VALERO ENERGY CORPORATION

Lehman Brothers Analyst Teach-In

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Refining Fundamentals & Impact of Changing Fuel Specifications

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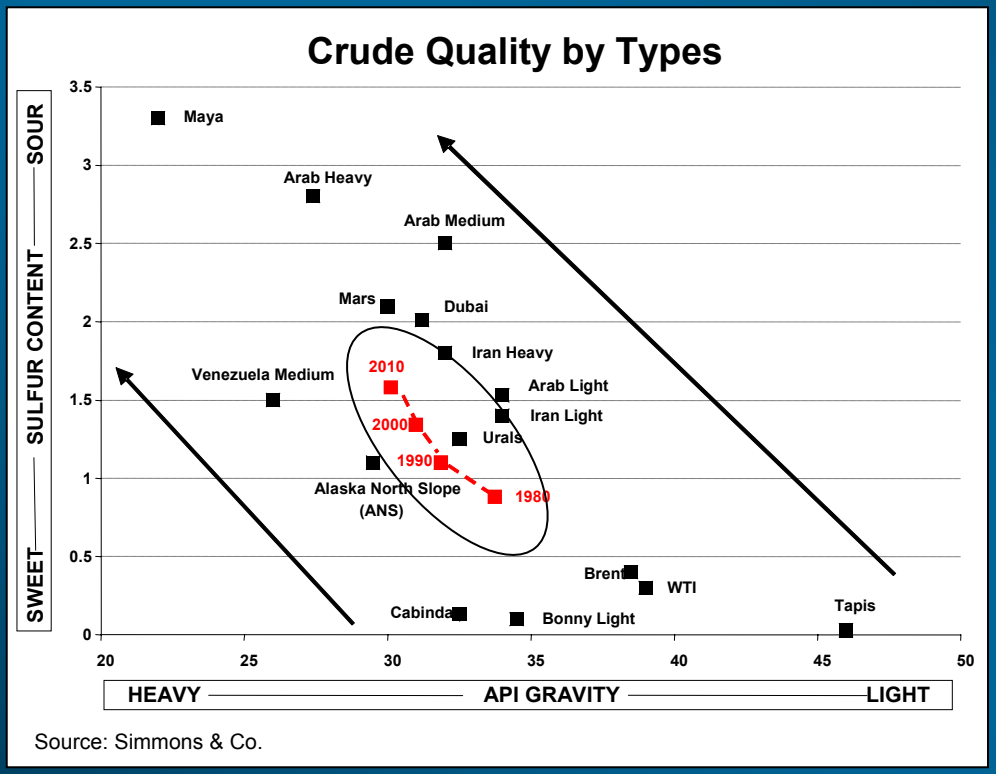
Senior Vice President, Refining Operations

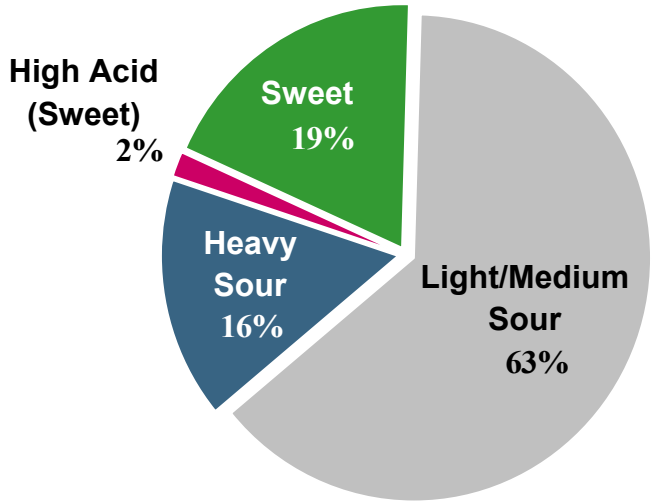
Crude Oil Characteristics

- Crude density is commonly measured by API gravity
  - API gravity provides a relative measure of crude oil density … the higher the API number, the lighter the crude
  - Classified as light, medium, or heavy
    - Light crudes are easier to process
    - Heavy crudes are more difficult to process
- Sulfur content measures if a crude is sweet (low sulfur) or sour (high sulfur)
  - Less than 0.7% sulfur content = sweet
  - Greater than 0.7% sulfur content = sour
  - High sulfur crudes require additional processing to meet regulatory specs
- Acid content measured by Total Acid Number (TAN)
  - Acidic crudes highly corrosive to refinery equipment
  - High acid crudes are those with TAN > 0.7

Crude Oil Basics



Source: Simmons & Co.



Source: Oil & Gas Journal, Company Information

- Majority of global reserves are light/medium sour
- Most quoted benchmark prices are light sweet crudes
  - WTI (West Texas Intermediate), Western Hemisphere
  - Brent (North Sea Crude), Europe
- Global crude supply is becoming heavier and more sour

Basic Refining Concepts

Crude Types	Characteristics	Yields
Sweet Crude (i.e. WTI, Brent)	34+ API Gravity < 0.7 % Sulfur 35% Demand Most Expensive	3% 30% 34% 33%
Medium Sour Crude (i.e. Mars, Arab Light, Arab Medium)	24 - 34 API Gravity > 0.7 % Sulfur 50% Demand Less Expensive	3% 21% 26% 50%
Heavy Sour Crude (i.e. Maya)	< 24 API Gravity > 0.7 % Sulfur 15% Demand Least Expensive	1% 14% 22% 63%

2004 U.S. Refinery Production

- *8%* Propane/ Butane 
- *49%* Gasoline
  - RFG
  - Conventional
  - CARB
  - Premium

