

# Transportation Fuels: Supplying the Nation

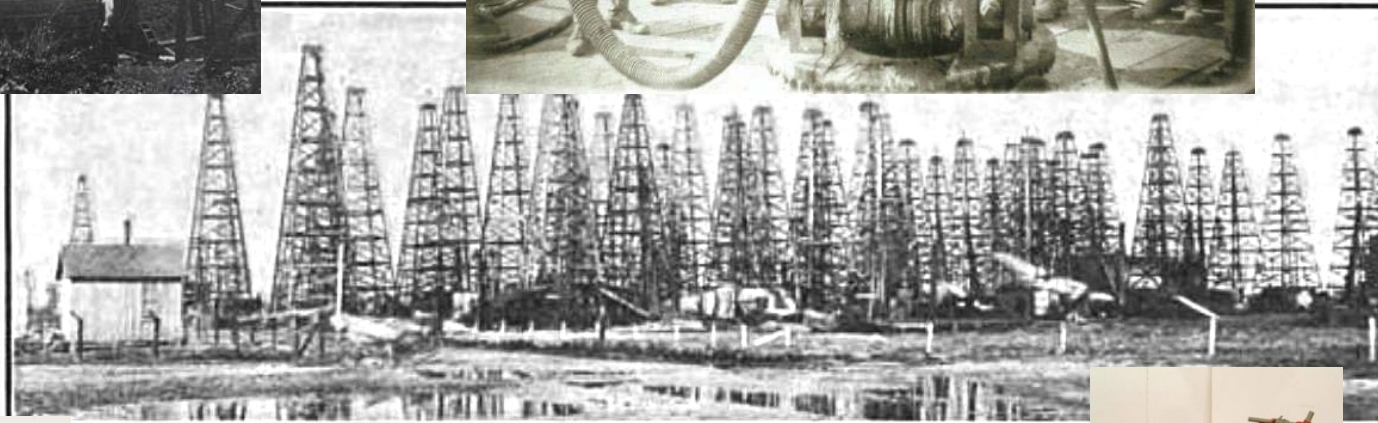
Presented to National Conference on Weights and Measures  
July 17-20, 2017

Prentiss Searles, American Petroleum Institute  
Russ Lewis, Marathon Petroleum  
Kevin Ferrick, American Petroleum Institute

# The Start



Woodford well and  
Phillips well, Titusville,  
PA (1862)



Spindle Top, TX (1903)

Martin Oil Co. (1909)

[www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania.html](http://www.priweb.org/ed/pgws/history/pennsylvania/pennsylvania.html)  
[www.martinoilco.com/reighards](http://www.martinoilco.com/reighards)  
[www.thestoryoftexas.com/discover/campfire-stories/roughneck](http://www.thestoryoftexas.com/discover/campfire-stories/roughneck)  
[commons.wikimedia.org/wiki/File:Spindletop\\_Oil\\_Field\\_1.jpg](https://commons.wikimedia.org/wiki/File:Spindletop_Oil_Field_1.jpg)  
[aoghs.org/transportation/first-gas-pump-and-service-stations/](http://aoghs.org/transportation/first-gas-pump-and-service-stations/)

Gasoline  
Pump (1916)

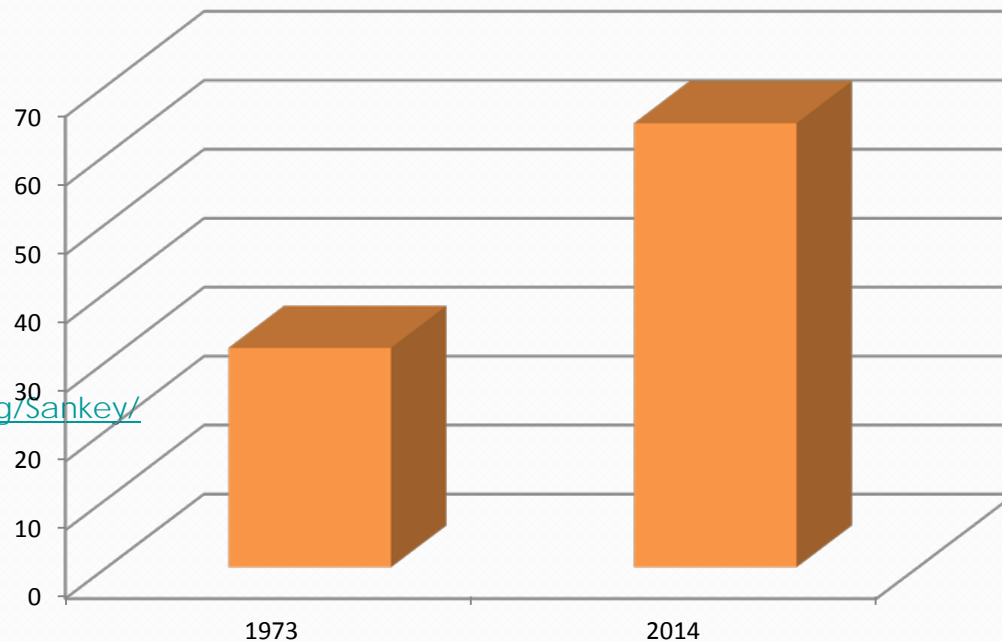


# Worldwide Energy Consumption (all energy)

1973 – 31.9 billion barrels of oil equivalent

2014 – Consumption doubles to 64.5 billion barrels of oil equivalent

**Worldwide Energy Consumption**  
**Billion barrels of oil equivalent**



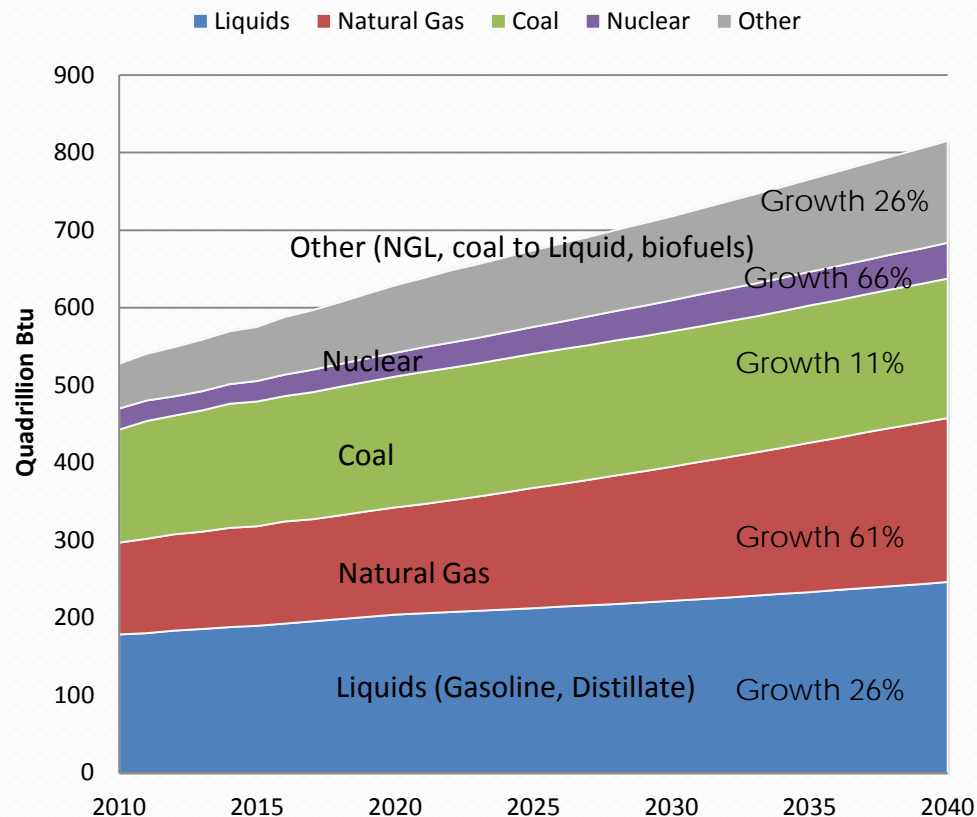
Source: IEA <http://www.iea.org/Sankey/>  
Charts by API

# Energy Outlook

Global population  
estimated 8.7 billion  
people in 2035<sup>1</sup>

According to EIA  
projections, oil and  
natural gas will supply  
more than 60 percent of  
U.S. energy needs by  
2040, even under  
optimistic scenarios for  
renewable energy  
growth<sup>2</sup>

## World Energy Consumption by Fuel<sup>3</sup>



1. <https://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2015/bp-energy-outlook-2035-booklet.pdf>
2. Jack Gerard, API State of American Energy 2017
3. Chart by Erica Bowman, API using EIA data

# Petroleum Product Supply and Refining Capacity by PADD

Petroleum Administration for Defense Districts

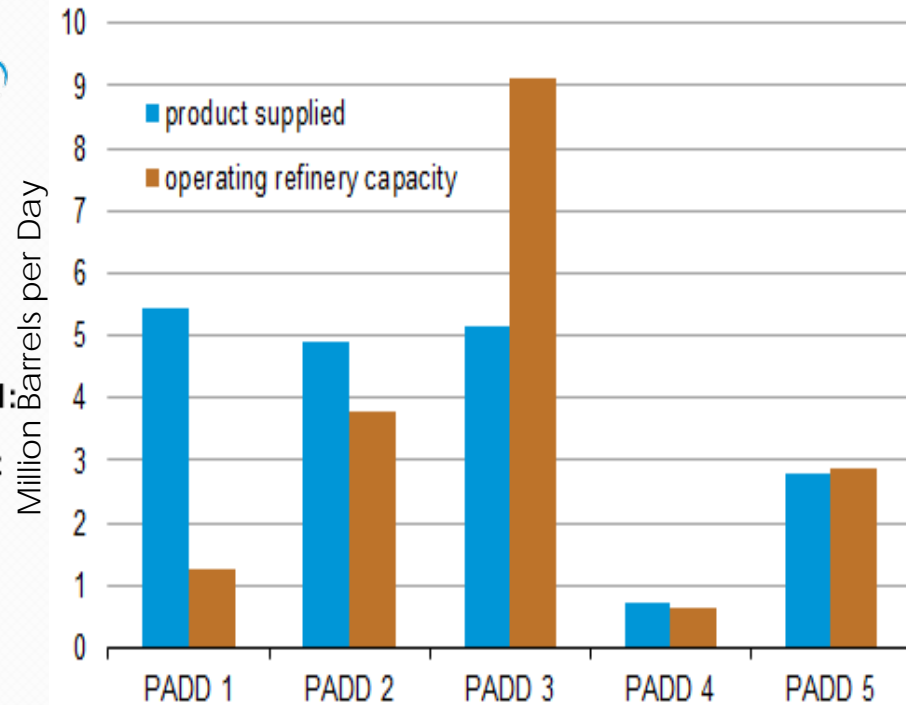
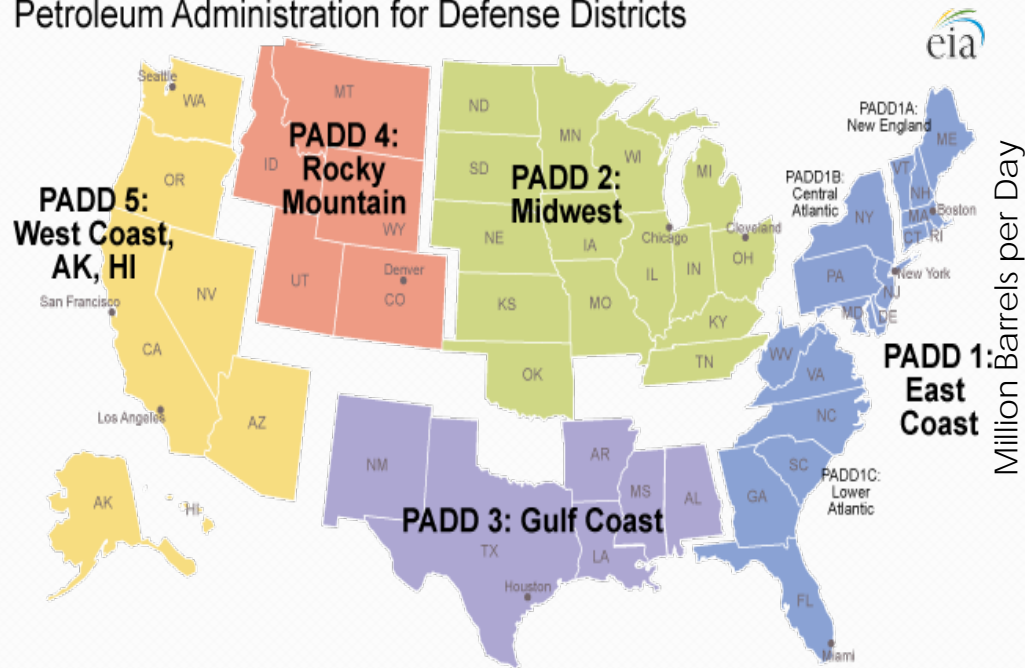


