APPENDIX

F. Valero Presentation: Benicia Refinery Tour - July 9, 2007

36 Pages

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Benicia Refinery Tour

July 9, 2007

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Agenda

- Basics of Refining
- Desulfurization
- Hydrocracking
- Valero Refining System
- Benicia Refinery Operations
- CARB Gasoline with 10% Ethanol
- Plant Tour

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Rich Marcogliese

Executive Vice President

Refining Operations

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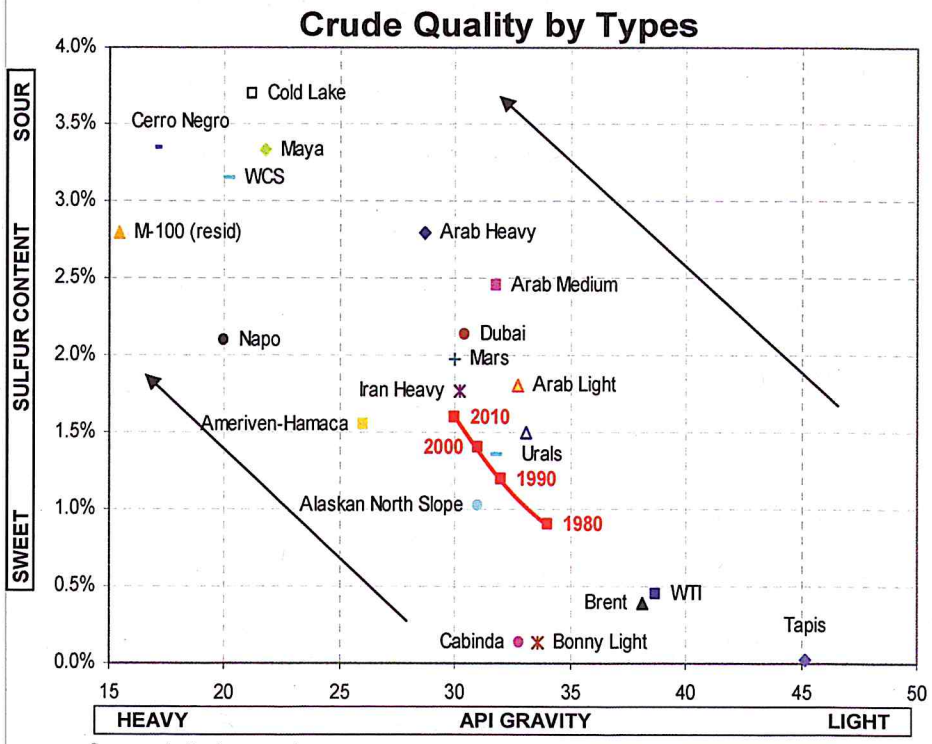
Crude Oil Characteristics

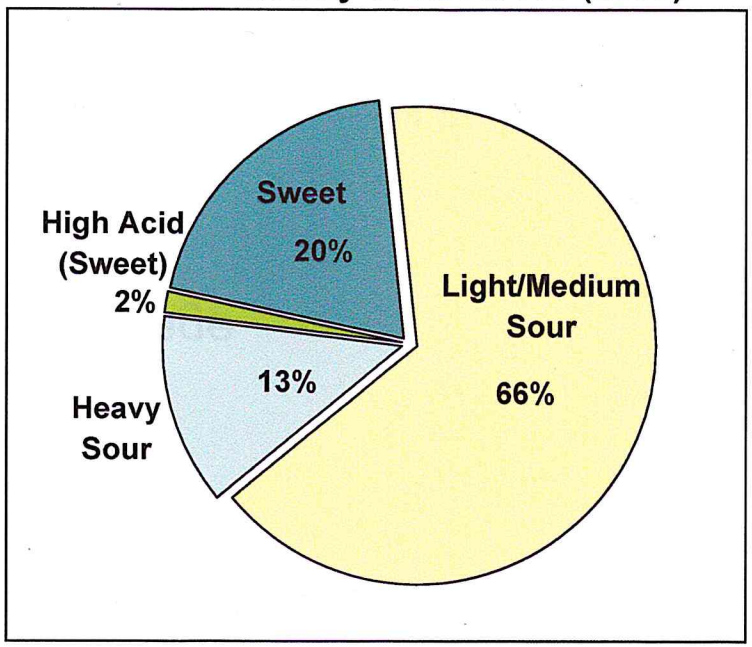
- Crudes are classified and priced by density and sulfur content
- Crude density is commonly measured by API gravity
  - API gravity provides a relative measure of crude oil density
  - The higher the API number, the lighter the crude
    - Light crudes are easier to process
    - Heavy crudes are more difficult to process
- Crude sulfur content is measured as a percentage
  - 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 is measured by Total Acid Number (TAN)
  - Acidic crudes highly corrosive to refinery equipment
  - High acid crudes are those with TAN greater than 0.7

Crude Oil Basics



Source: Industry reports

NOTE: Red line represents the average crude quality by decade (actual and projected)



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
- **Historical trend shows global crude supply becoming heavier and more sour**

What's in a Barrel of Crude Oil?

Crude Types	Characteristics	Yields
Light Sweet Crude (e.g. WTI, Brent, Saharan Blend)	> 34 API Gravity < 0.7 % Sulfur 35% Demand Most Expensive	3%, 30%, 34%, 33%
Medium Sour Crude (e.g. Mars, Arab Light, Arab Medium, Urals)	24 – 34 API Gravity > 0.7 % Sulfur 50% Demand Less Expensive	3%, 21%, 26%, 50%
Heavy Sour Crude (e.g. Maya, Cerro Negro, Cold Lake, Western Canadian Select)	< 24 API Gravity > 0.7 % Sulfur 15% Demand Least Expensive	1%, 14%, 22%, 63%