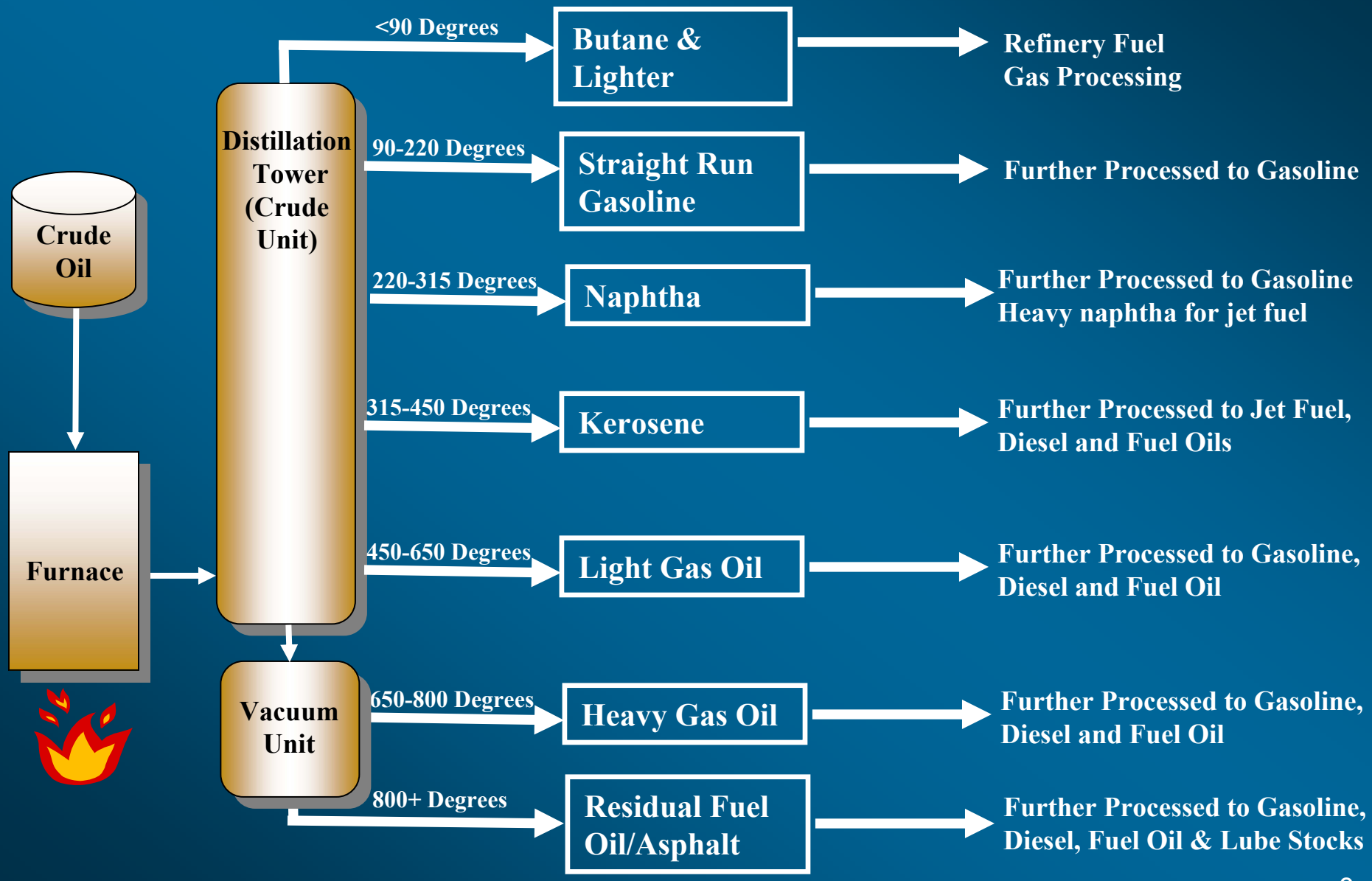
  
- *32%* Distillate
  - Jet Fuel
  - Diesel
  - Heating Oil

  
- *11%* Heavy Fuel Oil & Other 

Source: EIA Refiner Production

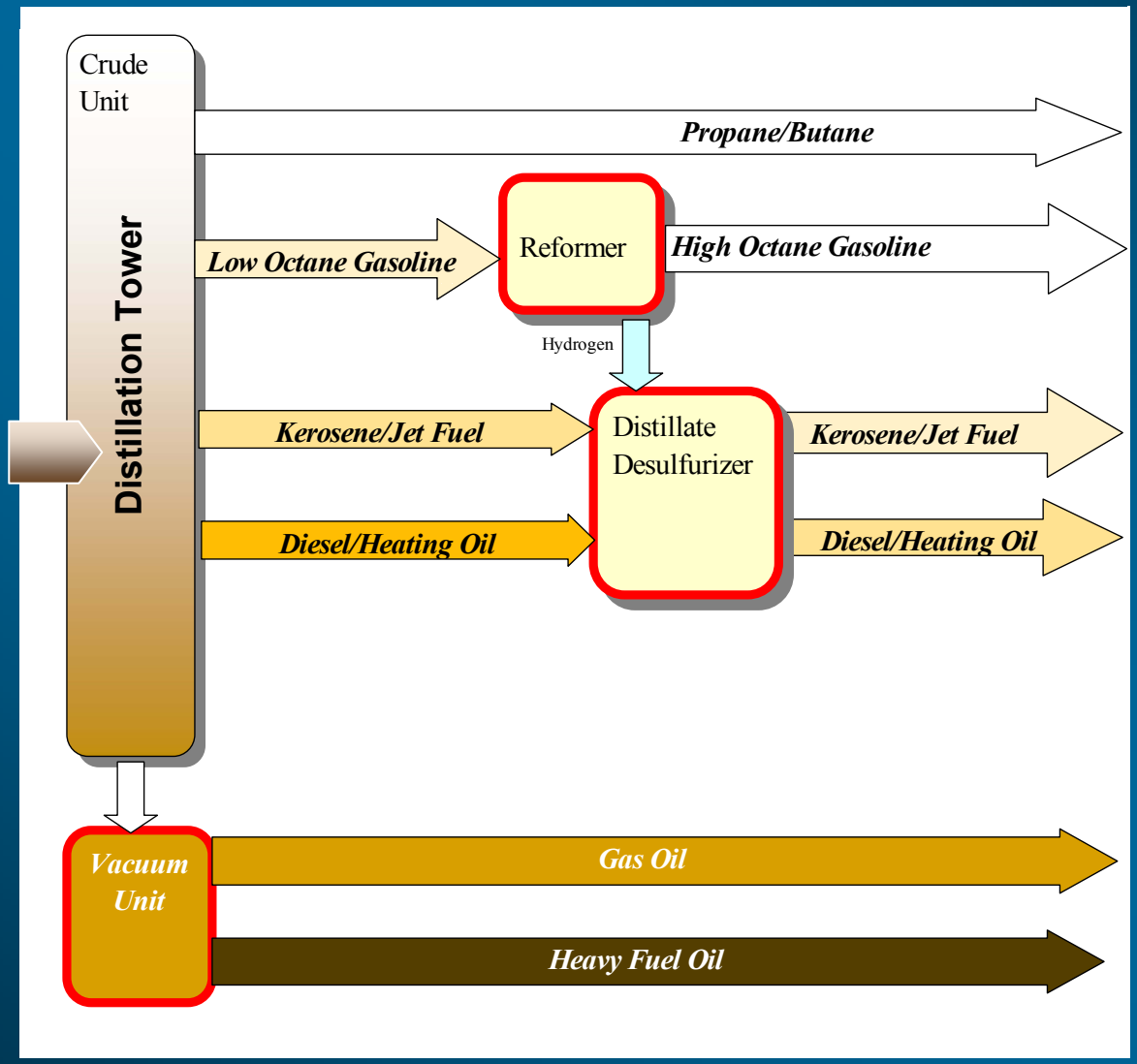
Refineries upgrade crude oil to higher value products

