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PURVIN & GERTZ™

Crude Oil Valuation and Supply / Demand Overview

Prepared for:

Indian Oil Valuation Negotiated Rulemaking Committee

Denver, Colorado

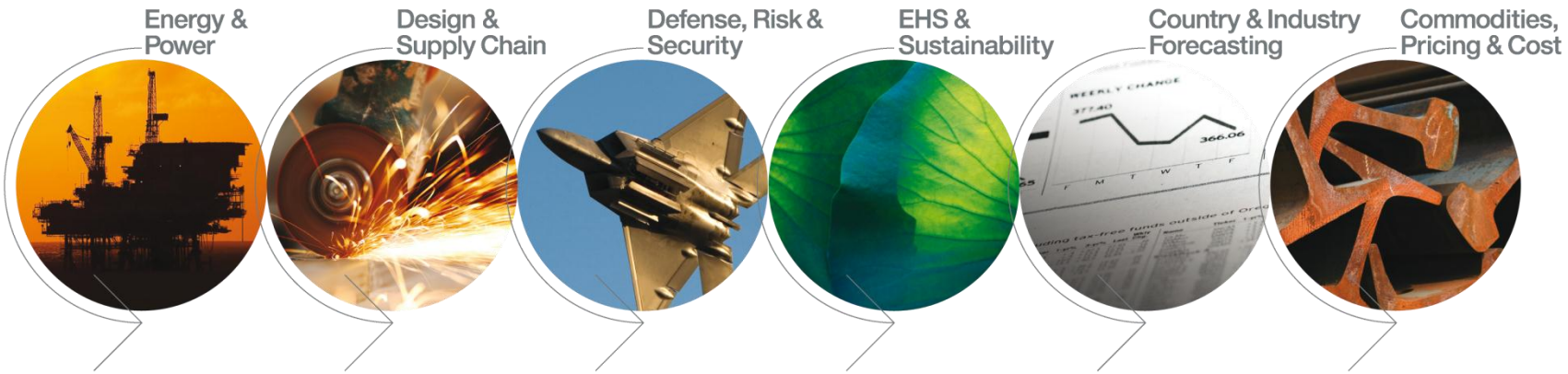
June 18, 2012

About Purvin & Gertz..... and IHS

- Purvin & Gertz, an independent consulting firm since 1947
  - **Global presence with offices in Houston, Calgary, London, Singapore, Dubai, and Moscow**
  - **Consulting staff of Chemical Engineers/MBAs**
  - **Possess combination of technical and commercial experience**
  - **Global company populated with global colleagues**
- IHS acquired Purvin & Gertz in November 2011
  - **IHS is 5,400+ people, in 30 countries, speaking 50 languages**
  - **Serving businesses and all levels of governments worldwide**
  - **Provide comprehensive content, software and expert analysis and forecasts**

IHS Capabilities

IHS is the leading information company with comprehensive content, insight and expert analysis in key areas shaping today's global business landscape, including:

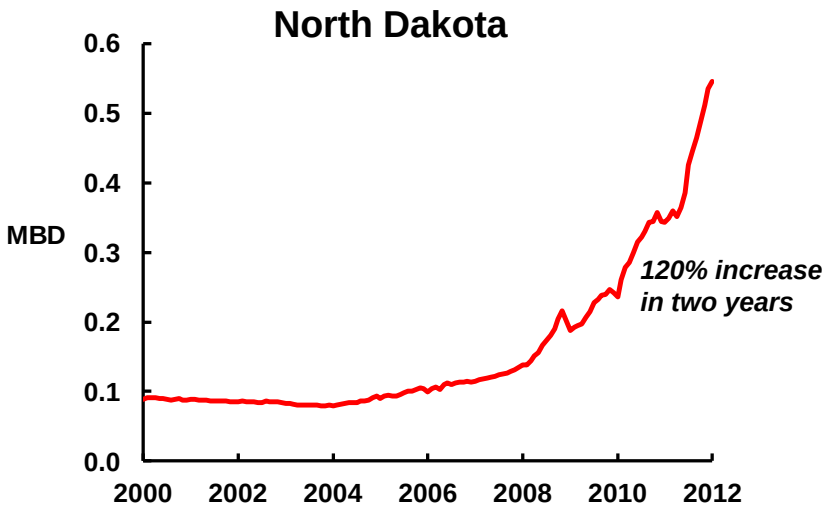


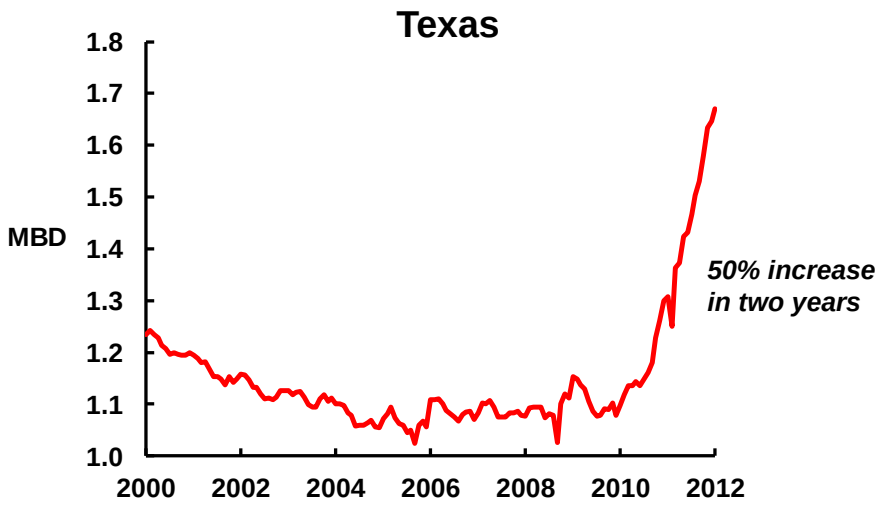
Advancing Decisions that Advance the World

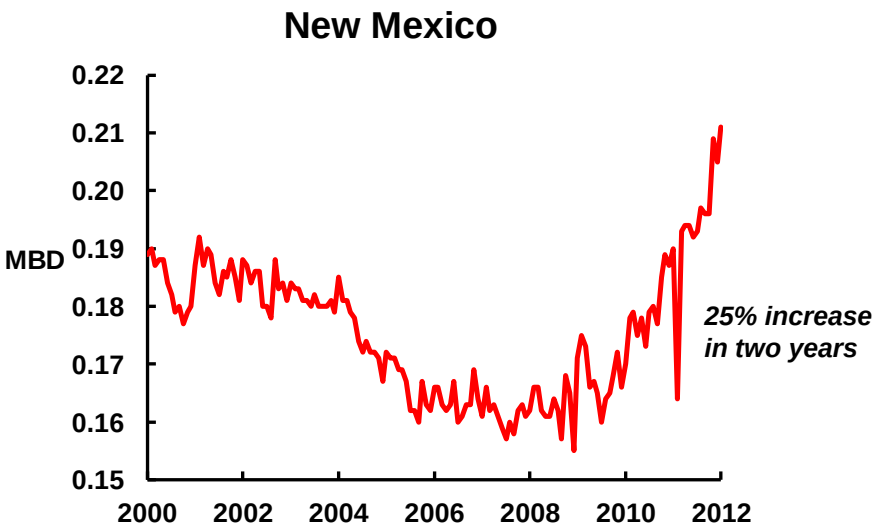
Crude Oil Valuation and Supply / Demand Overview

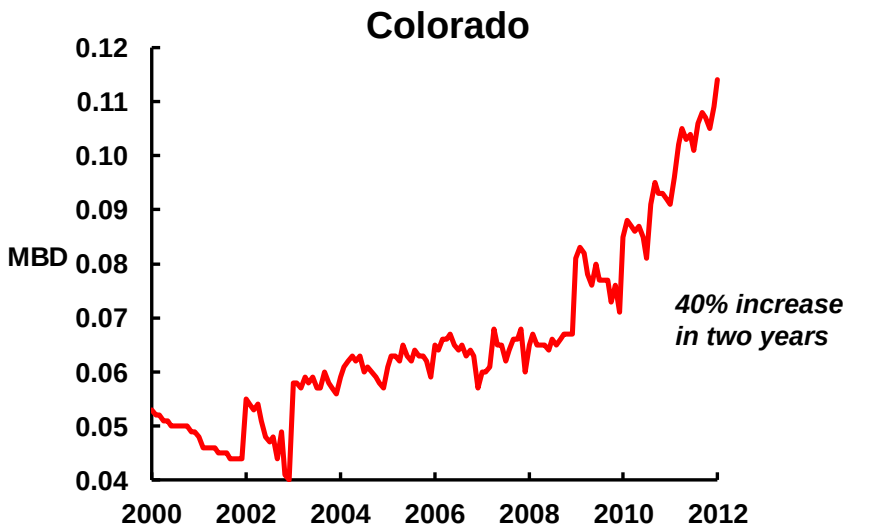
- **Crude Oil Supply / Demand**
- **Crude oil quality**
- **Refinery Configurations**
- **Crude Oil Valuation Basics**
- **Simplified crude valuation approaches**

Tight Oil development are moving rapidly creating increased uncertainty for forecasters









Source: US Energy Information Administration, IHS CERA

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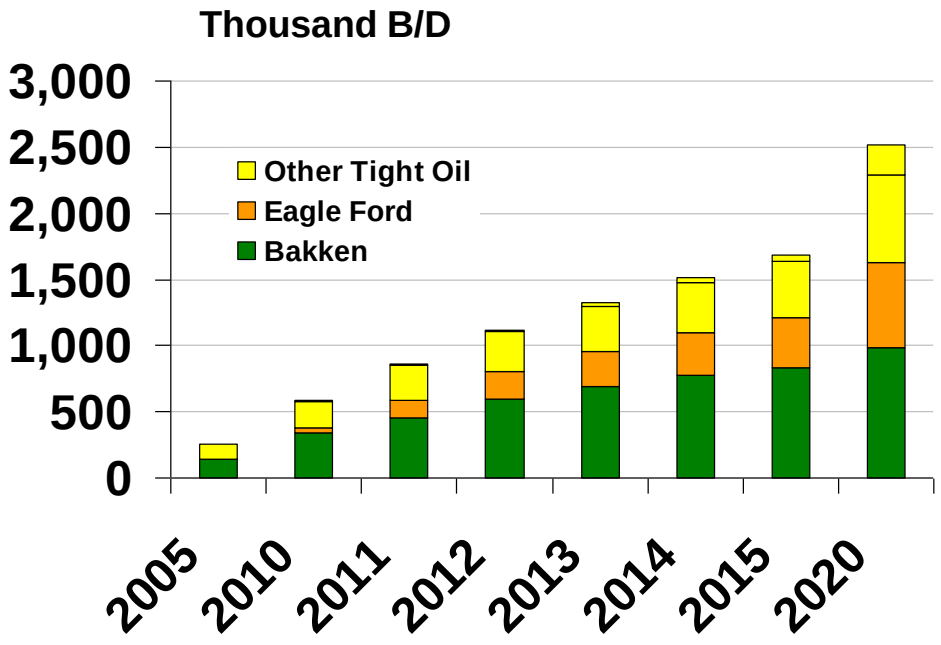
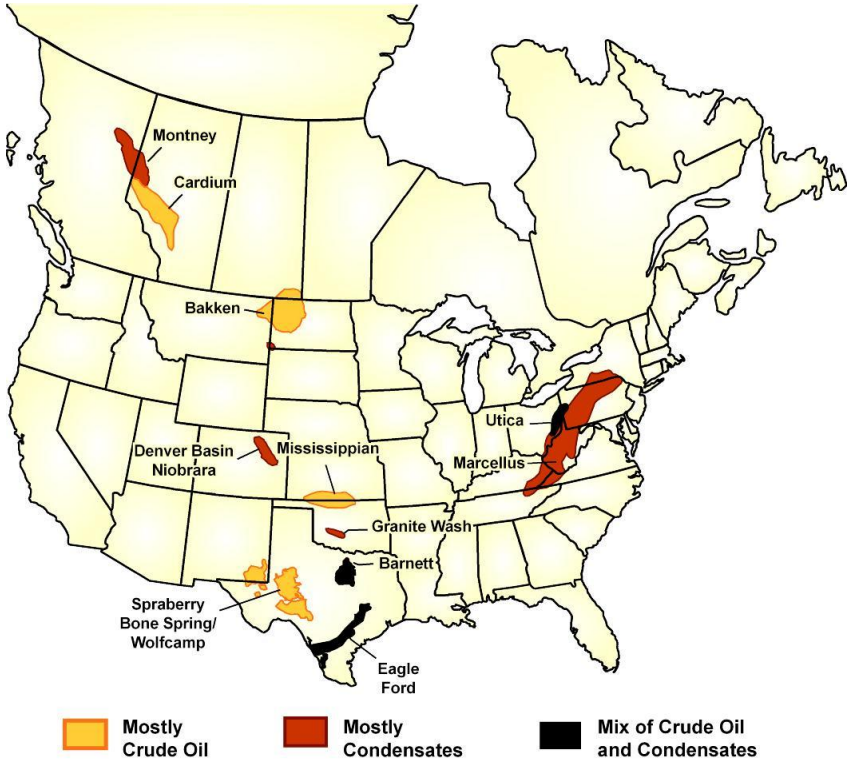
Major Liquids-Producing Tight Oil and Shale Gas Plays





Note: Chart does not include segregated condensate production from Eagle Ford.