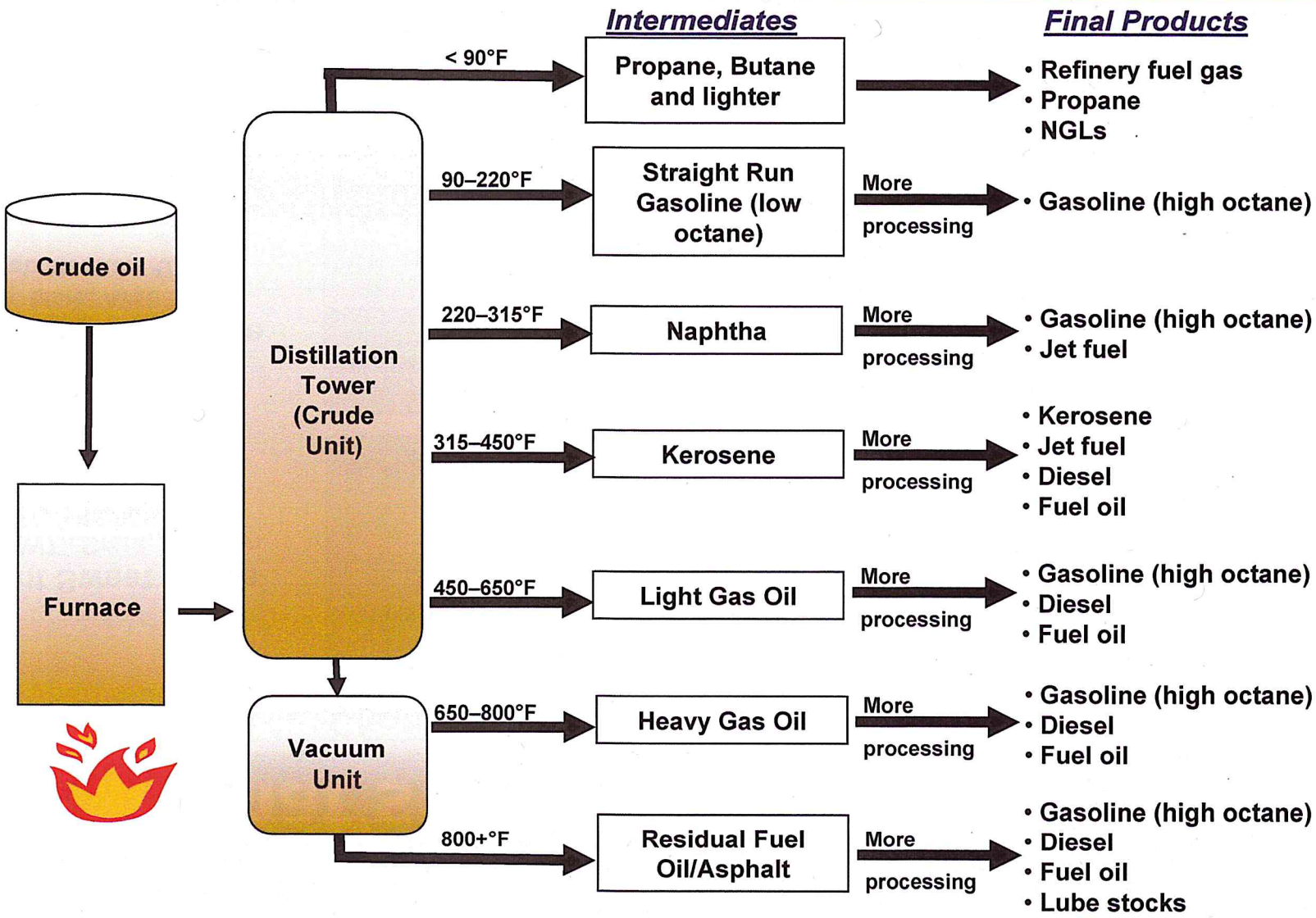
2005 U.S. Production

7%	Refinery Gases
50%	Gasoline RFG Conventional CARB Premium
33%	Distillate Jet Fuel Diesel Heating Oil
10%	Heavy Fuel Oil & Other

