

KBC
NextGen Performance®

Maximizing Refining Value With Abundant Shale Oil

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Coking.com®
More Production - Less Risk!

May 2013
Galveston, Texas

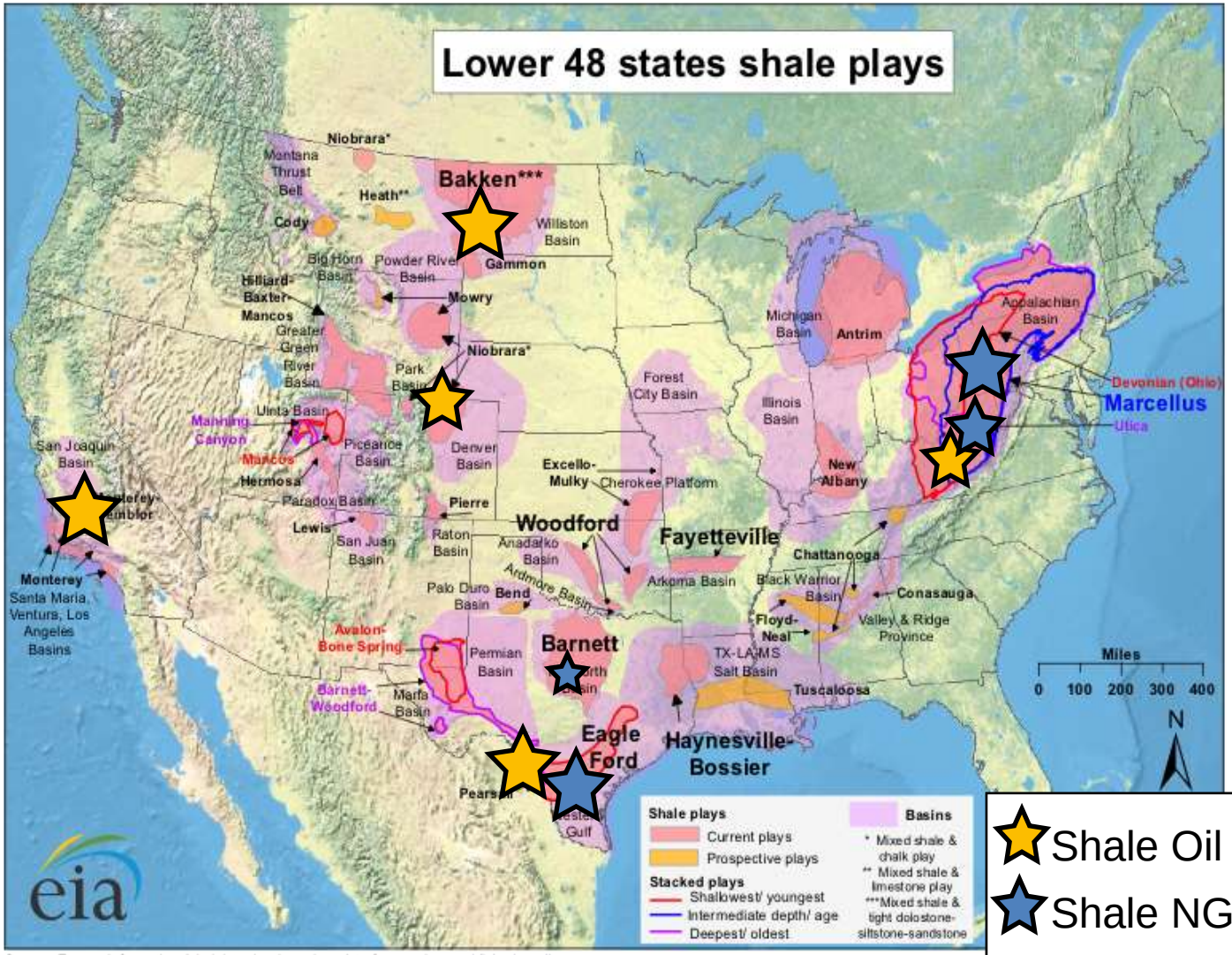
Topics for Thought

- Defining the Boundaries
- Where are the Shale Oil Plays located
  - What is the accessibility issues
- What are the potential impacts?
- Economic Drivers in the Global Market
  - Market trends and impact to US operations
  - How does shale plays impact the interaction of refining and other industries
- Environmental Value of Shale Plays
- Delayed Coking – What to consider
- FCC – What is Next?
- Wrap Up

Defining the Boundaries

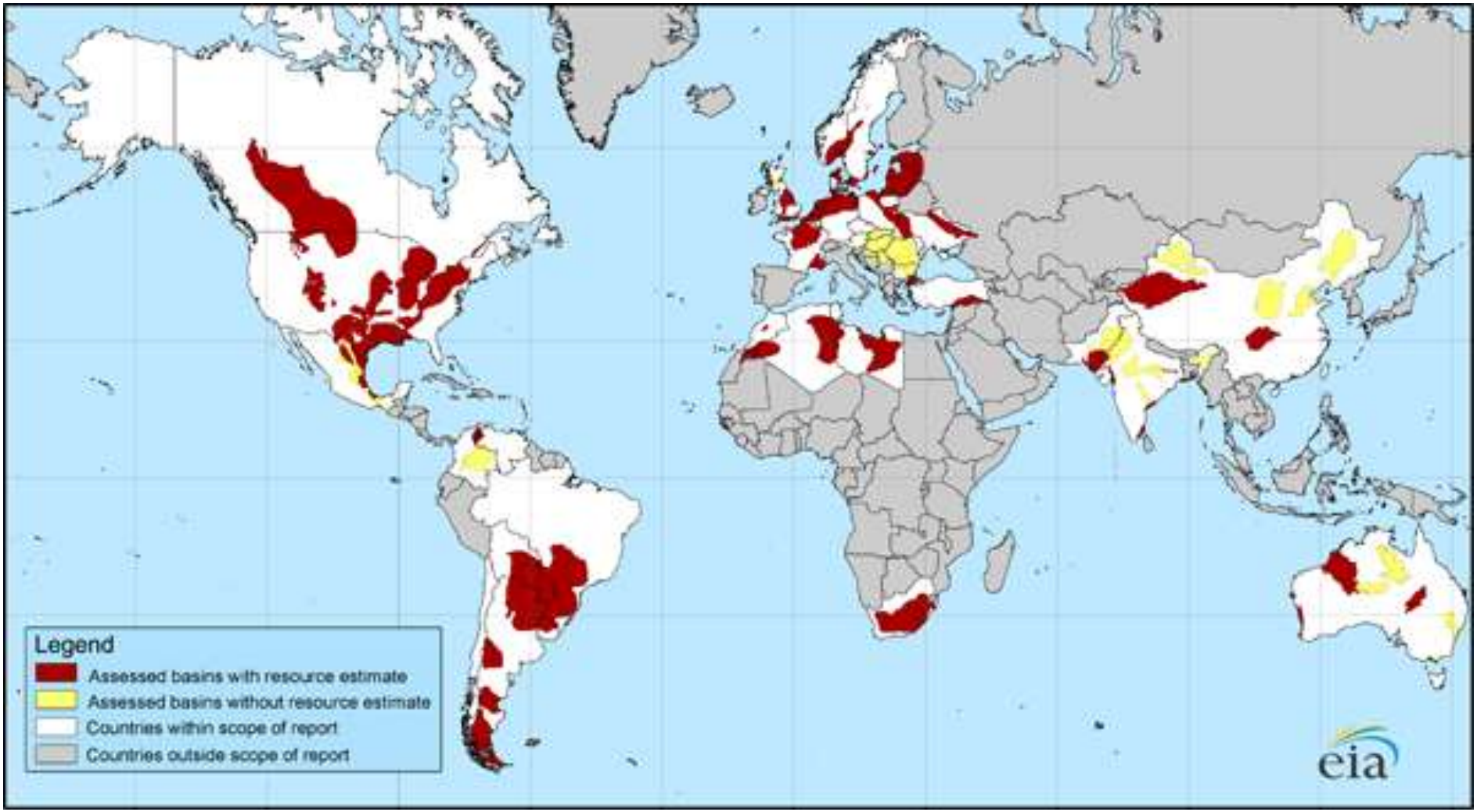
- Shale Oil will be consumed within USA
  - USA is legally prohibited from selling (exporting) crude to other nations
  - Shipping crude to coasts limited by **Merchant Marine Act of 1920 (**better known as the Jones Act) vessels
- Shale Oil and the new juggling act
  - Domestic energy policy, environmental legislation, and free market
    - Tier 3 Gasoline, CAFÉ (mpg of fleet), E15
    - Diesel cetane (CNG/LNG on horizon for heavy ground transporation)
- USA exports Gasoline and Diesel into other markets
  - Demand growth in exports to Latin America
    - Growth follows population and economic growth (modernization)
  - What is the future in export market?
    - New refinery build / expansion in Latin America, etc.
  - Near-term (5 - 8 yrs) no major changes in domestic demand
    - Latin America refinery growth is lagging behind projection