Source: IHS CERA.
11004-9

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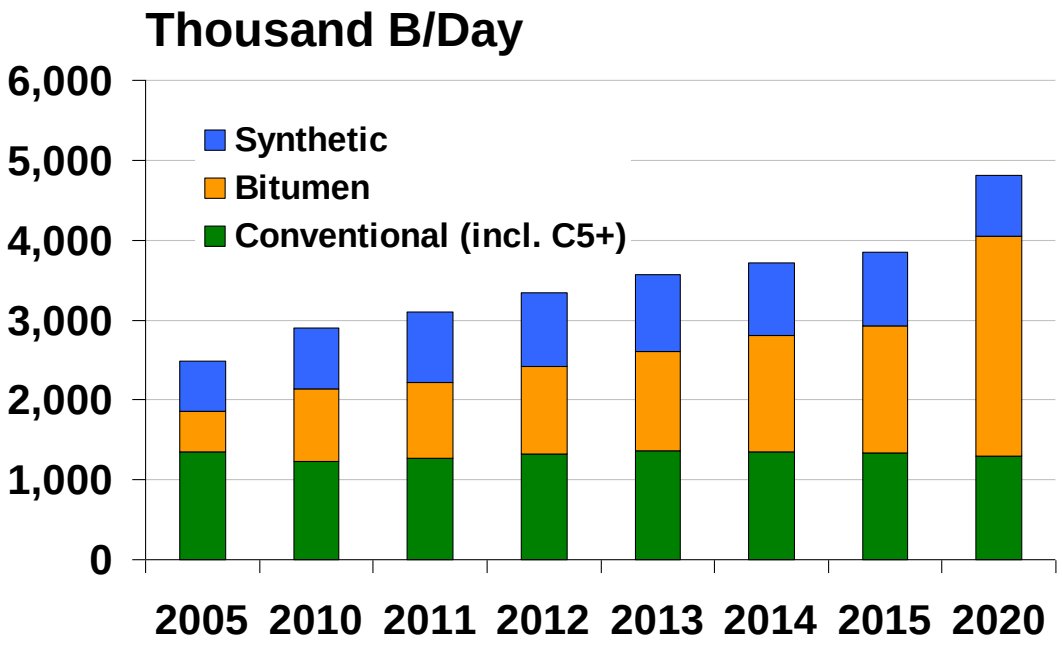
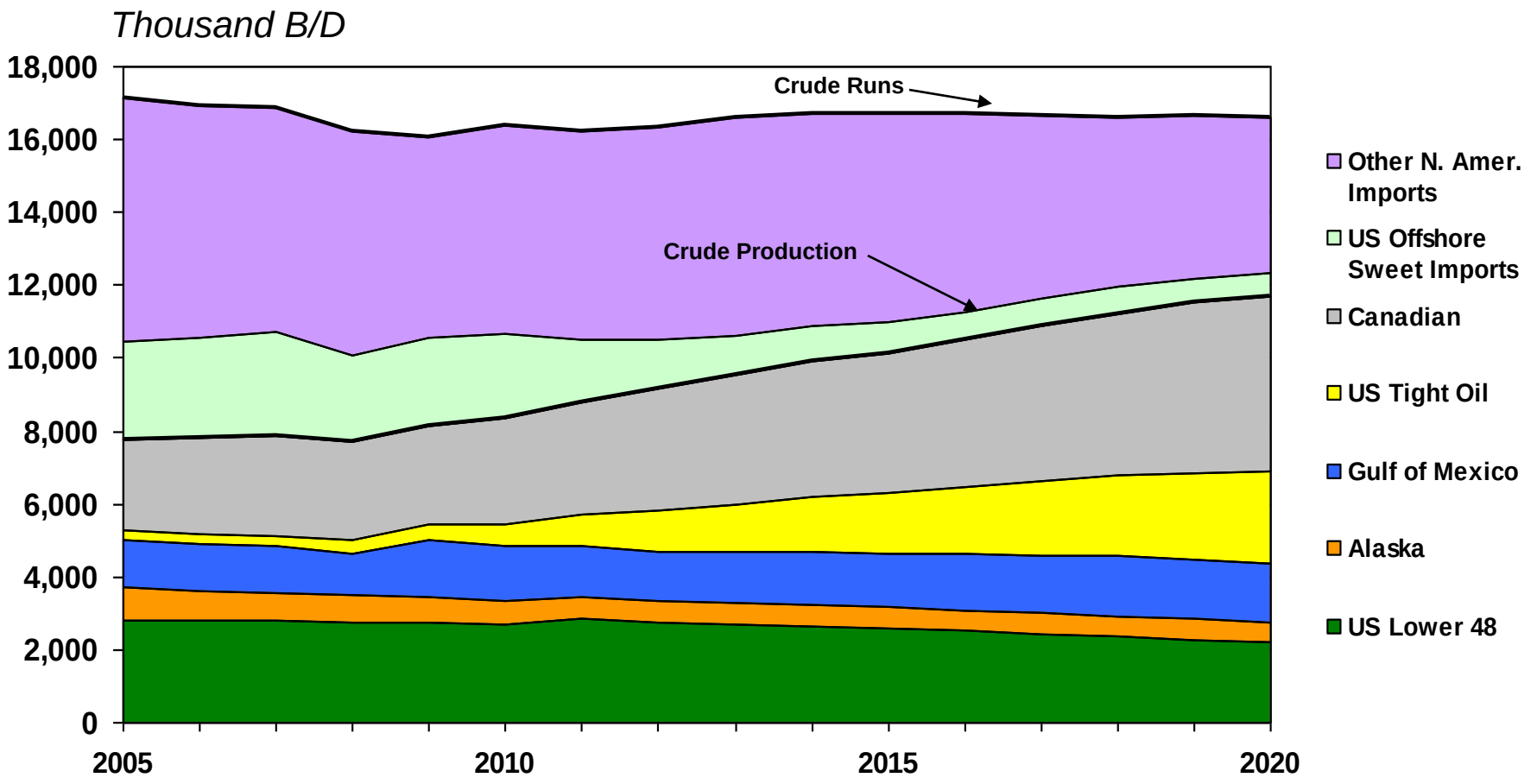
Western Canada Production Outlook... Tight oil is a wild card in Canada too



- **Total Western Canadian oil supply is forecast to continue increasing**
  - **3 million BPD by 2015, an increase of 700 kBPD**
- **Shale oil developments in Canada have potential to moderate the conventional crude decline**

North America becoming *less* dependent on foreign imports, but not entirely...



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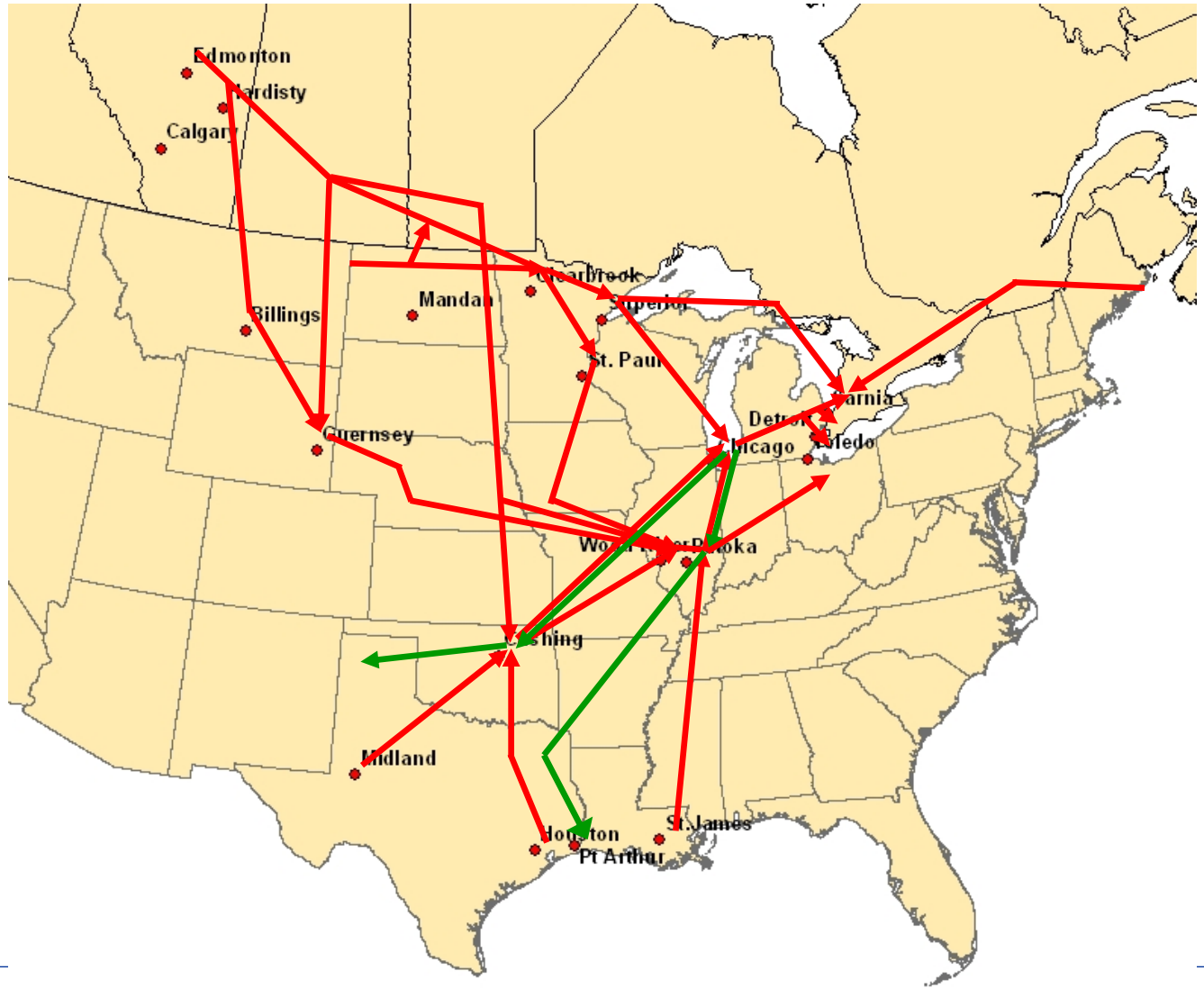
Current Situation:
Significant Midwest Inbound Pipeline Capacity

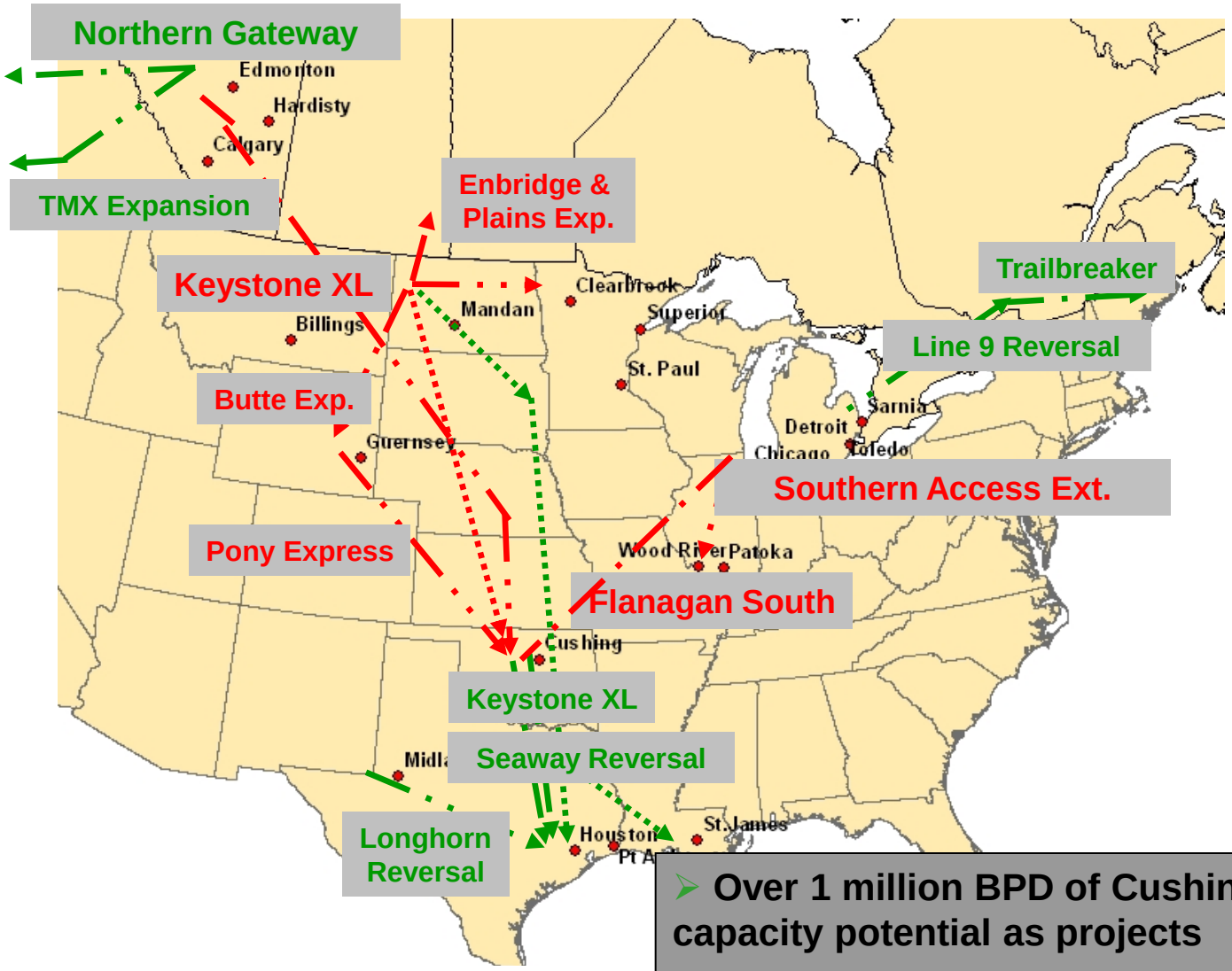


Existing Midwest Inbound pipeline capacity ~ 5.3 million BPD compared to 200,000 BPD of existing outbound capacity

Existing Inbound Pipelines

Existing Outbound Pipelines

Proposed Pipeline / Rail Projects is shifting flows to match production with refining centers



Existing Midwest Inbound pipeline capacity ~ 5.3 million BPD compared to 200,000 BPD of existing outbound capacity

Proposed Inbound Pipelines

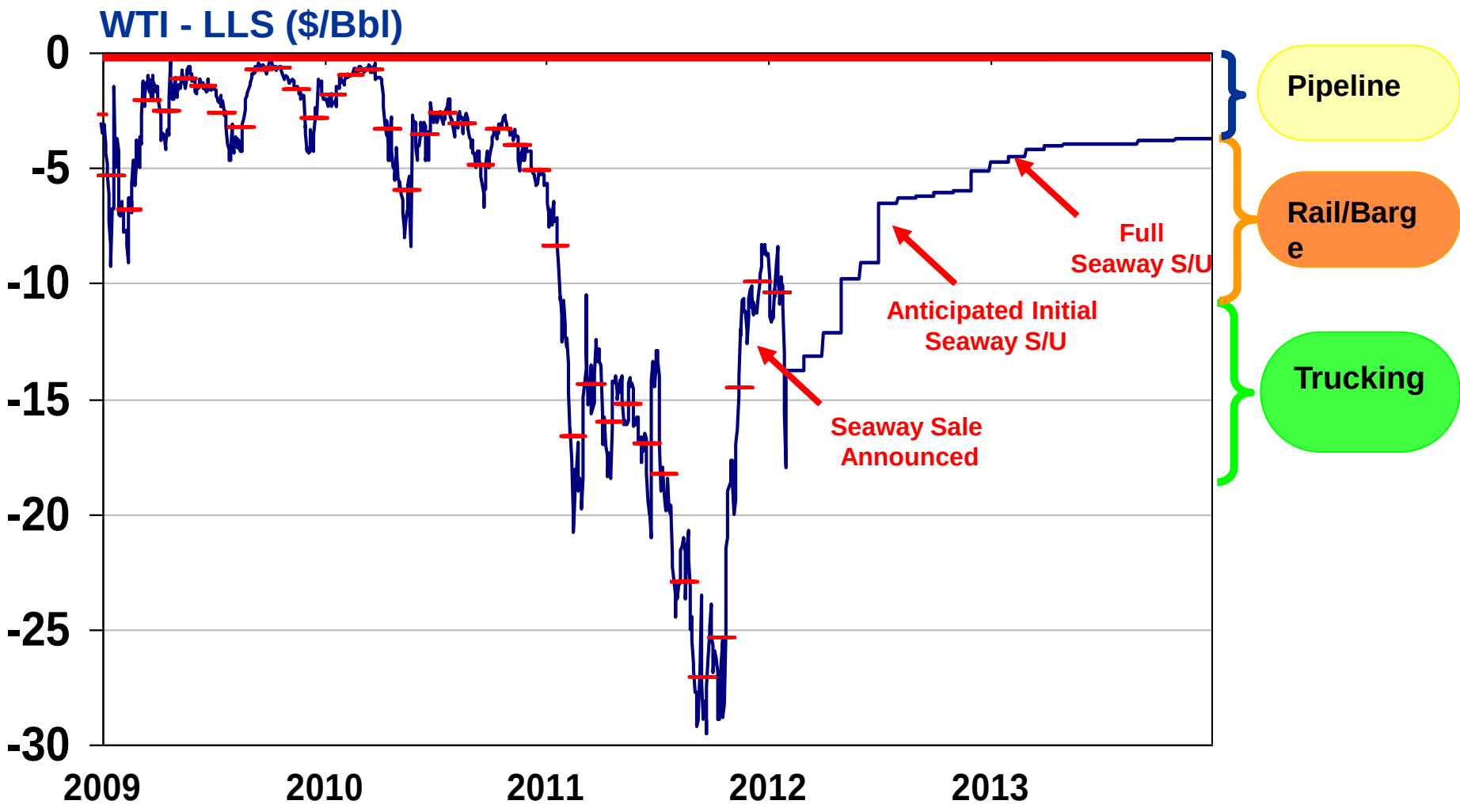
Proposed Outbound Pipelines

Proposed Inbound Rail Links

Proposed Outbound Rail Links

- Over 1 million BPD of Cushing outbound pipeline capacity potential as projects
- West coast projects add up to 1 million BPD outbound capacity

WTI prices have been discounted as a result of supply exceeding outbound pipeline capacity...