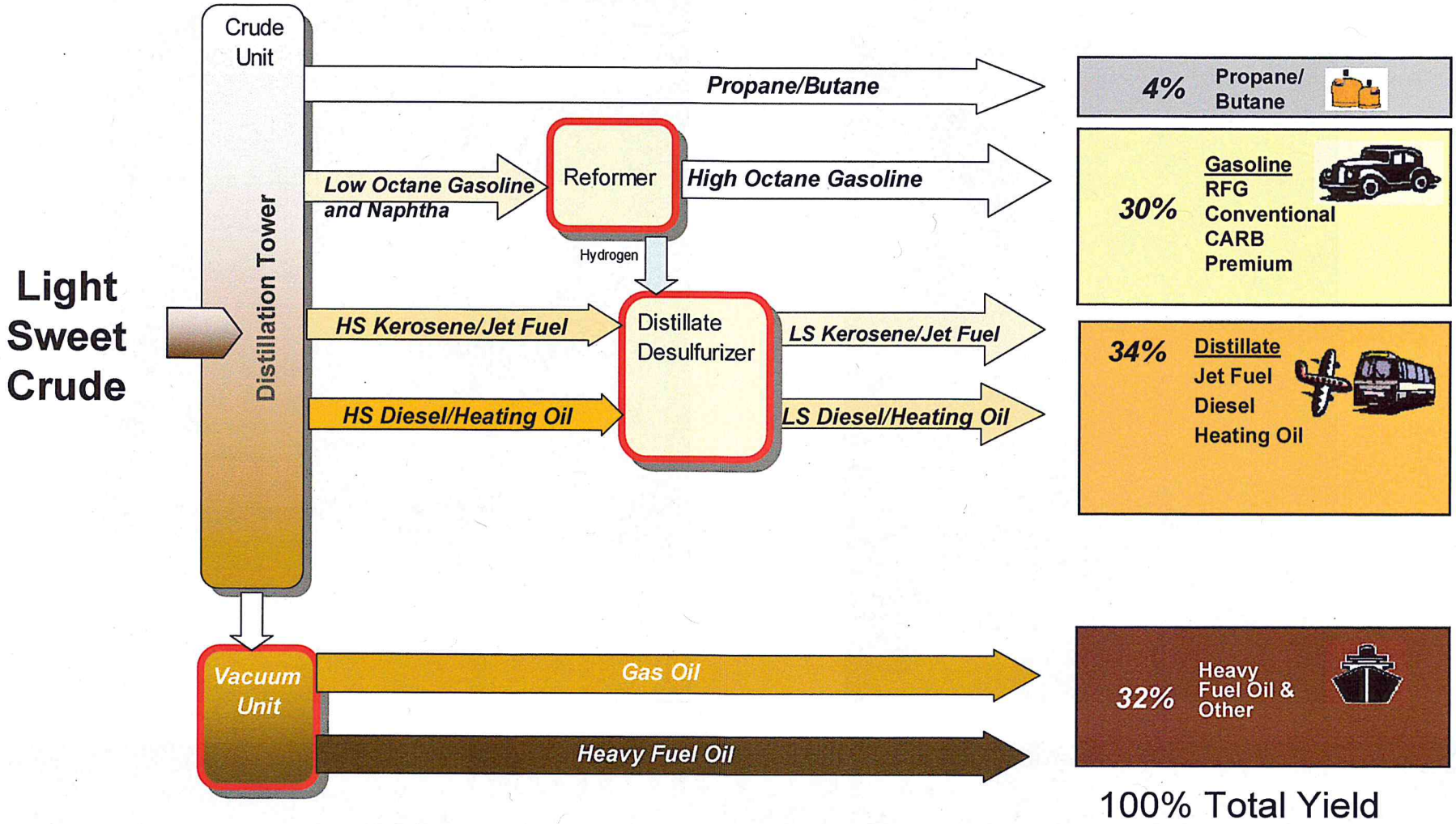
Source: EIA Refiner Production

Refineries upgrade crude oil to higher value products

Basic Refining Concepts



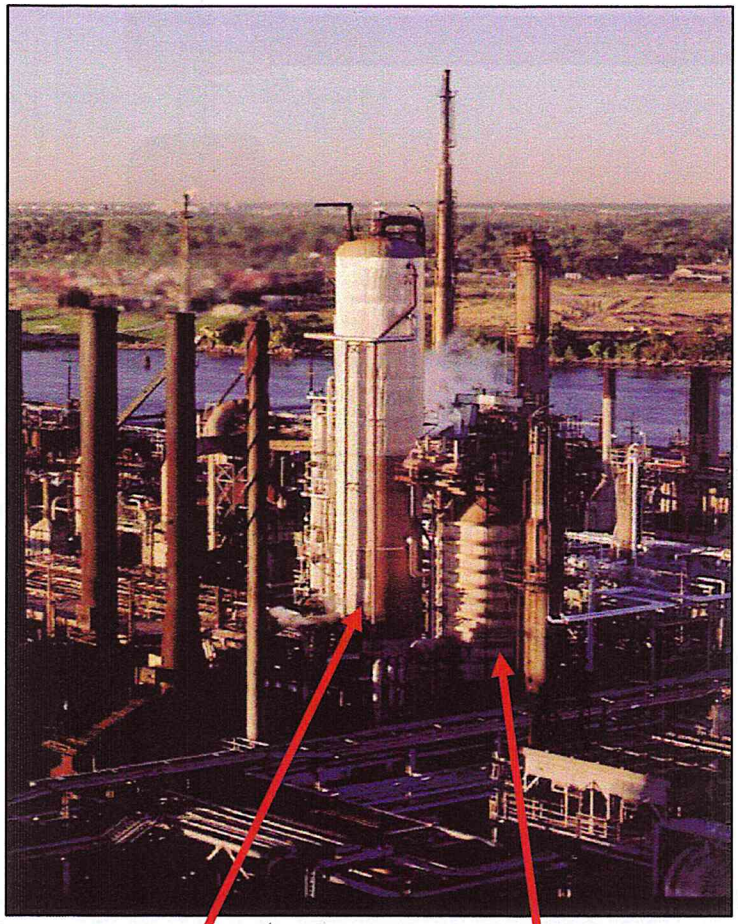
Hydroskimming/Topping Refinery



100% Total Yield

Simple, low upgrading capability refineries run sweet crude

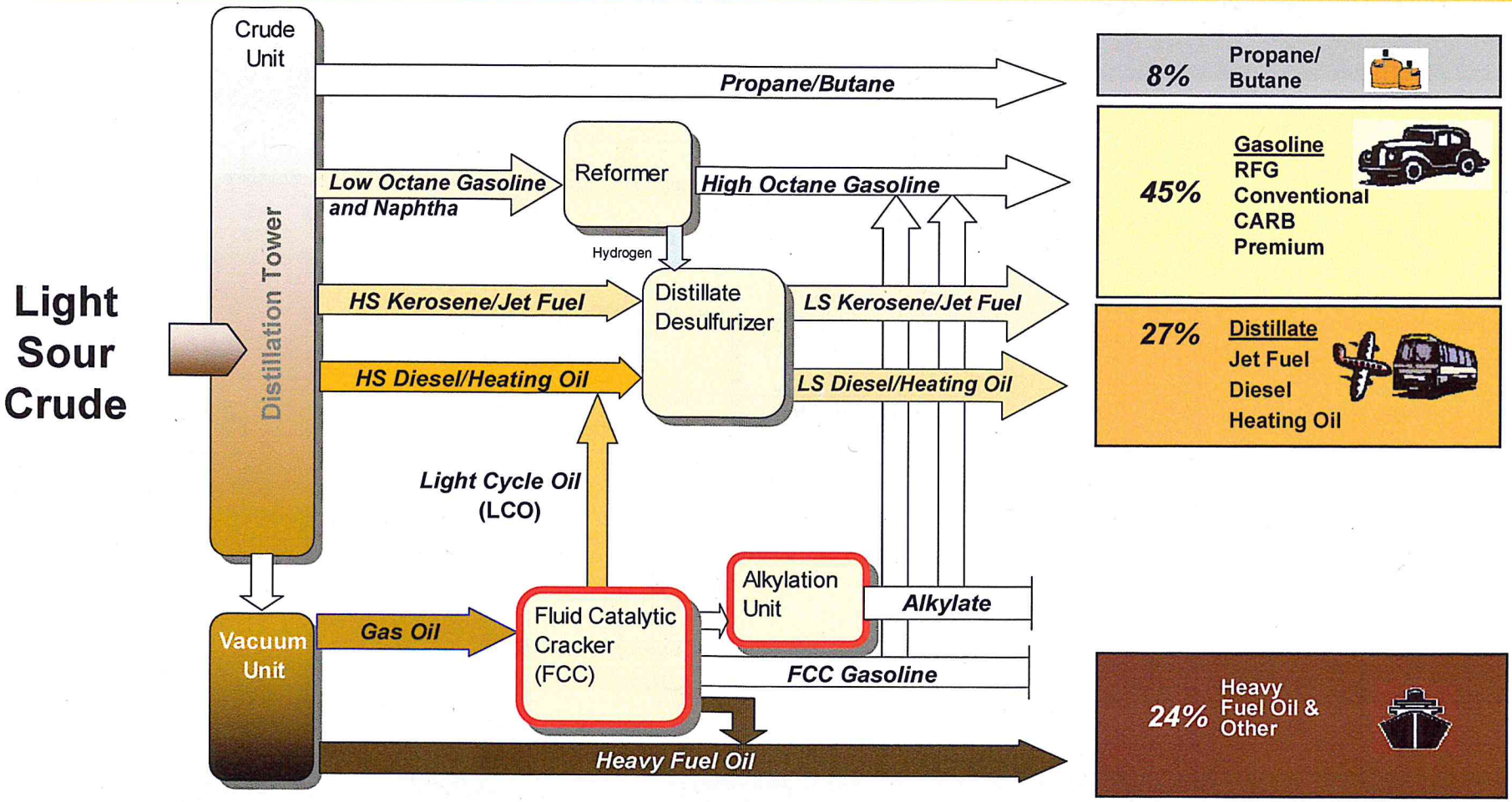
Crude and Vacuum Towers



Crude Atmospheric Tower Vacuum Tower

Reformer

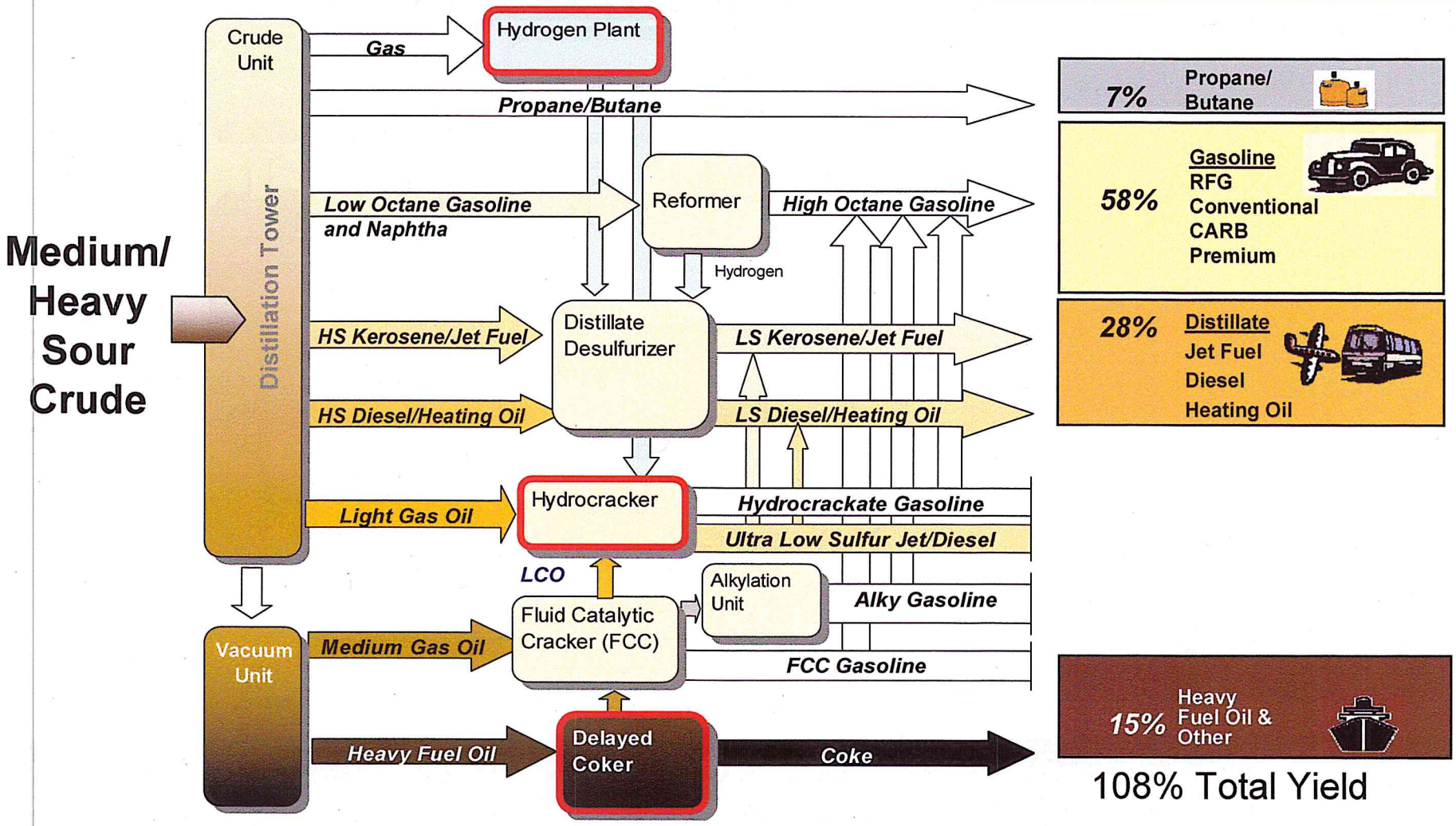
