3/24/09 LUNCH & LEARN: REFINING FUNDAMENTALS

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REFINING FUNDAMENTALS

Presentation Outline

- **Crude Oil Characteristics**
- **Refining Processes**
- **Refining Economics**

Crude Oil Characteristics

Crude oil quality & price is determined by 2 primary characteristics:

- 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 = generally above 30 degrees API
    - Heavy Crude = generally below 30 degrees API
  - Examples
    - Tar – Gravity of about 8
    - Motor Oil – Gravity of about 40

Crude Oil Characteristics

Crude oil quality & price is determined by 2 primary characteristics:

- 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
    - Acid rain
  - Measured in weight percent
    - Sweet Crude = generally below 1%
    - Sour Crude = generally above 1%

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Crude Oil Characteristics

Crude oil quality & price is determined by 2 primary characteristics:

- Examples – marker crudes (large volume, pricing bases)

Crude	Gravity	Sulfur	Price(2005)
WTI (West Texas Intermediate)	39.6	0.24	$56.43
Brent (North Sea Crude)	38.3	0.37	$54.72
ANS (Alaska North Slope)	30.0	1.09	$53.35
Maya (Mexico)	21.8	3.33	$40.40

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Crude Oil Characteristics

Miscellaneous:

- Other Crude Characteristics
  - Metals- Nickel/Vanadium- poisons
  - Acid- TAN (Total Acid Number)
  - Distillation- what % boils off at each temperature
- Crude/Refining measure volume in barrels = 42 gallons
- Crude is made up of hundreds of chemical components
  - Most products produced are not pure components, but a range molecular sizes (boiling points)

    Gasoline – 100 - 400 degrees F
    Jet Fuel – 300 - 550
    Diesel – 350 - 650

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Refining Processes

Every refinery is different in terms of what units it has and how big each unit is

- Determined by crudes to be run & products to be produced
  - Far East refineries run light crude to produce distillates
  - East Coast refineries must produce home heating oil
  - Rocky Mountain refineries have limited crude access
  - West Coast refineries run heavy crude to make gasoline
- Major Groups: margin vs investment
  - Topping plants- mostly distillation
  - Cracking plants- contain cracking units to make gasoline
  - Coking plants- contain cokers to run heavy crude

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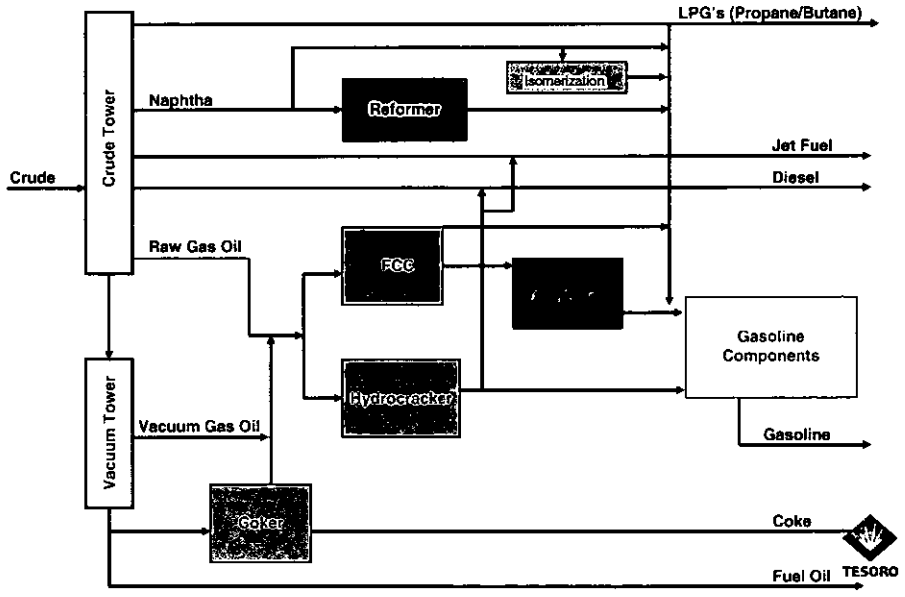
Refining Processes