Summary: Supply / Demand

- Demand for petroleum products (and crude oil runs) in North America is projected to be flat
- Tight oil development is shifting the North American crude oil balance
- Canadian crude oil continues to grow at a high rate
  - But is utterly dependent on pipeline developments
- The US will continue to import crude oil
- A major logistical scramble is underway

Crude Oil Valuation and Supply / Demand Overview

- Crude Oil Supply / Demand
- Crude oil quality
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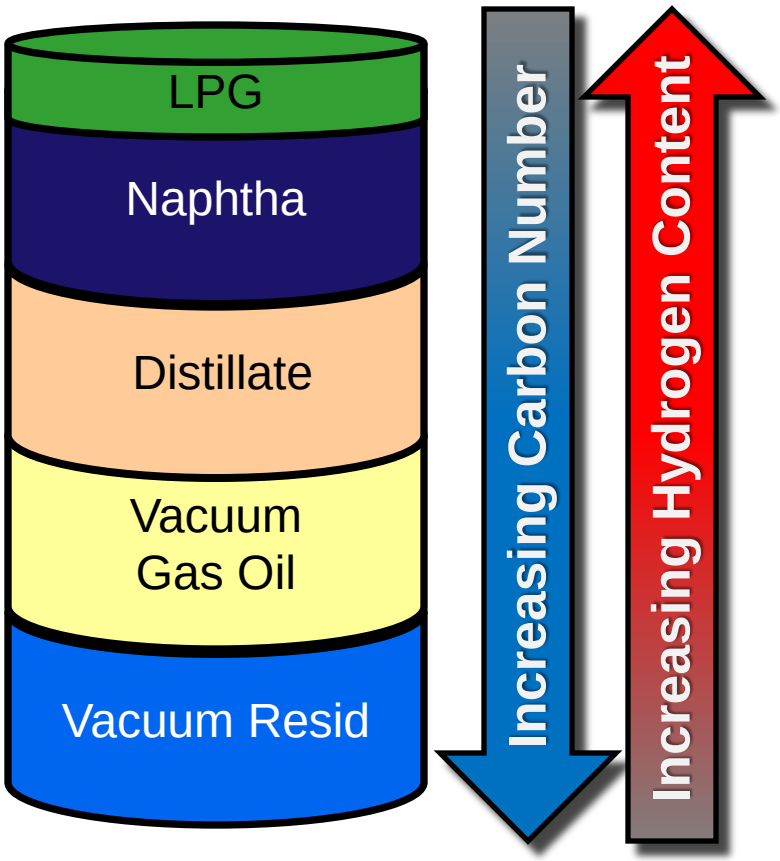
Crude oil is a broad mix of hydrocarbons, which must be refined prior to commercial use

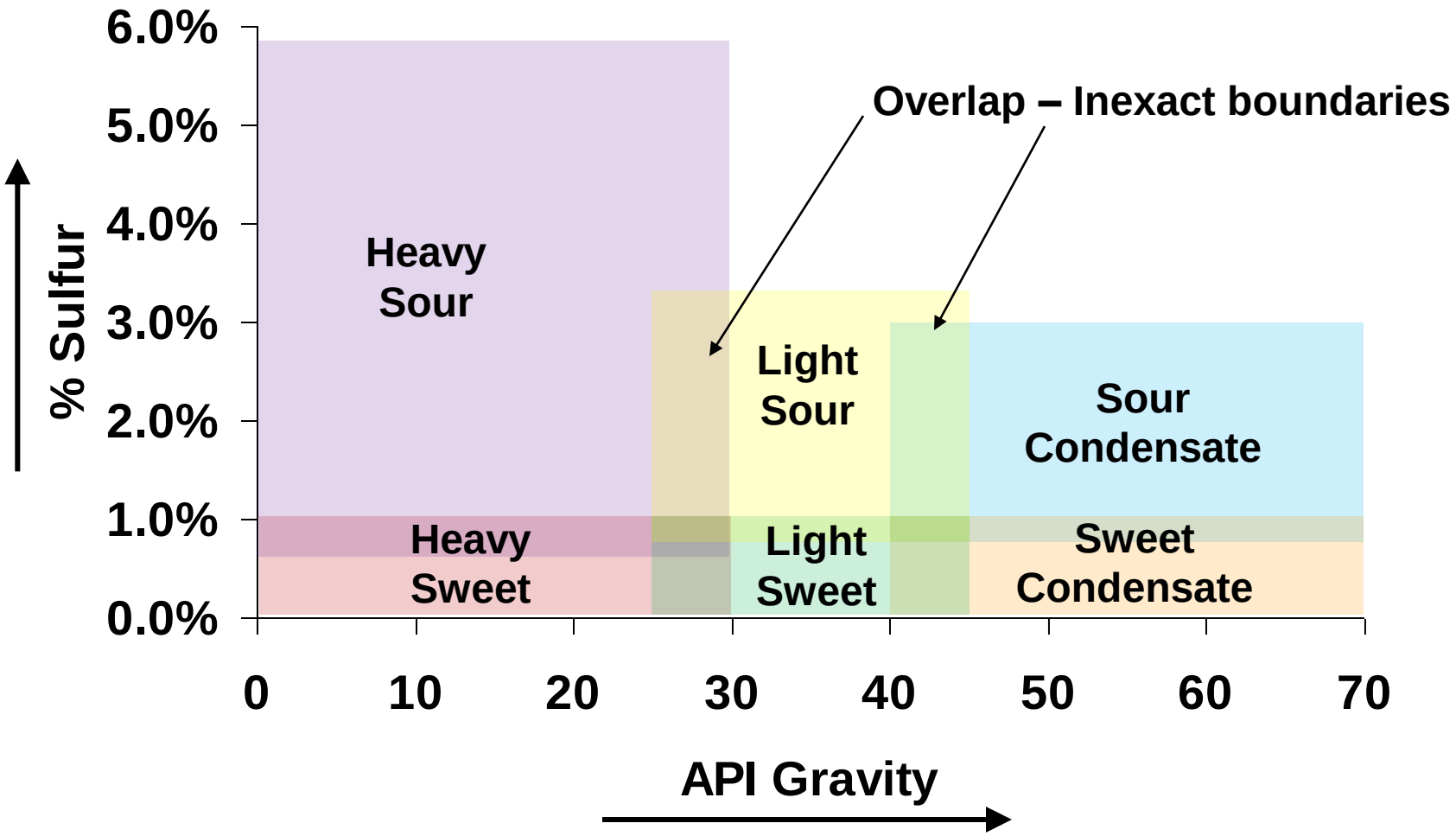


- Crude oil contains many different naturally hydrocarbon compounds
  - Primarily carbon & hydrogen atoms
  - Impurities (sulfur, nitrogen, metals)
- Molecules are categorized by the number of carbon atoms or molecular weight
  - Refinery processing schemes are largely based on boiling ranges, which are largely defined by molecular weight
- The molecular structure becomes more varied and complex as the molecular weight increases
  - Paraffins
  - Iso-Paraffins
  - Naphthenes
  - Aromatics
  - Asphaltenes, Other

Crude oils are defined by the crude oil assay...

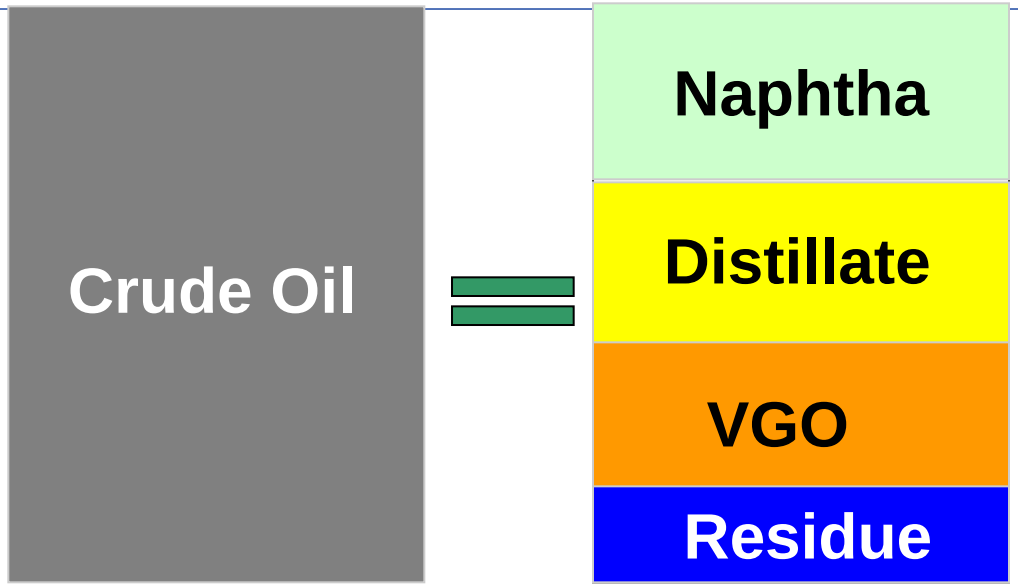
- **Major bulk properties defining crude oils include:**
  - **API Gravity**
  - **Sulfur**
  - **API Gravity and Sulfur generally relate to the "grade" of crude oil, and the degree of processing severity required to refine into usable products**
- **A crude oil distillation provides greater definition of the crude oil:**
  - **Defines the boiling cut fractions**
  - **Properties of the cut fractions provide further definition**
- **Other bulk crude properties also define the crude oil:**
  - **Total Acid Number (TAN)**
  - **Pour point**

In simple terms, a crude's quality can be summarized by API Gravity and Sulfur



- Light sour and light sweet are by far the most common grades

Each barrel of crude oil contains the various fractions that can be separated

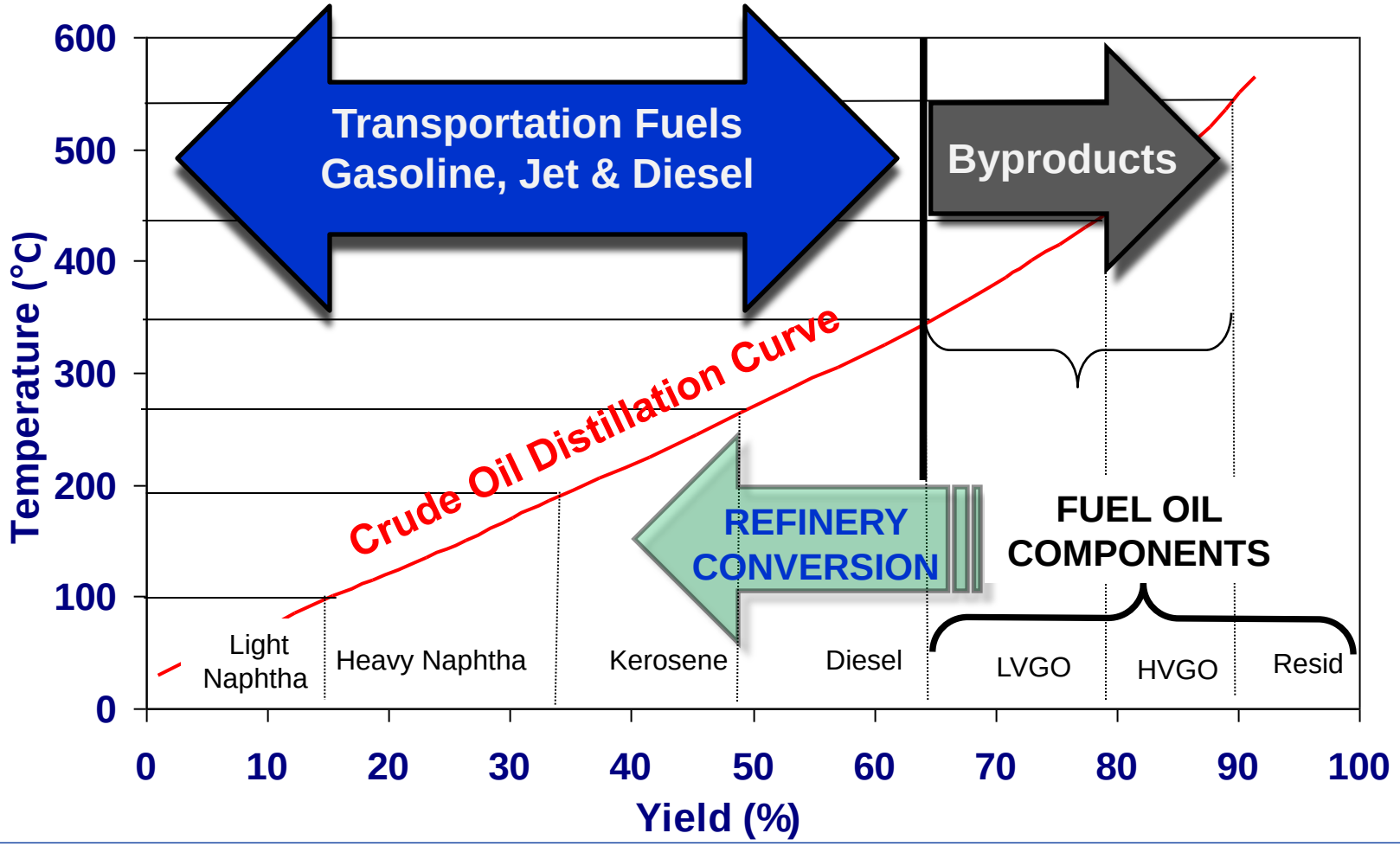


Fraction	Application	Boiling Range, ° C
Naphtha	Petchem feed Gasoline	IBP - 200°
Distillates	Jet Fuel Diesel Fuel	150° - 350°
Vacuum Gas Oils (VGO)	Lube Oil Fuel Oil	300° - 545°
Residue	Asphalt Fuel Oil	350° +