Medium Conversion: Catalytic Cracking



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: Coking/Resid Destruction



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

FCC and Hydrocracker Reactors

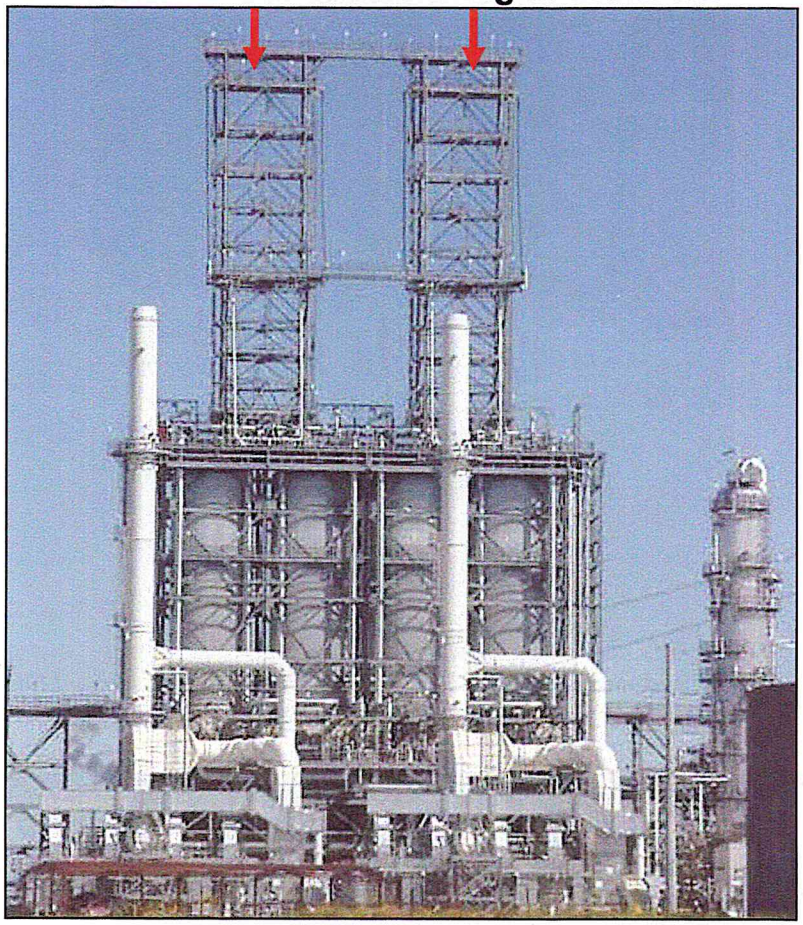
Fluidized Catalytic Cracker

Hydrocracker Reactors

Cokers

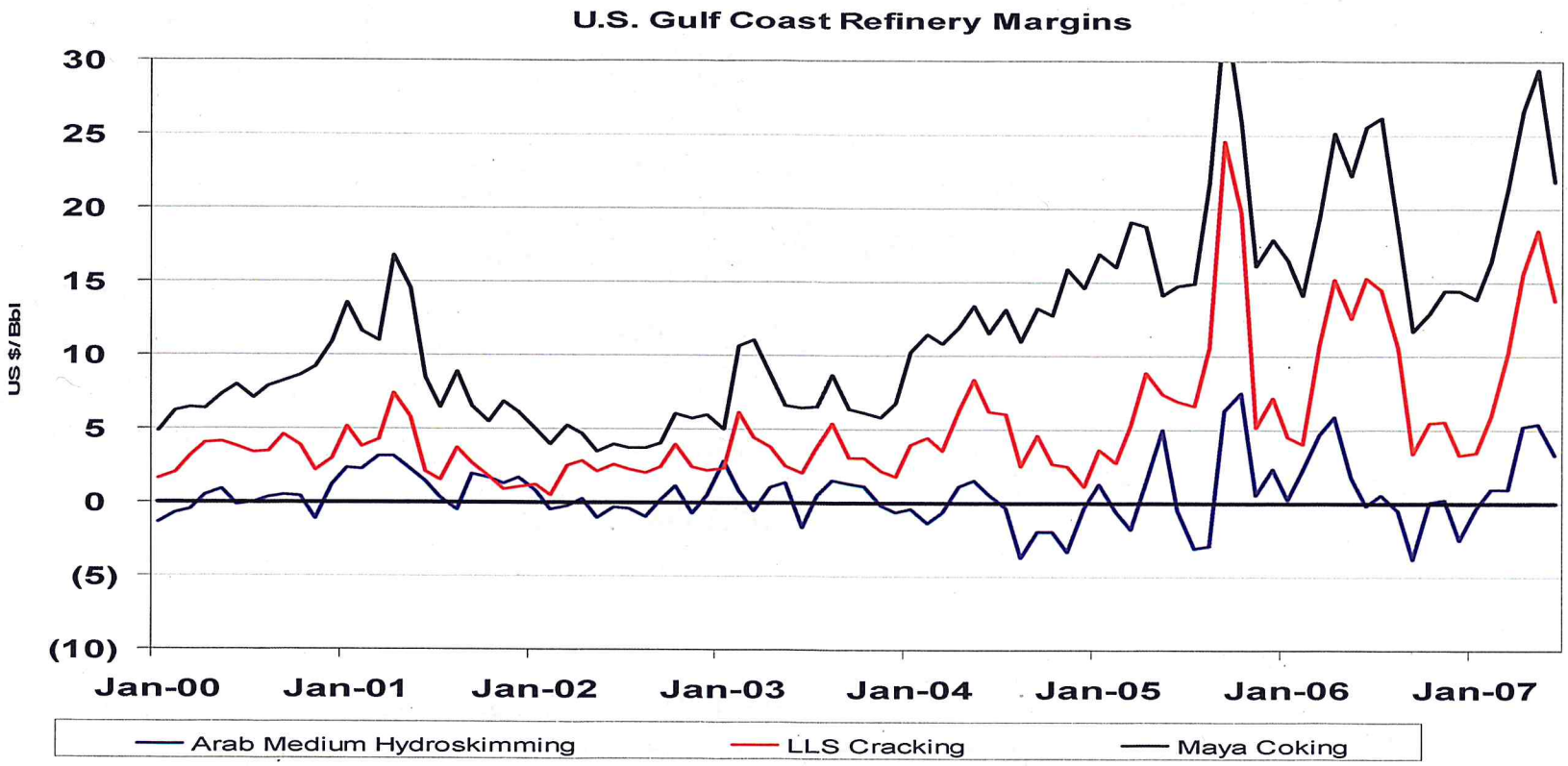
Delayed Coker

Superstructure holds the drill and drill stem while the coke is forming in the drum



