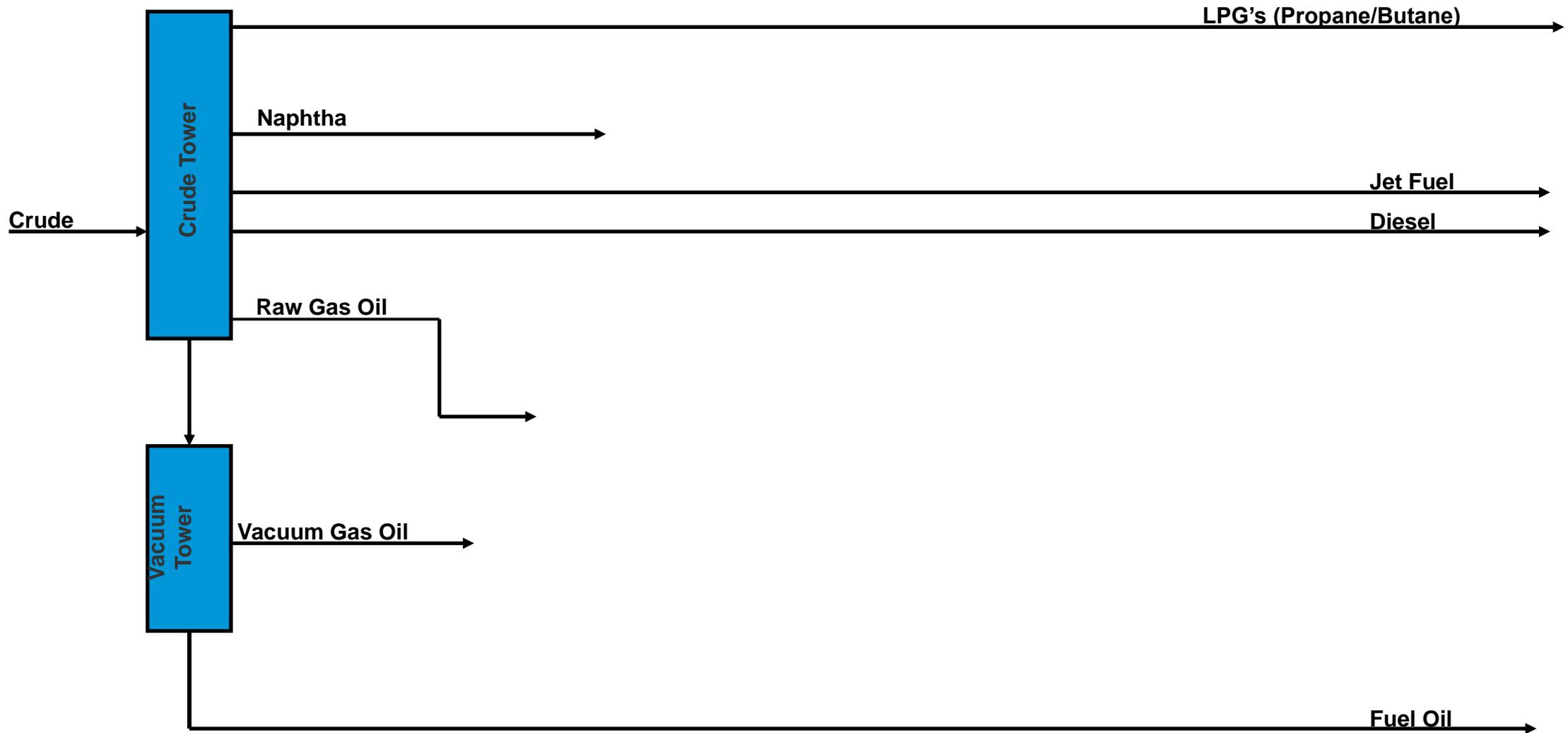
<u># Carbon Atoms</u>	<u>Boil (atmo:</u>
1 (methane)	(:
2 (ethane)	(
3 (propane)	
4 (butane)	:
5 (pentane)	:
6 (hexane)	:
7 (heptane)	:
8 (octane)	:
9 (nonane)	:
10 (decane)	:

Distillation is the process of separating a mixture of components according to their differences in boiling points

<u># Carbon Atoms</u>	<u>Boiling Point (°F)</u> <u>(atmospheric pressure)</u>
1 (methane)	(259)
2 (ethane)	(127)
3 (propane)	(44)
4 (butane)	34
5 (pentane)	97
6 (hexane)	155
7 (heptane)	209
8 (octane)	258
9 (nonane)	304
10 (decane)	346