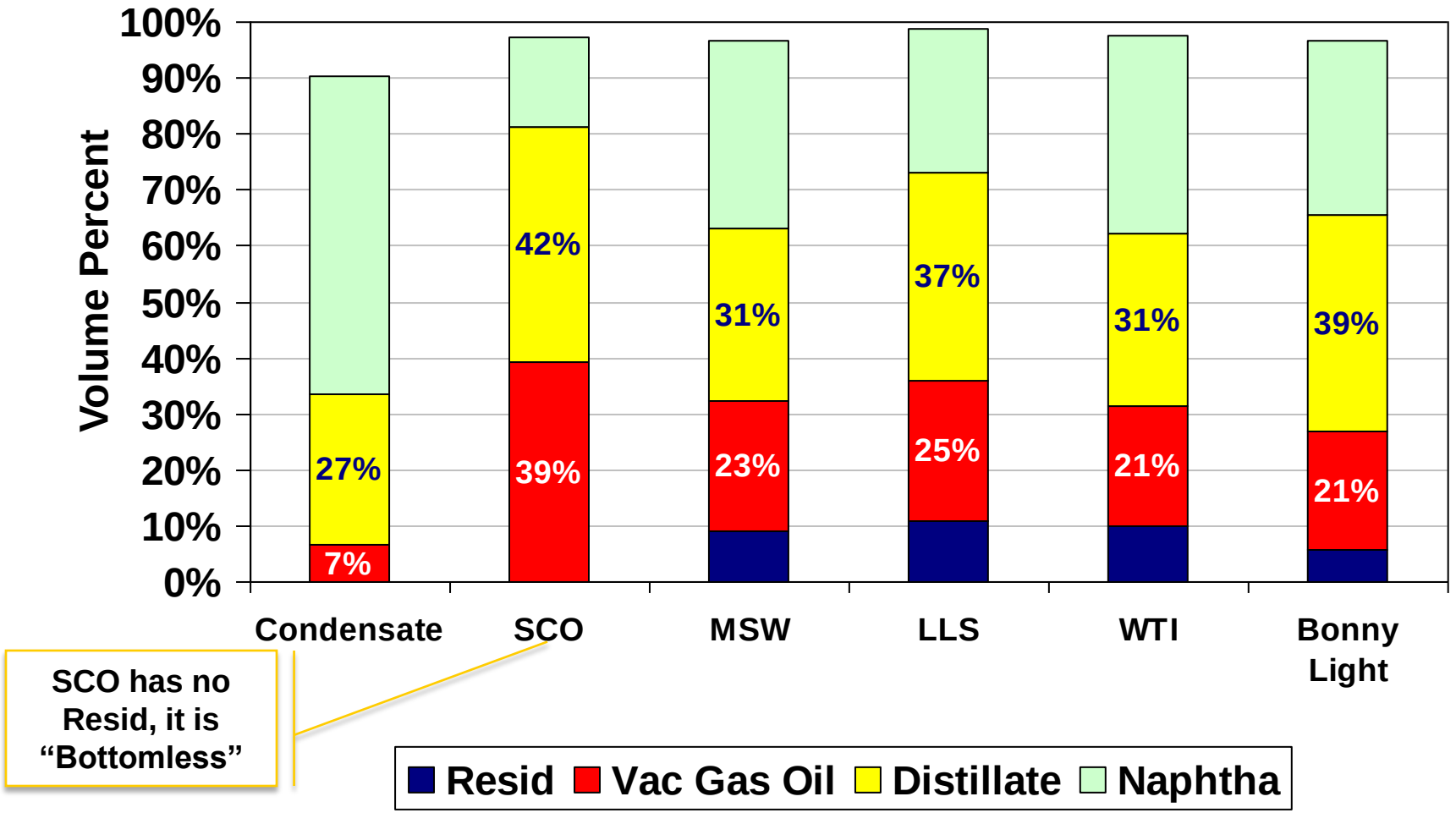
- Properties can be measured on the whole crude or on any part

- Each petroleum fraction has a typical boiling range

Most crude oils are first evaluated based on their distillation or transportation fuel content



Distillation Comparison—Light Sweet Crude



Note: Missing fraction is light ends.
Source: IHS Purvin & Gertz .

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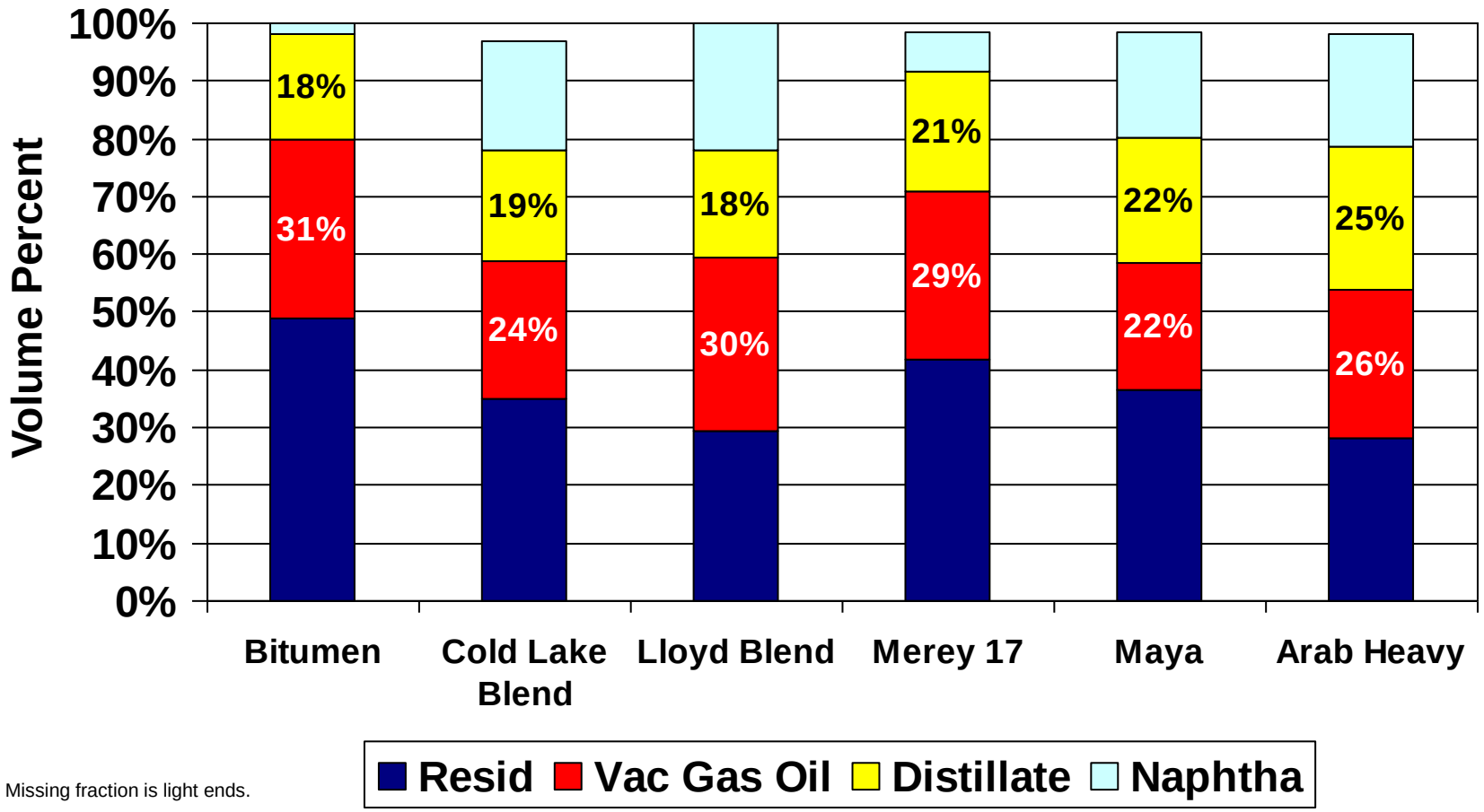
Distillation Comparison—Heavy Sour Crude



Note: Missing fraction is light ends.

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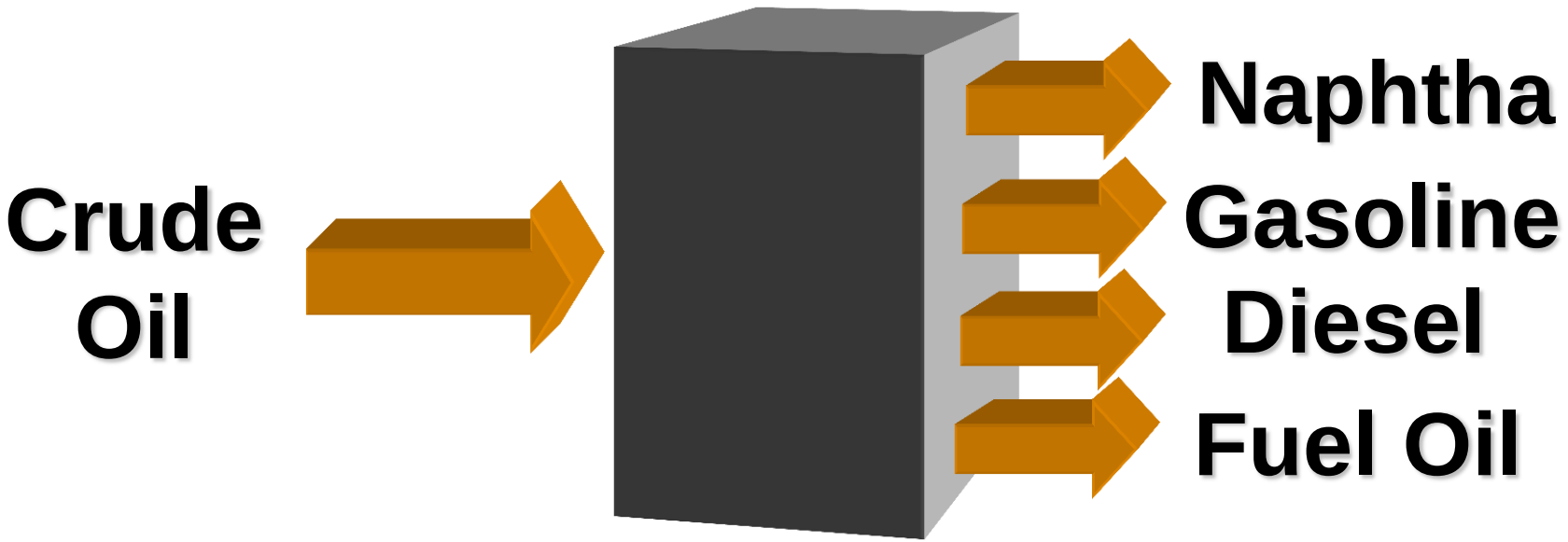
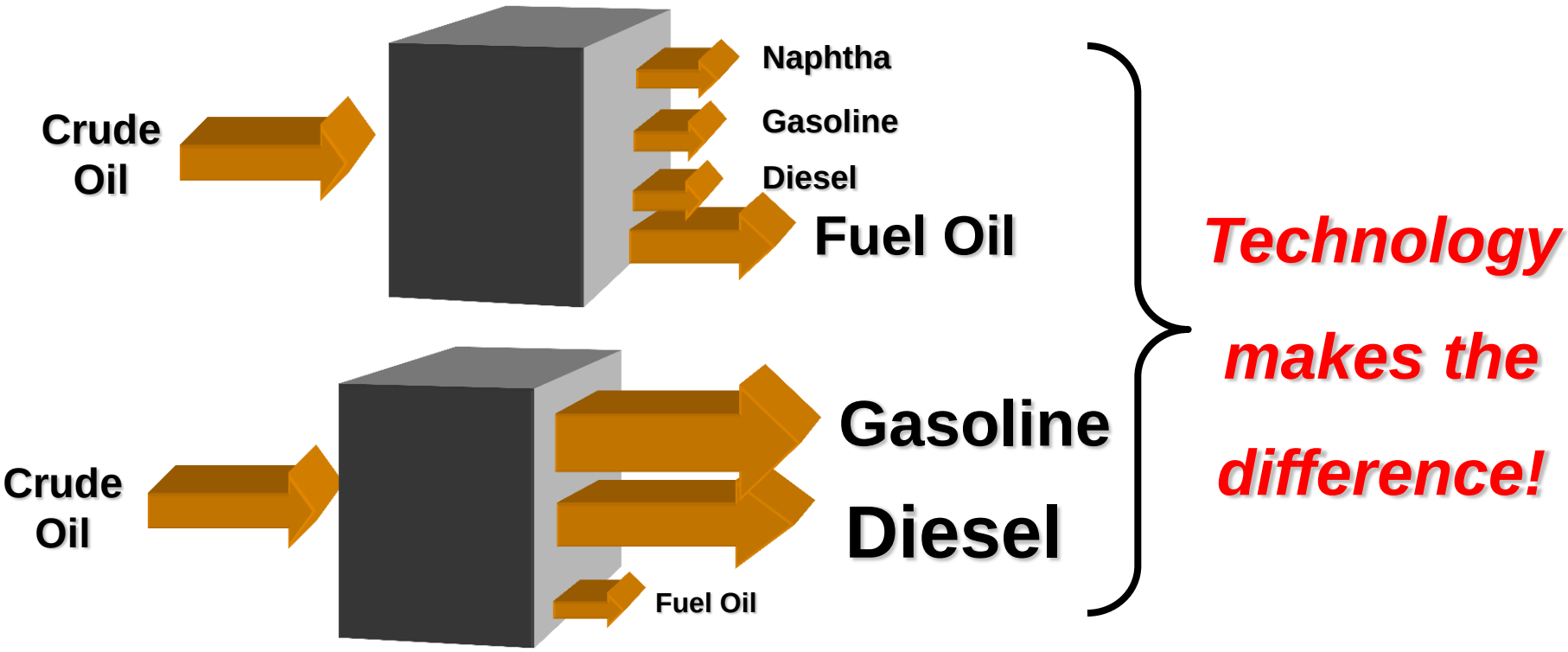
Refineries can seem to be black boxes converting crude oil to products…