Fluid Coker - Benicia

Conversion Economics

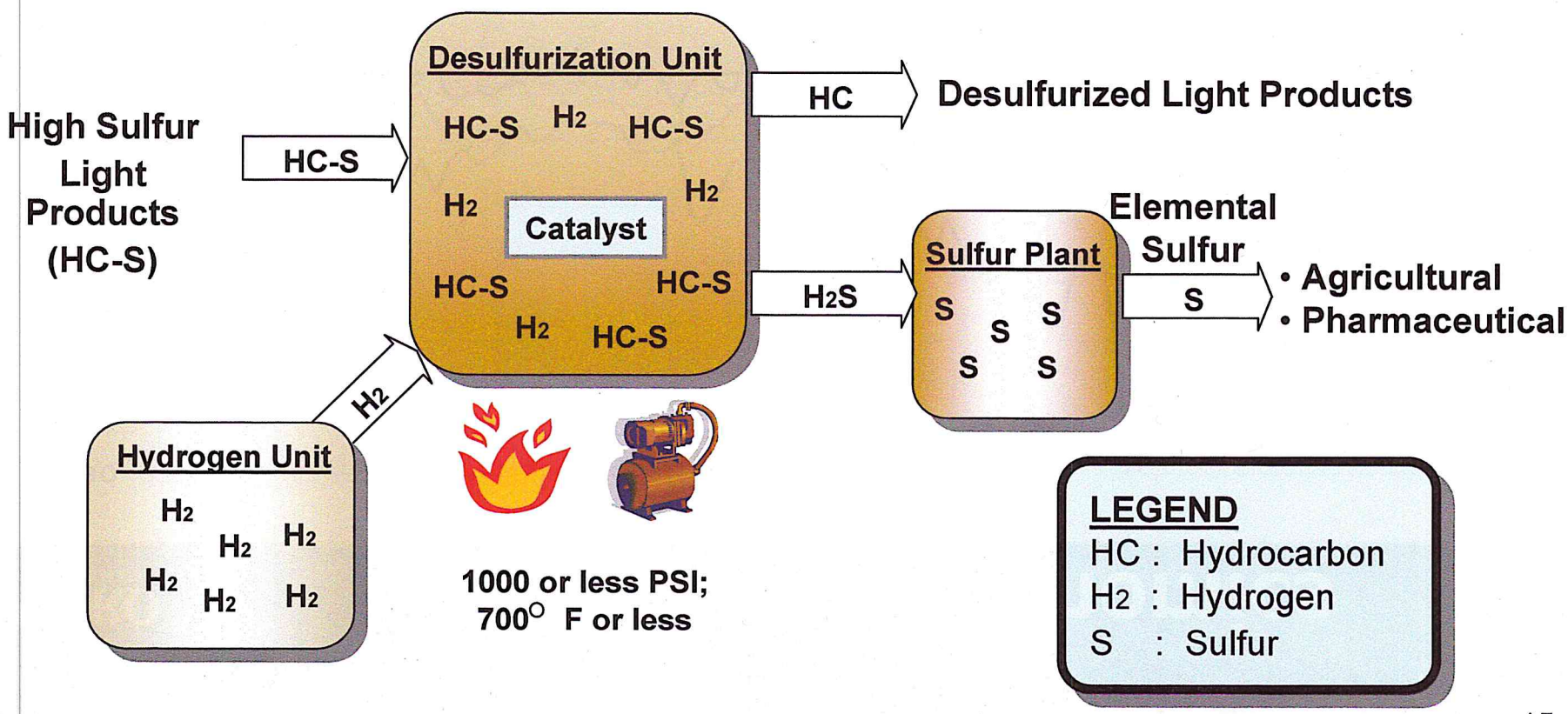


- **Need conversion capacity to capitalize on sour crude discounts**
  - Hydroskim – Breakeven or moderate margins; High resid yield
    - When margins are positive – increase crude runs
    - When margins are negative – decrease crude runs
  - Cracking – Better margins; Lower resid yield
  - Coking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

Desulfurization Basics

Objective

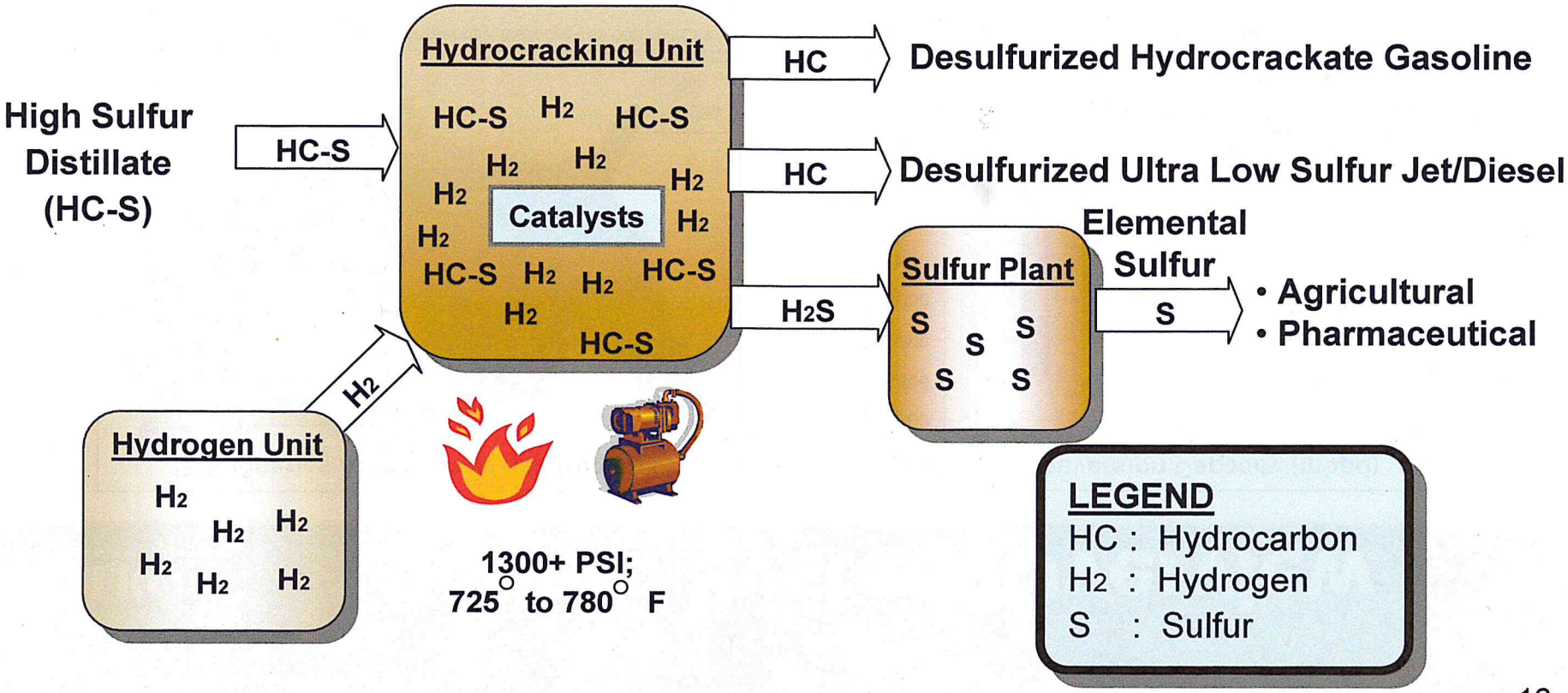
- Remove sulfur from light products (gasoline or diesel) to meet air quality requirements for clean burning fuels



Hydrocracking Basics

Objective

- Value added upgrading of high sulfur distillates to low sulfur gasoline and ultra low sulfur jet/diesel to meet air quality requirements for clean burning fuels



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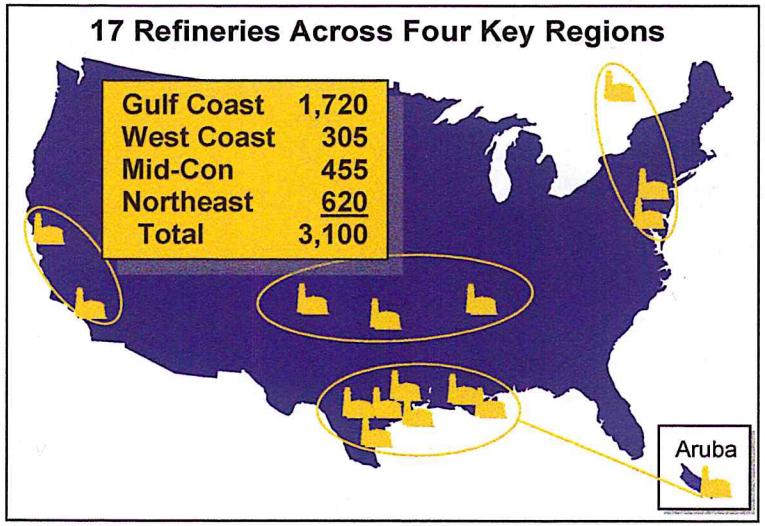
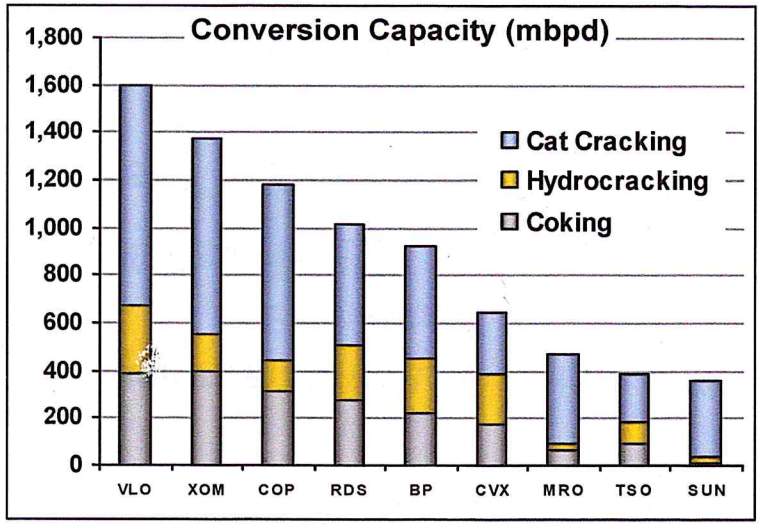
Valero System Overview