Refinery Processes

- Refinery processes generally fall into one of three categories:

  - Distillation

  - Conversion

  - De-Sulfurization

Refining 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/purification

Refining Processes

- **Distillation (continued)**
  - Refinery Products in Order of Distillation-boiling point
    - Natural Gas- methane
    - LPG's- propane/butane
    - Jet Fuel
    - Gasoline Components
    - Diesel Fuel
    - Fuel Oil

Lighter, less dense

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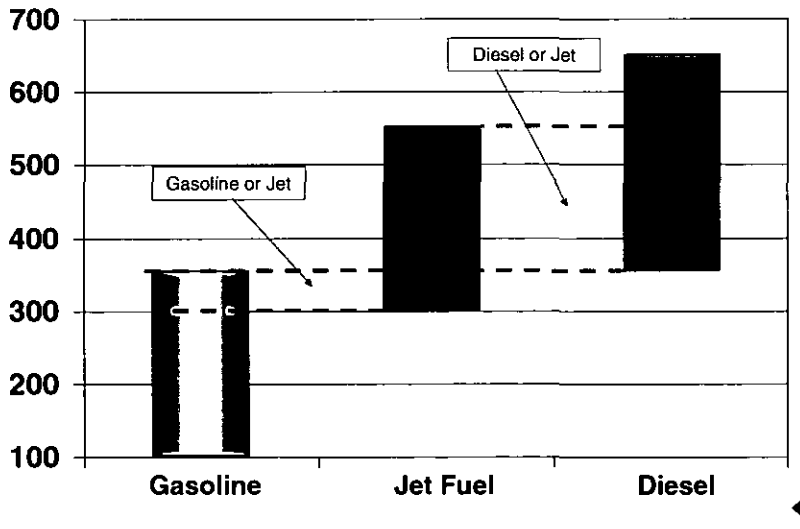
Initial Crude Yields

Boiling Range Degrees Fahrenheit

There is some interchangability between products



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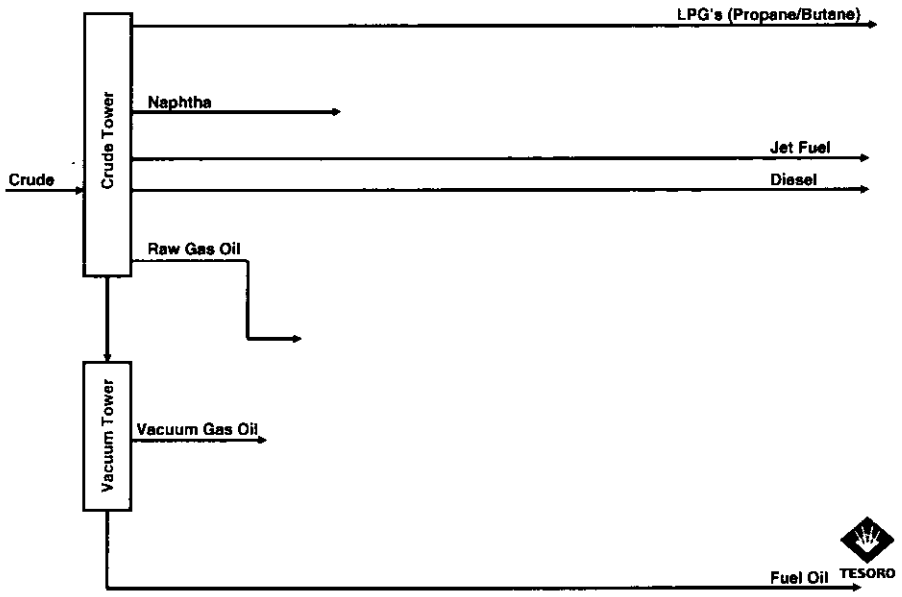
Refining Processes



Refining 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 separation
    - Gasoline is a blended product (3-8 components)
      - Heavy components are made lighter
      - Light components are made heavier
      - Natural components are changed to improve octane