Basic Refining Concepts



Hydroskimming Refineries – Distillation Process

Light Sweet Crude



4% Propane/ Butane

30% Gasoline RFG Conventional CARB Premium

34% Distillate Jet Fuel Diesel Heating Oil

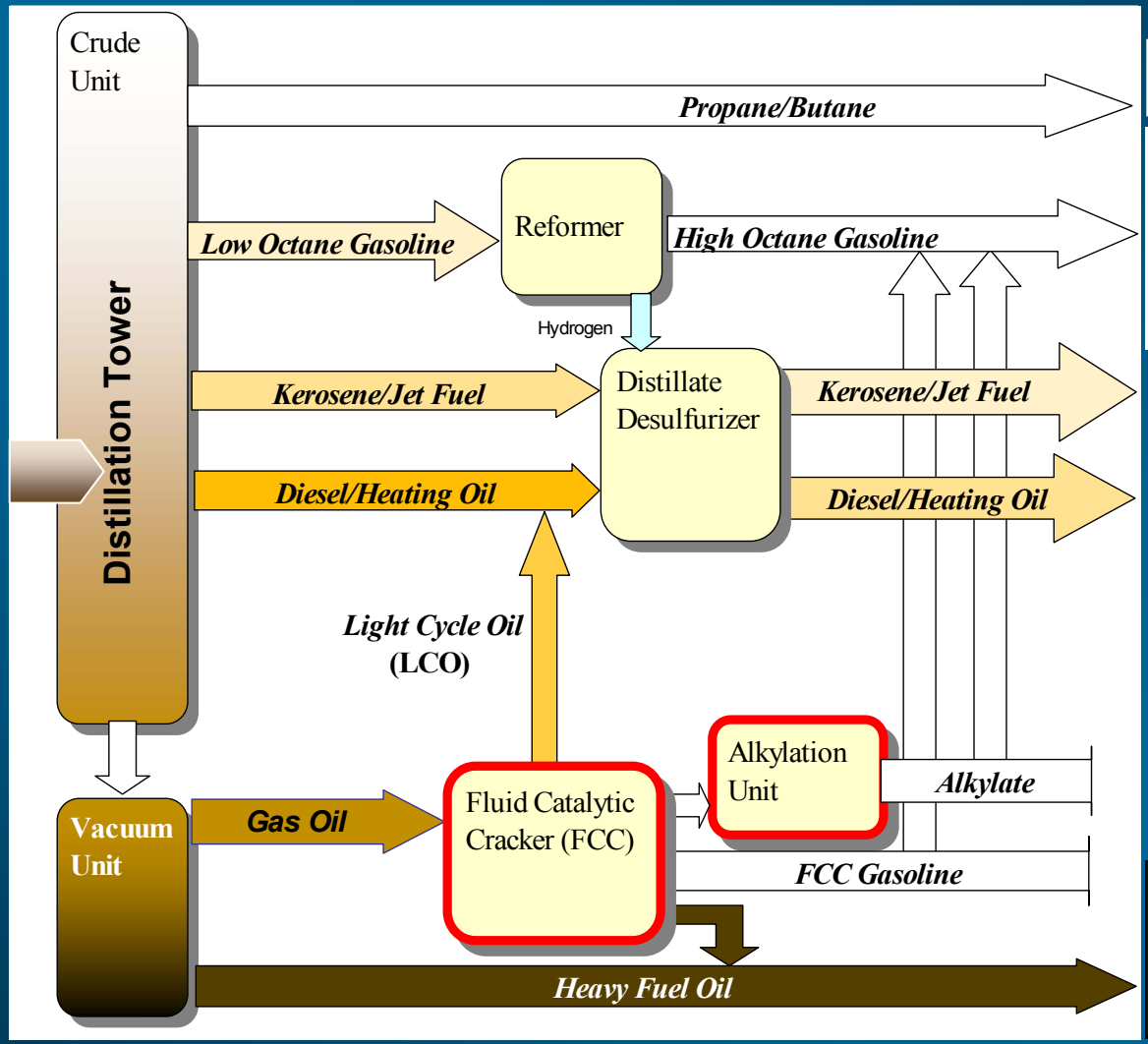
32% Heavy Fuel Oil & Other

100% Total Yield

Simple low upgrading capability refineries tend to run sweet crude

Medium Conversion Refineries - Catalytic Cracking

Light Sour Crude



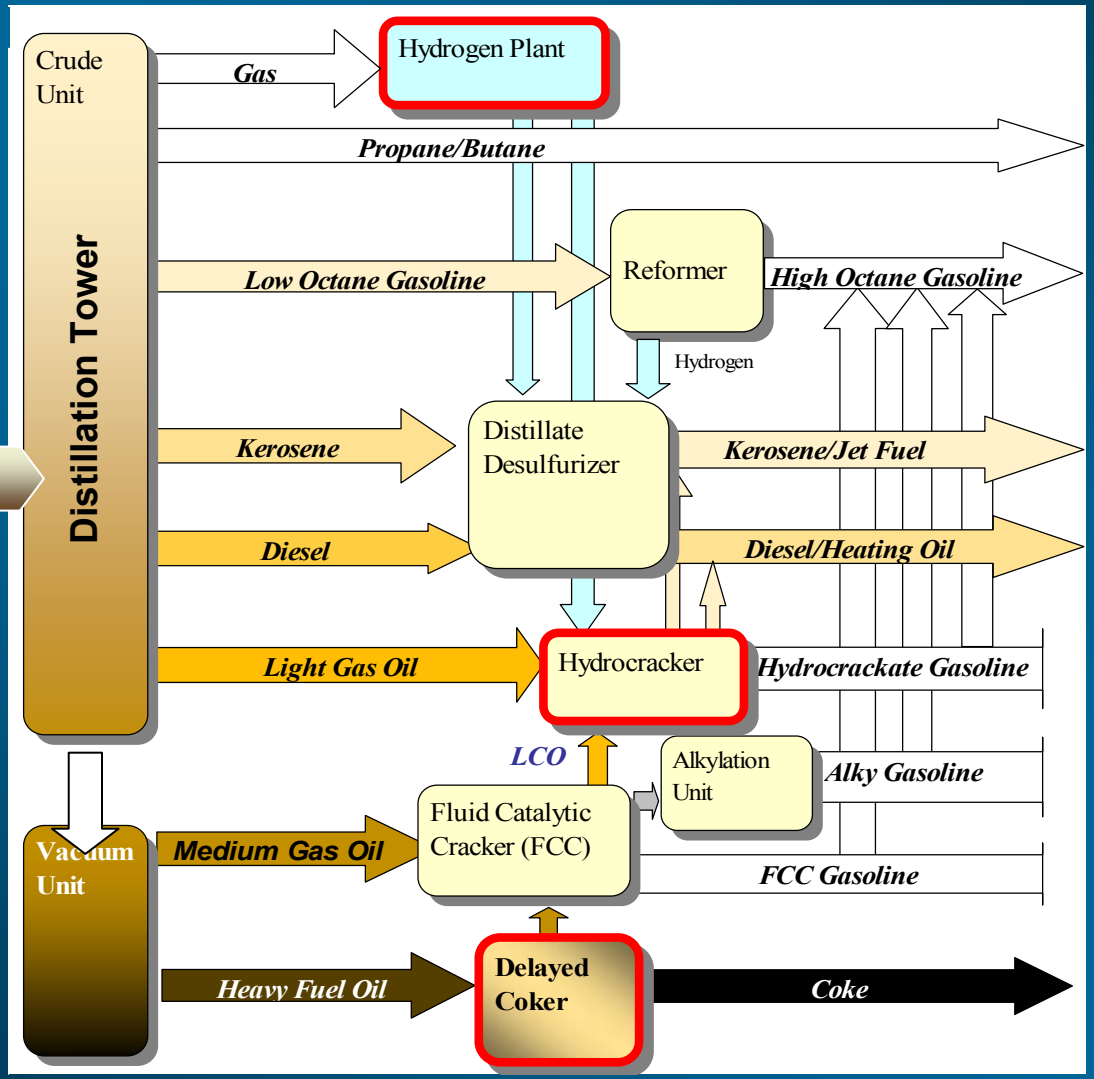
8%	Propane/ Butane	
45%	Gasoline RFG Conventional CARB Premium	
27%	Distillate Jet Fuel Diesel Heating Oil	
24%	Heavy Fuel Oil & Other	

104% Total Yield

Moderate upgrading capability refineries tend to run more sour crudes while achieving increased higher value product yields and volume gain.