Figure 2. Petroleum product supply and refining capacity by PADD (Sept 2015)

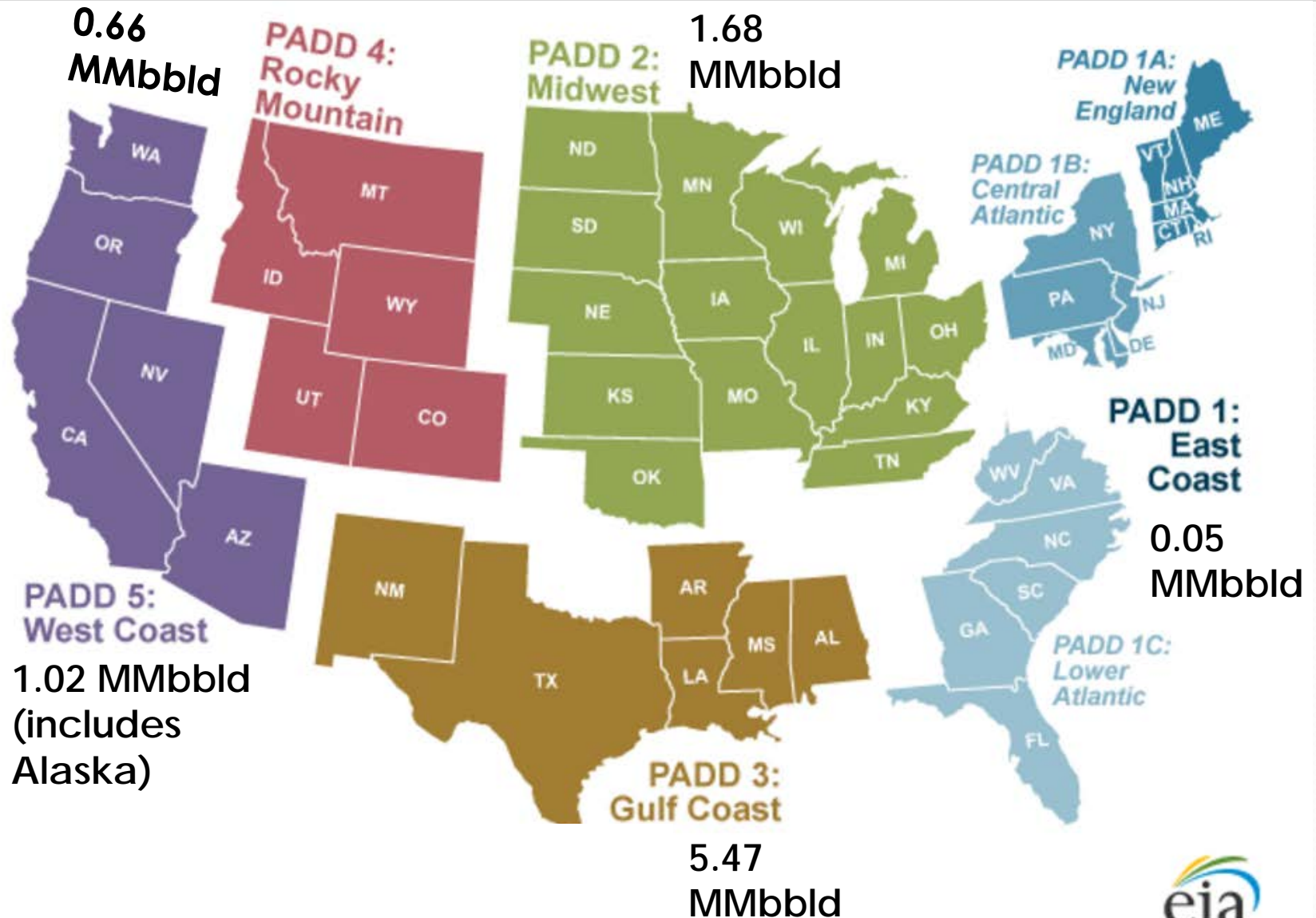
<https://www.eia.gov/todayinenergy/detail.php?id=4890>

"West Coast Transportation Fuels Markets," EIA, September 2015 (p. 4), [https://www.eia.gov/analysis/transportationfuels/padd5/pdf/transportation\\_fuels.pdf](https://www.eia.gov/analysis/transportationfuels/padd5/pdf/transportation_fuels.pdf)



# U.S. Crude Oil Production 2016

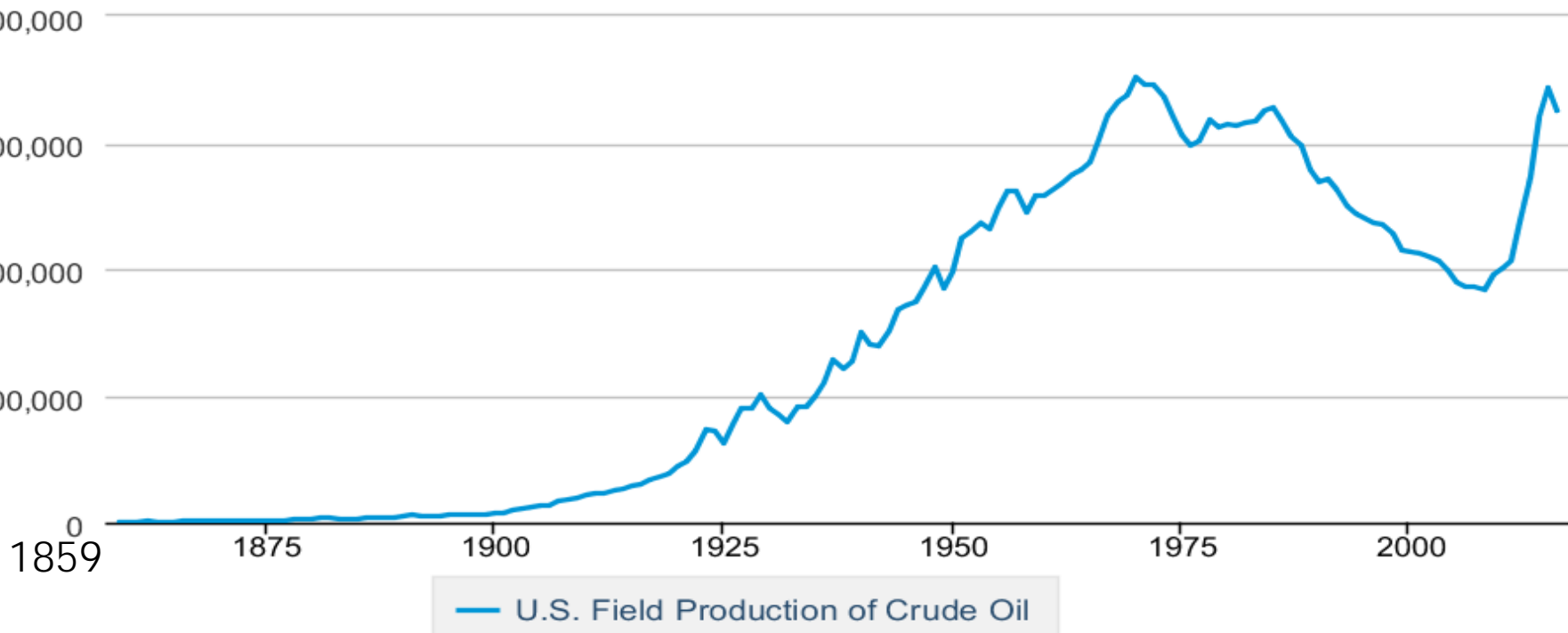
## 8.88 Million Barrels per day



# Barrels per year

## U.S. Field Production of Crude Oil

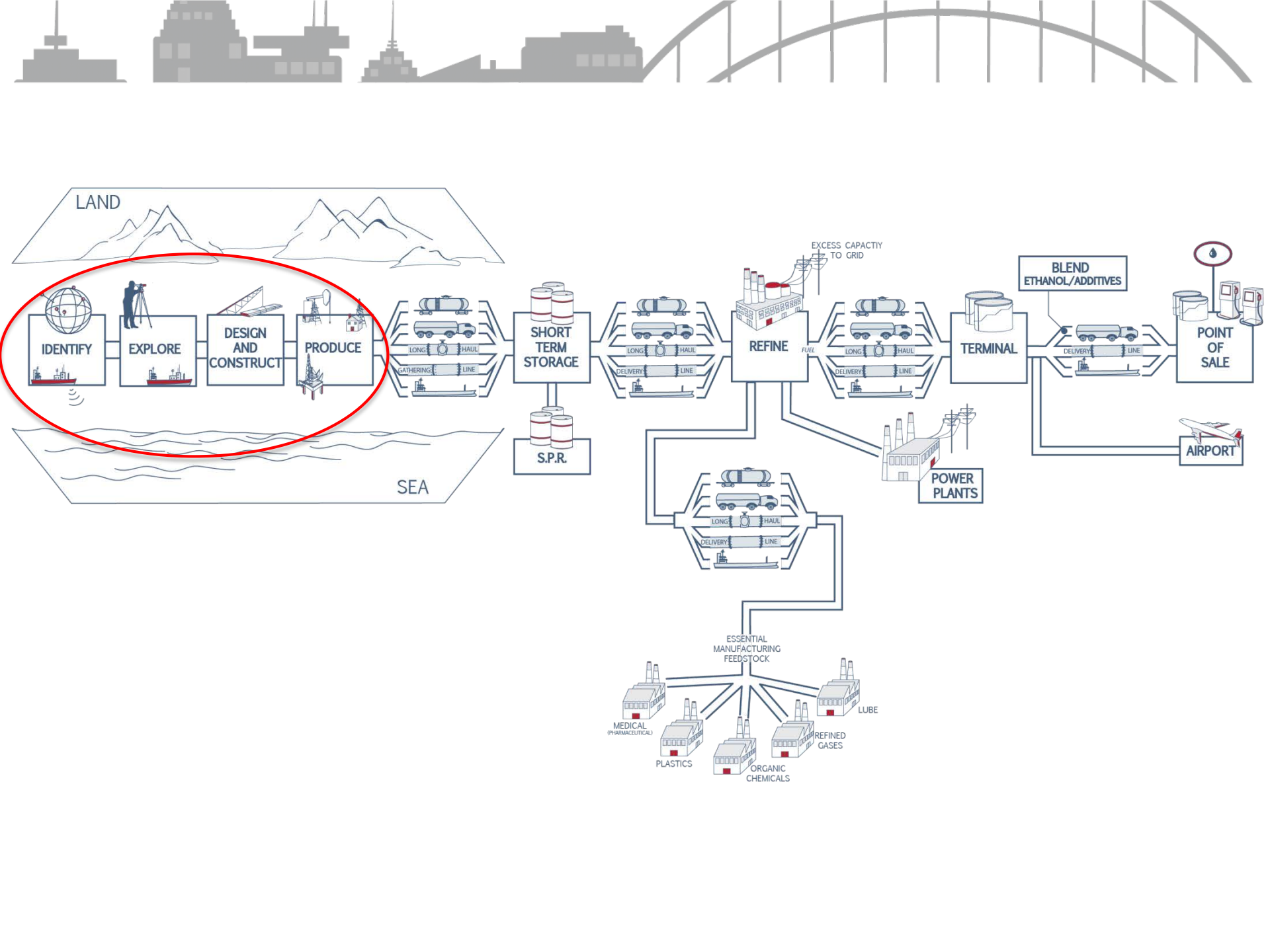
Thousand Barrels



Source: U.S. Energy Information Administration

1859 – 2,000 bbls

2016 – 3.248 Billion bbls





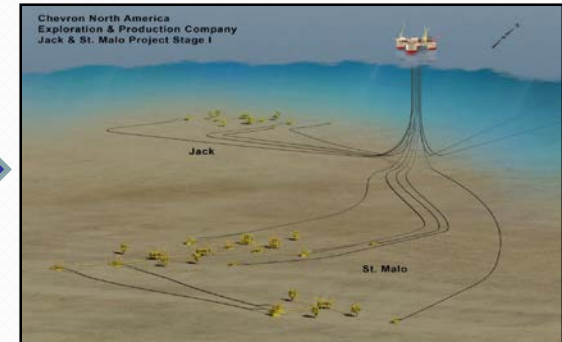
# Offshore Oil and Gas Development Life Cycle