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Refining Processes

- **Conversion (continued)**

  Heavy components are made lighter

  - Coking- high temperature & pressure to breakup the heaviest components of crude- no catalyst
  - Hydrocracking- high pressure hydrogen/catalysts breakup the next heaviest components
  - FCC- fluidized catalytic cracking- uses catalysts to breakup diesel quality components

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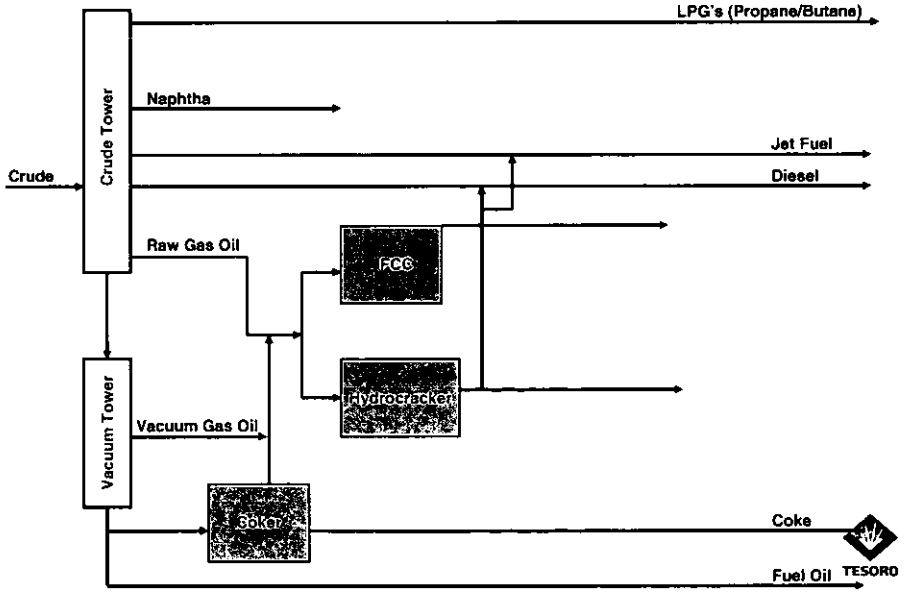
Refining Processes



Refining Processes

- **Conversion (continued)**

Light components are made heavier

- Alkylation
  - light ends from crude combined with by products from FCC
  - catalyst is either sulfuric acid or hydrofluoric acid

- Other older process- polymerization

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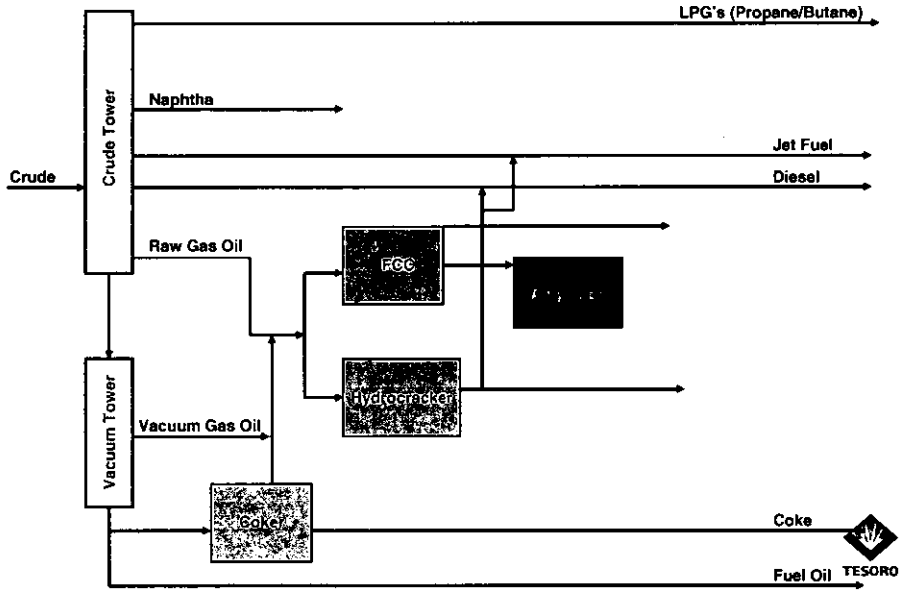
Refining Processes