Refinery processes: Distillation



Refinery processes: Conversion

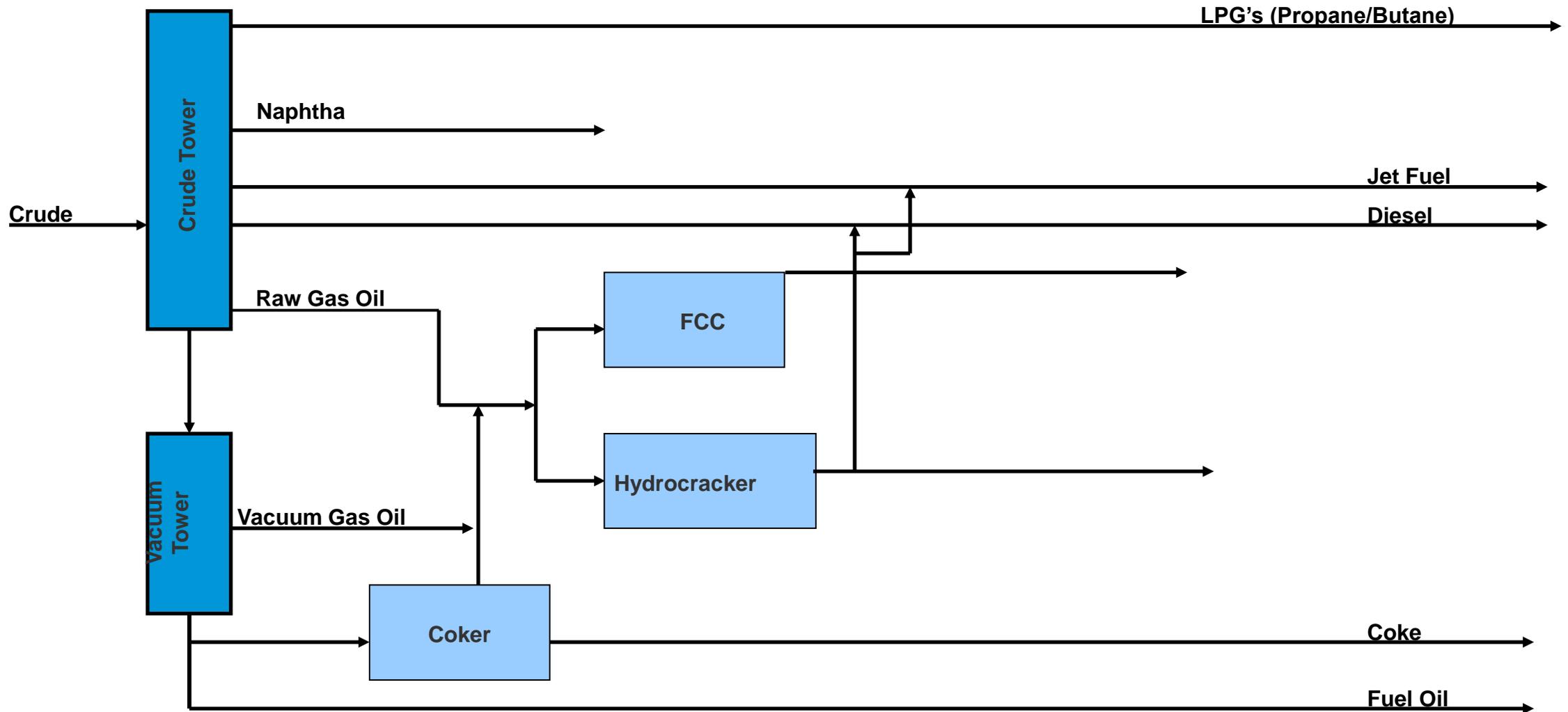
- Changes the chemical nature of the components
- Generally require catalysts
- Generally directed at producing gasoline components
 - Jet/Diesel occur naturally in crude-need only separation
 - Gasoline is a blended product (combines 3-8 components from various units)
 - Heavy components are made lighter
 - Light components are made heavier
 - Natural components are changed to improve quality i.e., octane

Refining processes: Conversion (continued)

Heavy components are made lighter

- Coking: high temperature is used to breakup the heaviest components of crude oil without using a catalyst
- Hydrocracking: high pressure hydrogen/catalysts break up the next heaviest components into gasoline and diesel
- Fluid catalytic cracking (FCC): uses catalysts to break up diesel-quality components into gasoline-quality molecules