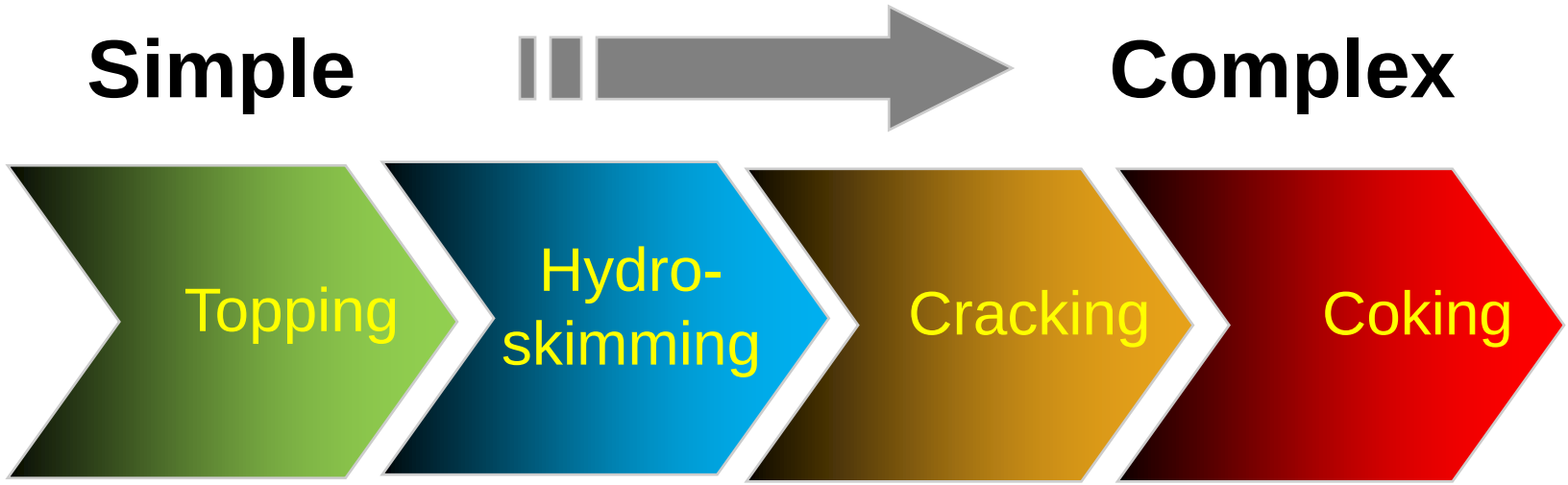
… but they are different in important ways



Refineries vary in:

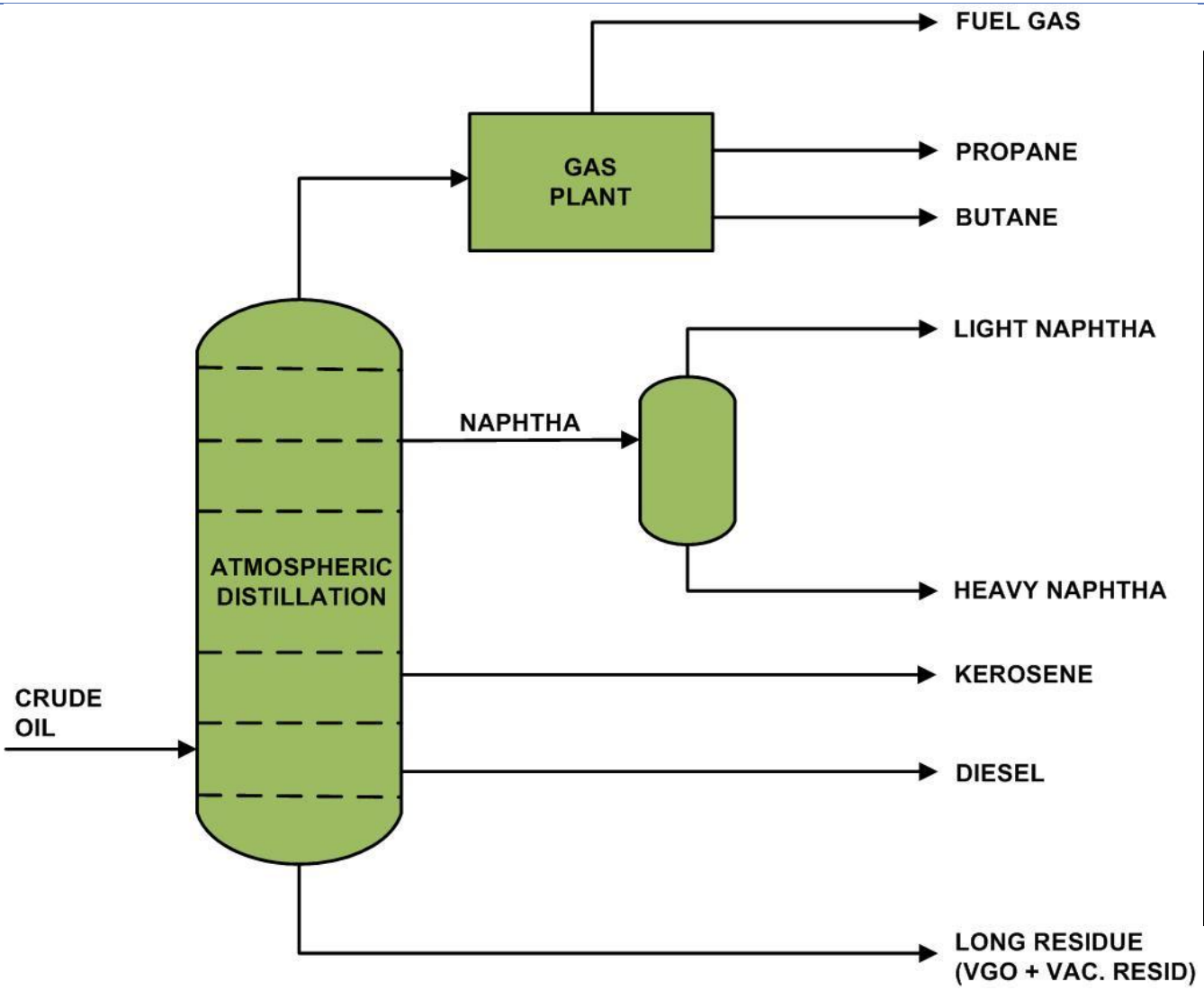
- What kind of crude they can process
- How much they can process
- What they can make from a given crude

Refineries may be classified by type of the processing employed



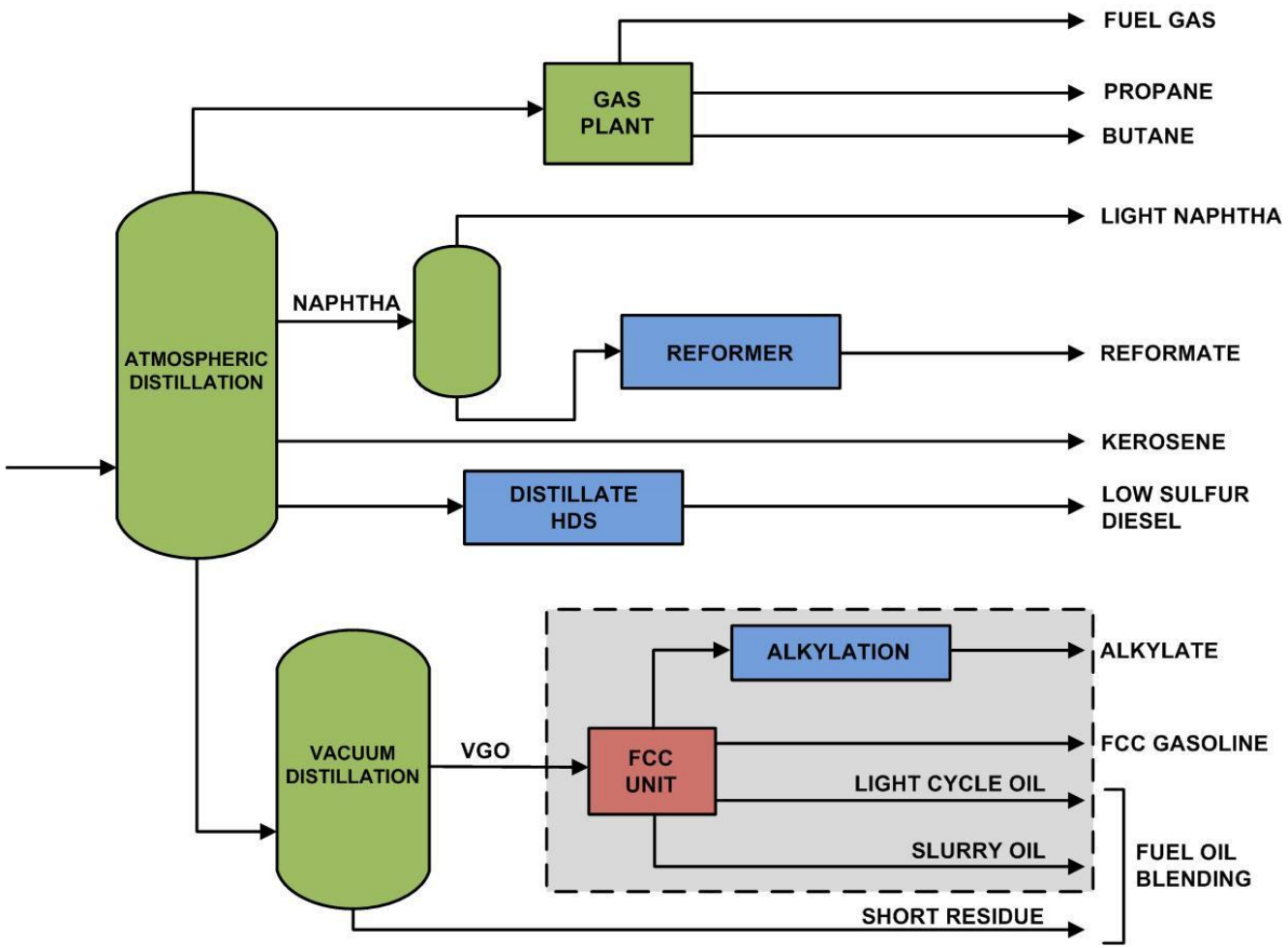
"Low Conversion" → "High Conversion"

Simple Topping Refinery



- Refinery topping operations generally require niche economics
- Not competitive in most coastal regions
- Produces refinery intermediates and is often associated with small scale asphalt production
- No treating or conversion

Typical Cracking Refinery



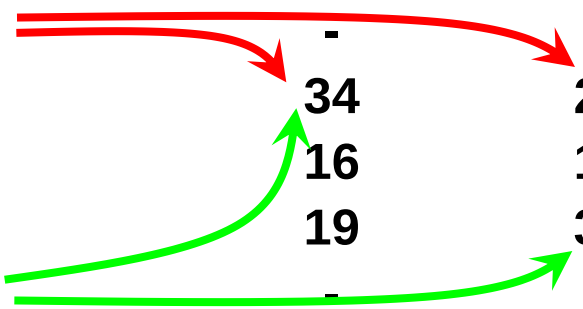
- Cracking refineries are the most common outside of the U.S.
- Vacuum gas oil (VGO) is converted via hydrocracking (HCU) or fluid catalytic cracking (FCC)
- Vacuum (short) residue is blended with cutter stock (lighter streams) to meet fuel oil viscosity specifications

Cracking refineries convert vacuum gasoil into lighter transportation fuels

Volume % Yields

TYPICAL REFINERY YIELD

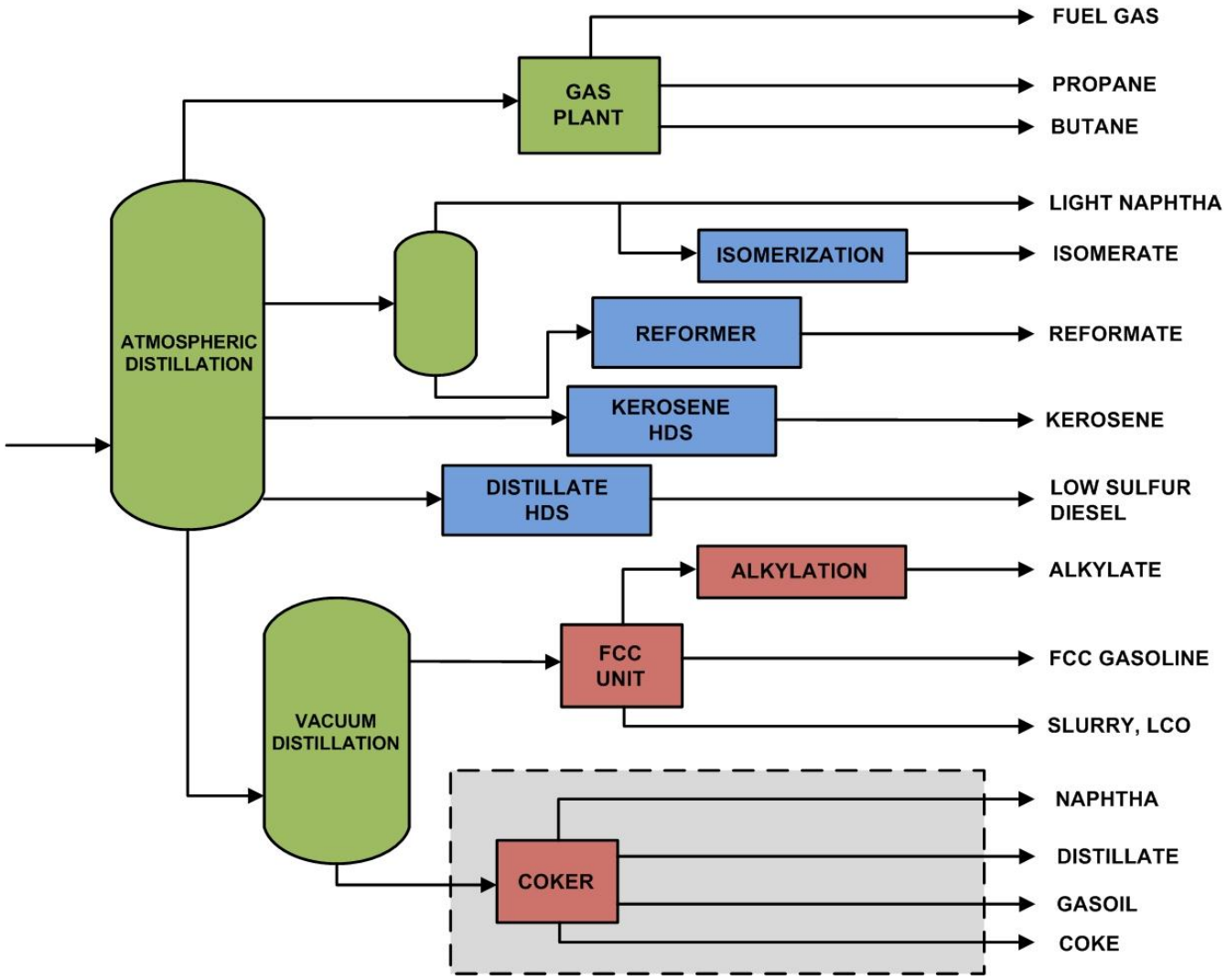
	Crude	FCCU	HCU
LPG	2	8	6
Naphtha	16	-	-
Gasoline	-	34	24
Kerosene	16	16	19
Distillate	25	19	30
Vac. Gasoil	26	-	-
Vac. Resid	15	-	-
Fuel Oil	-	23	23



HCU refineries more oriented to distillates

FCCU refineries make mostly gasoline

Typical Complex (Coking) Refinery



- Vacuum residue is converted to light products
- Required to economically process heavy crude oils from Canada and Latin America
- Delayed coking produces low quality gas oil, distillate, and naphtha that require further treating
- Petroleum coke is produced
  - Low-value byproduct