Shale Oil Plays

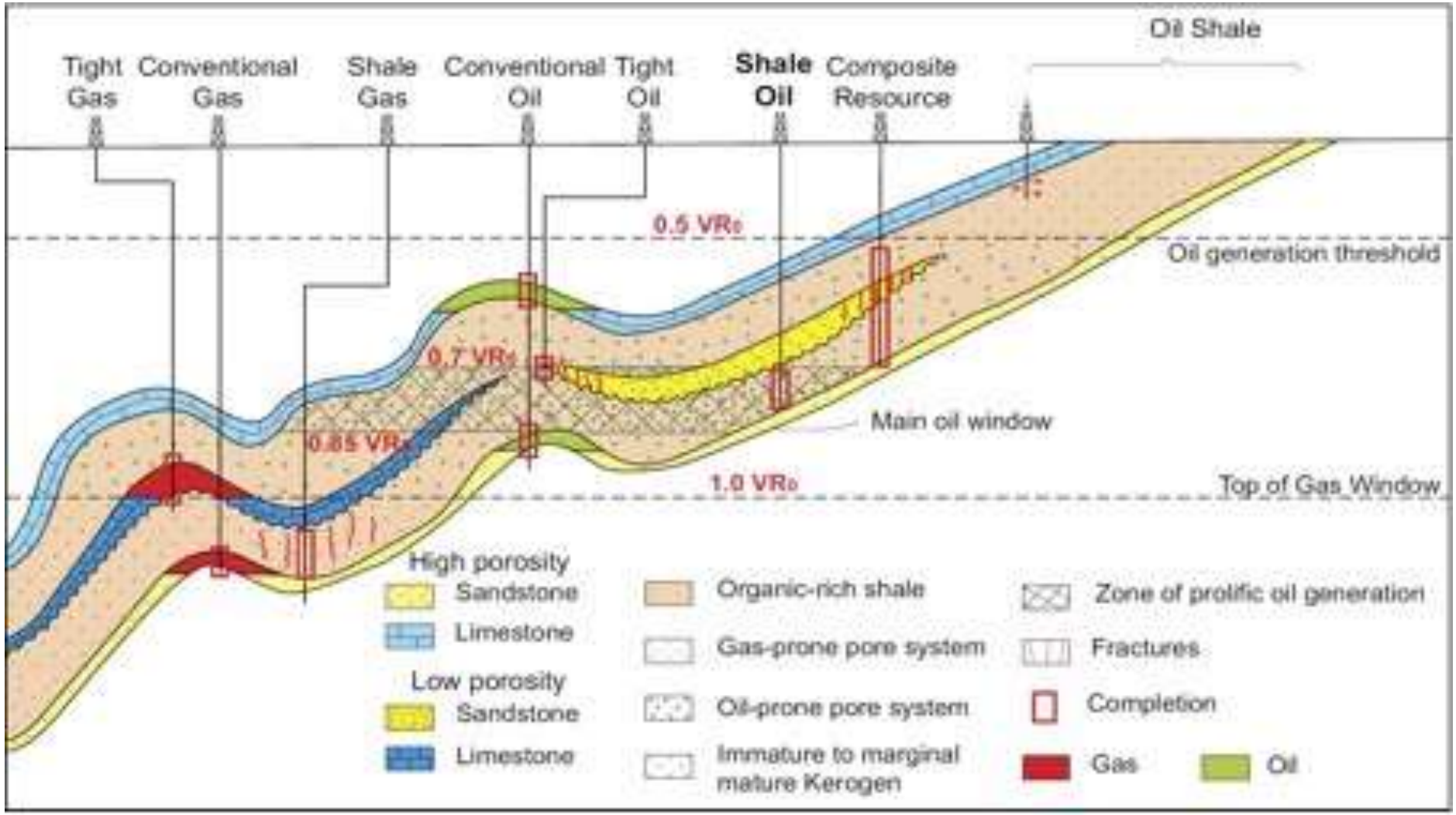


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

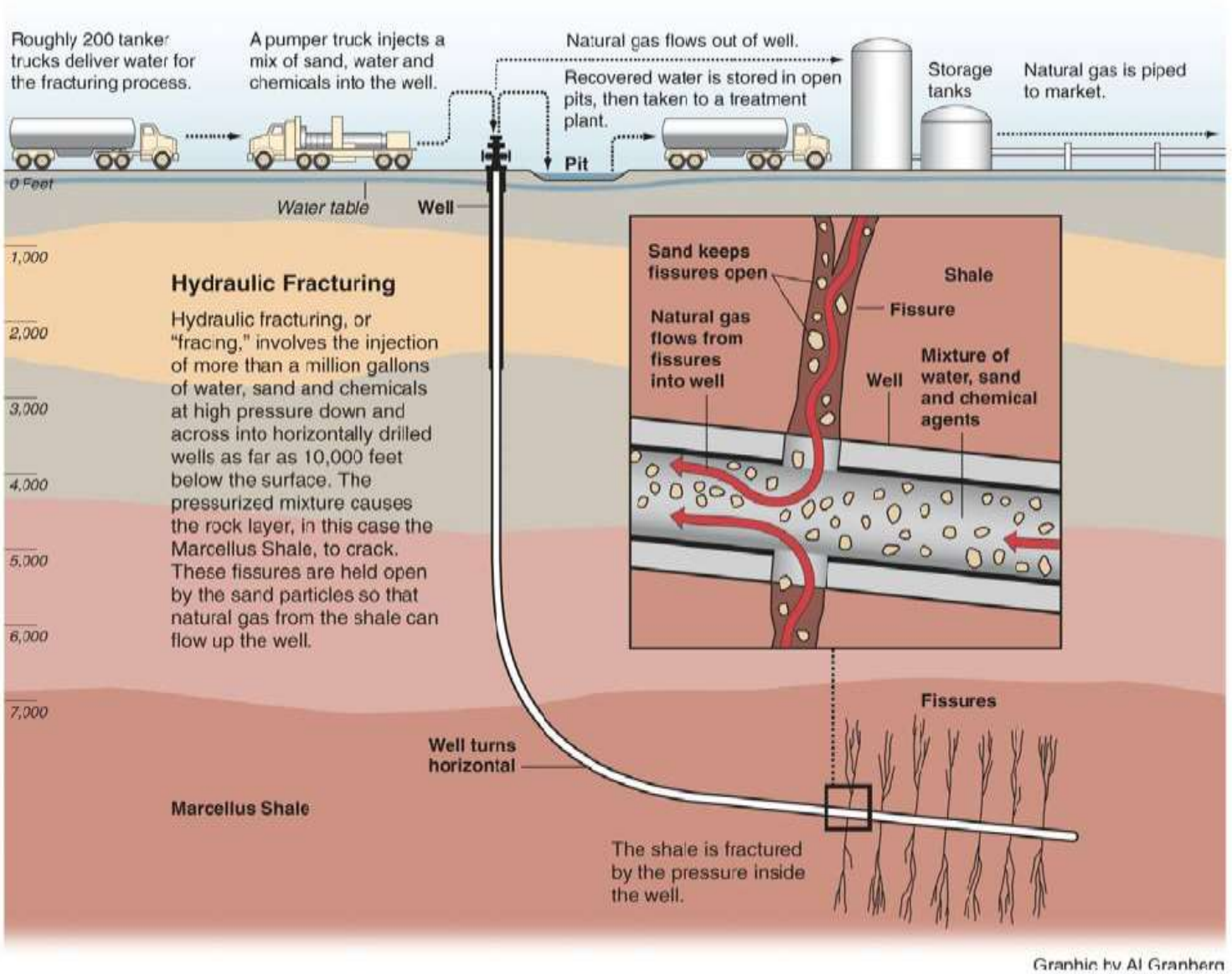
Global Shale Oil Plays



Conventional / Shale Oil Formations



Shale Oil / Gas
Horizontal Drilling, Hydraulic Fracturing

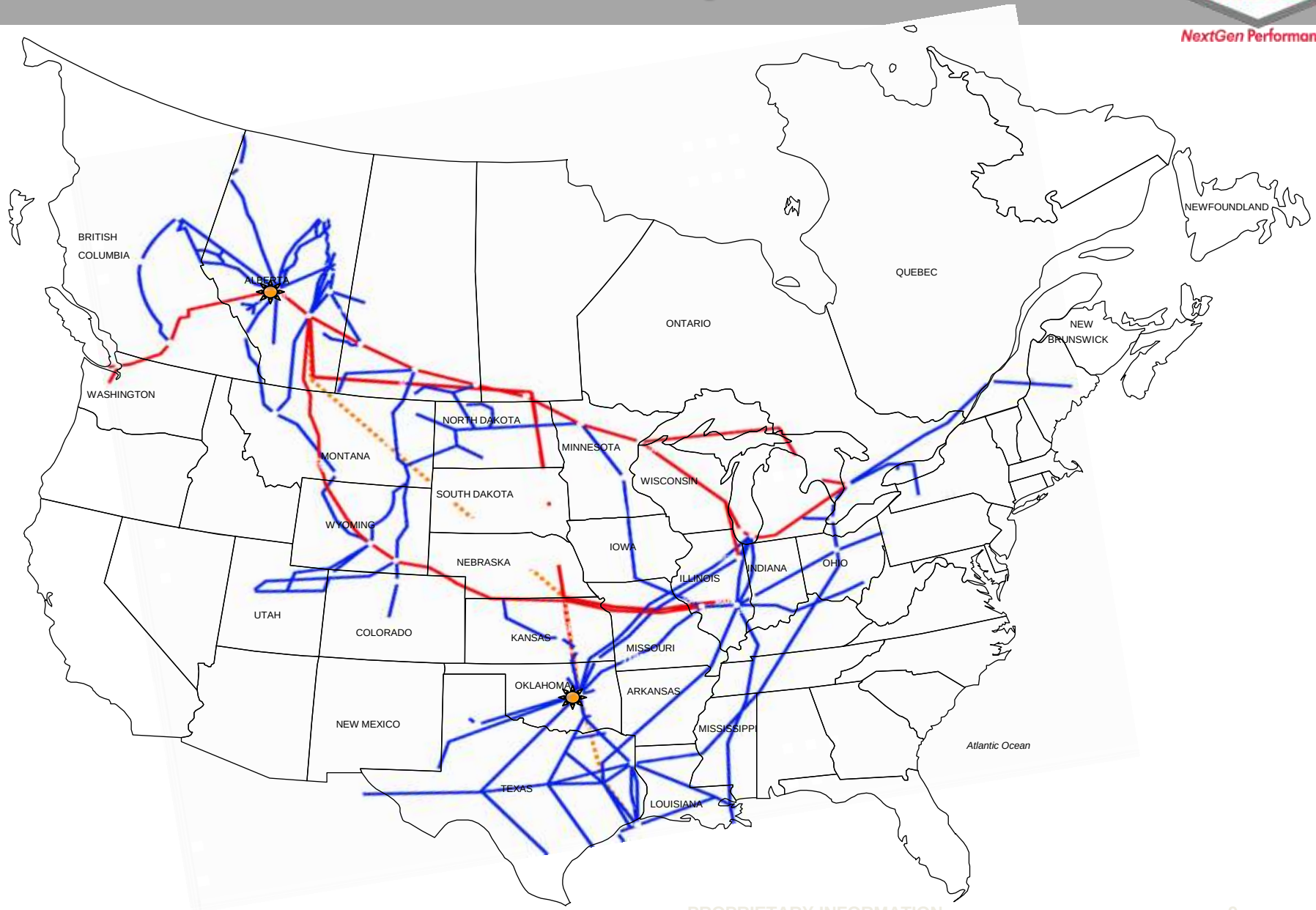


Graphic by Al Granberg

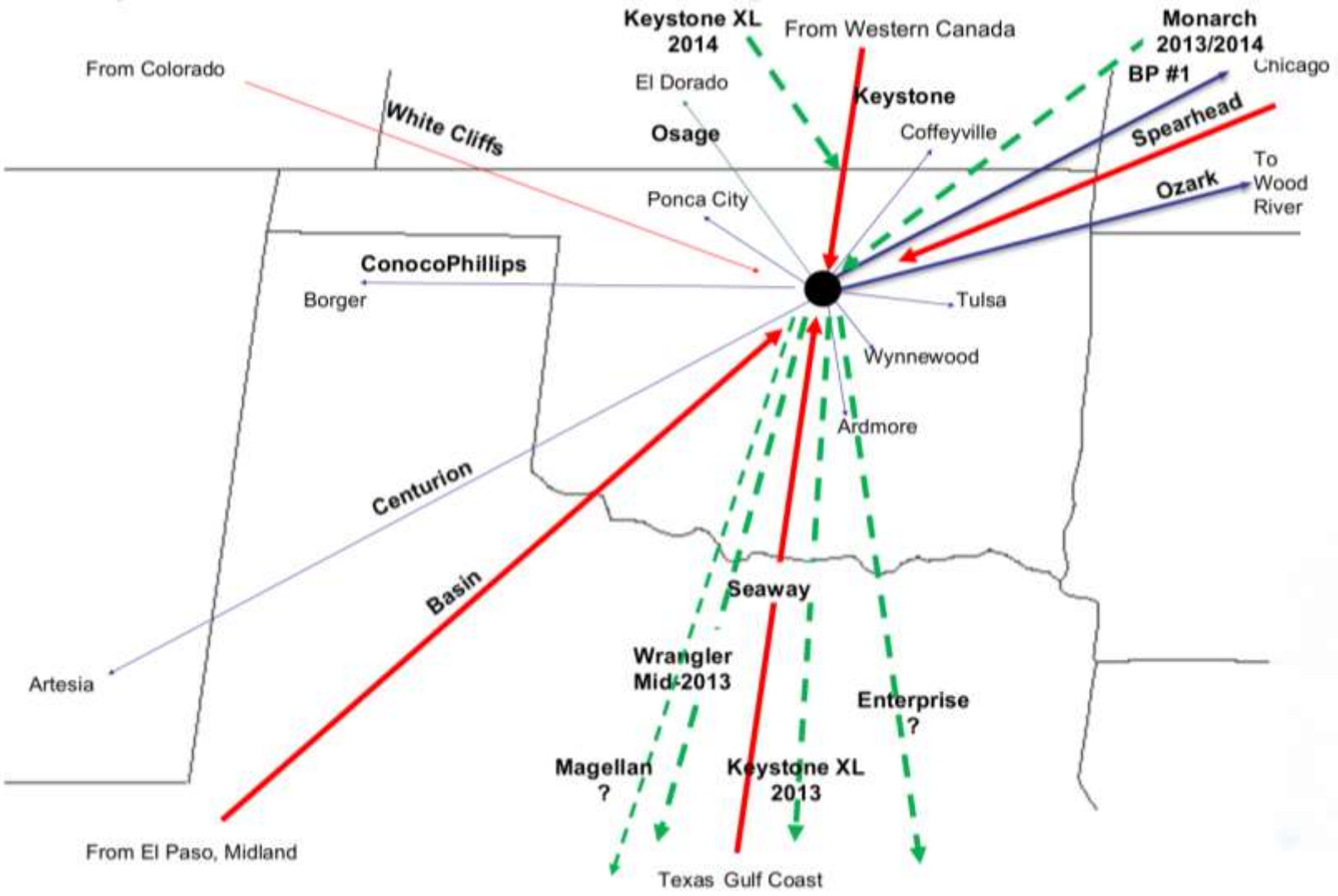
Access Matters

- Regional Availability
  - East Coast / West Cost refineries not as advantaged as Mid-Continent and US Gulf Coast, however
    - Companies investing in rails for Bakken crude
    - Ocean barges moving from USGC to East Coast and to West Coast through Panama Canal (or pipeline transfer across canal)
- Access to Shale Oil
  - 65 - 70 refineries with immediate access
    - Refiners investing in rail systems to move crude beyond pipeline limitations
  - Processing capacity nearly 10 Million Barrels / Day
- Mid-Continent /USGC vs East/West Coastal Refineries
  - Center of significant Motor Fuel / Petrochemical production
  - Maximizing refinery assets may be a challenge
  - Shale impacts on Canadian Crude and access improving value to process
  - Logistic systems full or pinched out

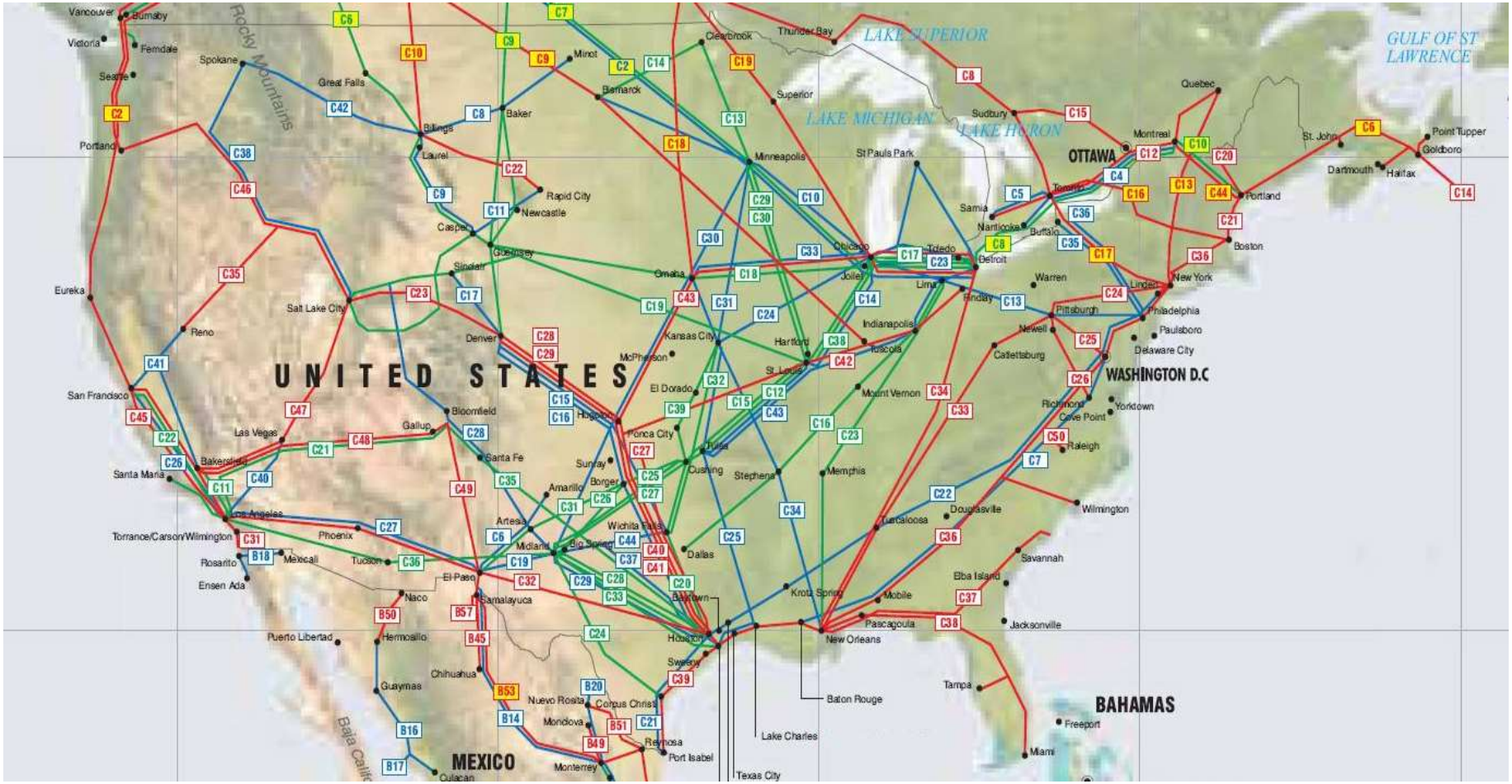
North American Crude Pipeline Network



Cushing OK Crude Pipeline Network



US Product Pipelines



Latin America Pipeline System

Sectoral Trends: Refining vs. Shale Oil/Gas

Refining Sector	Shale Hydrocarbons Sector
• Oil price relatively high	• Natural gas price low
• US gasoline growth flat; Diesel growing at 2%	• Producers aggressively moving into liquids plays
• US refined product exports on the rise	• Ethane from shale gas gaining favor as ethylene feedstock

- Widening oil-natural gas price differential
- Both refining and shale sectors in transition
- Increasing interplay between both markets
- Domestic Oil cheaper than foreign sources

Impact of Shale Oil / Gas

- Quality of Shale Oil
  - Sweet / light crude
    - Price points lower than equivalent Middle Eastern or West African Sources
  - Shale Oils become “Enabler” Crudes
    - Canadian sour crudes dropping in price from Shale Oil
    - “Blending” of Canadian or other sour crudes may provide a unique price advantage thus margin value overall
- Secondary impacts – cheaper light oils
  - Cheaper Natural Gas
    - Hydrogen production / Hydroprocessing options
  - Petrochemical feedstock competition
    - Refinery Propane through Naphtha may be at lower prices
    - Tightens outlet of refinery fuels products