Explore & Lease



Drill, Discover & Appraise



Plan Development



Design



Fabricate & Install



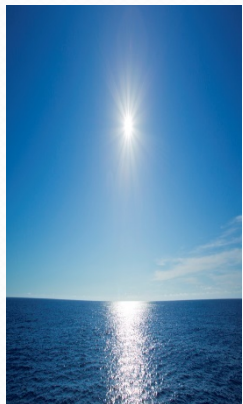
HUC, Start Up & Ramp Up



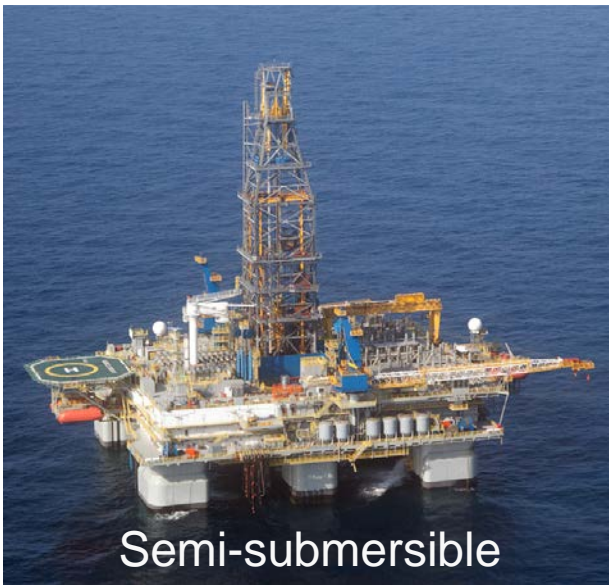
Production Operations



Decommissioning

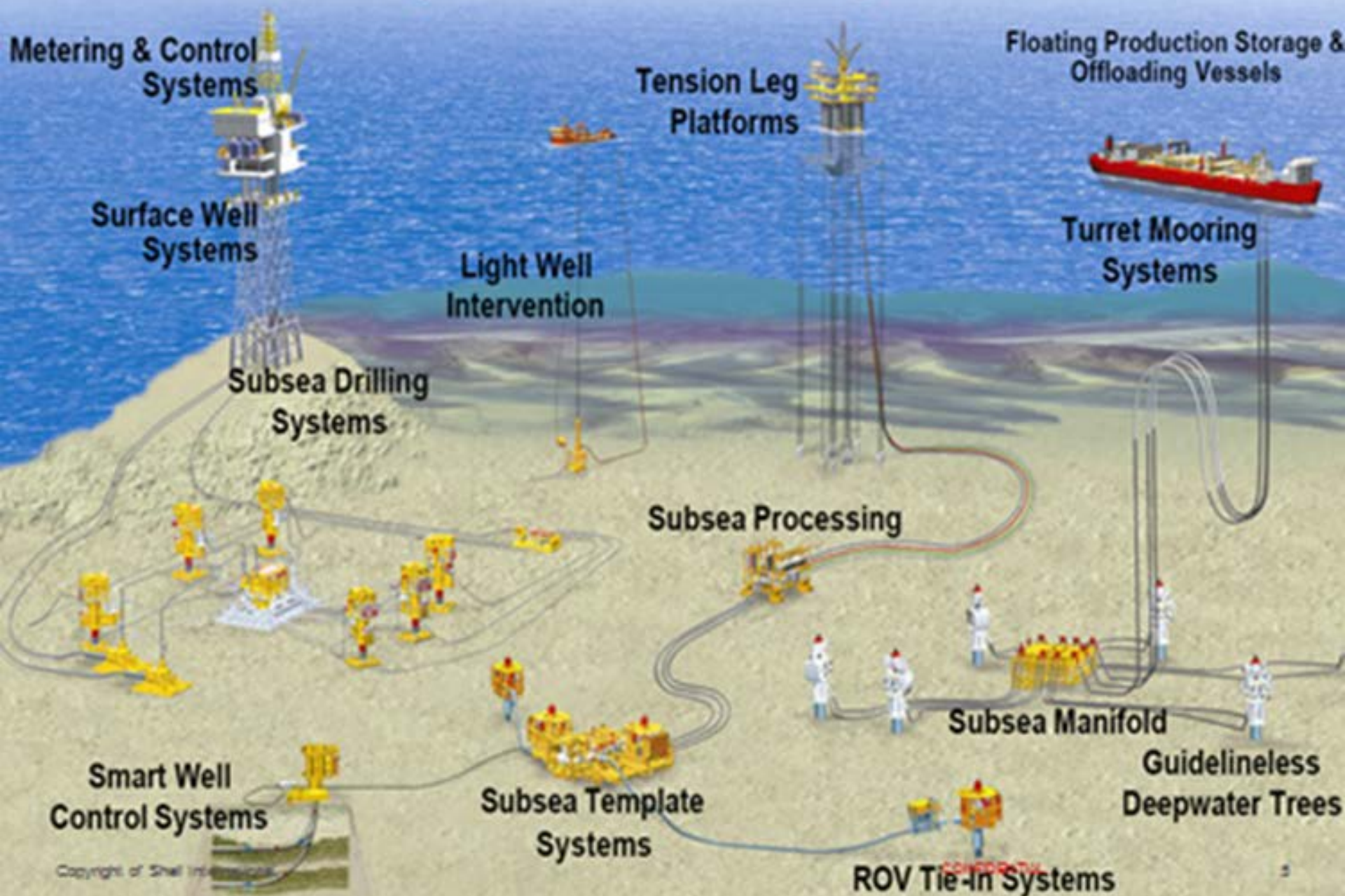


# Drilling Rig Types

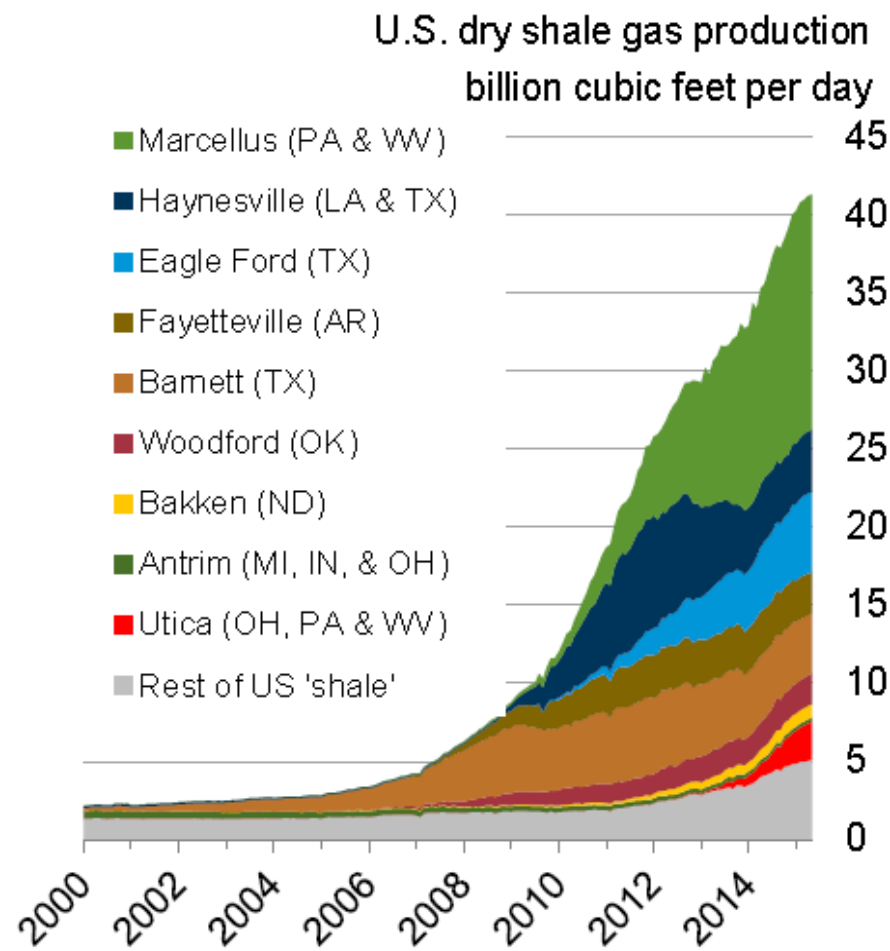
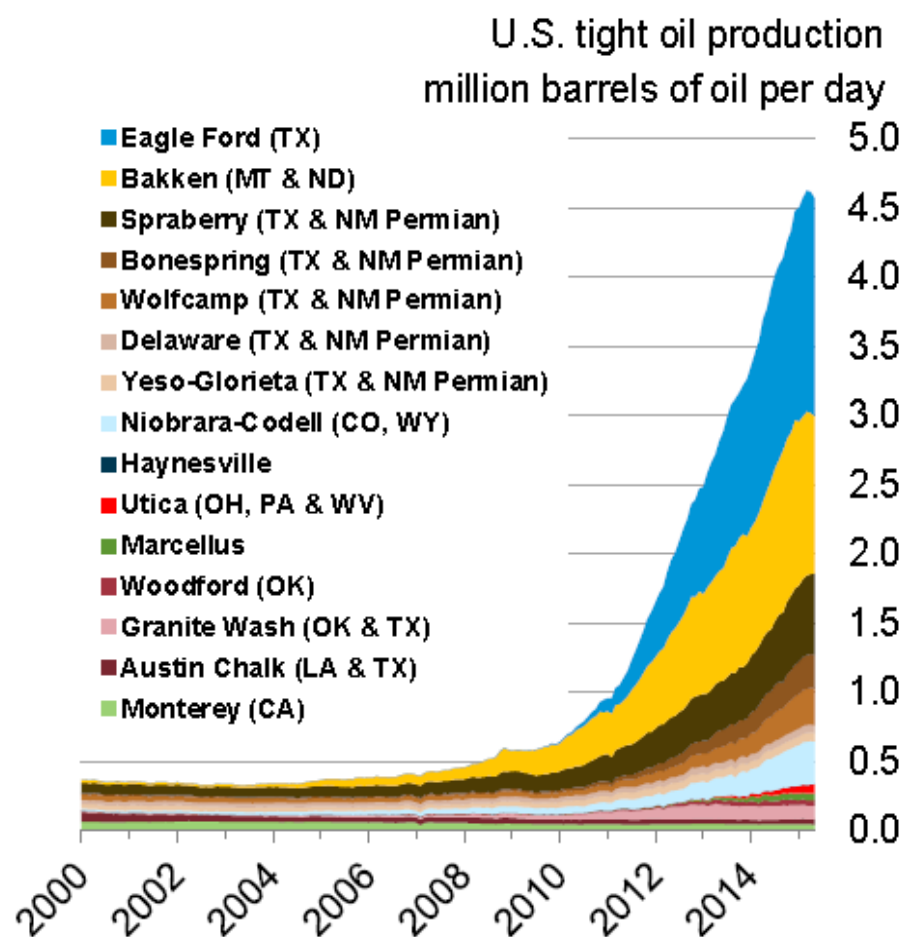




# Deepwater Production Systems



## The U.S. has experienced a rapid increase in natural gas and oil production from shale and other tight resources



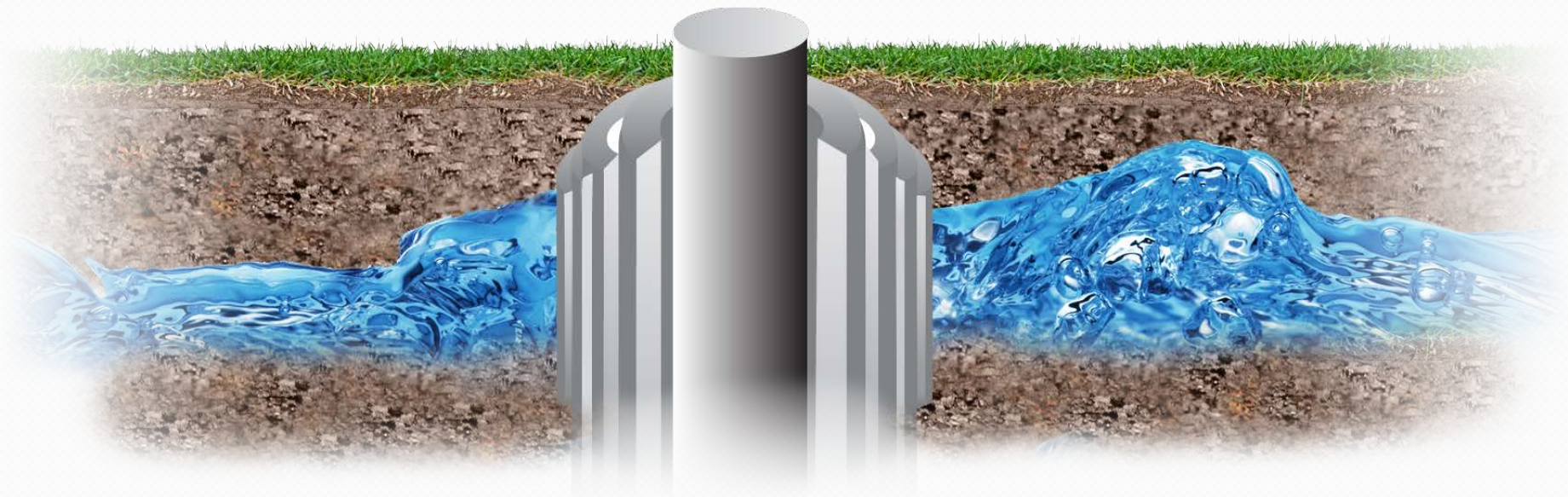
Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through May 2015 and represent EIA's official tight oil & shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).