Refinery processes: Conversion of heavy components

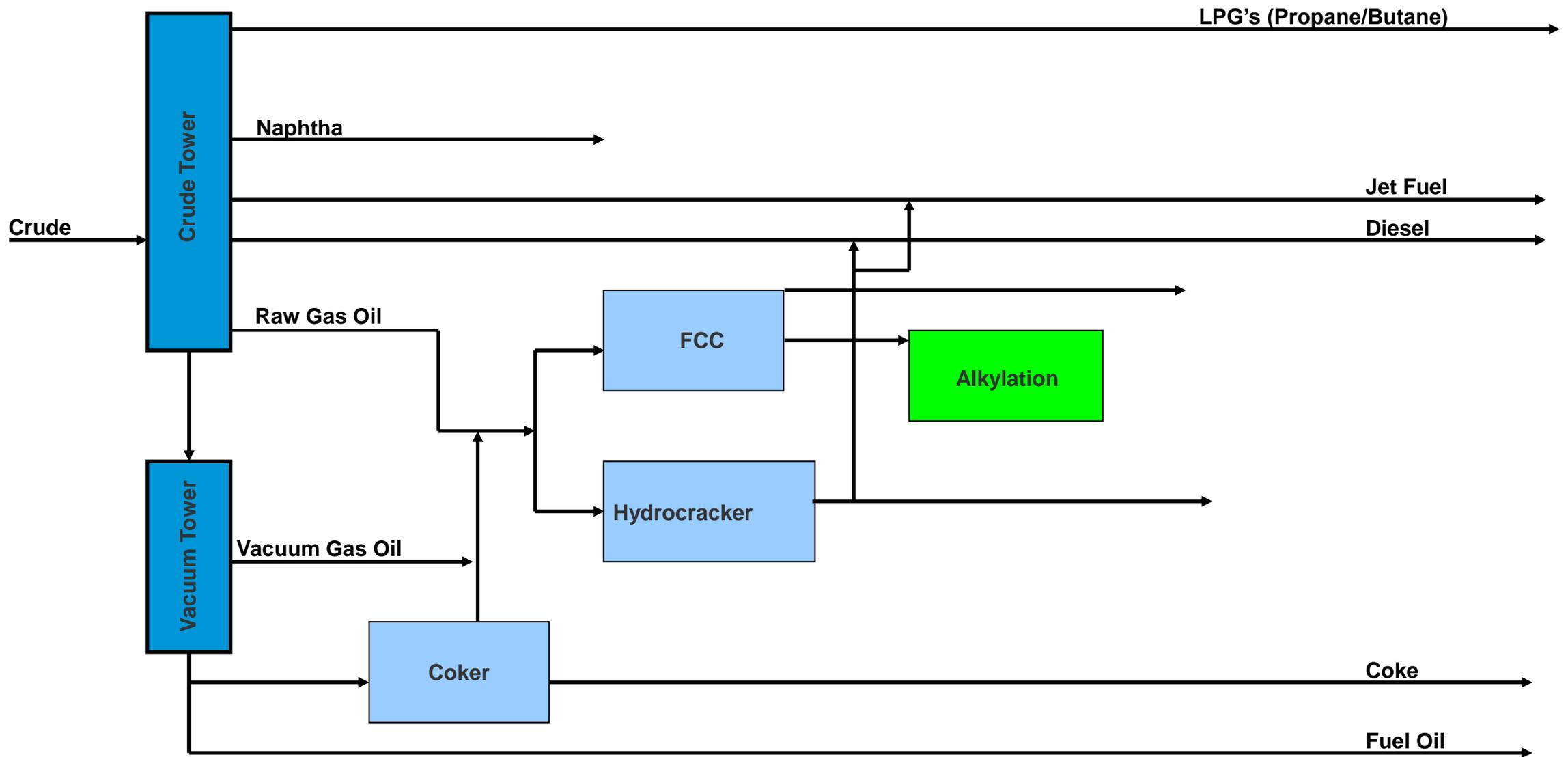


Refining processes: Conversion (continued)

Light components are made heavier

- Alkylation: light ends from crude combined with products from FCC unit. Catalyst is either sulfuric acid or hydrofluoric acid
- Other older process – polymerization

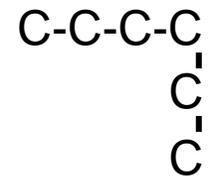
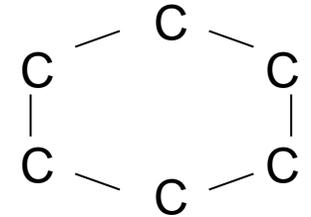
Refinery processes: Conversion of light components



Refining processes: Conversion (continued)

Natural components are changed to improve octane

- Straight chained molecules have low octane
- Reforming changes straight chains to rings
- Isomerization changes straight chains to branches



Refining processes: De-sulfurization

Desulfurization takes place throughout the refining process to remove sulfur by using catalysts and pressurized hydrogen

- Low pressure (600-800 psi) reduce sulfur to 500 ppm
- Medium pressure (800-1200 psi) reduce sulfur to 50 ppm
- High pressure (1200-1800 psi) reduce sulfur to 5 ppm