Impact of Shale Oil / Gas

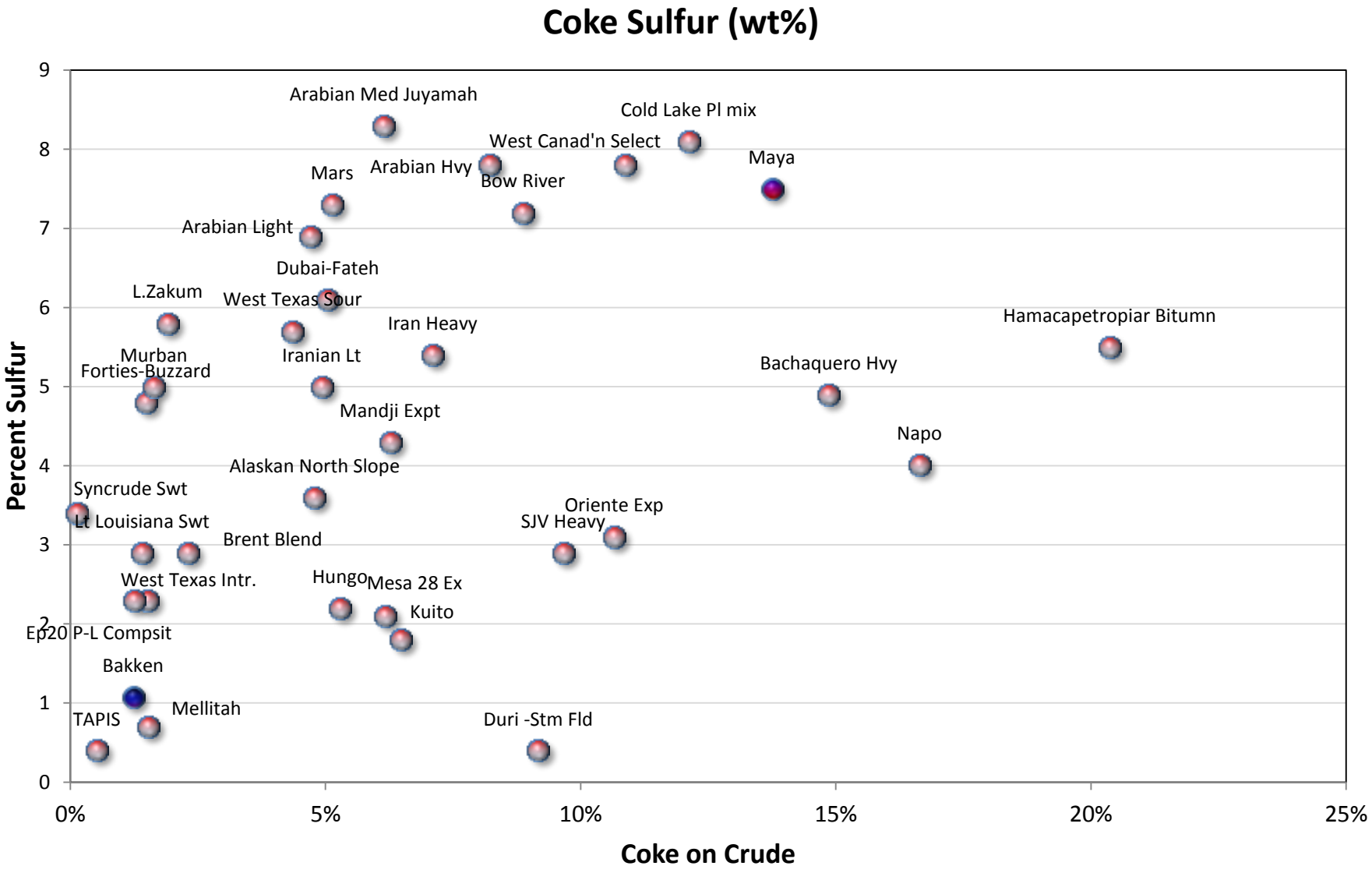
- All Shale Oil is not equal even from same region!
  - Canadian crudes not all equal either
  - Market to “request” more consistent quality of shale oil to refiners
- Yield Shifts
  - Shale Oil Naphtha + Middle Distillates > than Maya or other Heavy crude blends
    - Naphtha more paraffinic
  - Less native resid thus less secondary gasoil / diesel from Delayed Coker operations

Estimated Crude Unit Yield

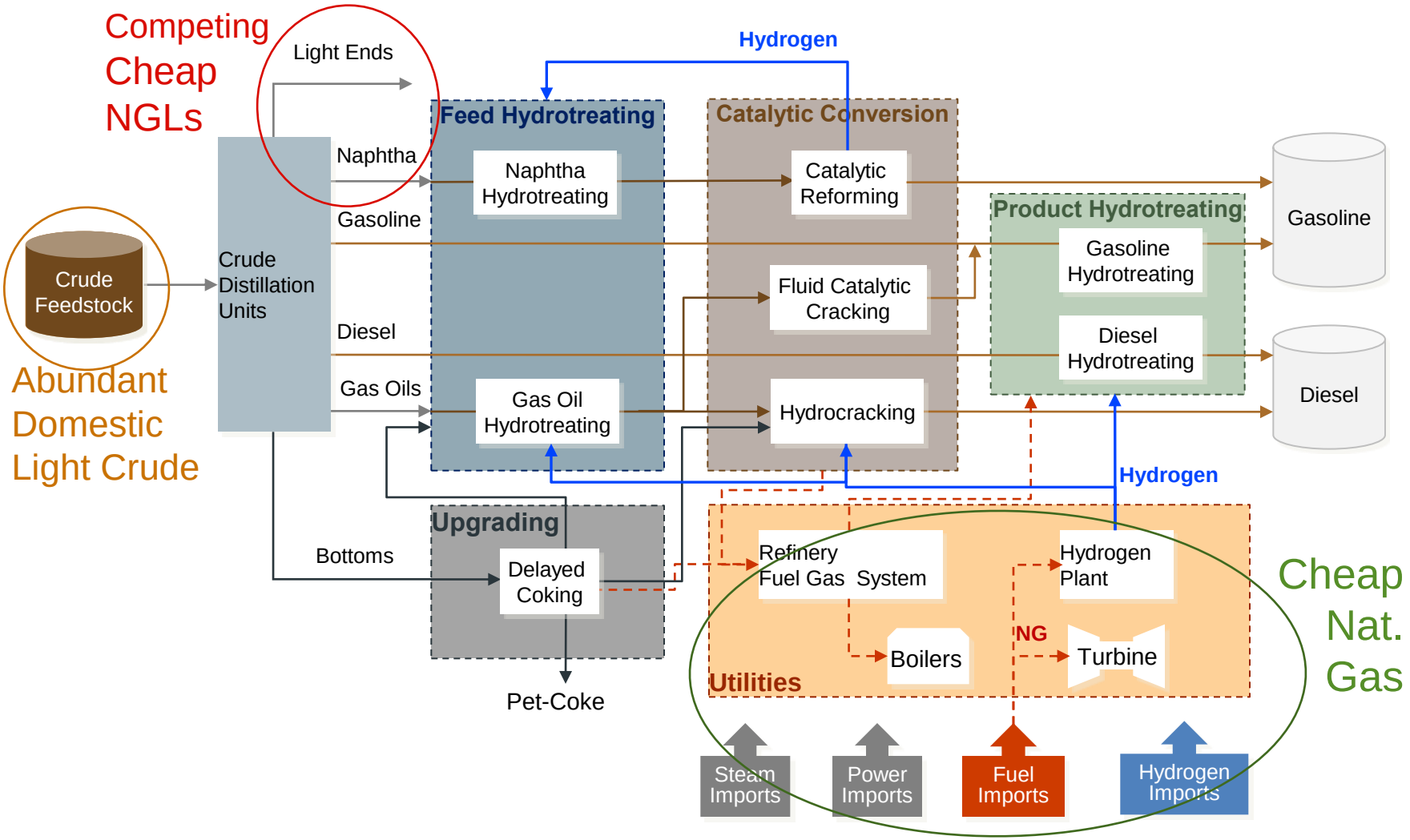
- Crude compatibility issues in blending of shale with other crudes
  - Compatibility **will be** tackled or managed going forward
- Note differences in Naphtha / Middle Distillates between typical "heavy" crude and Shale Oils

Yield	WTI	Maya blend	Bakken Core	Tx Shale	Cold Lake	Peace River5	Wabasca
Crude API	41.0	31.2	41.9	47.9	20.3	32.3	19.2
Crude sulfur	0.32	1.84	0.14	0.09	3.90	2.00	3.99
Offgas	1.8%	1.5%	2.7%	3.0%	1.6%	2.3%	0.6%
Naphtha	24.6%	18.0%	27.8%	27.4%	16.3%	15.7%	12.9%
Mid Distilate	38.6%	33.7%	36.9%	40.2%	18.1%	33.6%	26.2%
VGO	26.7%	28.2%	27.2%	26.0%	28.4%	28.6%	32.6%
Vac Resid	8.3%	18.6%	**5.5%**	**3.4%**	35.6%	19.9%	27.8%