# Tight Oil and Gas Drilling Technologies

- Hydraulic fracturing is a well completion technology for the development of unconventional resources, such as shale oil and natural gas that is trapped in shale rock formations. It is used to create a fracture network through which oil and gas can migrate to the wellbore.
- Horizontal drilling is a technique where the well is drilled first vertically and then horizontal to and into formation.



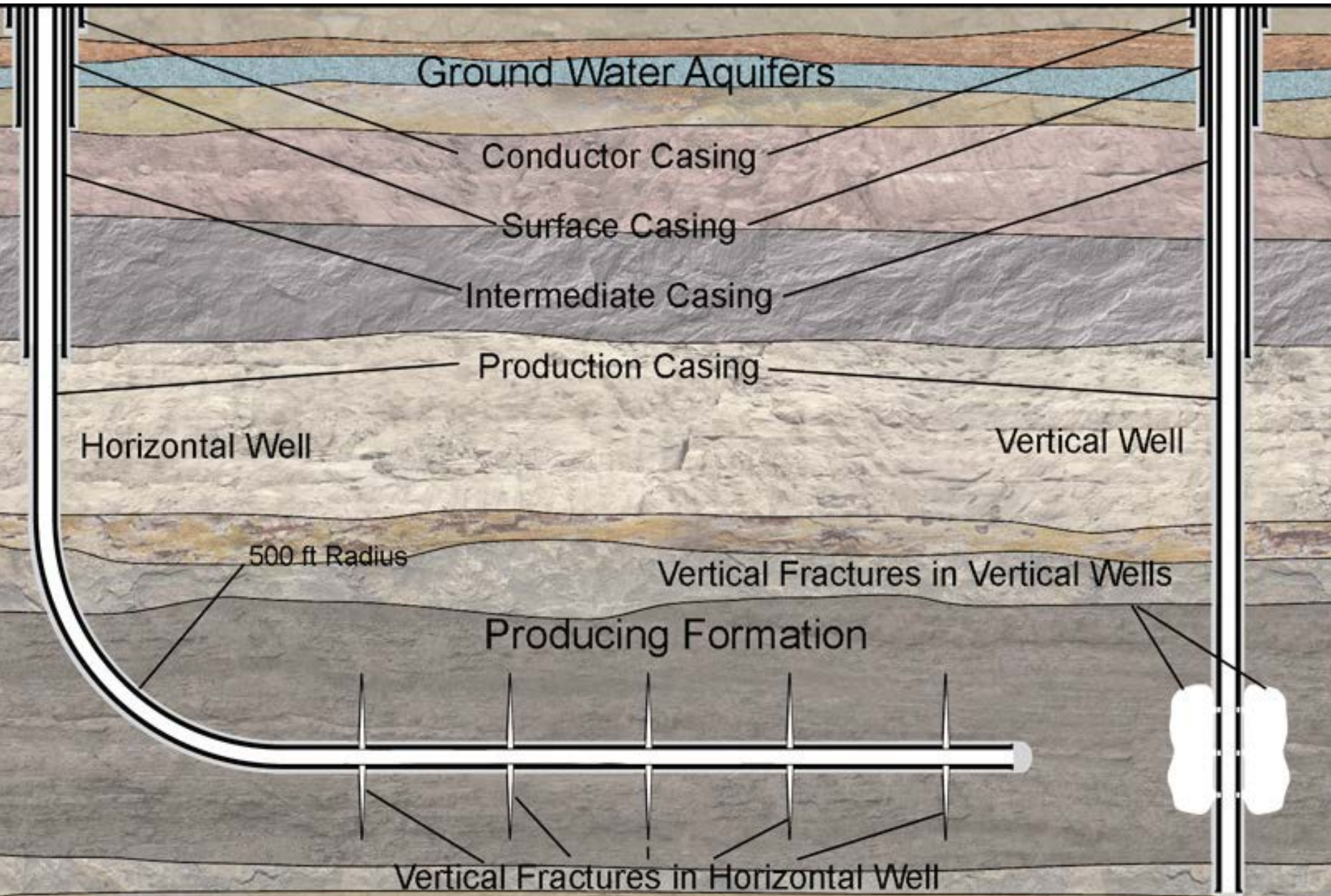
## Each well contains multiple layers of casing and cementing to protect groundwater



Well design and construction has four main components:

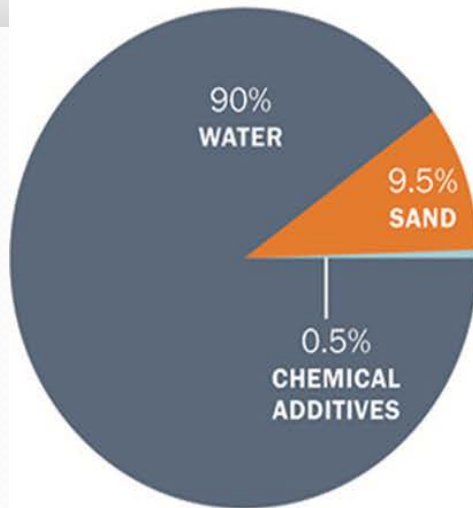
1. Conductor casing (isolate shallow groundwater and surface sediments)
2. Surface casing (isolate groundwater aquifers)
3. Intermediate casing (isolate subsurface formations, protect from pressure)
4. Production casing (isolate production zone)

# Well Production Casing



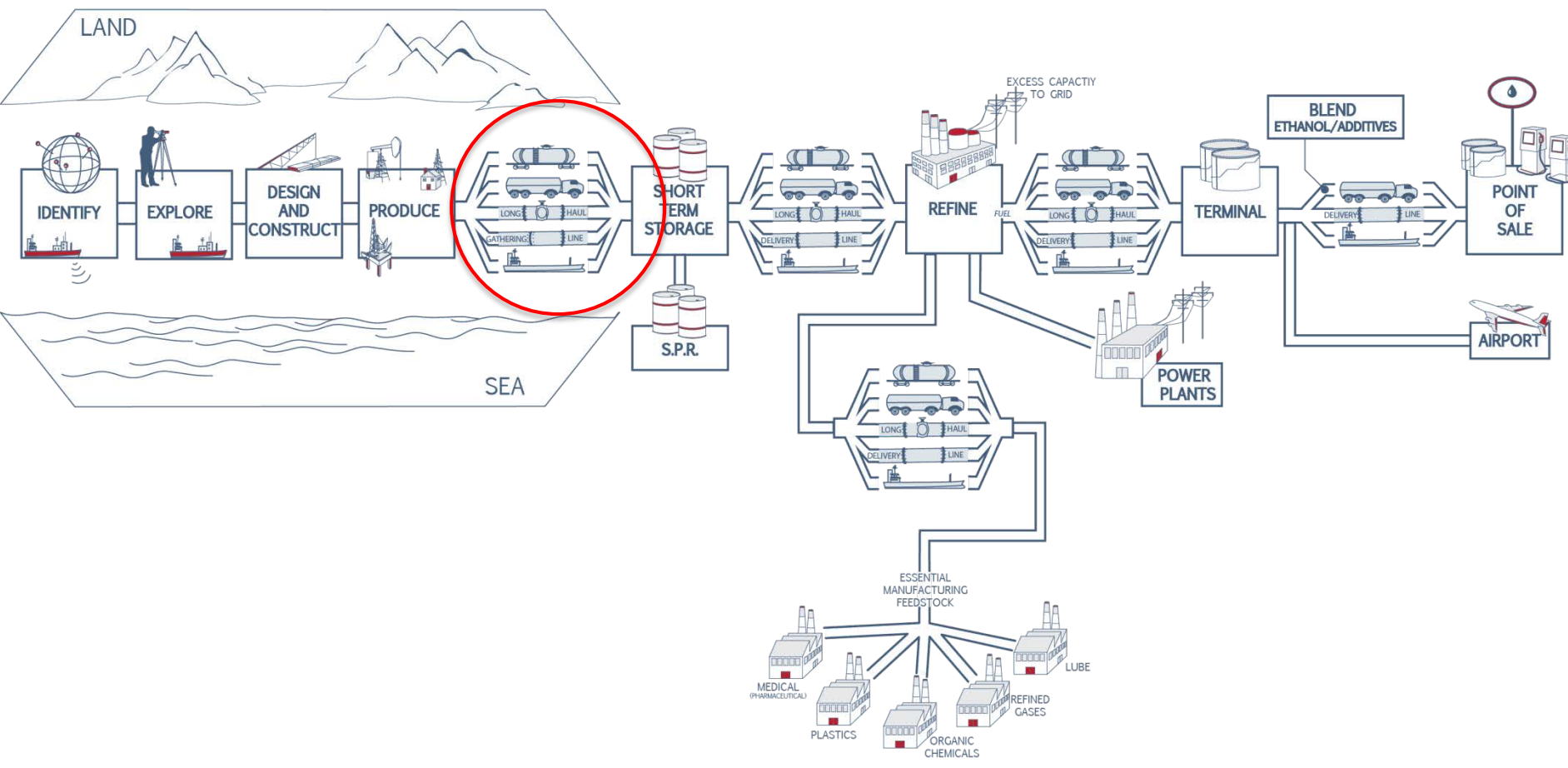


# Understanding Fracturing Fluids

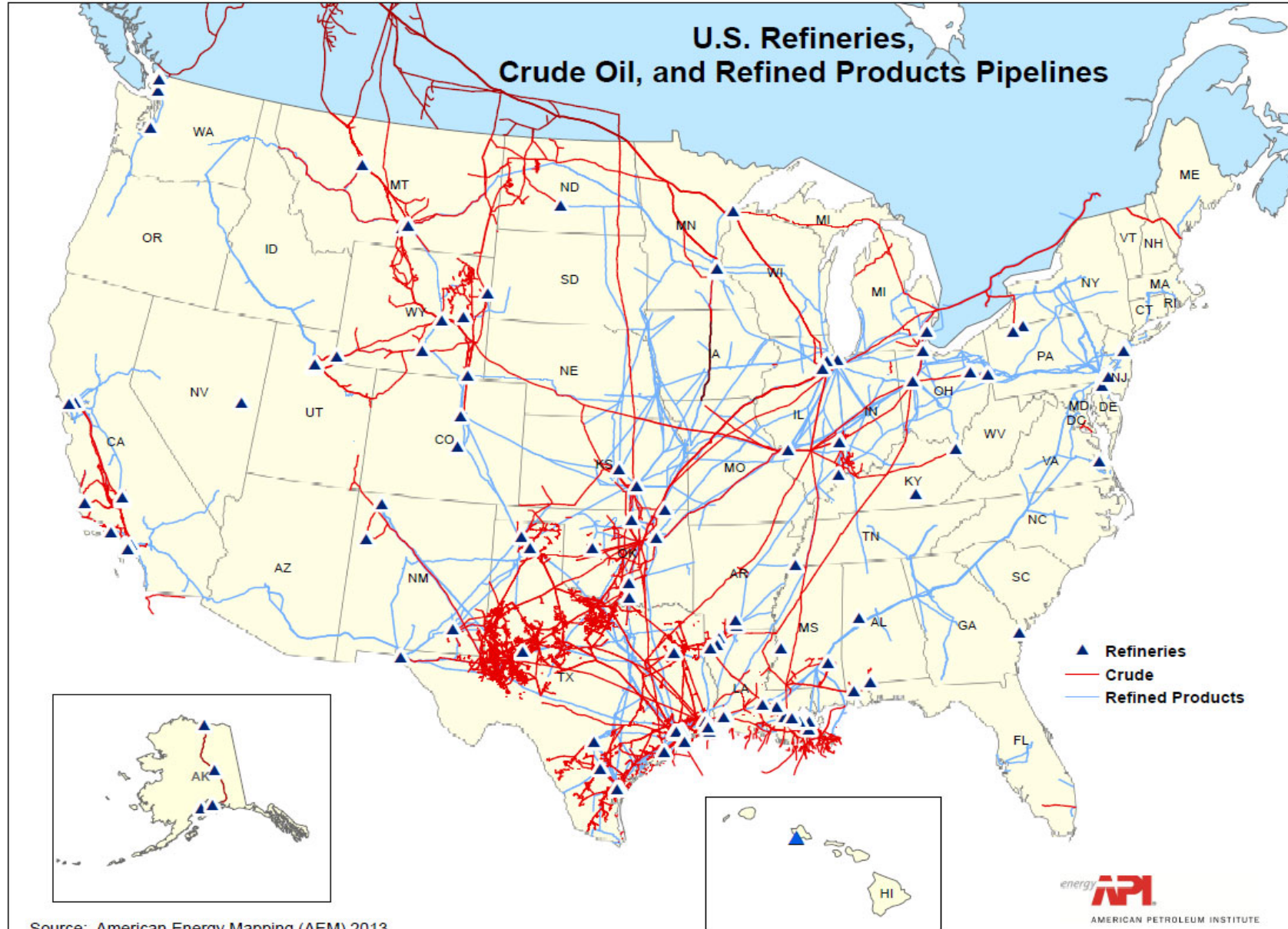


Compound	Purpose	Common application
<b>Acids</b>	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
<b>Sodium Chloride</b>	Allows a delayed breakdown of the gel polymer chains	Table salt
<b>Polyacrylamide</b>	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
<b>Ethylene Glycol</b>	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
<b>Borate Salts</b>	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics
<b>Sodium/Potassium Carbonate</b>	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
<b>Glutaraldehyde</b>	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
<b>Guar Gum</b>	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
<b>Citric Acid</b>	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
<b>Isopropanol</b>	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring



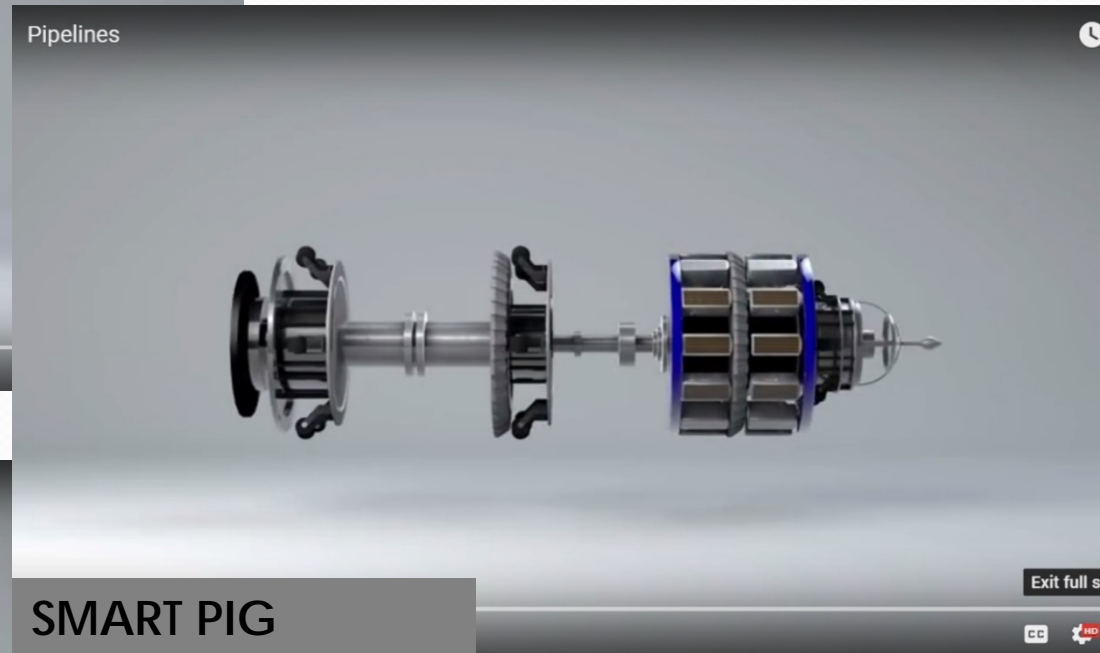


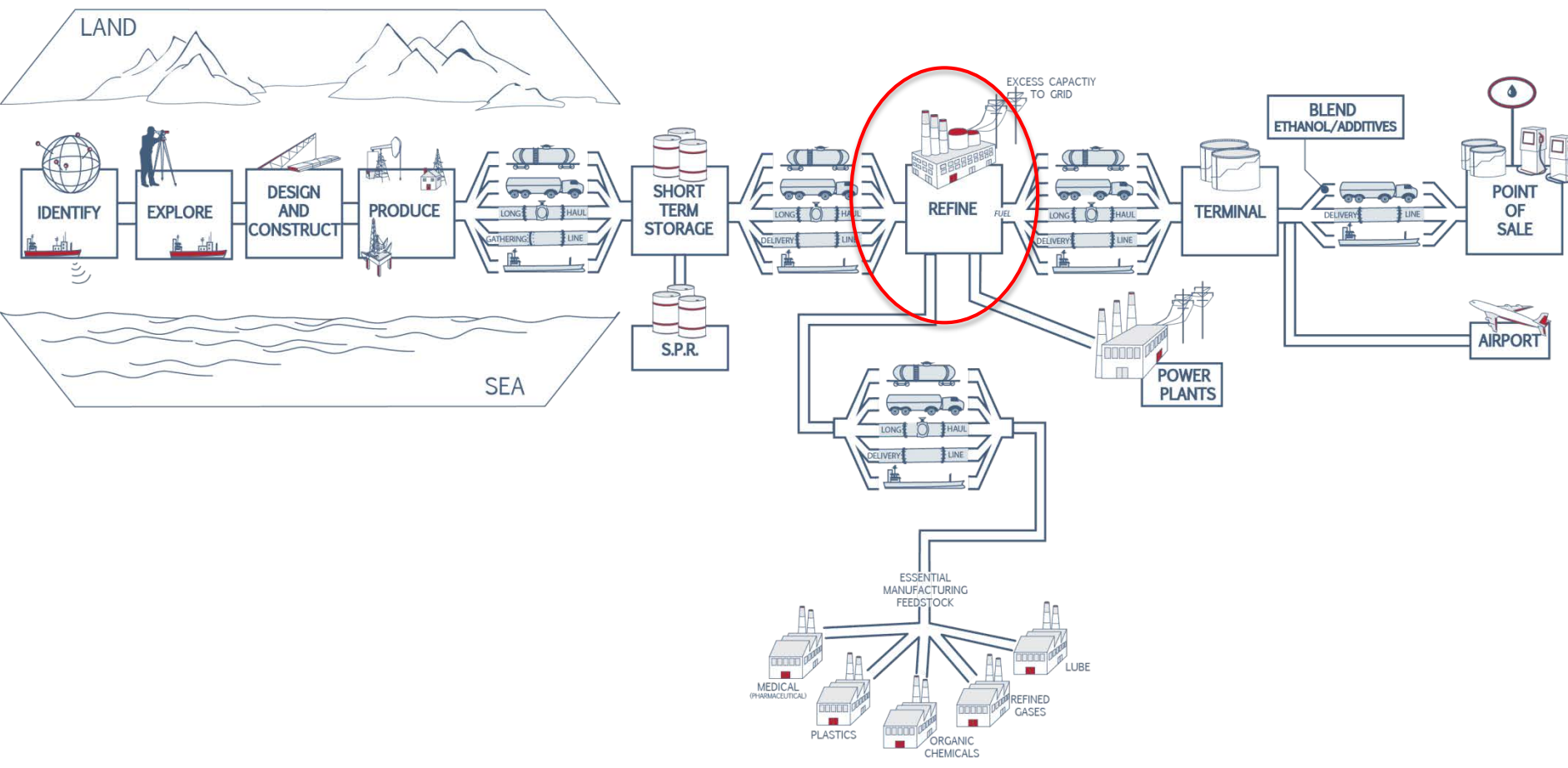
# Pipeline System





# Pipeline Pigs





# What is Crude Oil?

Not a single compound, but a mixture of thousands of compounds

Naturally occurring

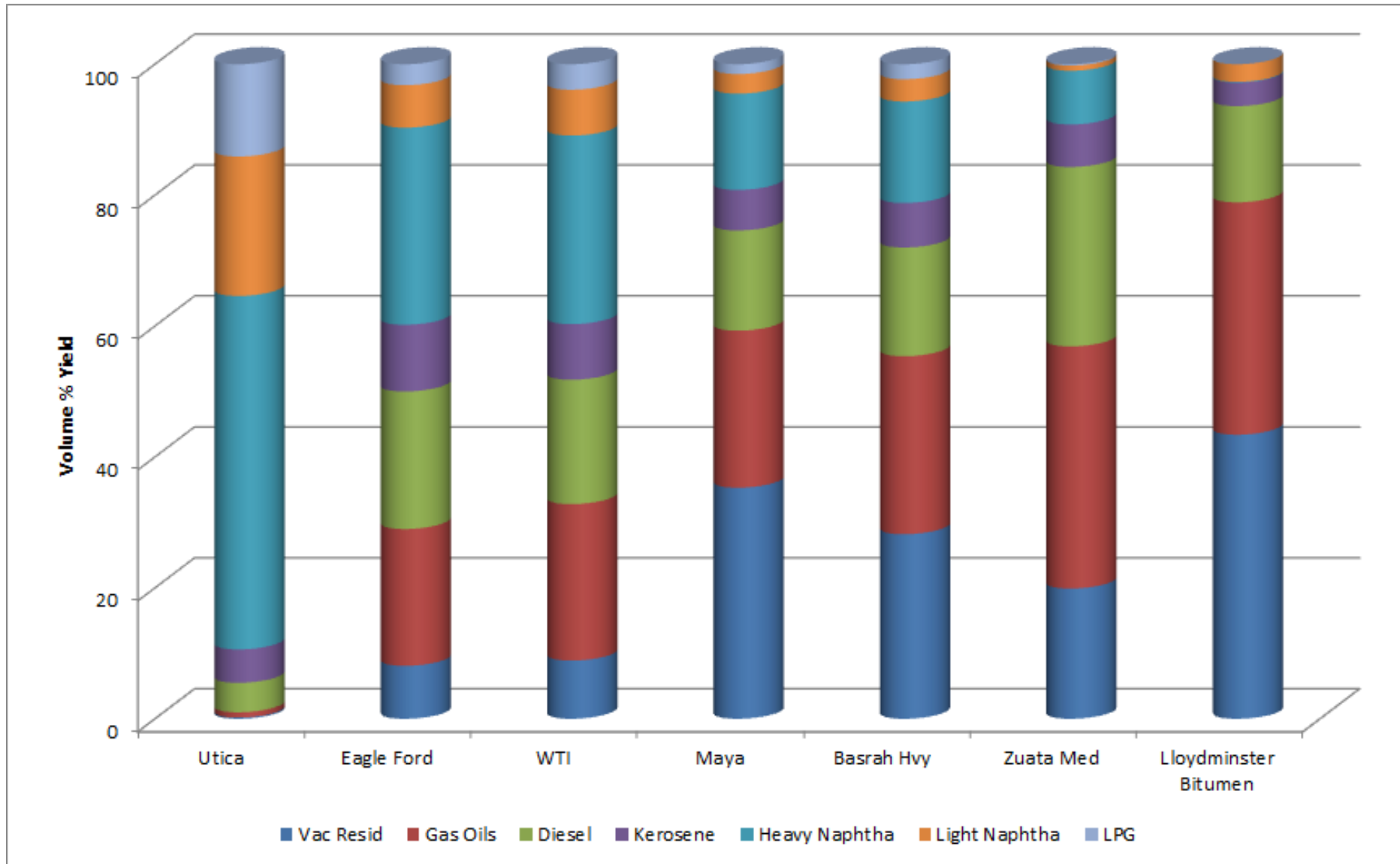
Wide boiling range

Mostly hydrocarbons (compounds with carbon and hydrogen) but traces of other elements are present

Classified by density (light, heavy) and sulfur content (sweet, sour)