High Conversion Refineries – Coking/Resid Destruction

Medium/ Heavy Sour Crude

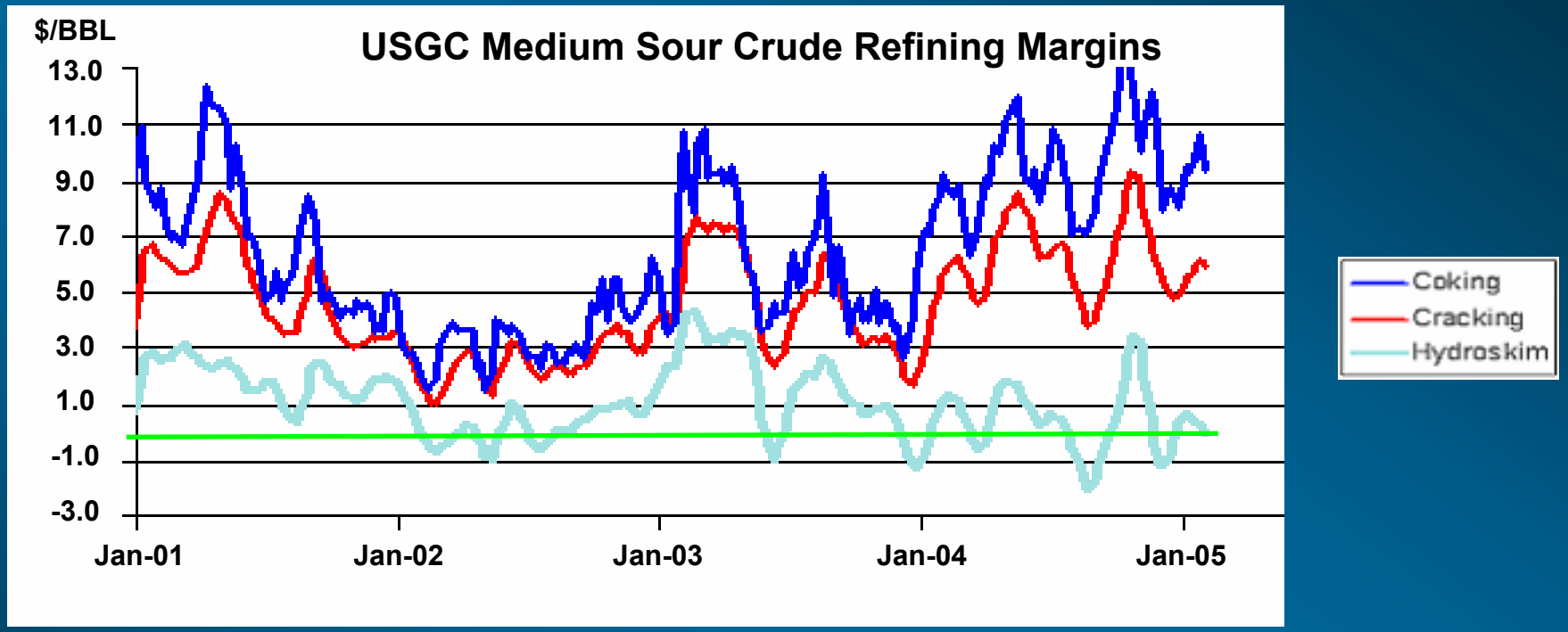


7%	Propane/ Butane
58%	Gasoline RFG Conventional CARB Premium
28%	Distillate Jet Fuel Diesel Heating Oil
15%	Heavy Fuel Oil & Other

108% Total Yield

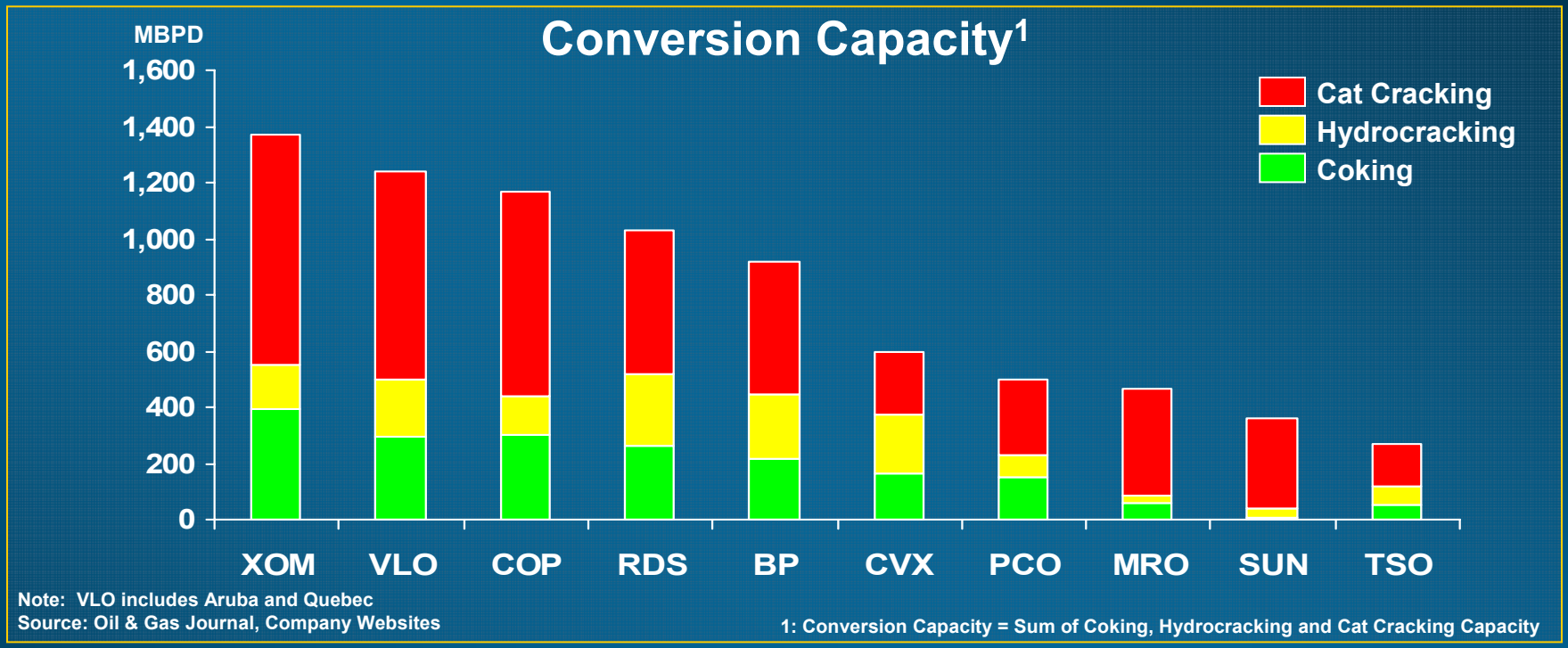
Complex refineries can run heavier and more sour crudes while achieving the highest light product yields and volume gain.