Throughput capacities in thousand barrels per day; Excludes 165,000 bpd Lima, OH refinery

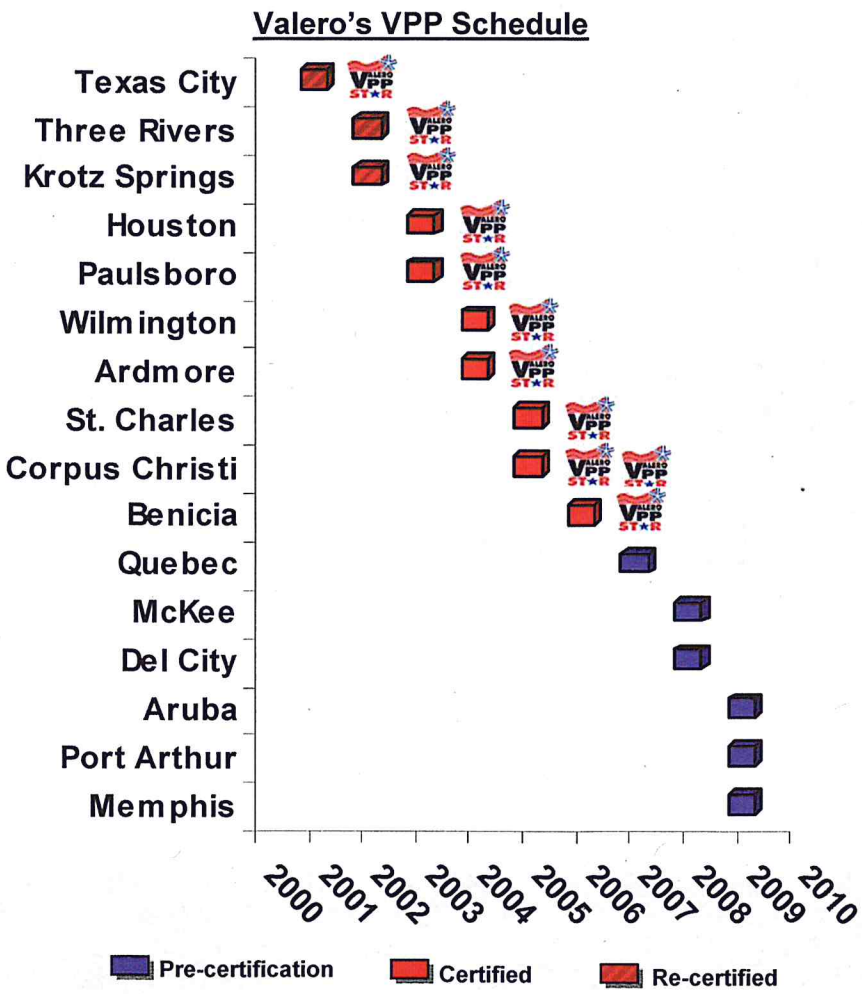


Source: Company reports; VLO figures exclude Lima, OH refinery

- 3.1 million barrels per day of throughput capacity
  - Scale helps mitigate effect of specific outages
- Geographically diverse
  - Valero participates in four key regions
- Optimization among regional refining systems

- High-complexity system and leader in conversion capacity
  - Enables us to convert more low-quality, discounted feedstocks into high-quality products
- Refining system designed for feedstock flexibility
  - Increased variety of heavy sour and resid feedstocks from 27 in 2002 to 40 in 2006

Valero's Commitment to Safety



- Continued commitment to OSHA's Voluntary Protection Program (VPP)
  - VPP is a recognized OSHA program for excellence in safety
  - Valero has 11 of only 23 VPP Star Sites in the U.S.
- New Process Safety Management (PSM) initiative underway
  - Created VP position in Operations to focus efforts on safety
  - Achieve best-in-class PSM at all our facilities

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Doug Comeau

Vice President

and General Manager

Benicia Refinery

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Valero Benicia Refinery

- Built by Exxon in 1969 on the site of the former Benicia Army Arsenal
- Significant modifications and upgrades have made the refinery one of the most complex and profitable refineries in the United States
- Valero acquired the refinery in 2000 and has made additional improvements since that time
- Valero acquired Huntway Refining Company in 2001

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Aerial View of Benicia

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Benicia Refinery Operations

- Recognized as an OSHA VPP Star Site September 2006
- Total throughput of 170,000 bpd
- Primary products include "CARBOB" gasoline, diesel, jet fuel, LPG, fuel oil and asphalt
- High conversion operation
  - 70%+ gasoline yield
- Located on 425 acres with 475 acre buffer zone
- Staffed by 480 full-time employees
- 200 continuing service contractors

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Benicia Feedstocks

- Crude slate includes Alaska North Slope (ANS), San Joaquin Valley (SJV) and a wide variety of other crudes
  - 80% received by ship across Refinery docks
  - 20% received by pipeline
- Shifting crude slate
  - When acquired in 2000, 80% of Benicia's crude was ANS
  - Today, less than 40% ANS
- Versatile, high-conversion facility with ability to process heavy, sour crudes
  - 35% heavy sour, 47% medium/light sour, 2% acidic sweet, 16% other
- Capable of processing imported intermediate feedstocks
- Primary utilities used include natural gas, electric power and fresh water

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Benicia Products

- California gasoline - "CARBOB"
  - 80% CARBOB distributed through pipeline system
  - 20% finished gasoline blended at Refinery terminal
- Major supplier of Military jet fuel in northern California (pipeline)
- Refinery also produces EPA diesel fuel (pipeline)
  - Ultra Low Sulfur Diesel (ULSD) Unit nearing completion
- Flexible light-ends system allows for a variety of propane and butane dispositions and minimizes external natural gas purchases (LPG's shipped by rail and truck)
- Benicia Asphalt Plant supplies 25% of northern California asphalt market (shipped by truck)

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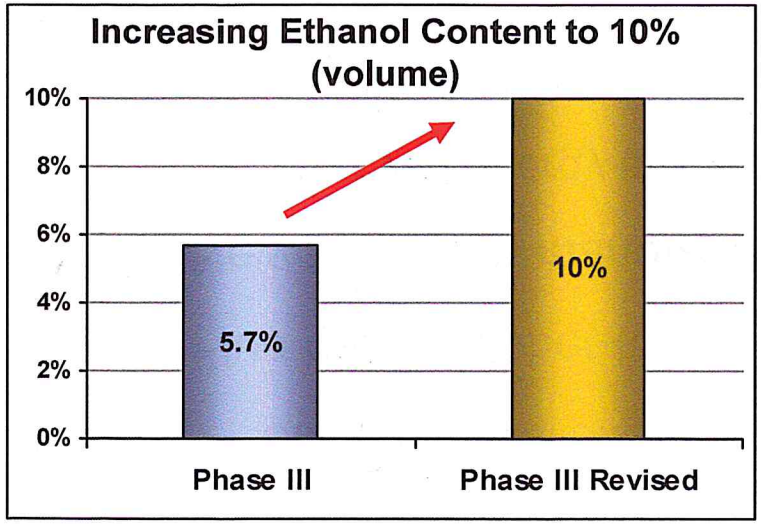
Benicia Capital Investments