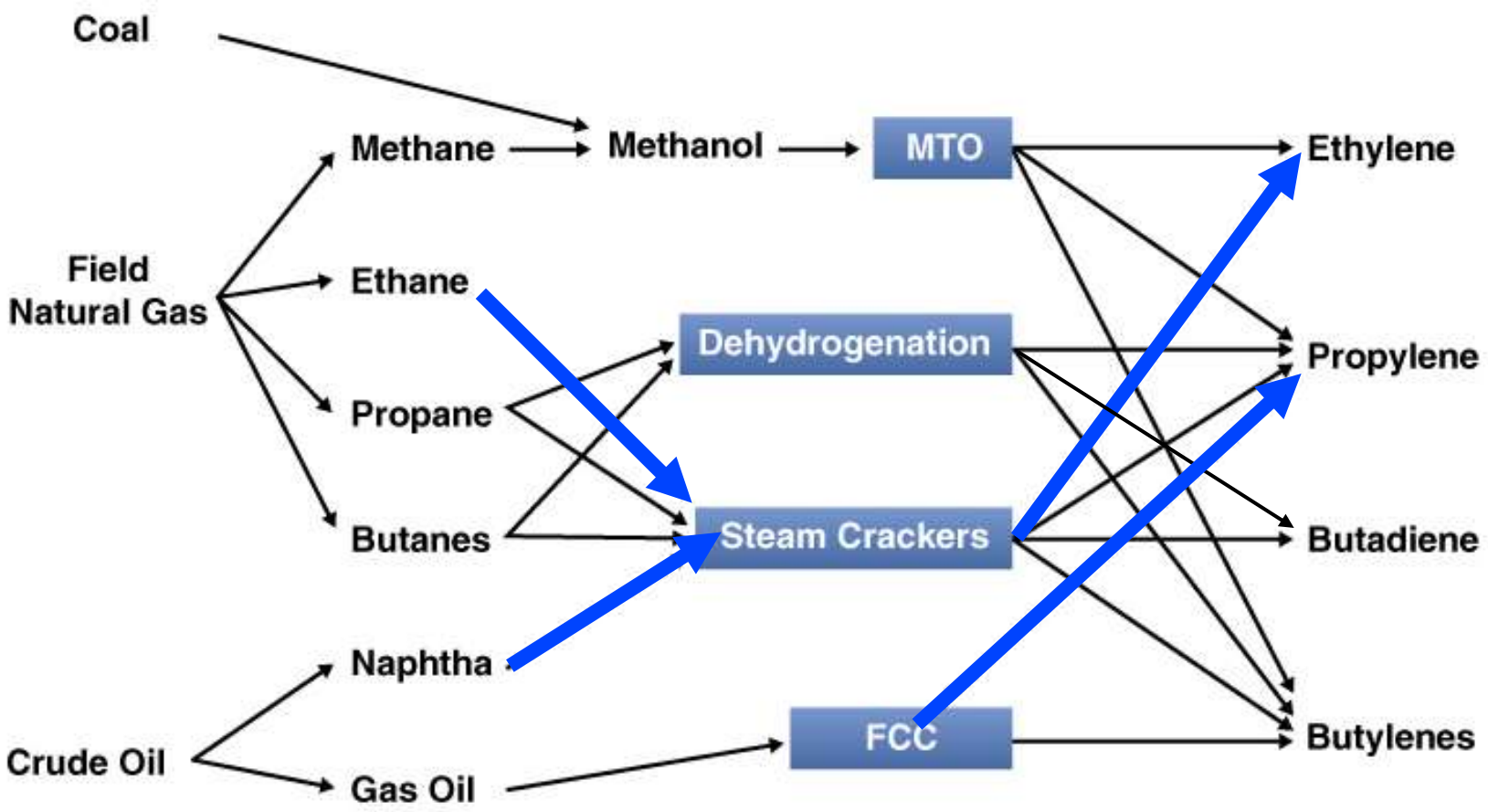
Marker Crude, Coke Qualities



Shale Hydrocarbon Impact on Refining Operations



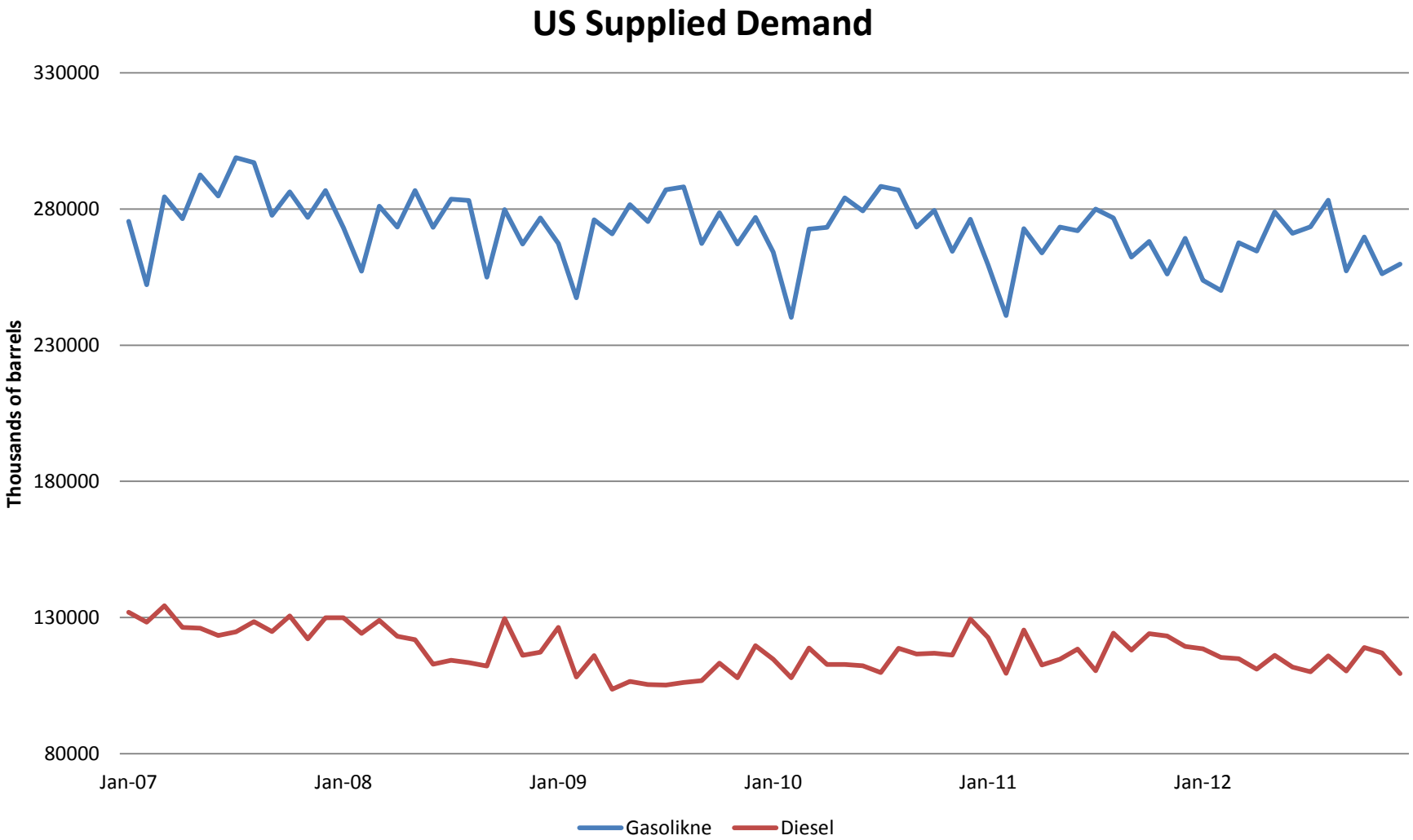
Shale Oil Impact on Petrochemicals



Global Drivers

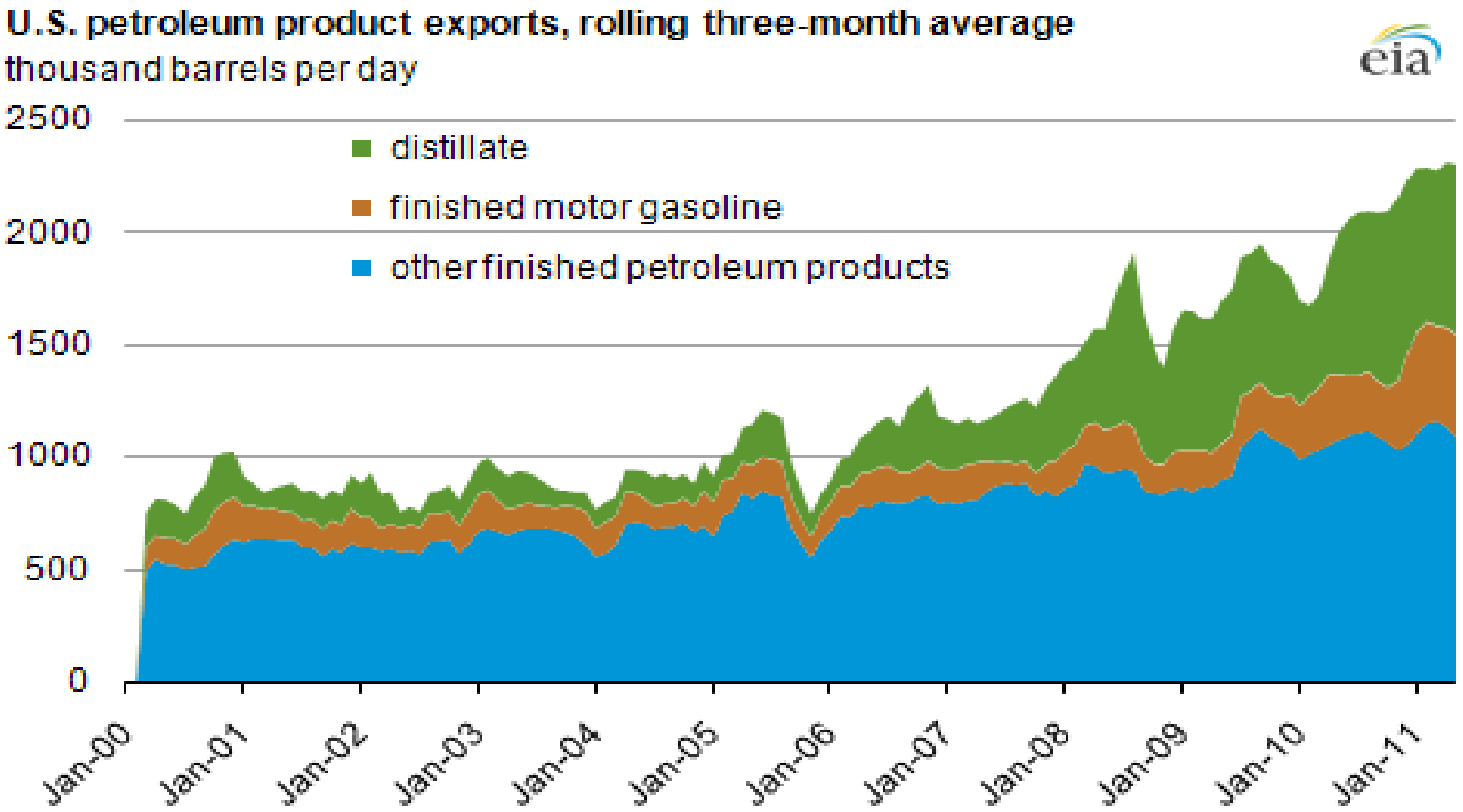
- Cheaper crude source + high product demand = Profit
  - Shale oil is produced with an economic advantage against imported Crudes (like for like on the order of 30$/bbl)
  - Canadian oil sand crudes provide additional price advantages
  - US Gasoline / Diesel demand relatively flat
- Crude source security is critical for economic growth and security
  - Cheaper domestic and Canadian crude displaces Middle Eastern, Mexican, and Latin American crude Sources
  - USA exporting gasoline / diesel into Latin America
  - WSJ reports USGC refiners export 95% of Petcoke production