Conversion Economics



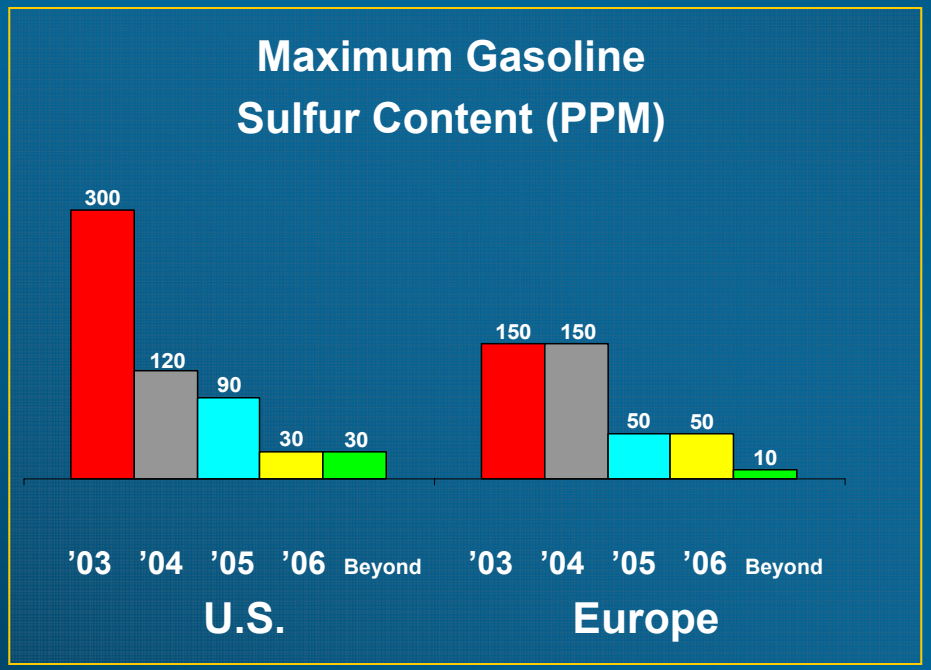
- Conversion capacity needed to capitalize on sour crude discounts
  - Hydroskim - Breakeven or moderate margins; High resid yield
    - When margins are positive - increase crude runs
    - When margins are negative - decrease crude runs
  - Cracking - Better margins; Lower resid yield
  - Coking - Best margins; Lowest resid yield
    - Maximize heavy crudes