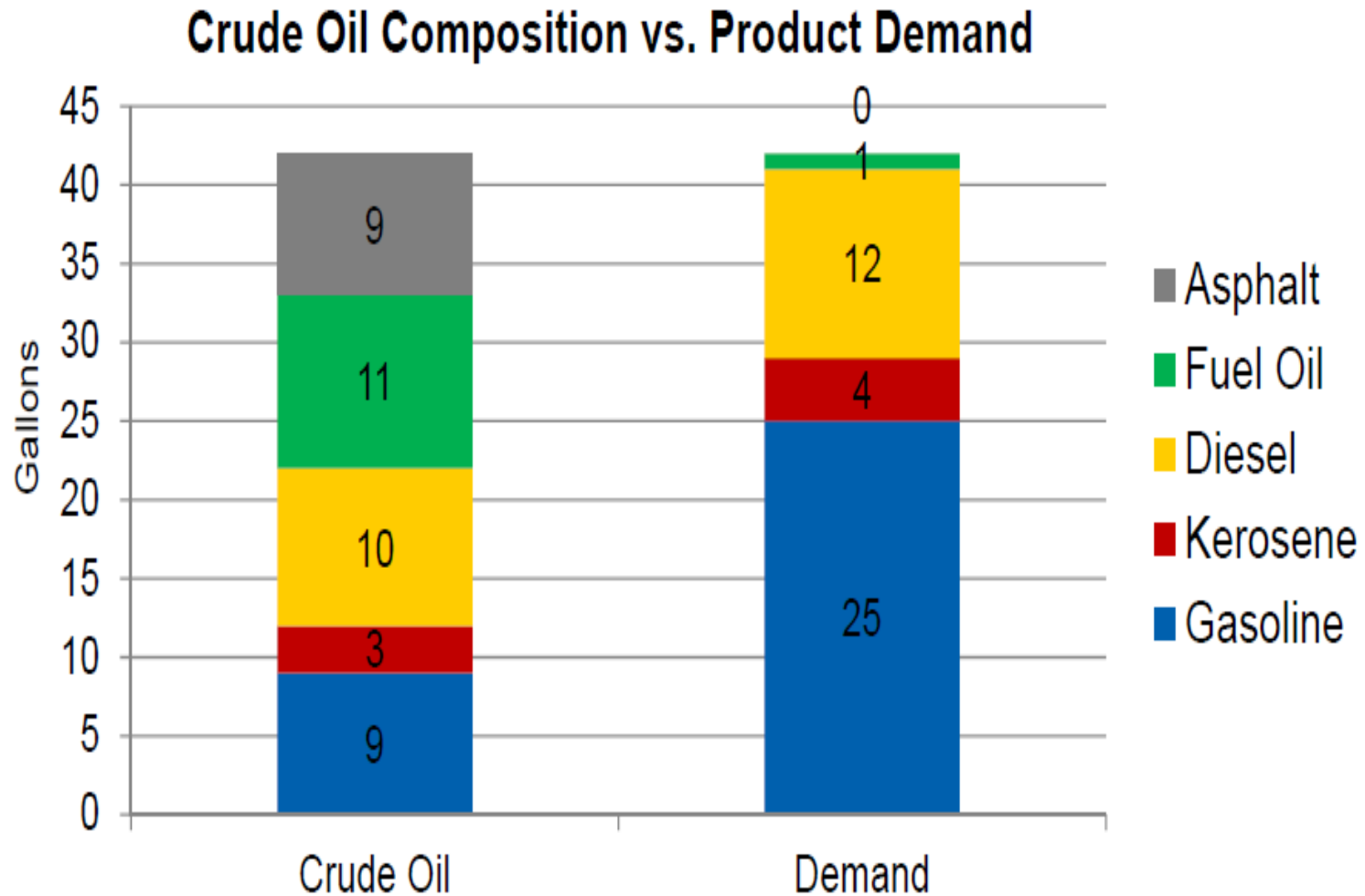
Element	Wt%
Carbon	84-87
Hydrogen	11-14
Sulfur	0-5
Nitrogen	0-0.2
Other Elements	0-0.1

# Natural Product Yields for Varying Crude Oils



Source: Marathon Crude  
Assay Data

# Why Refineries are Important





# Examples of Crude Oil Properties/Yields

## Crude Type

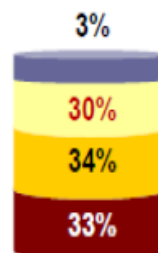
## Properties

## Yields

## Typical Refinery Production

Sweet Crude  
(WTI, LLS)

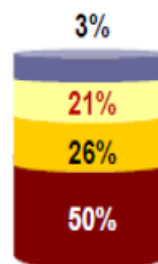
>34 API Gravity  
<0.7% Sulfur  
Most Expensive



**4%** Propane  
Butane

Medium Sour Crude  
(Poseidon, Mars)

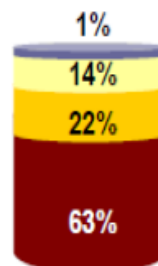
24-34 API Gravity  
0.7-2.0% Sulfur  
Less Expensive



Gasoline  
Regular  
**49%** Premium  
RFG  
Naphtha

Heavy Sour Crude  
(Maya, Cold Lake)

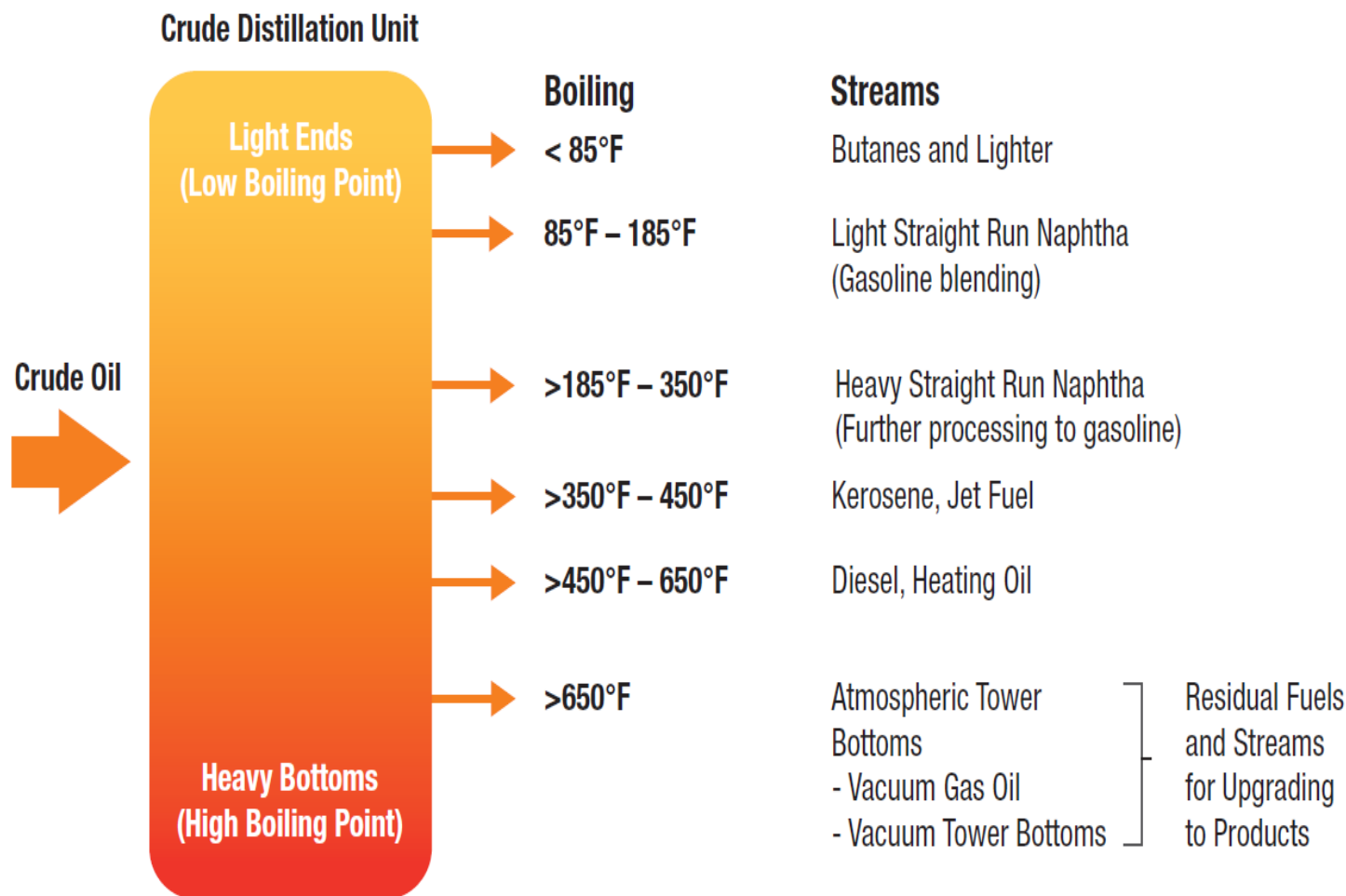
<24 API Gravity  
>2.0% Sulfur  
Least Expensive



Distillates  
Diesel  
**35%** Jet Fuel  
Kerosene

Asphalt  
**12%** Heavy Fuel Oil  
Coke

# REFINING 101



# Gasoline Production Processes

<u>Process</u>	<u>Gasoline Blending Stream</u>	<u>Contribution to Gasoline Pool*</u>
Cat Cracking	Cat Naphtha	43%
Catalytic Reforming	Reformate^	31%
Alkylation	Alkylate^	14%
Isomerization	Isomerate	4%
Straight Run	LSR	4%
Hydrocracking	Hydrocrackate	3%
Other		1%

**\*Industry Data – Excludes Butane, MTBE & Ethanol**

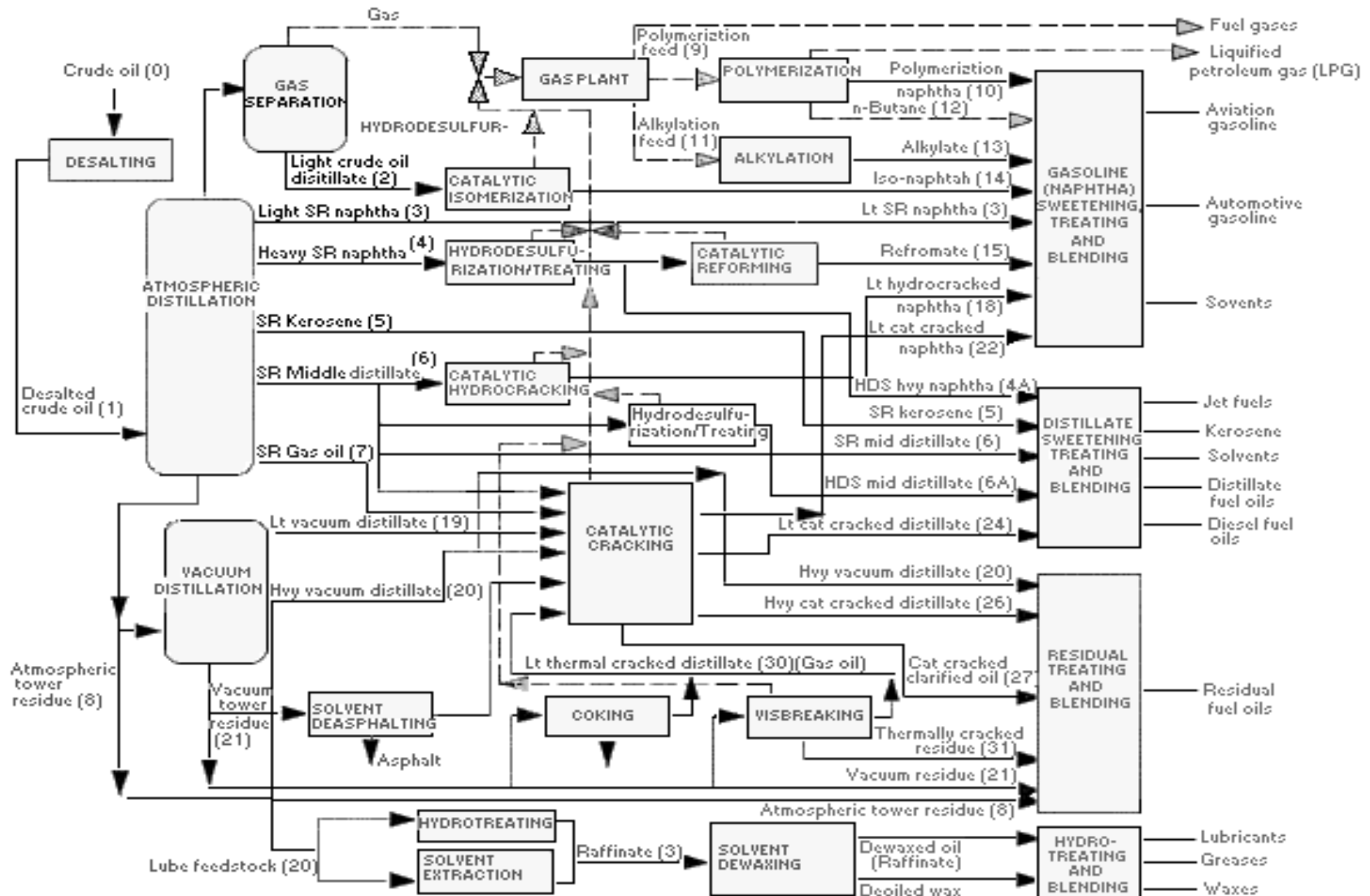
**^Higher Octane Gasoline Blending Components**