US Motor Fuels Demand Flat



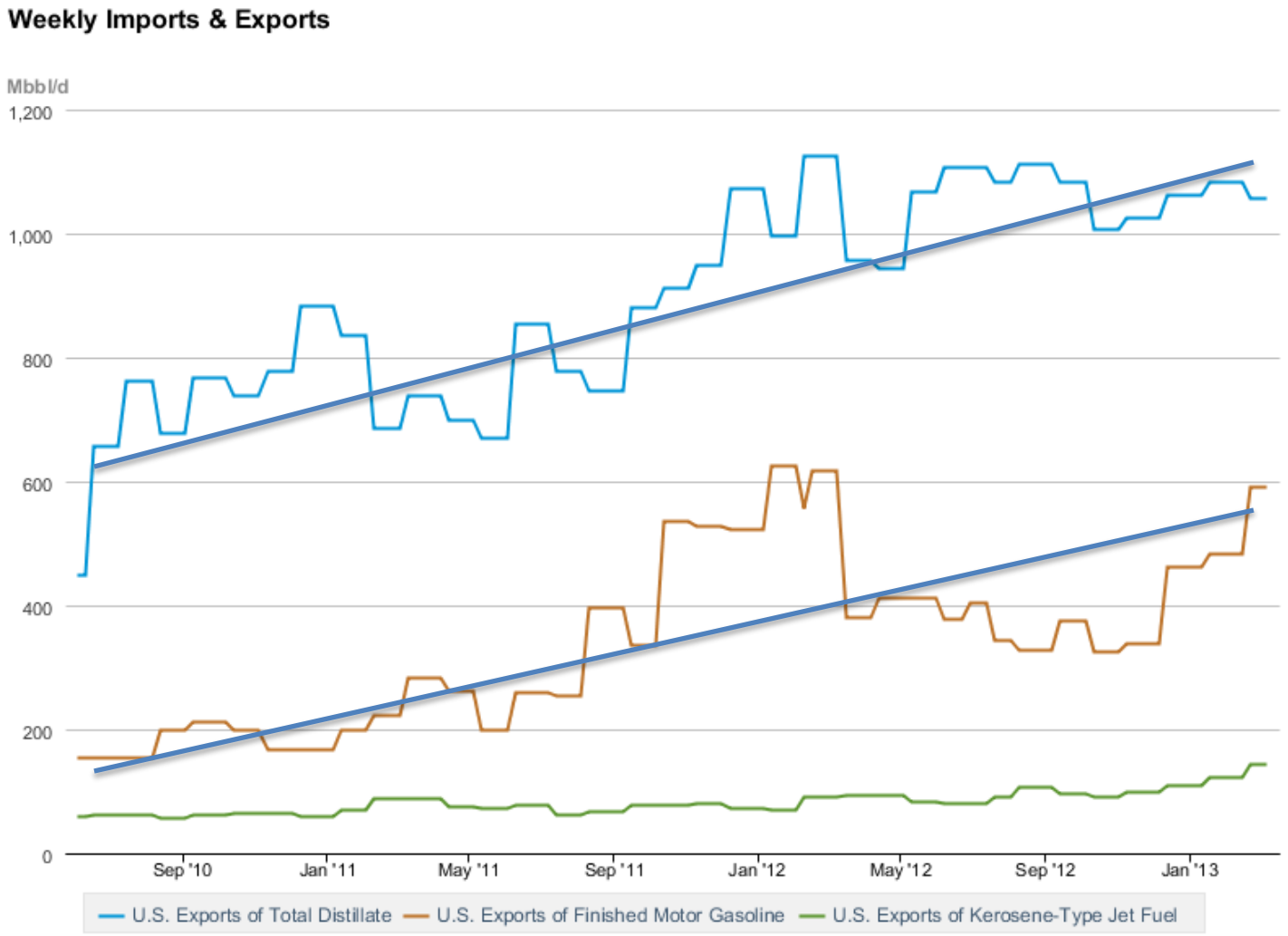
Source: U.S. Energy Information Administration

U.S. Distillate Exports

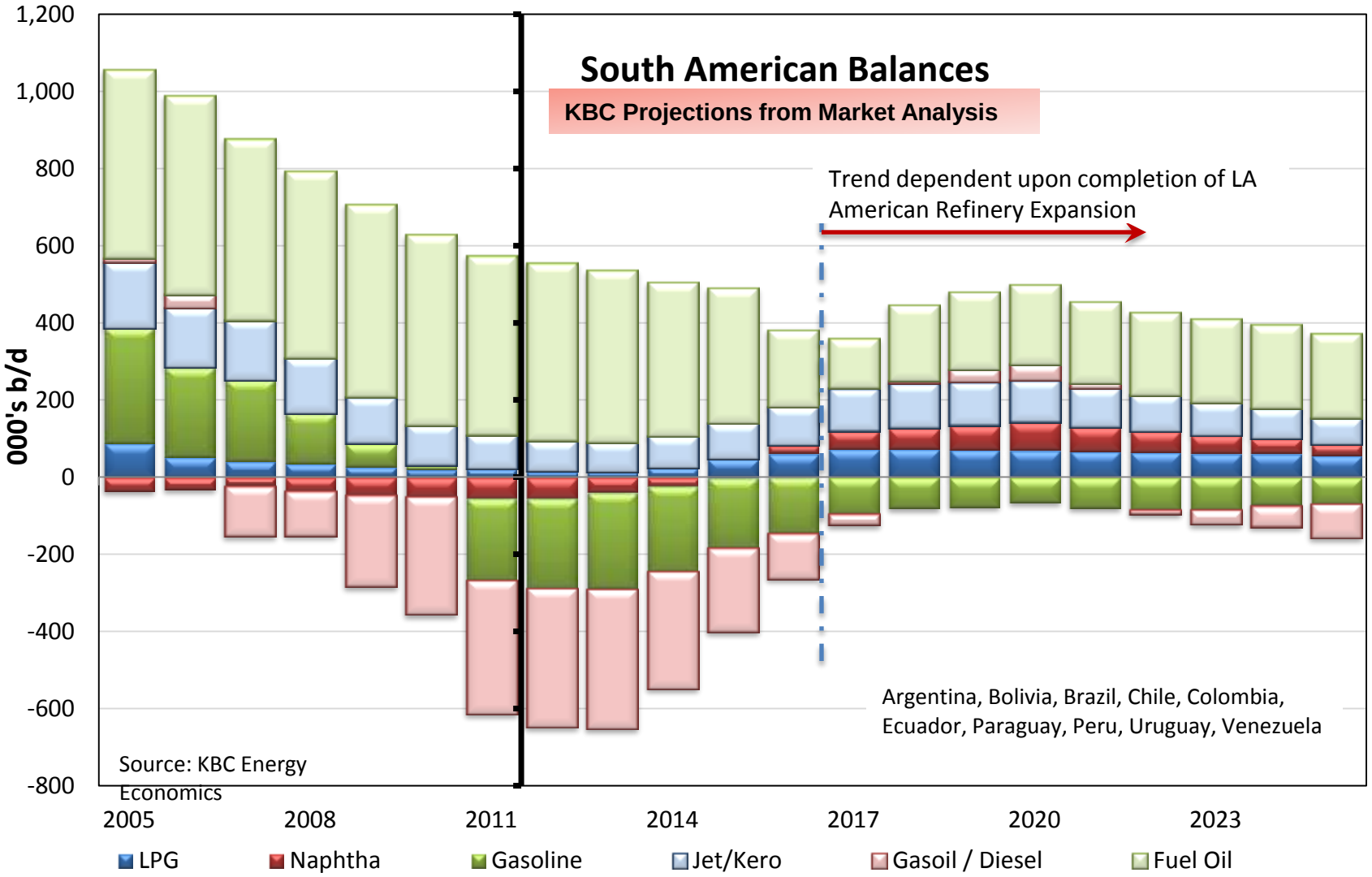


Total U.S. exports of finished petroleum products have increased more than 60% since 2007 as markets have become more globally integrated. This trend is driven primarily by finished motor gasoline and distillate fuel oil which are increasingly exported to Latin America. Annual U.S. exports of gasoline and distillate increased by 133% and 144%, respectively, from 2007 to 2010, with growth continuing near term

Last 2 yrs of export Growth



South American Balances



Environmental Value of Shale Plays

Emissions – Cleaner Feed / Fuel

- Shale Plays bring lower sulfur crude and natural gas
- Lower sulfur in products reduces total sulfur load across the refinery
  - Sulfur plants running below rated capacity (good or bad)
- Lower intermediate stream sulfurs mean reduced severity on hydrotreating and longer catalyst life
- EPA focusing on even more restrictive pollutant limits per August 2012 AFPM Cat Cracking meeting
  - Lower SOx, NOx, and Particulate limits
- Coker steam vent before unheading is a new target for capture and control

Tier 3 Gasoline

- Tier-3 gasoline is here
  - Rules to be applied

•10 ppm sulphur
•No change in RVP
•No change in olefins/aromatics
•No change in octane

- But the ‘devil is in the details’:
  - Batch-to-batch limits of 30 ppm Sulfur may be gone—puts a high premium on reproducibility
  - E15 not gone, just sleeping

Tier 3 Gasoline Issues - 1

- Tier-3 S target
  - Too much loss of octane in FCC (single largest contributor to sulfur in gasoline pool)
  - Require greater diligence in all sulfur sources
- Unknown availability of sweet high octane blend-components and what price?
  - KBC Energy Economic's view is that alkylate will become increasingly valuable, and expensive—particularly if E15 pushes forward
    - Additionally, EPA may STILL increase gasoline octane requirements
  - There is a commercial, not technical, risk if you have to approach the market to meet existing supply obligations
    - And its not just octane, its V/L, drivability, etc