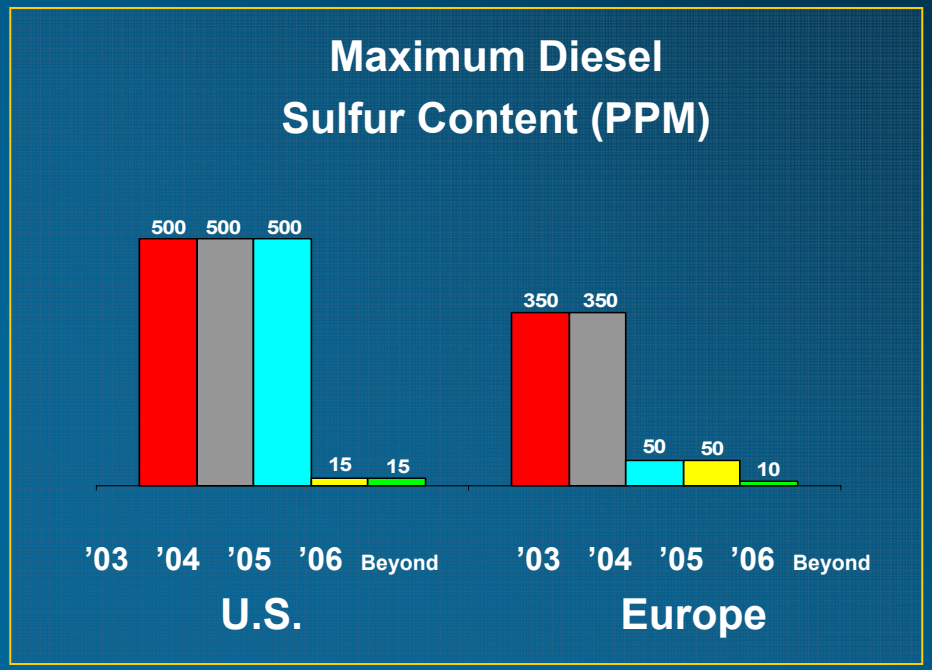
Comparison of Sour Conversion Capacity



- Valero is an industry leader in upgrading capacity
- Valero's upgrading capacity provides superior operational flexibility
- Significant capital investment and long lead time required to add conversion capacity
- No significant growth in conversion capacity expected until at least '07 to '09 time period