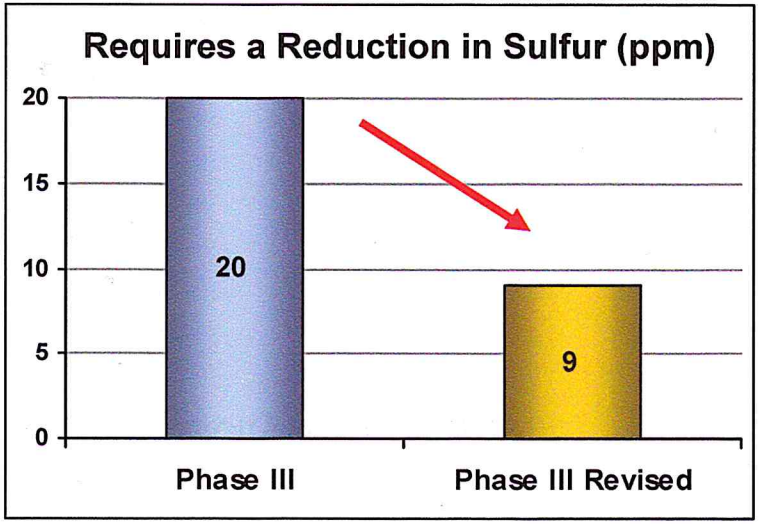
- $484 MM invested in capital improvements and $233 MM for turnaround maintenance at Benicia since Valero acquisition
- Ultra Low Sulfur Diesel Unit (ULSD) - $105 MM
- Constructing New Crude Tanks (2 – 650 MB) - $60 MM
- Major plant-wide turnaround completed in 4Q2004
- Alky expansion project commissioned in the 1Q2004 – eliminated need to export pentanes or import high octane, low vapor pressure blendstocks - $25 MM
- MTBE phase-out 2003 - $25 MM
- 51 MW cogeneration facility completed in 2002 - $60 MM

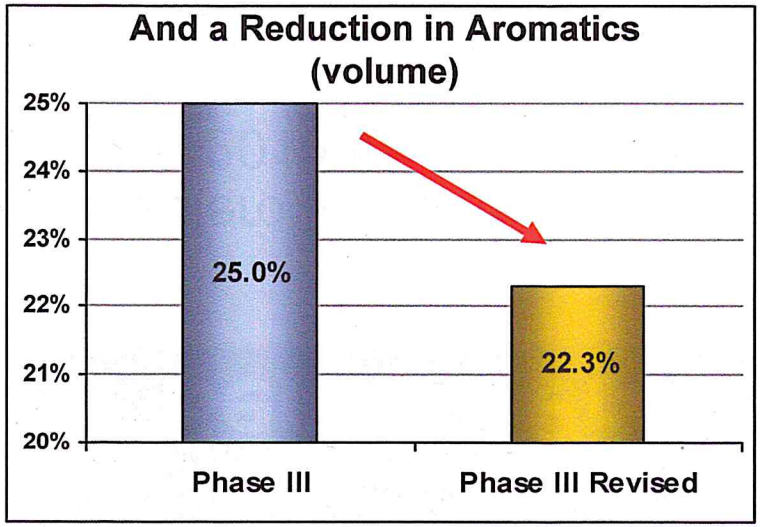
Benicia Projects in Development

- Valero Improvement Project (VIP) development under way for 2010 turnaround and beyond
  - Crude "Sour-up" to reduce dependence on ANS
    - New desalter
    - Sulfur removal and sulfur recovery capacity improvements
  - Flue gas scrubber for Coker and FCC
  - New hydrogen manufacturing unit
    - Improved energy efficiency
    - Greenhouse Gas (GHG) reduction

CARB Phase III Gasoline Model Revisions for 10% Ethanol







Depending on refinery configuration, CARB gasoline pool could be reduced by 2% to 4% net of ethanol

- Model changes drive increase in ethanol content from 5.7% to 10% by volume
- Sulfur content must be reduced to accommodate NOx increases from ethanol
- Sulfur reductions require additional hydrotreating of FCC gasoline
- Aromatics change reduces reformate blending and FCC gasoline cut points, which increases need for alkylate and raffinate

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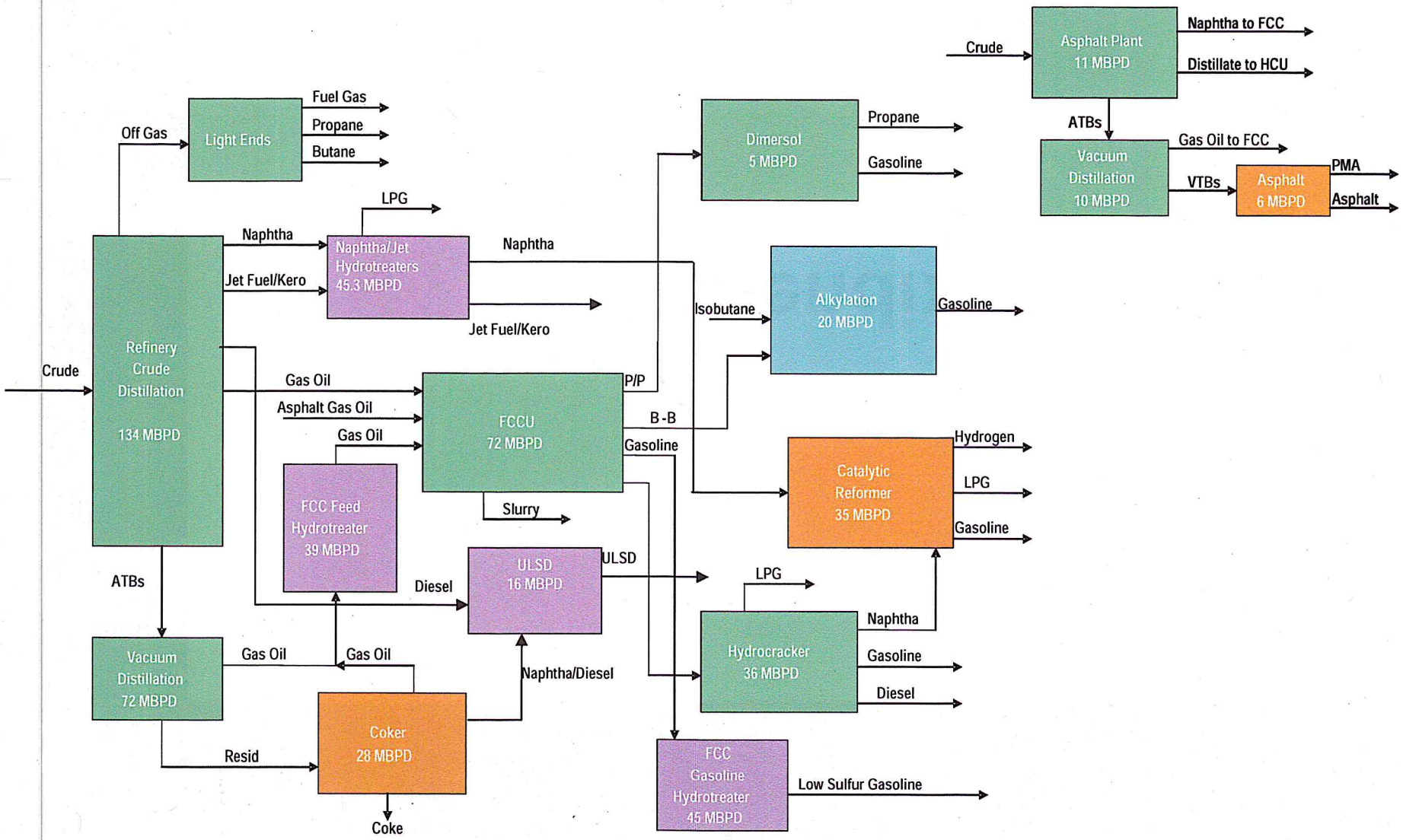
Appendix