**REFINERIES are like  
snowflakes ...**

**No two are the same!!**

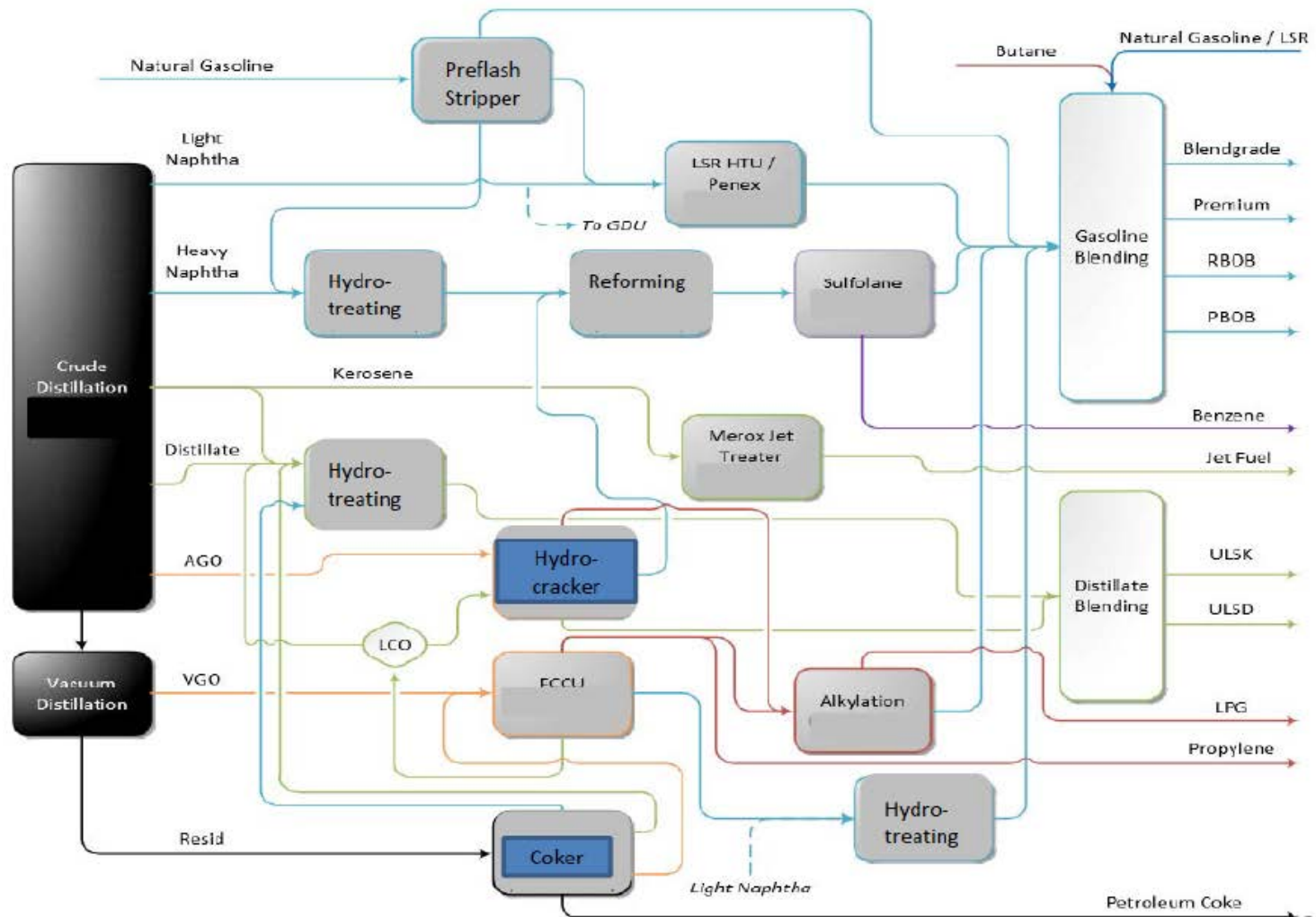
# OSHA Example of "Omni"-Refinery



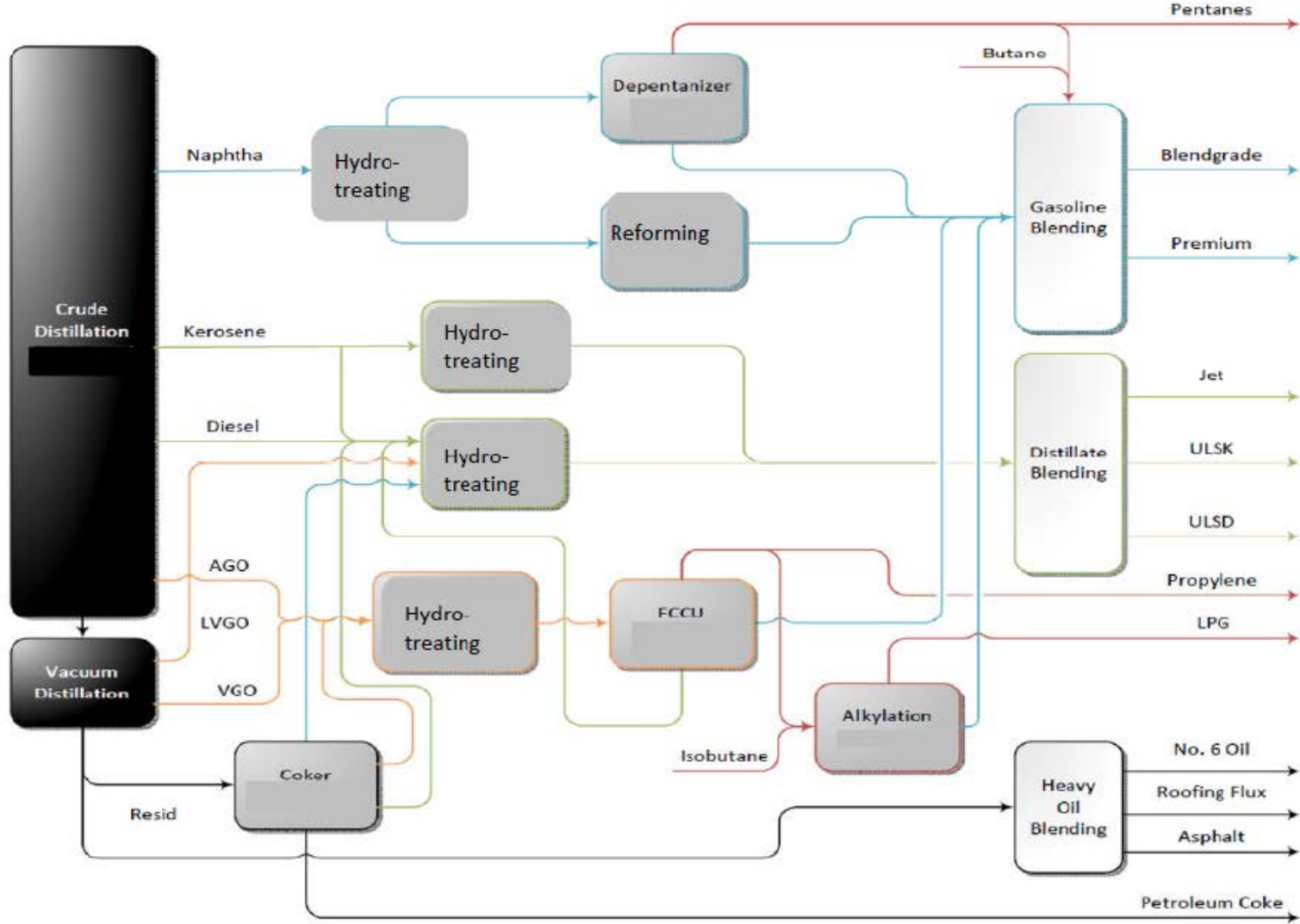
Source: OSHA Technical Manual Section IV Chapter 2



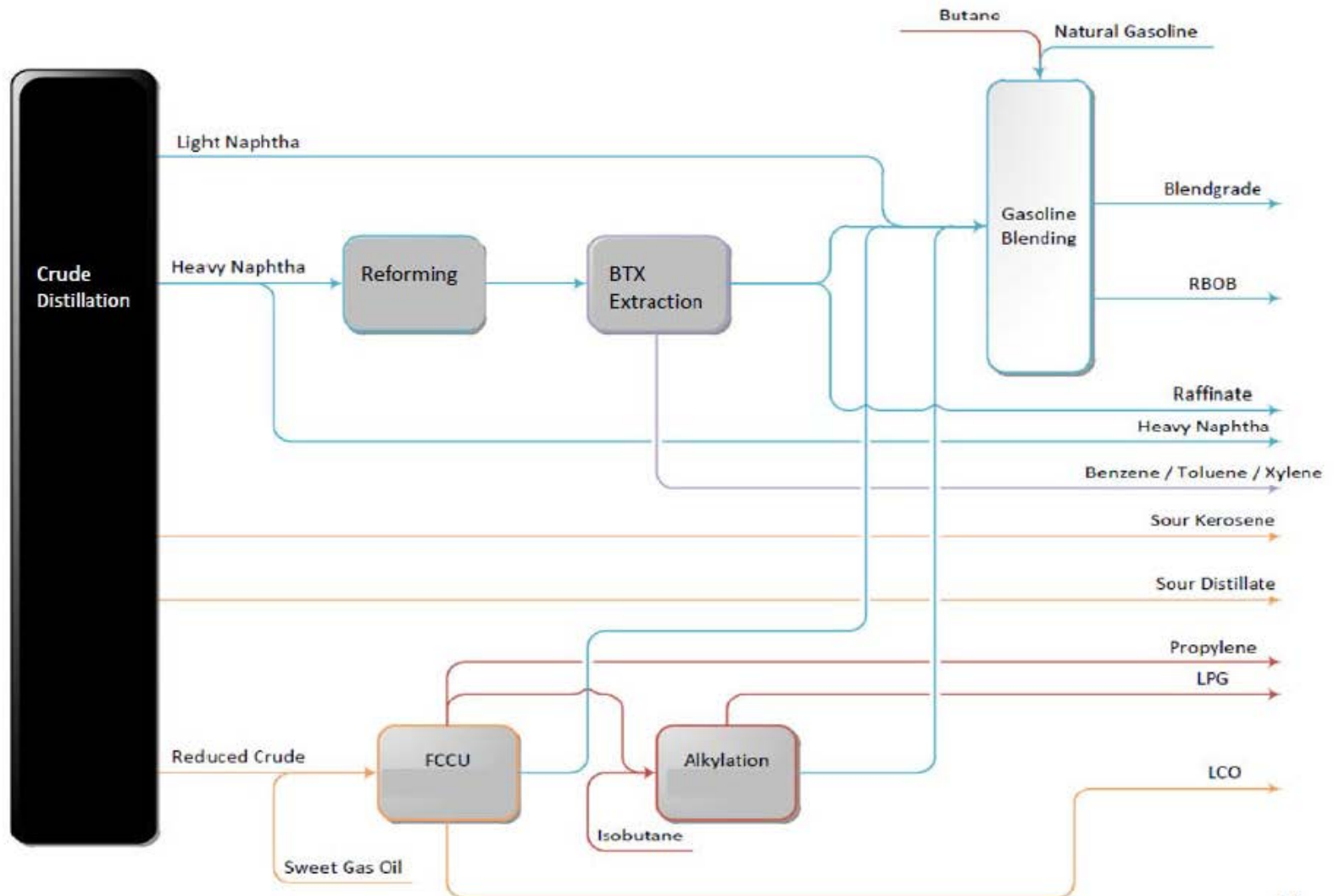
# Large U.S. Refinery



### Mid-Size U.S. Refinery



## Small U.S. Refinery



# Hitting the Targets

## ASTM Specifications

- D4814 - Gasoline
- D975 - Diesel
- D396 – Home Heating Oil
- D3699 - Kerosene
- D1655 – Aviation Turbine
- D???? -- other