Regulatory Changes Impacting Supply

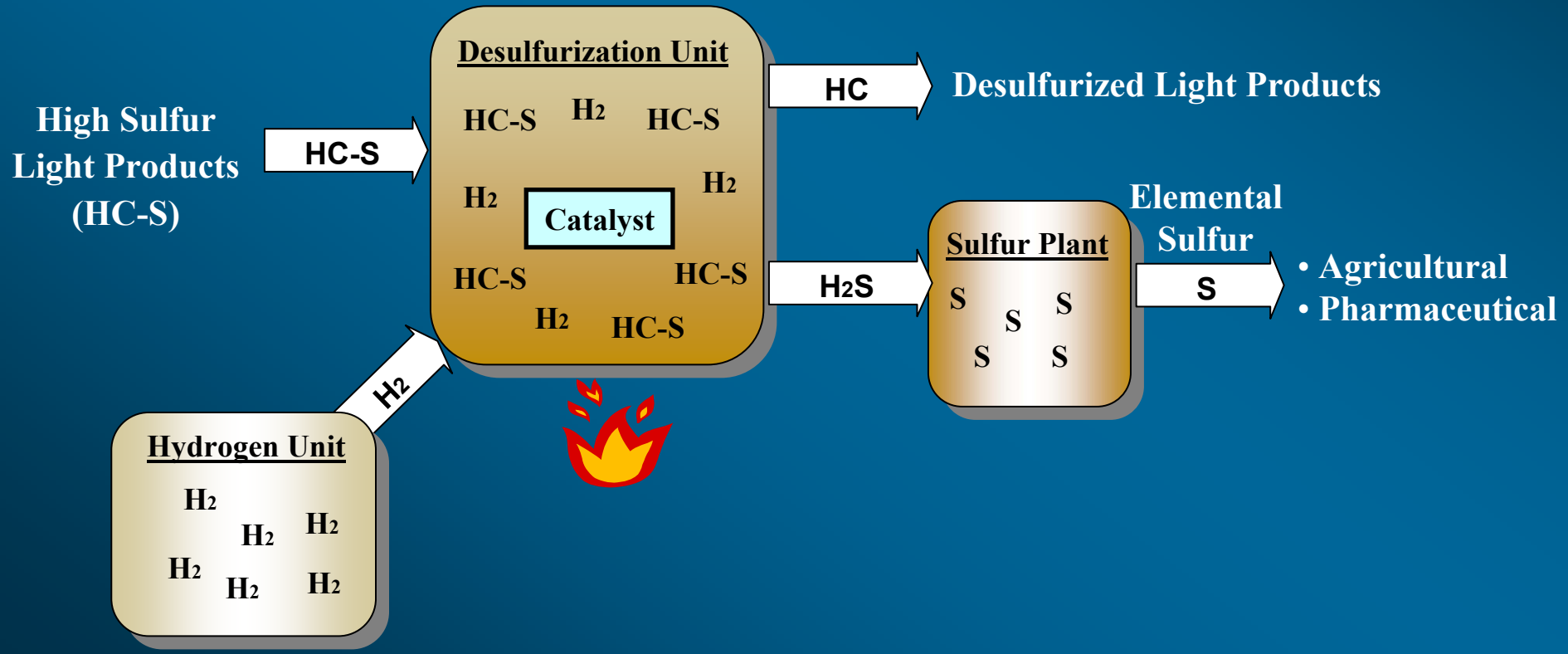




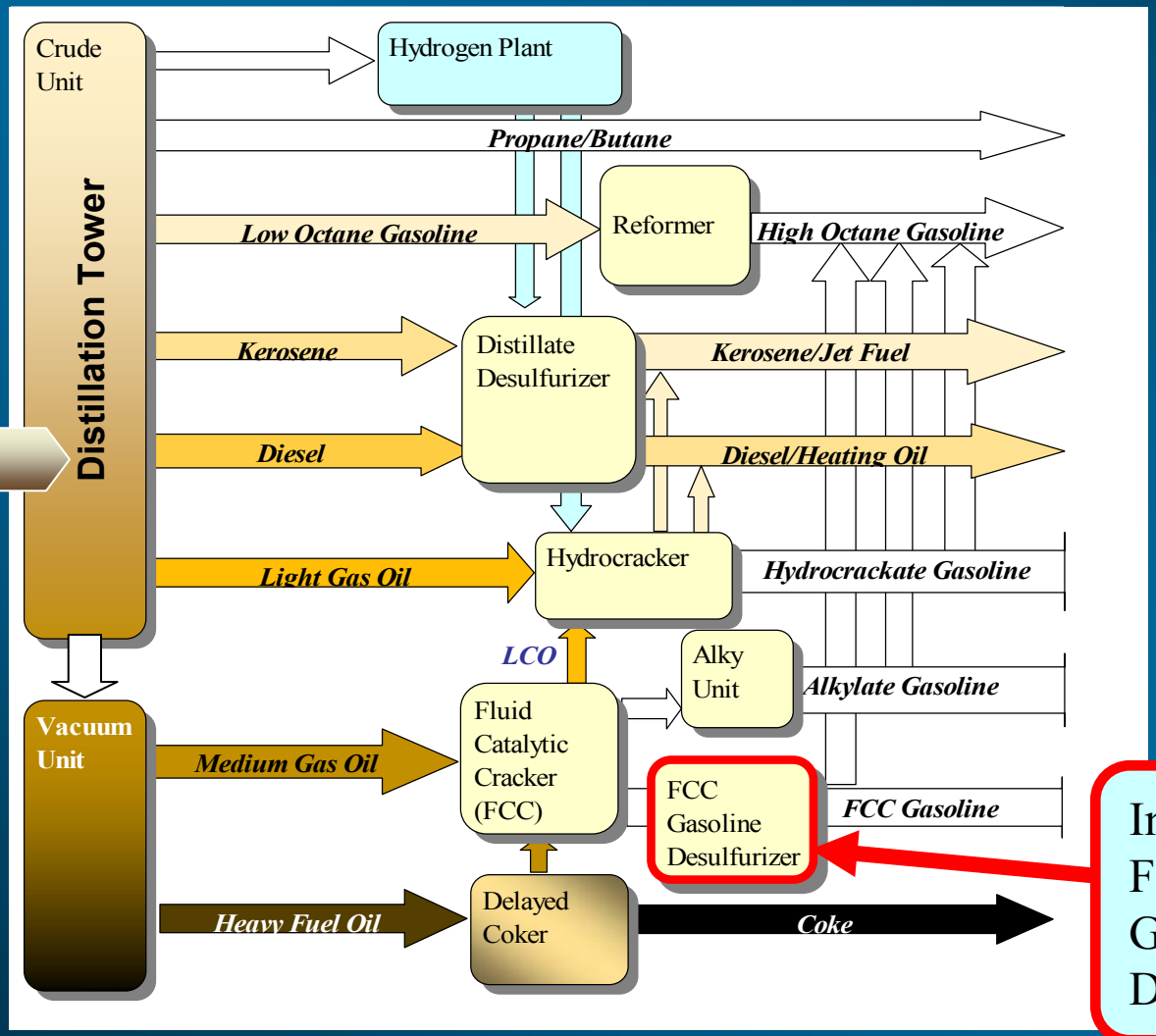
- Major changes in sulfur specs
  - 2005 in Europe and 2006 in U.S.
- Capital diverted to regulatory compliance rather than capacity increases
- U.S. Refining Industry expected to invest around $20 billion for Tier II

Desulfurization Basics

- **Goal**
  - Removal sulfur from light products (gasoline or diesel) to meet air quality requirements for clean burning fuels
- **Process**