Benicia Refinery Flow Diagram



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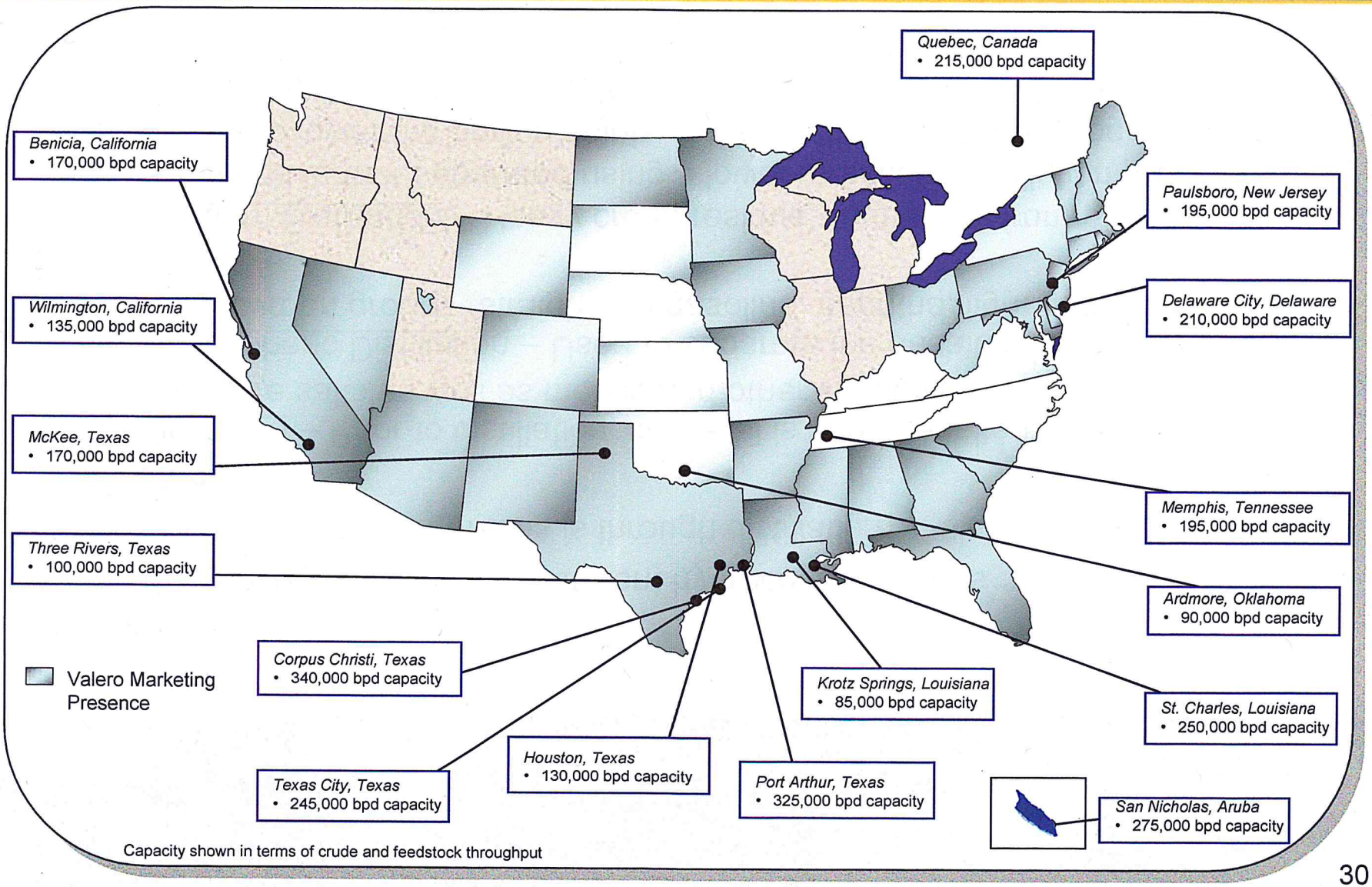
Map of Valero Refineries



Capacity shown in terms of crude and feedstock throughput

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Major Refining Processes – Topping

- **Definition**
  - Separating crude oil into different hydrocarbon groups
  - The most common means is through distillation
- **Process**
  - 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.

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Major Refining Processes – Cracking

- **Definition**
  - "Cracking" or breaking down large, heavy hydrocarbon molecules into smaller hydrocarbon molecules thru application of heat (thermal) or through the use of catalysts
- **Process**
  - 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.

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Major Refining Processes – Combination

- **Definition**
  - Linking two or more hydrocarbon molecules together to form a large molecule (e.g. converting gases to liquids) or rearranging to improve the quality of the molecule
- **Process**
  - 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 whereby 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.

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Major Refining Processes – Treating

- **Definition**
  - Processing of petroleum products to remove some of the sulfur, nitrogen, heavy metals, and other impurities.
- **Process**
  - Catalytic Hydrotreating, Hydroprocessing, sulfur/metals 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.

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List of Refining Acronyms

- AGO – Atmospheric Gas Oil
- ATB – Atmospheric Tower Bottoms
- B–B – Butane–Butylene Fraction
- BBLS – Barrels
- BPD – Barrels Per Day
- BTX – Benzene, Toluene, Xylene
- CARB – California Air Resource Board
- CCR – Continuous Catalytic Regenerator
- DAO – De–Asphalted Oil
- DCS – Distributed Control Systems
- DHT – Diesel Hydrotreater
- DSU – Desulfurization Unit
- EPA – Environmental Protection Agency
- ESP – Electrostatic Precipitator
- FCC – Fluid Catalytic Cracker
- GDU – Gasoline Desulfurization Unit
- GHT – Gasoline Hydrotreater
- GOHT – Gas Oil Hydrotreater
- GPM – Gallon Per Minute
- HAGO – Heavy Atmospheric Gas Oil
- HCU – Hydrocracker Unit
- HDS – Hydrodesulfurization
- HDT – Hydrotreating
- HGO – Heavy Gas Oil
- HOC – Heavy Oil Cracker (FCC)
- H2 – Hydrogen
- H2S – Hydrogen Sulfide
- HF – Hydroflouric (adic)
- HVGO – Heavy Vacuum Gas Oil
- kV – Kilovolt
- kVA – Kilovolt Amp
- LCO – Light Cycle Oil
- LGO – Light Gas Oil
- LPG – Liquefied Petroleum Gas
- LSD – Low Sulfur Diesel
- LSR – Light Straight Run (Gasoline)
- MON – Motor Octane Number
- MTBE – Methyl Tertiary–Butyl Ether
- MW – Megawatt
- NGL – Natural Gas Liquids
- NO_X – Nitrogen Oxides
- P–P – Propane–Propylene
- PSI – Pounds per Square Inch
- RBOB – Reformulated Blendstock for Oxygen Blending
- RDS – Resid Desulfurization
- RFG – Reformulated Gasoline
- RON – Research Octane Number
- RVP – Reid Vapor Pressure
- SMR – Steam Methane Reformer (Hydrogen Plant)
- SO_X – Sulfur Oxides
- SRU – Sulfur Recovery Unit
- TAME – Tertiary Amyl Methyl Ether
- TAN – Total Acid Number
- ULSD – Ultra–low Sulfur Diesel
- VGO – Vacuum Gas Oil
- VOC – Volatile Organic Compound
- VPP – Voluntary Protection Program
- VTB – Vacuum Tower Bottoms
- WTI – West Texas Intermediate
- WWTP – Waste Water Treatment Plant

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