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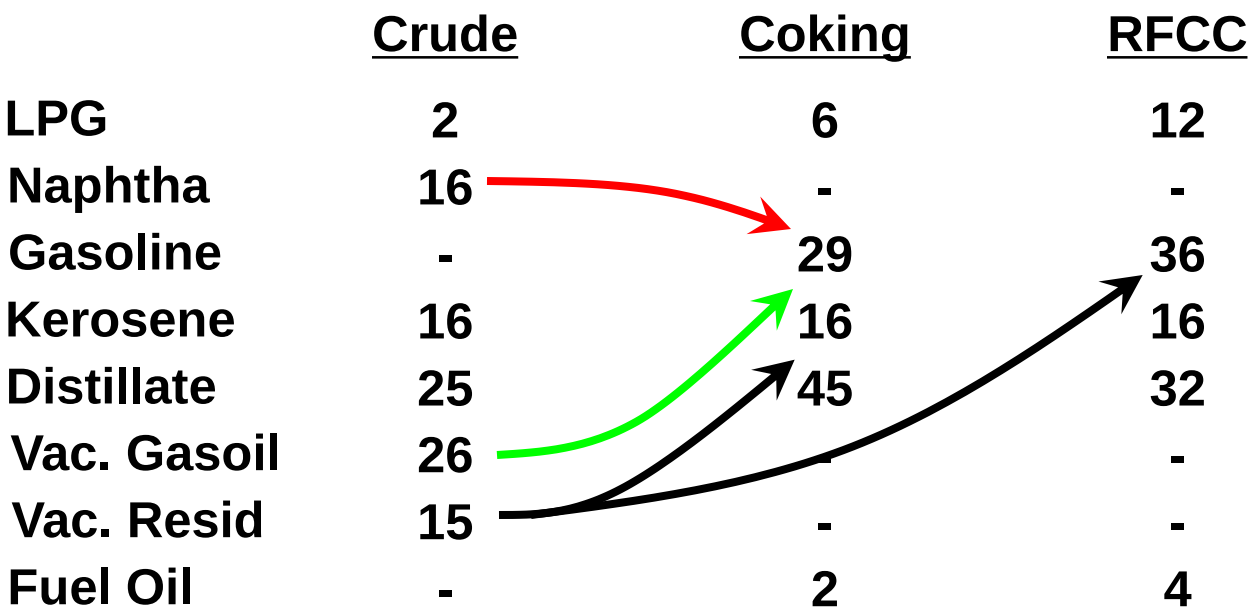
“Full conversion” refineries upgrade the bottom of the barrel to lighter streams

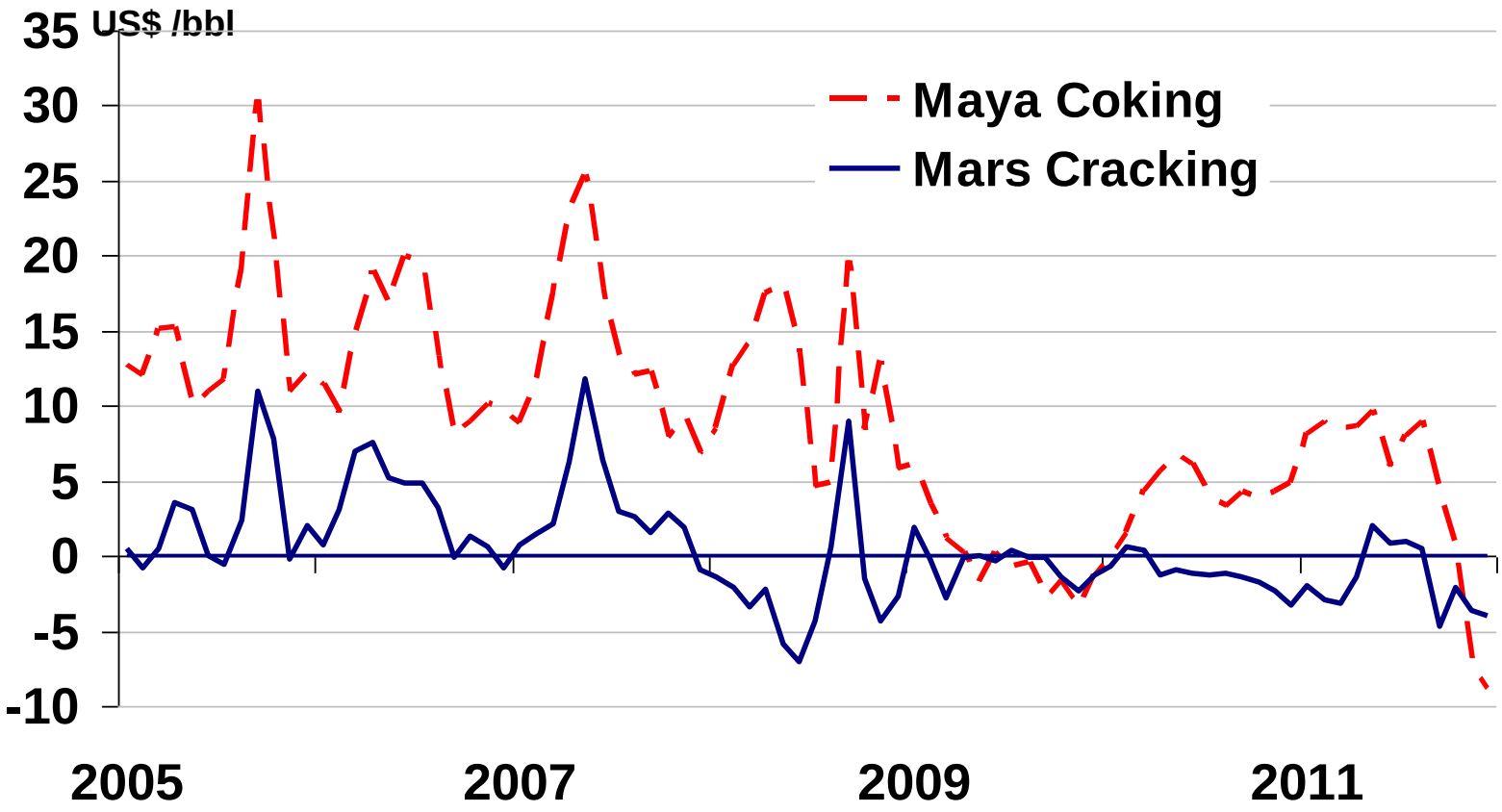
Volume % Yields

TYPICAL REFINERY YIELD



	Crude	Coking	RFCC
LPG	2	6	12
Naphtha	16	-	-
Gasoline	-	29	36
Kerosene	16	16	16
Distillate	25	45	32
Vac. Gasoil	26	-	-
Vac. Resid	15	-	-
Fuel Oil	-	2	4

Heavy Sour Coking Margins Are Typically Much Higher than Light Sour Crude Oil Cracking Margins...



Source: IHS Purvin & Gertz, Platts.

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Why don't all refiners have cokers?

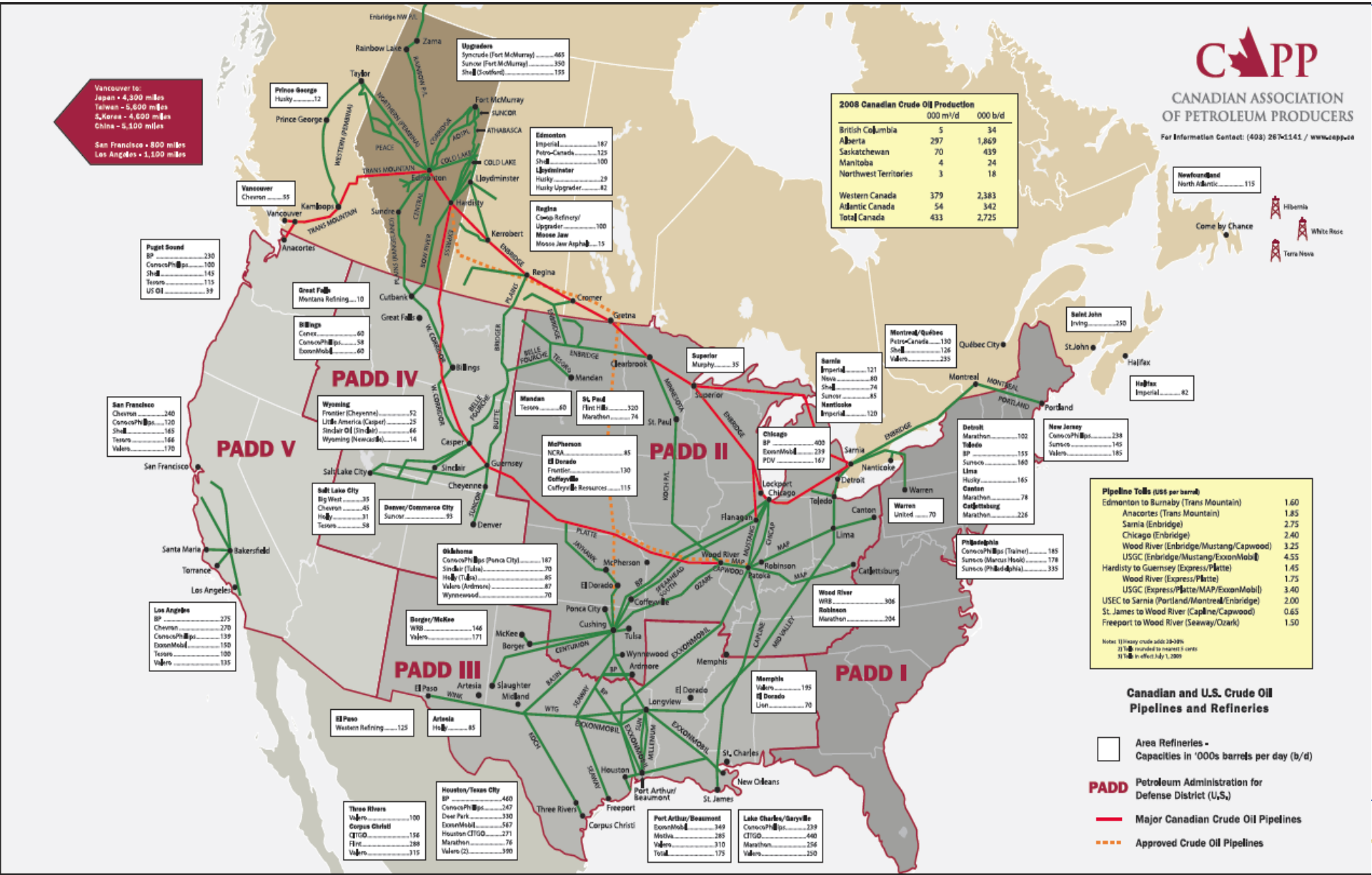
- **Capital cost requirements for a coking refinery are high**
- **Refiner expects a return on capital for investment in coker**
  - **Ability to process heavier, sourer crude oils**
    - Lower cost of crude

Representative Capital Investment

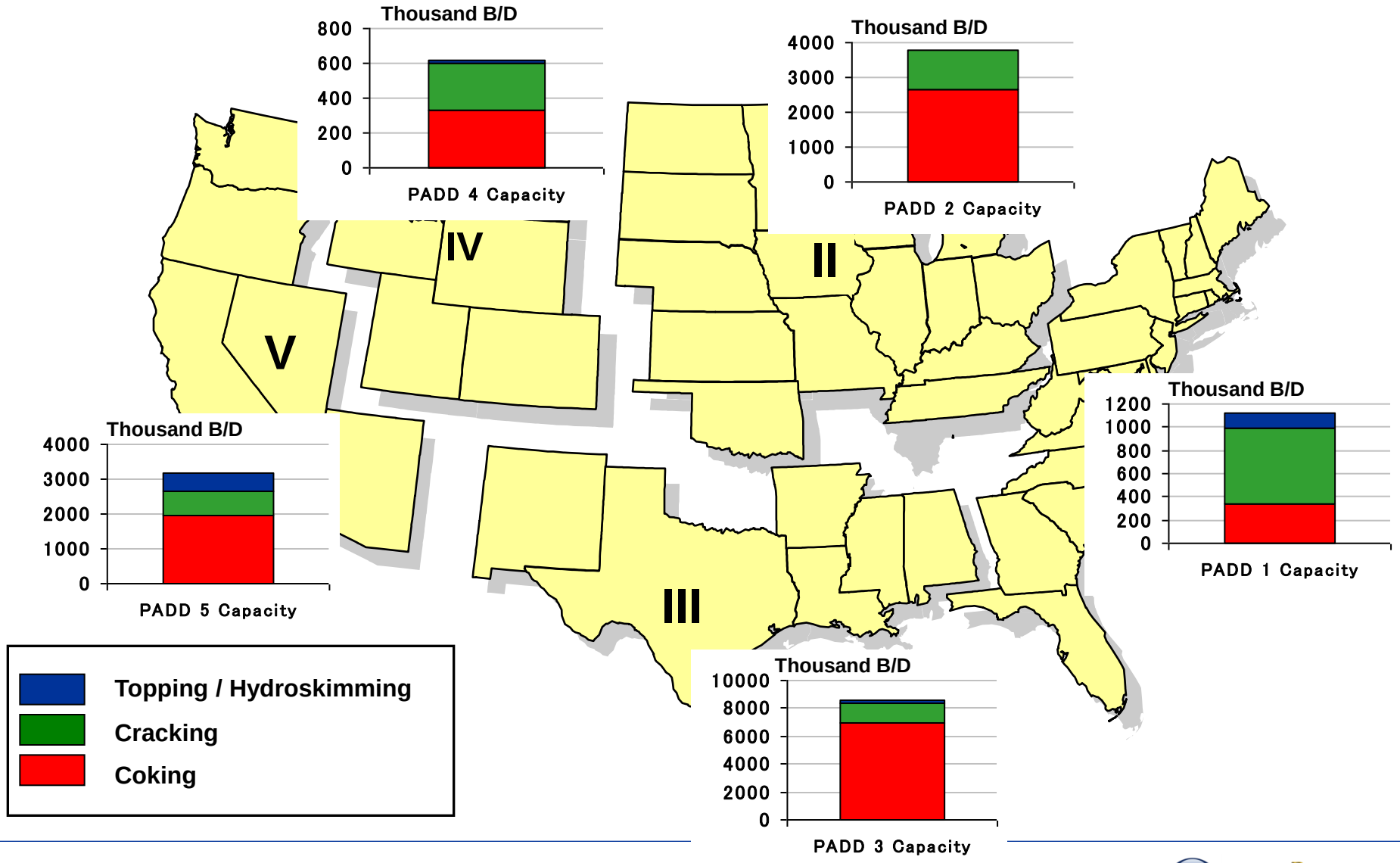
200,000 BPD CRUDE OIL THROUGHPUT
(Million US$)

	Mars Cracking	Maya Coking
Inside Battery Limits		
Crude / Vacuum	213.2	226.2
FCCU	172.5	205.7
Coker	-	350.9
Hydrotreating	193.7	312.6
Naphtha Reforming / treating	148.5	181.4
Alkylation	34.8	50.2
Hydrogen	36.3	68.3
Sulphur	78.2	185.2
Other	12.0	14.3
Sub-Total ISBL	889.2	1594.7
Offsites	578.3	774.0
Sub-Total ISBL / OSBL	1467.4	2368.7
Initial Cat Fill / Licensing Costs	62.4	100.7
Owner's Cost	208.4	336.4
Escalation and Contingency	389.2	628.2
Total	2127.4	3433.9

Overview of US Refineries / Pipelines



US refinery capacity is concentrated in USGC....