## NIST Handbook 130 Model Regulations

## Federal Regulations

- USEPA
- FTC

## State/Local Requirements & Regulations

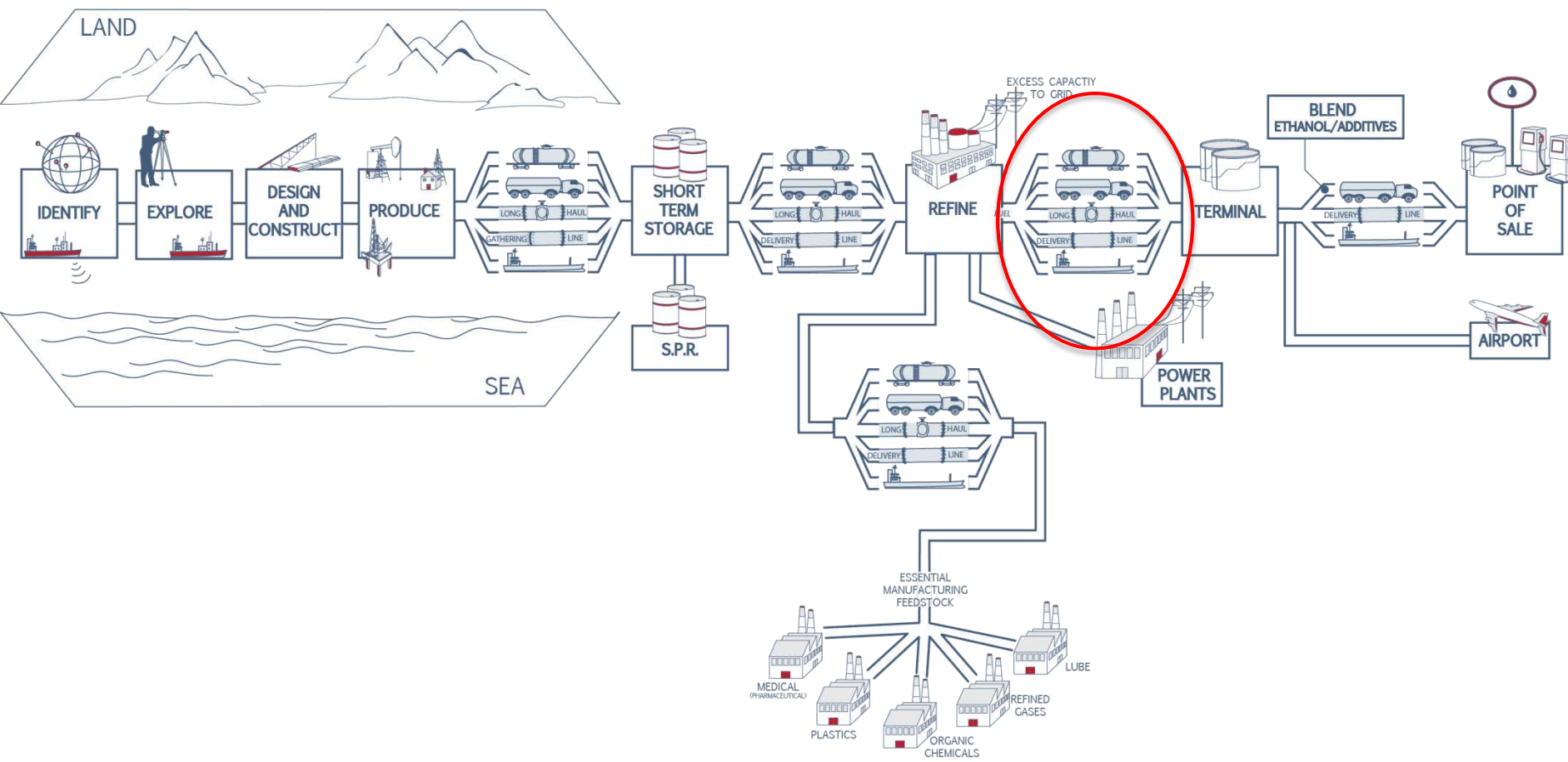
## Pipeline Specifications

## Individual Customer and Marketing Requirements



# Fuel Can Change: Historical Precedent

	• 1974	Unleaded Gasoline
	• 1979	E10 Ethanol Subsim Waiver
	• 1989	Phase 1 Gasoline Summer RVP Limits
	• 1991	Phase 2 Gasoline Summer RVP Limits (including 1-psi E10 waiver)
	• 1992	Winter Oxyfuels Program (39 cities)
	• 1993	Highway diesel fuel sulfur control (500 ppm)
	• 1995	Phase 1 RFG and Anti-dumping
	• 1996	Full prohibition on lead
Effective dates	• 2000	Phase 2 RFG
	• 2002	Mobil Source Air Toxics (MSAT1)
	• 2004	Tier 2 Gasoline Sulfur Control (30 ppm avg, 80 cap)
	• 2006	Renewable Fuels Standard
	• 2006	Removal of RFG Oxy Mandate
	• 2006	Ultra Low Sulfur Highway Diesel Fuel (15 ppm)
	• 2006	Boutique Fuels List
	• 2007	Renewable Fuel Standard (RFS)
	• 2010	Ultra Low Sulfur Nonroad Diesel Fuel (15 ppm)
	• 2010	Renewable Fuel Standard 2 (RFS2)
	• 2011	MSAT2 – Gasoline Benzene
	• 2012	E15 Subsim Waiver
	• 2017	Tier 3 Gasoline Sulfur Control (10 ppm avg)





# Example Pipeline Specification

## Product Acceptance Terms

- Sampling Requirements

- Reporting Certificate of Analysis

- Workmanship

## Additive Specifications

- Gum Inhibitors and Metal Deactivators

- Corrosion Inhibitors

- Stability additives (diesel, fuel oil)

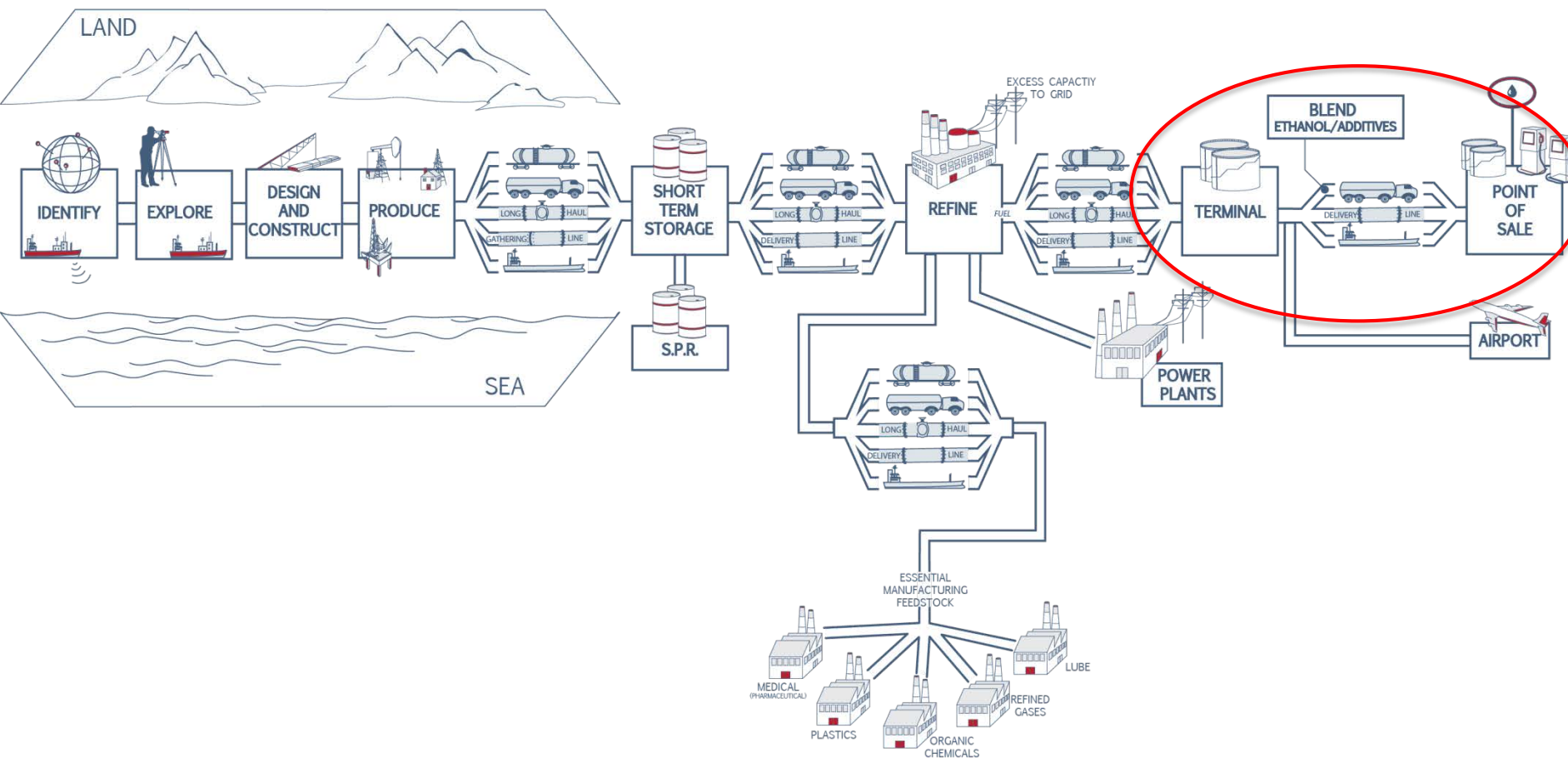
- Cold Flow Additives

- Dyes

Seasonal Volatility Classes (RVP, distillation, V/L, Driveability Index)

Schedule of Origin Volatility Requirements (15 grades alone on one pipeline)

[https://www.magellanlp.com/uploadedFiles/Commercial\\_Info\\_Assets/Product\\_Pipeline\\_Specifications/Magellan%20Pipeline%20Product%20Specifications.pdf](https://www.magellanlp.com/uploadedFiles/Commercial_Info_Assets/Product_Pipeline_Specifications/Magellan%20Pipeline%20Product%20Specifications.pdf)



# Terminal Product Quality

About 1,300 Terminals

Terminals through complex system management

- About 60 Billion gallons of distillate consumed
- More than 140 Billion gallons of gasoline consumed

API RP 1640, Product Quality in Light Product Storage and Handling Operations, 2013

Multiple studies on importance of housekeeping at terminals and retail

- Water and Microbial Activity Responsible for Corrosion and Particulate
- Good Housekeeping Greatly Reduces These Concerns

Standards must be met at all times

# Terminal Operations, RP 1640

## API 1640, Product Quality in Light Product Storage and Handling Operations, Published 2013

Scope: This RP is intended to provide **guidance on the minimum equipment standards and operating procedures for the receipt, storage, blending of light products**, including but not limited to gasoline, kerosene, diesel, heating oil and their blend components (i.e. ethanol, biodiesel, and butane) at distribution and storage terminals, as well as light product shipments directly via a pipeline, marine vessel (barge or ship) or road and rail transport.



# RP 1640, Product Quality Management

Terminals are complex facilities operated by experts receiving 10s of 1000s of barrels at a time

- Health, Safety, Security and Environment
- Quality Assurance
- Tankage, product receipt, pipework management, loading, unloading, filtration
- Planned maintenance, inspection, and testing
- Strainers and filtration
- **Sampling and testing (throughout distribution system)**
- Product segregation, inventory variations, settling, post-receipt tank testing, product release, oversight testing

# RP 1640, Product Quality Management

Terminals are complex facilities (Continued)

- Receipts from pipelines, ocean/inland tankers, rail/truck
- Interface transmix from pipeline
- Storage of diesel, biodiesel, ethanol, gasoline, water management
- Product blending, Product delivery from running tanks, product transfer
- Product grade changes
- Additives, dyes, markers

# Terminal Fuel Quality

Product flows at 300-500 gallons/minute of flammable/combustible product over rack

Clean product (no water, particulate, microbes etc.) needed to ensure proper operation of equipment

- Prevents plugged filters
- Ensures accurate meters
- No erosion of valves and piping
- Proper valve operation

# Delivery

- Product is delivered in 8,800 gallon increments
- Trucks - 4 or 5 compartment
- Fueling arm, vapor recovery, overfill protection devices
- Product delivered to station
- Meters proven at terminal



# Station

- EPA Office of Underground Storage Tanks requires equipment compatible with fuel stored
- Must be able to demonstrate compatibility
- State rules must be no less stringent than Federal rules
- More than 150,000 stations nationwide
- More than 60% are owned by single store owners
- 95% are owned by a non-refiner
- Meters prove at station
- Product delivered to consumer

# Motor Oil and Transmission Fluid

- Motor oil and transmission fluid combination of base oil from refinery and additive (finished oil)
- API standard-setter for motor oil for last 70 years
  - In 1947, "Regular," "Premium," and "Heavy Duty"
  - Then in 1952, MS, MM, ML for gasoline oils and DS, DM, DG for diesel oils
  - Since 1970, S, C, and now F categories
- API licensing introduced in mid 1980's for Service Symbol Donut and early 1990's for Certification Mark
- Today, more than 700 licensed oil marketers in almost 60 countries offering more than 14,000 licensed brands



QUESTIONS?