Tier 3 Gasoline Issues - 2

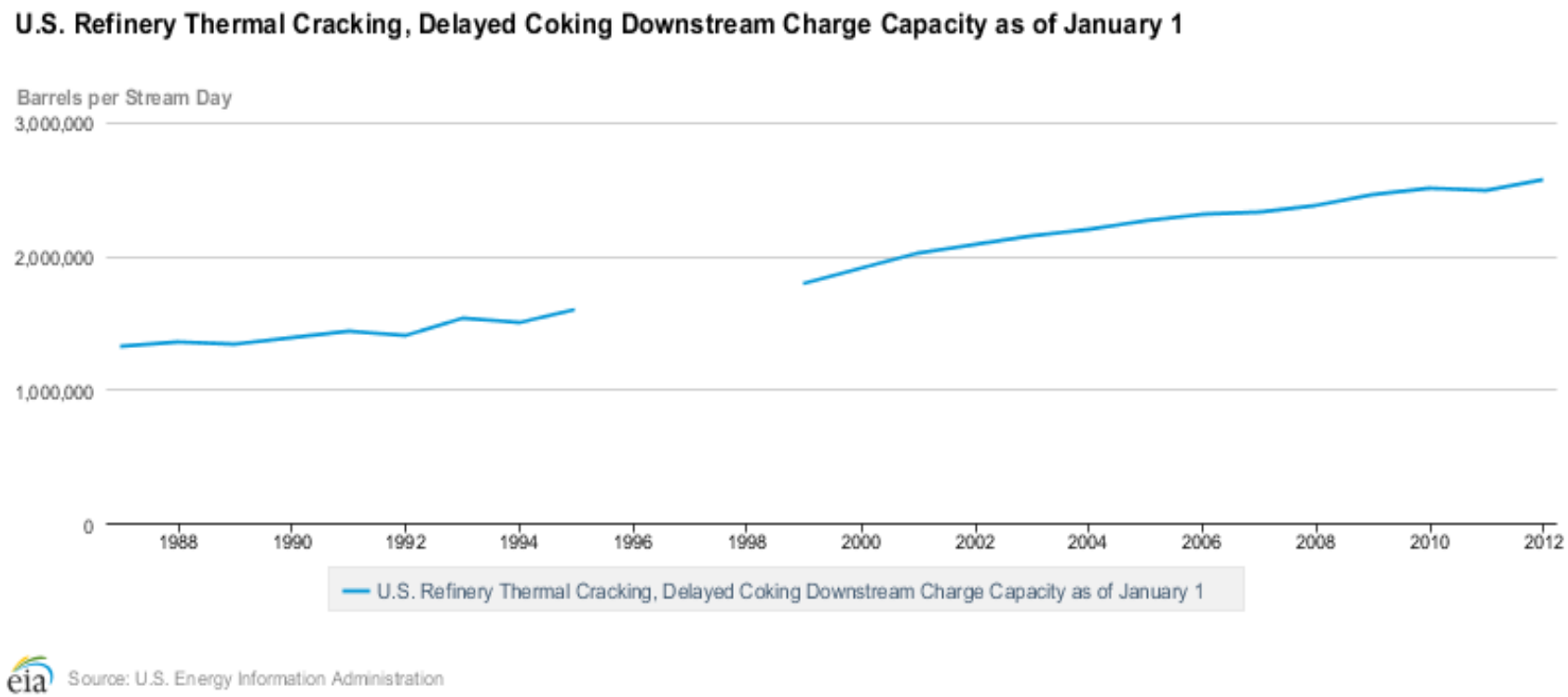
- What is the sulfur content of purchased blendstocks (i.e. butane)?
  - Mt. Belvieu spec mixed C4 140 ppm (typ: 30-75 ppm)
  - Chem grade iC4 10 ppm
  - FCC naphtha ~30-50 ppm @ 40-60% of gasoline pool (today)
- Is there still going to be a market for higher sulfur (30, 100, 1000 wppm) gasoline?
  - No. Never. Not at all. Don't even think of it in North America
  - Export markets will be higher for a while, however most Latin American markets are moving to 30 ppm or lower only lagging behind USA.
    - Logistically dual sulfur systems for commodities increases risk of off spec domestic shipments

Shale Oil Value - Possible Solutions

- Shale oil and Tier 3
  - Lower FCC feed sulfur through
    - Increased hydrotreating severity without yield losses
    - Increased or similar FCC octane with lower post treat severity
      - octane losses maybe be flat
    - Consideration of making more olefins for alkylation
      - ZSM-5, recycling naphtha, increased severity
  - FCC Flue Emissions “easier” to meet with Shale Oil
    - Regenerator operations less severe, lower temperature
- All blending streams will be low / zero sulfur content
  - The tail now wags the dog—this is part of plan, plan, plan
    - Sulfur removal from any purchase stream
    - Price and control leverage of being able to treat butane or gasoils will be competitive advantage

Delayed Coking
What to Consider

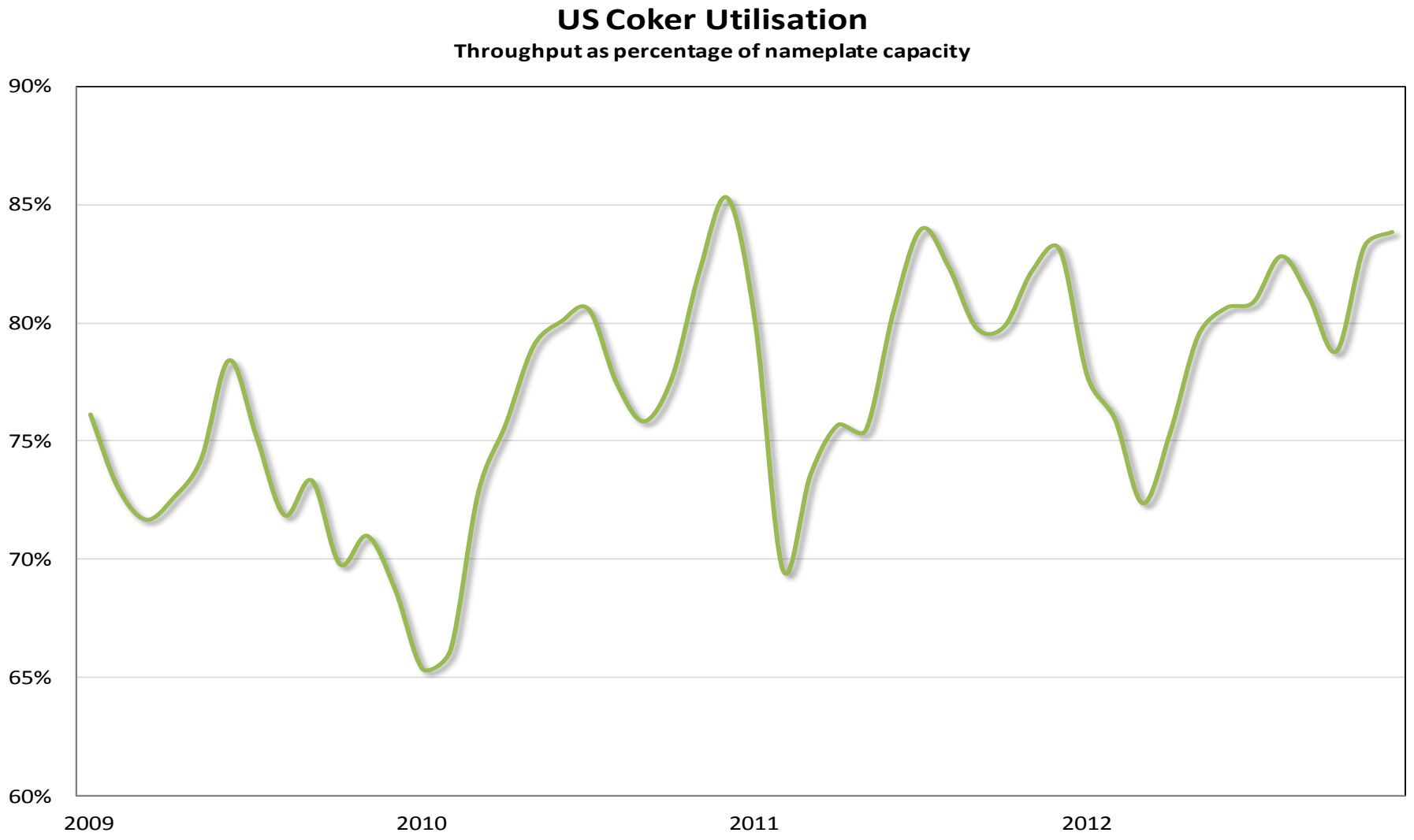
Delayed Coker Capacity



eia Source: U.S. Energy Information Administration

- Coker capacity continues to grow and cokers generally remain fully utilized
  - Bunker and heavy FO on the decline for environmental reasons
  - Margin on coking continues to be sufficient to source crude that maximizes refinery profit even to export market