Summary

- More complex refineries make progressively more light product and less heavy product out of the same crude oil
  - Said another way, a complex refinery can make the same product slate as simpler refineries, but with lower quality (lower priced) crude oil
- There are commercial examples of all levels of sophistication
  - Newer refineries tend to be more sophisticated and complex
  - Refinery complexity will shift with product demand
- The refinery configuration, and the configuration in which a crude oil processed, is important in establishing the value of a particular crude oil in a given market

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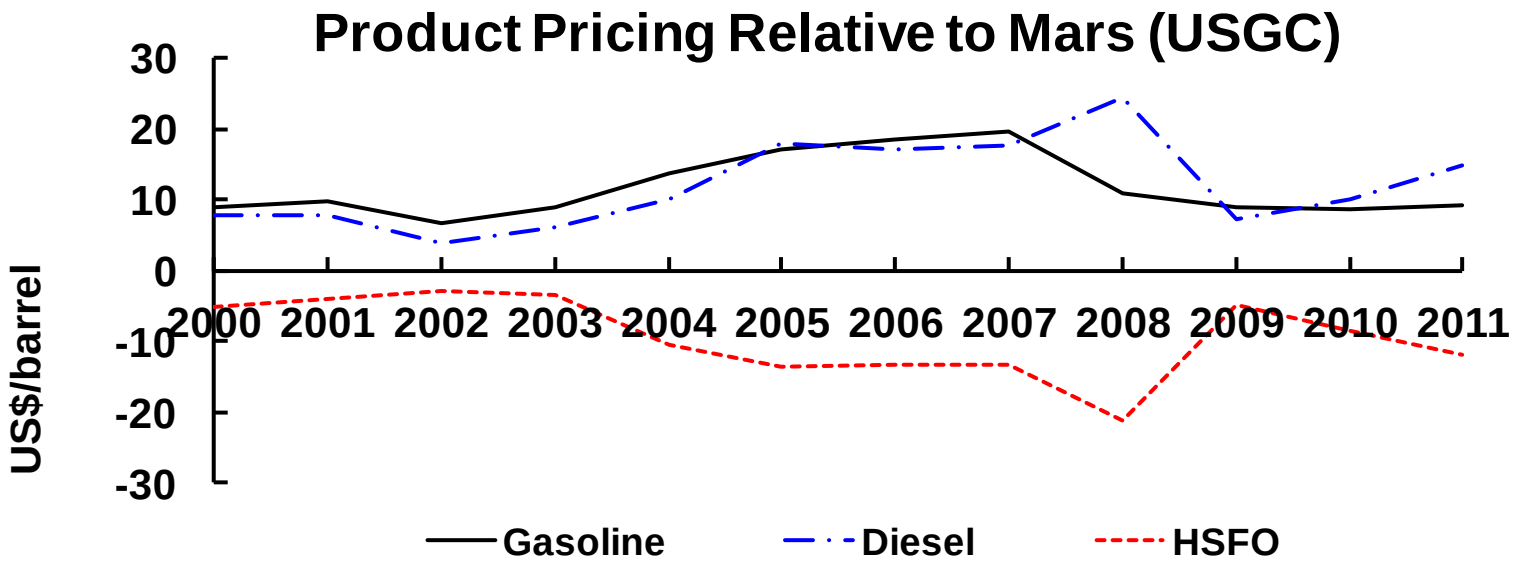
How does a refiner value a crude oil?

- **The value of crude oil is based on the products that can be produced from the crude within a refinery of a certain configuration**
  - **The value of a crude oil will vary dependent on the refinery configuration in which the crude oil is processed**

- **A crude oil price is established by a number of variables:**
  - **The benchmark crude oil for a region (prevailing price level)**
  - **Marginal refinery configuration for a given region**
  - **Transportation costs to transport crude to the refinery**
  - **Logistical and/or other market factors which impact crude price**

Basic Product Pricing Relationships

- Light products (gasoline, diesel) generally price above crude oil
- Fuel oil is generally priced *below* crude oil pricing
  - Provides incentive to convert residue to light products



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Example: Refinery Margin Calculation

Sales	MSW Cracker	Bow River Cracker	Bow River Coker
LPG	3	1	3
Gasoline	54	36	51
Distillate (Diesel/Jet Fuel)	32	12	41
Fuel Oil	13	54	2
Sulfur (T/kbbl)	0.2	1.6	3.3
Butane	(3)	(4)	(6)
Gross Product Value ($/Bbl)	$59.29	$49.10	$55.70
Crude Cost ($/Bbl)	$56.59	$42.80	$42.80
Gross Margin ($/Bbl)	$2.70	$6.30	$12.90

A coking refinery converts fuel oil to light products

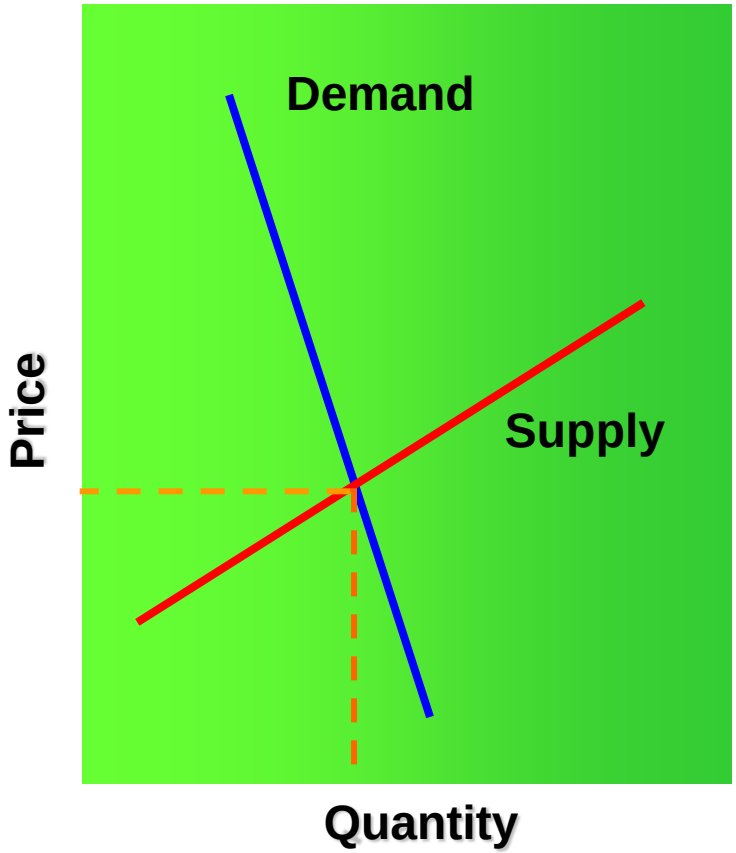
The GPV is the value of the crude oil after refining

Crude price is the same

The coking refinery benefits as the price of crude is set by a simpler configuration

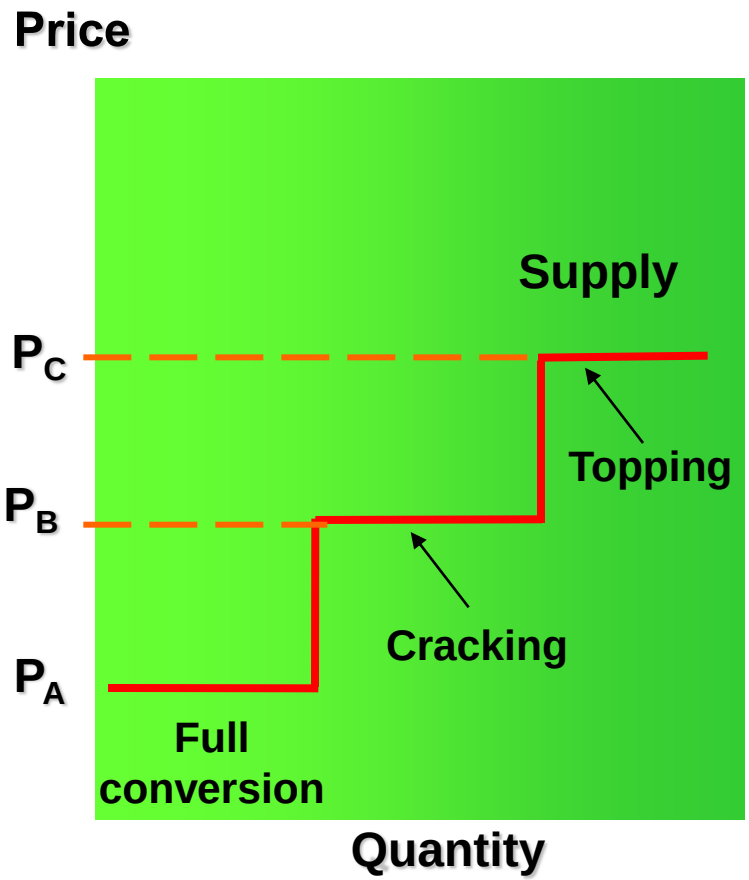
Determining the marginal refinery configuration.....

Supply and demand must balance



- Economics teaches that equilibrium pricing occurs at the price at which the supply and demand are in balance
- Prices below the equilibrium level are unstable as more product will be demanded than the suppliers can manufacture
- Prices above the equilibrium level lead to more supply than the market will absorb forcing prices back down

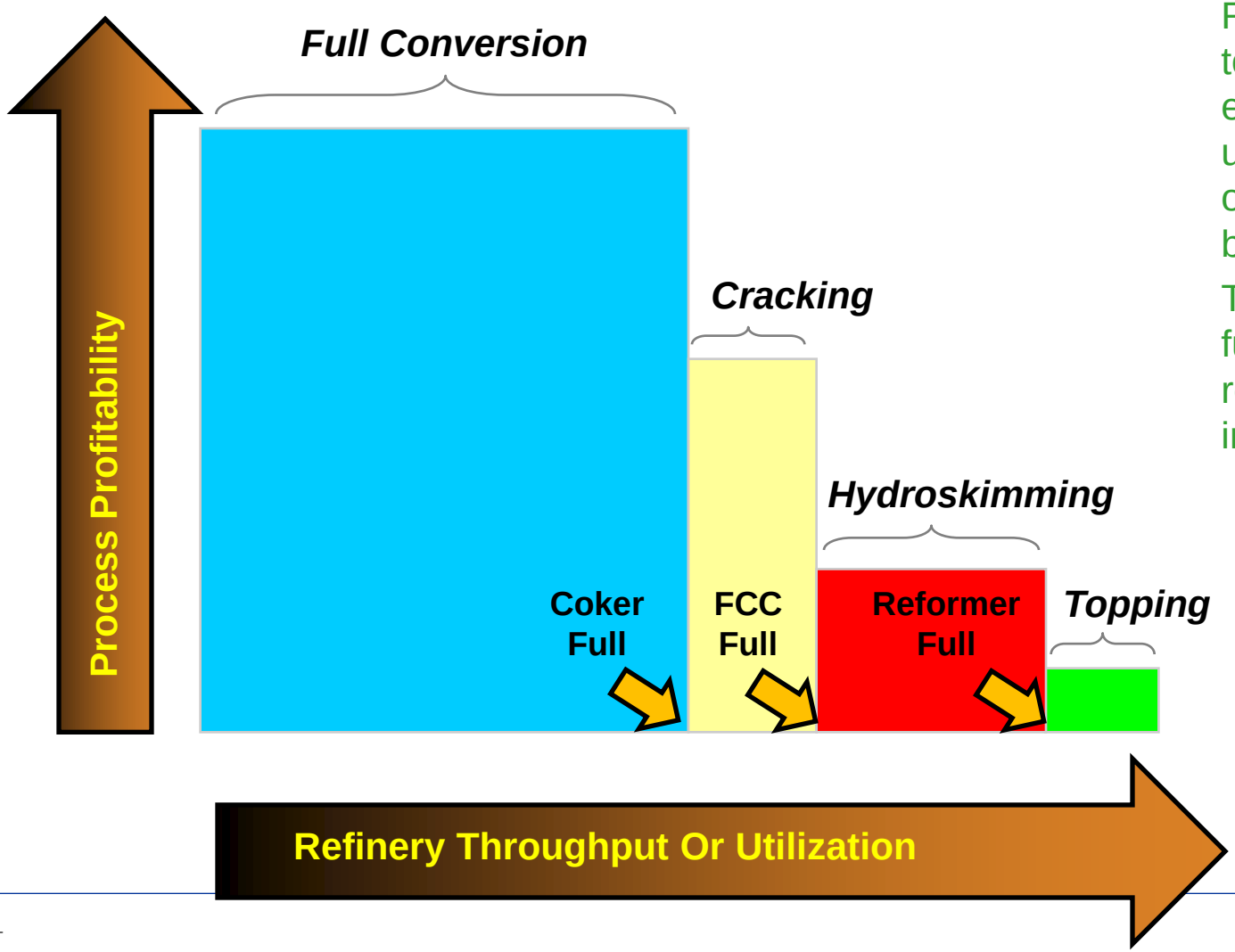
In refining, the supply curve is stepped based on the price level needed for each configuration



- Each step is set by the economics of a refinery configuration
- Full conversion refineries can make breakeven margins at poor pricing levels, P_A
- Cracking refineries must have better pricing, P_B, just to break even
- Topping or hydroskimming refineries can survive only if pricing is quite favorable, P_C

Lowest cost is supplied by the most efficient configuration

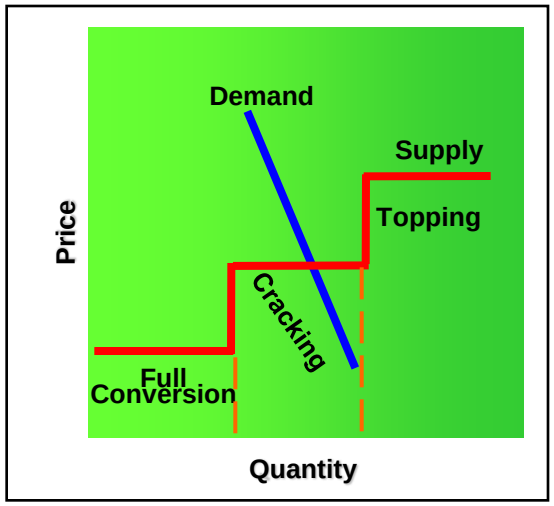
A refining market can be thought of as operating in different levels of complexity modes as throughput increases



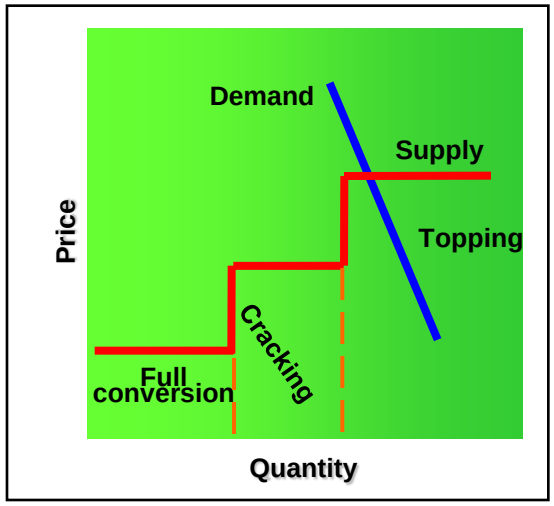
Refineries usually try to maximize profit by extending operations until the marginal operating mode has been filled