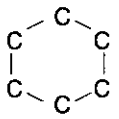
Refining Processes

- **Conversion (continued)**

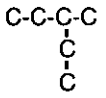
Natural components are changed to improve octane

- Straight chained molecules have low octane C- C- C- C- C- C

- Reforming- changes straight chains to rings



- Isomerization- changes straight chains to branches



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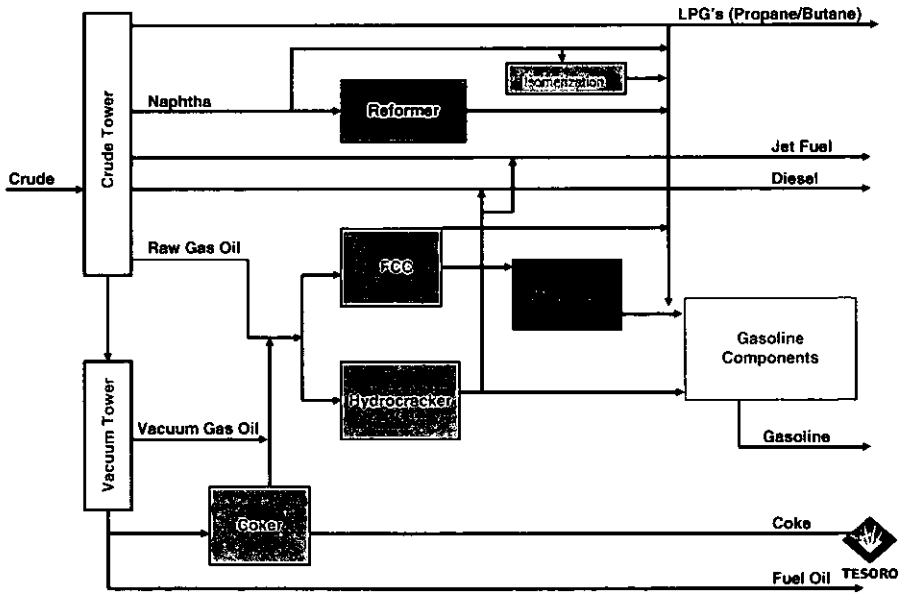
Refining Processes



Refining Processes

- **De-Sulfurization**

  Removes sulfur using catalysts and pressurized hydrogen

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

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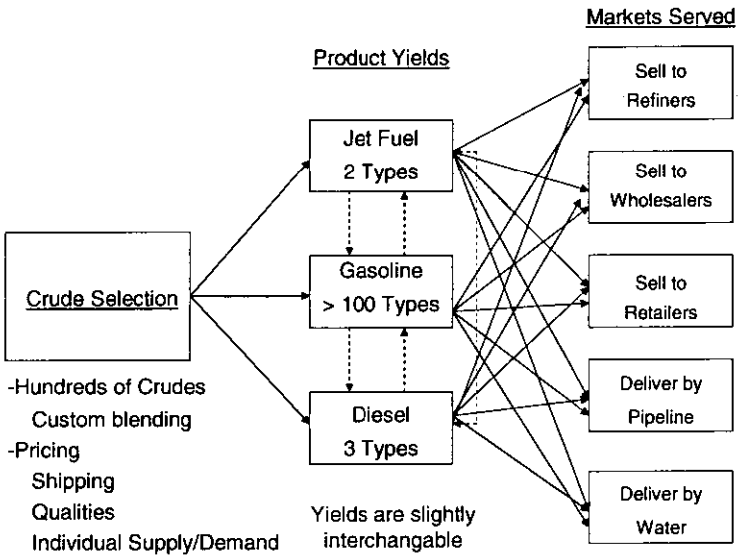
Refining Economics



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