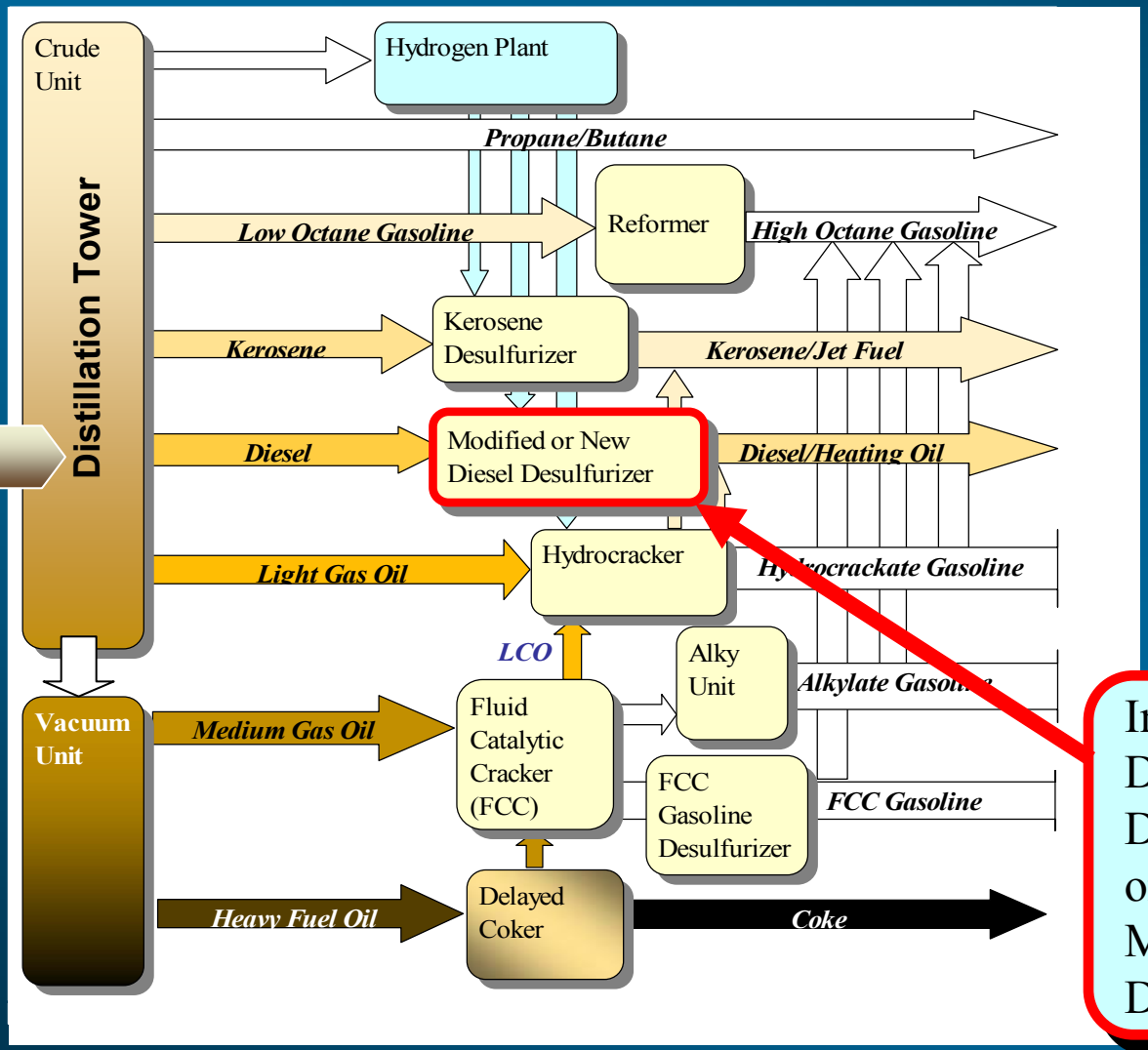


Gasoline Desulfurization



- Significant capital investment
- Lower FCC gasoline octane (yield loss)
- Other Options
  - Desulfurize FCC feed
  - Shift FCC gasoline into distillate

Diesel Desulfurization



Sour Crude

- Significant capital investment
- Significant project management time and focus
- Diesel yield loss

Install New Diesel Desulfurizer or Modify Existing Desulfurizer

Summary

Industry Environment

- Increasing global demand for clean products
- Regulatory changes limiting supply
  - Reduced yields
  - Capital spending focused on upgrading existing products versus capacity increase
- Increasing availability of lower quality crudes

Refiner's Challenges

- Process lowest cost crudes into highest value products
- Ensure compliance with changing regulatory requirements
- Improve efficiency to offset rising per barrel operating costs

Appendix

Major Refining Processes

Category	Definition	Process
Topping (Separation of Crude)	Separating crude oil into difference hydrocarbon groups. The most common means is through distillation.	Desalting – Prior to distillation, crude oil is often desalted to remove corrosive salts as well as metals and other suspended solids. Atmospheric Distillation – Used to separate the desalted crude into specific hydrocarbon groups (straight run gasoline, naphtha, light gas oil, etc.) or fractions. Vacuum Distillation – Heavy crude residue ("bottoms") from the atmospheric column is further separated using a lower-pressure distillation process. Means to lower the boiling points of the fractions and permit separation at lower temperatures, without decomposition and excessive coke formation.

Major Refining Processes

Category	Definition	Process
Thermal and Catalytic Cracking	"Cracking" or breaking down large, heavy hydrocarbon molecules into smaller hydrocarbon molecules thru application of heat or thru the use of catalysts.	Coking – Thermal non-catalytic cracking process that converts low value oils to higher value gasoline, gas oils and marketable coke. Residual fuel oil from vacuum distillation column is typical feedstock. Visbreaking – Thermal non-catalytic process used to convert large hydrocarbon molecules in heavy feedstocks to lighter products such as fuel gas, gasoline, naphtha and gas oil. Produces sufficient middle distillates to reduce the viscosity of the heavy feed. Catalytic Cracking – A central process in refining where heavy gas oil range feeds are subjected to heat in the presence of catalyst and large molecules crack into smaller molecules in the gasoline and surrounding ranges. Catalytic Hydrocracking – Like cracking, used to produce blending stocks for gasoline and other fuels from heavy feedstocks. Introduction of hydrogen in addition to a catalyst allows the cracking reaction to proceed at lower temperatures than in catalytic cracking, although pressures are much higher.

Major Refining Processes

Category	Definition	Process
Combination/ Rearrangement of Hydrocarbons	Linking two or more hydrocarbon molecules together to form a large molecule (e.g. converting gases to liquids).	Alkylation – Important process to upgrade light olefins to high-value gasoline components. Used to combine small molecules into large molecules to produce a higher octane product for blending with gasoline. Catalytic Reforming – The process where naphthas are changed chemically to increase their octane numbers. Octane numbers are measures of whether a gasoline will knock in an engine. The higher the octane number, the more resistance to pre or self-ignition. Polymerization – Process that combines smaller molecules to produce high octane blending stock. Isomerization – Process used to produce compounds with high octane for blending into the gasoline pool. Also used to produce isobutene, an important feedstock for alkylation. Ethers Manufacture – Alcohols and ethers (MTBE) are added to gasoline to increase octane levels and reduce generation of carbon monoxide.

Major Refining Processes

Category	Definition	Process
Treating	Processing of petroleum products to remove some of the sulfur, nitrogen, heavy metals and other impurities	Catalytic Hydrotreating, Hydroprocessing, sweeting/sulfur removal – Used to remove impurities (e.g. sulfur, nitrogen, oxygen and halides) from petroleum fractions. Hydrotreating further "upgrades" heavy feeds by converting olefins and diolefins to parafins, which reduces gum formation in fuels. Hydroprocessing also cracks heavier products to lighter, more saleable products.