This economic fundamental exists in regional markets and in individual refineries

The market clearing configuration varies from market to market



- North American market is characterized by high conversion capacity being adequate to meet demand



- Asian market is characterized by reliance on some unsophisticated capacity to meet demand

The value between crudes is determined by refining economics

- Refiners are constantly evaluating different crude grades and the price of those crudes
- Complex simulation models are utilized to optimize profitability on a daily, weekly and month period
  - Coordinated with crude trading group and product marketing
- In theory (and many actual situations) marginal refining margin explains the price difference between two crude oils

Reference Crude Oils

- Reference crude oils vary by location and crude type
  - WTI: Reference crude oil for North American inland crudes
  - LLS: Reference crude oil for sweet crude oils on the USGC
  - Mars: Light sour crude oil reference along the USGC
  - Brent: Light sweet European benchmark
  - Urals: Light / heavy sour European benchmark

- The difference in price between reference crude oils will vary due to:
  - Quality differences
  - Transportation adjustment
  - Market factors (i.e. WTI, LLS differential)

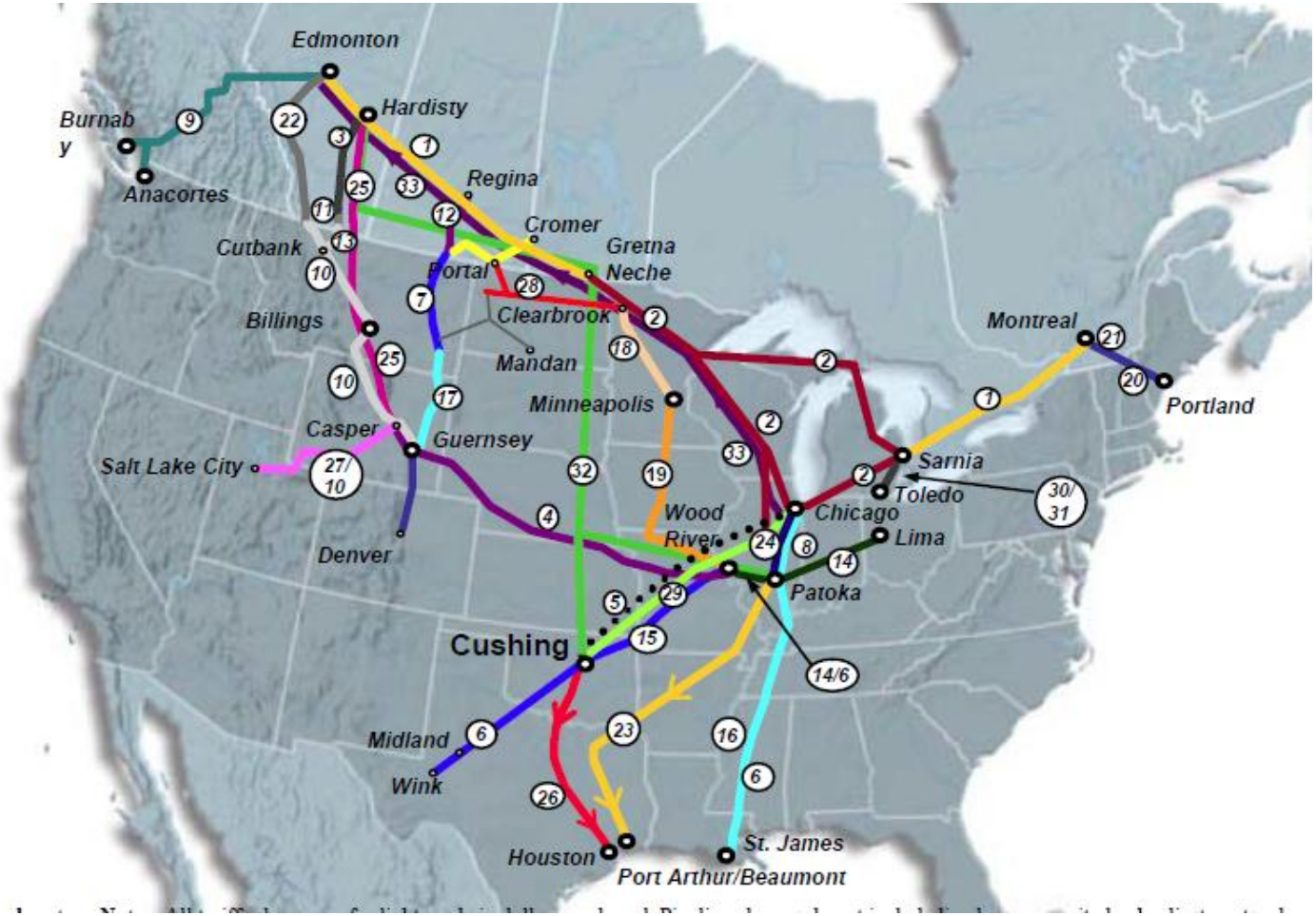
- When determining the price of a specific crude oil, it is critical that is the correct reference crude oil is applied

Transportation Costs

- **A refiner considers the crude value at the refinery gate**
  - **Refinery gate price = crude, fob + transportation**

- **For US inland crudes, transportation costs consist of:**
  - **Gathering costs**
  - **Terminaling**
  - **Pipeline tariff to refining hub**
  - **May also consist of trucking and/or rail costs, dependent on location**

Pipeline Tariffs - Example



Selected Tariffs

2. Edmonton to Chicago
Light - $3.49 /bbl
Heavy - $4.26 /bbl

6. Wink to Cushing
Light - $0.6359 /bbl

26. Cushing to USGC
Uncommitted tariffs
Light – $3.82 /bbl
Heavy – $4.32 /bbl

27. Casper to Divide Jct
Light - $0.699 /bbl
Heavy - $0.85 /bbl

28. Portal to Clearbrook
Light – $1.147 /bbl

Source: CAPP Crude Oil Report, May 2012

Summary

- **The value of crude oil is based on the products that can be produced from the crude within a refinery of a certain configuration**
  - **More complex refineries make progressively more light product and less heavy product out of the same crude oil**
  - **More complex refineries can make the same product slate as simpler refineries, out of lower quality crude oil**

- **The price of a specific crude oil is dependent on a number of complex factors:**
  - **The benchmark crude oil for a region**
  - **Marginal refinery configuration for a given region**
  - **Transportation costs to transport crude to the refinery**
  - **Logistical and/or other market factors which impact crude price**

Crude Oil Valuation and Supply / Demand Overview

- Crude Oil Supply / Demand
- Crude oil quality
- Refinery Configurations
- Crude Oil Valuation Basics
- **Simplified crude valuation approaches**

Simplified approaches can be used to estimate relative value of crude oils

- **Refining value crude valuation approaches are complicated**
  - **Generally requires sophisticated refinery models which includes many subjective assumptions**

- **Simplified crude valuation approaches are used by industry to estimate crude value approaches**
  - **Widely used for quality bank (also called equalization) applications**
  - **Adjustment for crude oil pricing versus a posted price**

Quality Banks

- Quality Bank procedures are needed when crude streams are commingled for shipping
  - Procedures used to compensate shippers for value differences between common and component streams
- Commingling means each crude loses its unique identity
- Shippers wishing to retain unique properties do not commingle their crude

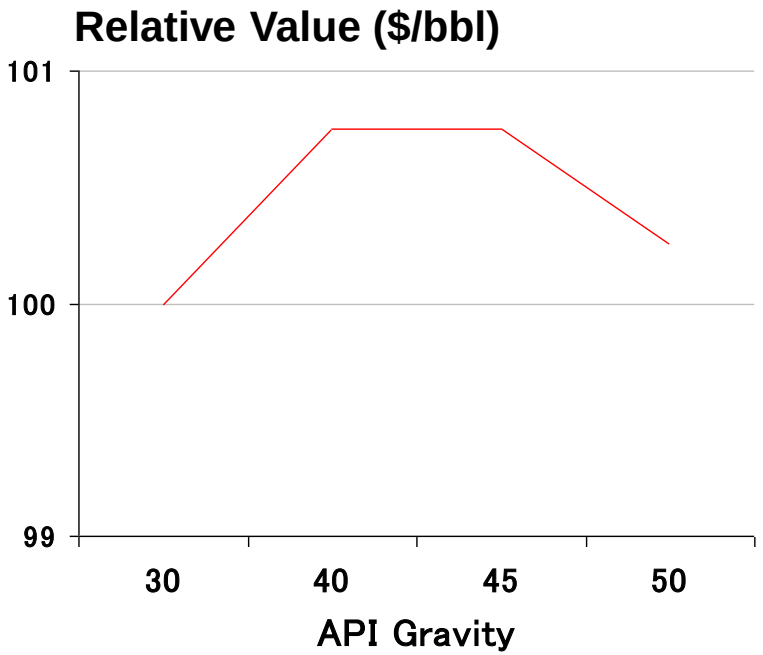
Quality Bank Methods Used by Industry

- Most U.S. quality banks use gravity or gravity and sulfur
  - Gravity alone is sufficient if sulfur varies systematically with gravity
  - Many quality parameters typically vary regularly with gravity
- Distillation cut methods widely used in Europe or when bulk property methods don't apply
- More complicated Refining value approaches are generally less desirable and rarely used

Example: Crude Oil Price Gravity Corrections

- **API Gravity coefficients may be fixed or market based**
  - **Historic adjustment of $0.15 /API-bbl (for crudes below 40° APU) used for postings and the USGC GravCap quality bank application**
- **Crude oil postings also use gravity adjustment factors to account for differences in the posted quality**

Example Gravity Scale



Example – Bulk Properties Method Determination of API and Sulfur Coefficients

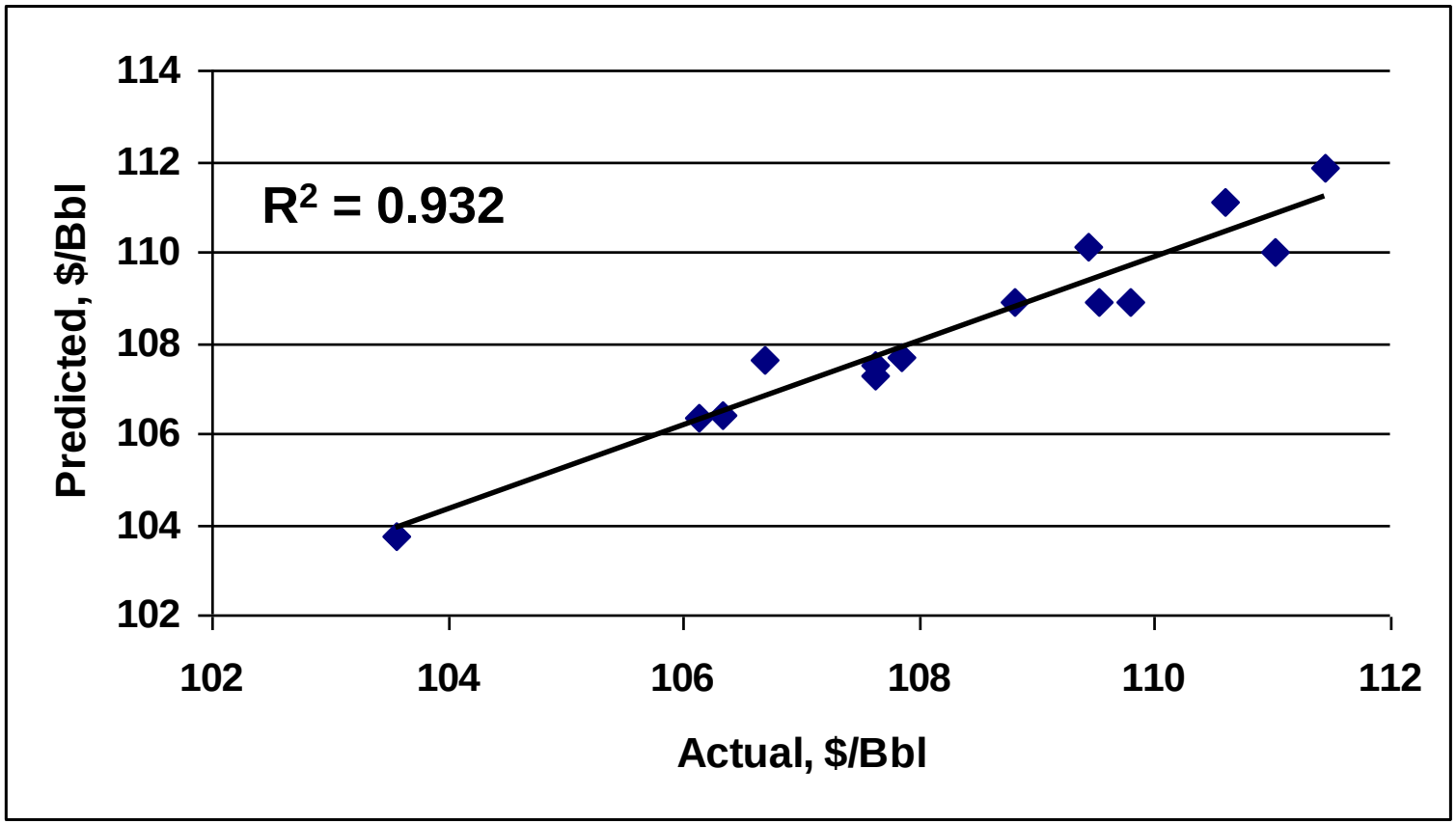
	API	Sulfur	October - December 2011 Average	Predicted	Residual
Arab Light	33.5	1.92	109.52	108.90	1.00
Arab Medium	30.4	2.44	107.64	107.50	0.22
Arab Heavy	27.9	2.86	106.13	106.37	0.38
Eugene Island	34.5	0.94	109.44	110.11	1.08
HLS	32.4	0.38	111.01	110.01	1.61
Kuwait	30.4	2.66	107.64	107.29	0.55
LLS	36.0	0.34	110.60	111.11	0.83
Mars	29.2	1.92	106.68	107.63	1.53
Maya	20.9	3.44	103.56	103.75	0.31
Vasconia	26.0	0.85	107.85	107.68	0.27
Isthmus	32.2	1.51	109.79	108.90	1.44
Brent	38.6	0.38	111.43	111.85	0.66
Oriente	23.8	1.52	106.32	106.40	0.13
Cano Limon	29.2	0.55	108.80	108.90	0.17

Independent Variables

Dependent Variables

Example – Market Based Bulk Properties Method

Crude Price = 100.77 + 0.296*(° API) – 0.931*(%Sulfur)



**** Time Frame – October 2011 – December 2011***

Summary

- **Simplified crude valuation approaches based on crude bulk properties are commonly applied in industry**
  - **Provide an estimate of more complex crude valuation methods**
- **Generally, API Gravity or API Gravity / Sulfur are used**
- **Factors may be fixed or market based**
  - **Fixed factor have historically represented a long-term average**
  - **Market based factors can be used to more accurately track the current market**

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