US Coker Utilization

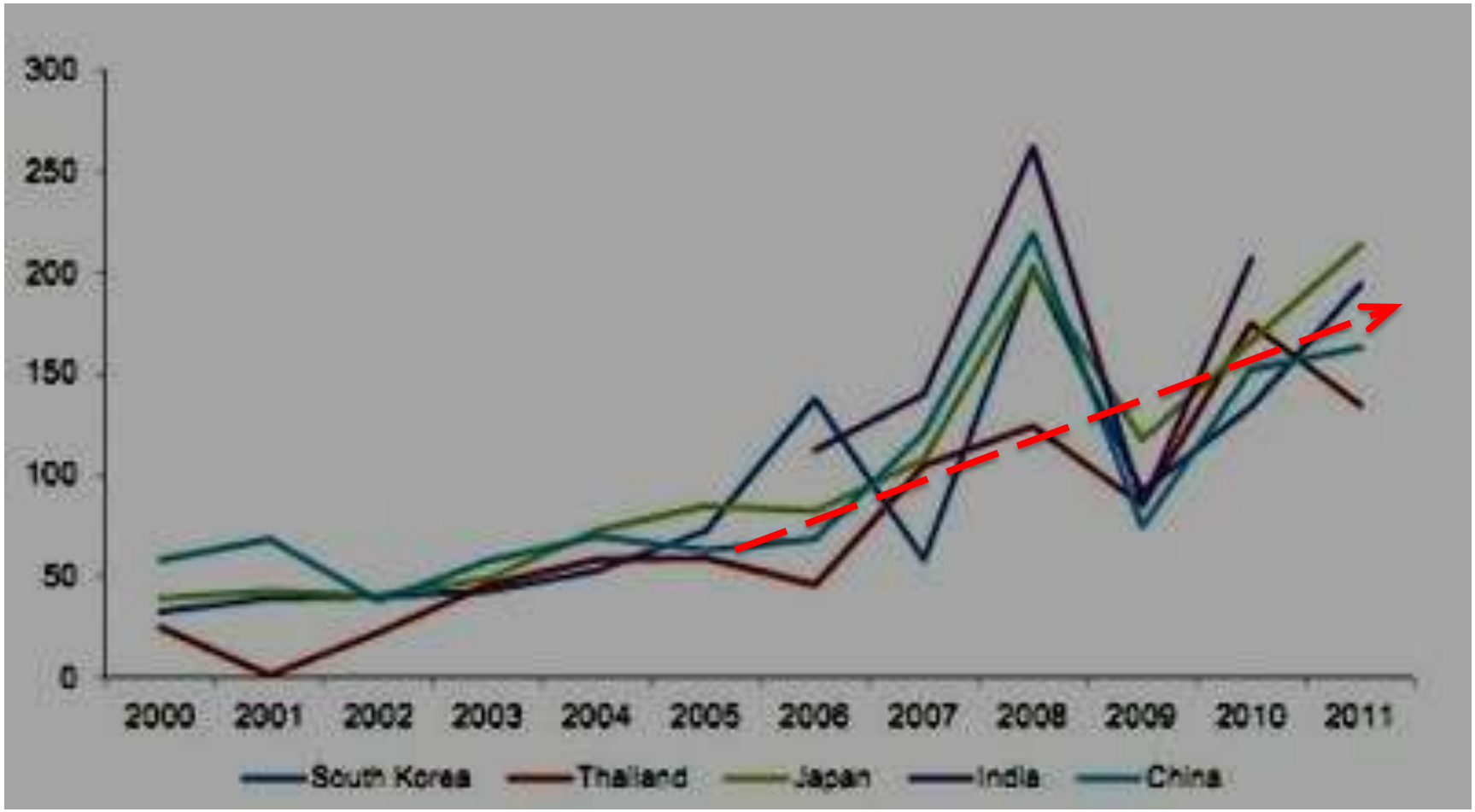


Future of Delayed Coking

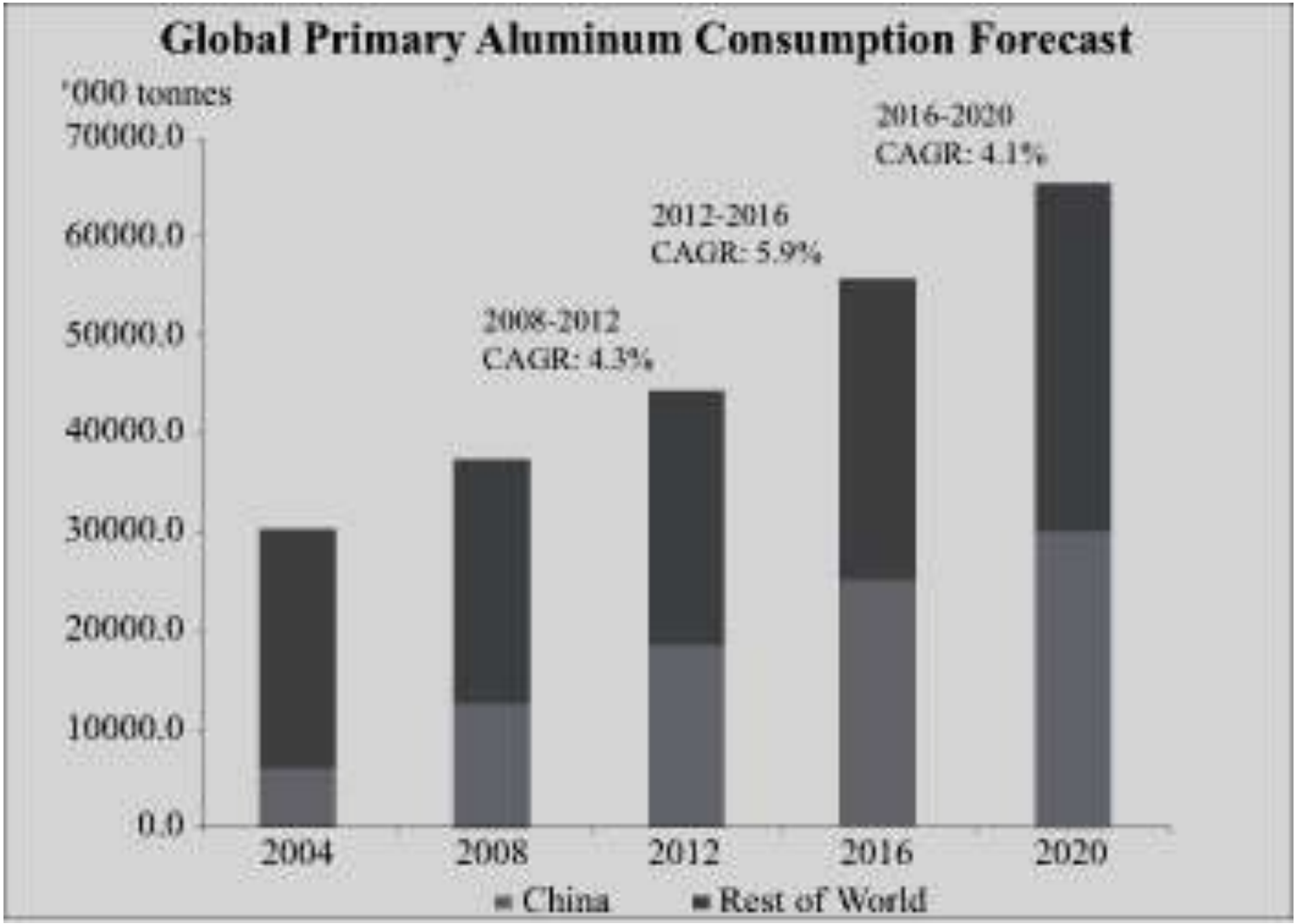
- Near Term (3-7 yr outlook)
  - The fuel coke (higher sulfur) and Anode Coke markets will continue to grow.
    - Fuel coke will continue to grow and expand into Asian markets.
      - Fuel coke used in cement kilns competes with Australian steam coal
      - Shipping and fuel content favor pet coke to export market
      - Competitive North American crude sourcing rich in middle distillate yields coke price is not “as” critical.
        - Fuel coke may only account for 5-12% of refinery margin depending upon price
  - Anode markets continue to have growth potential and are linked to global economic growth overall with increased aluminum demand.
    - Anode coke can contribute up to 25% of margin for refiner but..
    - Anode coke is a more restrictive and limited market

Petcoke Demand

Asia: Average value of imports of non calcined petroleum coke, 2000 to 2011



Aluminum Forecast



Aluminum Uses

Sector	Aluminum Consumption (%)
Transport	26
Packaging	22
Construction	22
Machinery	8
Electrical	8
Other	14
Total	**100**

As noted by the Table to the left, Aluminum demand is based upon consumer demand. Economic growth in a variety of industries drive the production and consumption of Aluminum.

Alcoa Outlook on Aluminum

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2012 Market Conditions

Alcoa End Markets: Current Assessment of 2012 vs. 2011

	North America	Europe	China	Global
 Aerospace				13%-14% sales growth
 Automotive	10%-14% prod growth	4%-9% prod decline	2%-7% prod growth	4%-8% prod growth
 Heavy Truck & Trailer	4%-8% prod growth	3%-8% prod decline	3%-8% prod decline	-3%-+1% prod flat
 Beverage Can Packaging	-1%-0% sales flat	5%-7% sales growth	15%-20% sales growth	2%-3% sales growth
 Commercial Building and Construction	5% sales decline	8% sales decline	7%-8% sales growth	2.5%-3.5% sales growth
 Industrial Gas Turbine				3%-5% airfoil market growth rate

Source: Alcoa analysis

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Various Vac Resid Qualities

- Consider WTI / Various Shale Oils / Canadian Oil Sands

		WTI	Maya blend	Bakken Core	Tx Shale	Cold Lake	Peace River5	Wabasca
Vac Resid	1050°F+ cut	8.3%	18.6%	5.5%	3.4%	35.6%	19.9%	27.8%
VABP	F	1,196	1,291	1,163	1,143	1,306	1,303	1,280
API Gravity		15.4	3.3	13.3	22.8	1.8	7.6	0.3
WatsonK		12.21	11.39	11.93	12.66	11.31	11.79	11.10
Sulfur	wt%	1.10	4.38	0.55	0.40	6.32	4.40	6.49
Nitrogen	wt%	0.5461	0.6505	0.3778	0.0270	0.4140	0.4040	0.9420
Nickel	ppm wt	31.92	97.04	14.84	3.56	136.10	72.60	149.64
Vanadium	ppm wt	25.08	537.66	5.25	3.51	406.69	210.34	417.18
Con Carbon	wt%	12.38	28.66	14.12	0.53	23.87	18.81	28.13
Coke Yield	wt% on FF *	20.32	37.20	22.15	8.22	32.36	26.98	36.84

* Approximate coke yield on wt basis from Coker Feed

Delayed Coker – What to Expect

- It depends!
  - If shale oil becomes a high percentage of crude, then feed to the Coker might be reduced
    - If there is an FCC and not processing Slurry to Coker consider adding this to Feed
    - Consider changing market into Anode (tough choice)
  - Shale Crudes are enablers to process more heavy sour Canadian crudes keeping cokers more fully utilized
    - If there is more than one CDU/VDU kit, consider segregated crude operation, tailor operations accordingly
    - Compatibility with Crude can result in
      - More asphaltene precipitation thus crude system plugging
      - More Iron in Resid
      - Monitor “additives” that can cause emulsions or other anomalies in processing

Delayed Coker – What to Expect

- Operations
  - Preheat / Furnace operation
    - Potential feed blend increasing asphaltene precipitation point as it passes through exchangers or furnace the heater
  - Concarbon content impact
    - As long as feed concarbon does not drop too much coke drum outages and quality of coke will remain about the same
      - There may be a need to drive temperatures up as the feed becomes more paraffinic to crack the carbon bonds
    - The diesel to gasoil ratio might shift a bit toward diesel
    - Bottom of the fractionator might be come problematic with asphaltene / coke lay down
      - Less aromatics in product means moving toward precipitation and “incompatibility” points
      - Bottoms system wetting and HKGO wash rates will need closer attention to managing potentials (CFR increase?)

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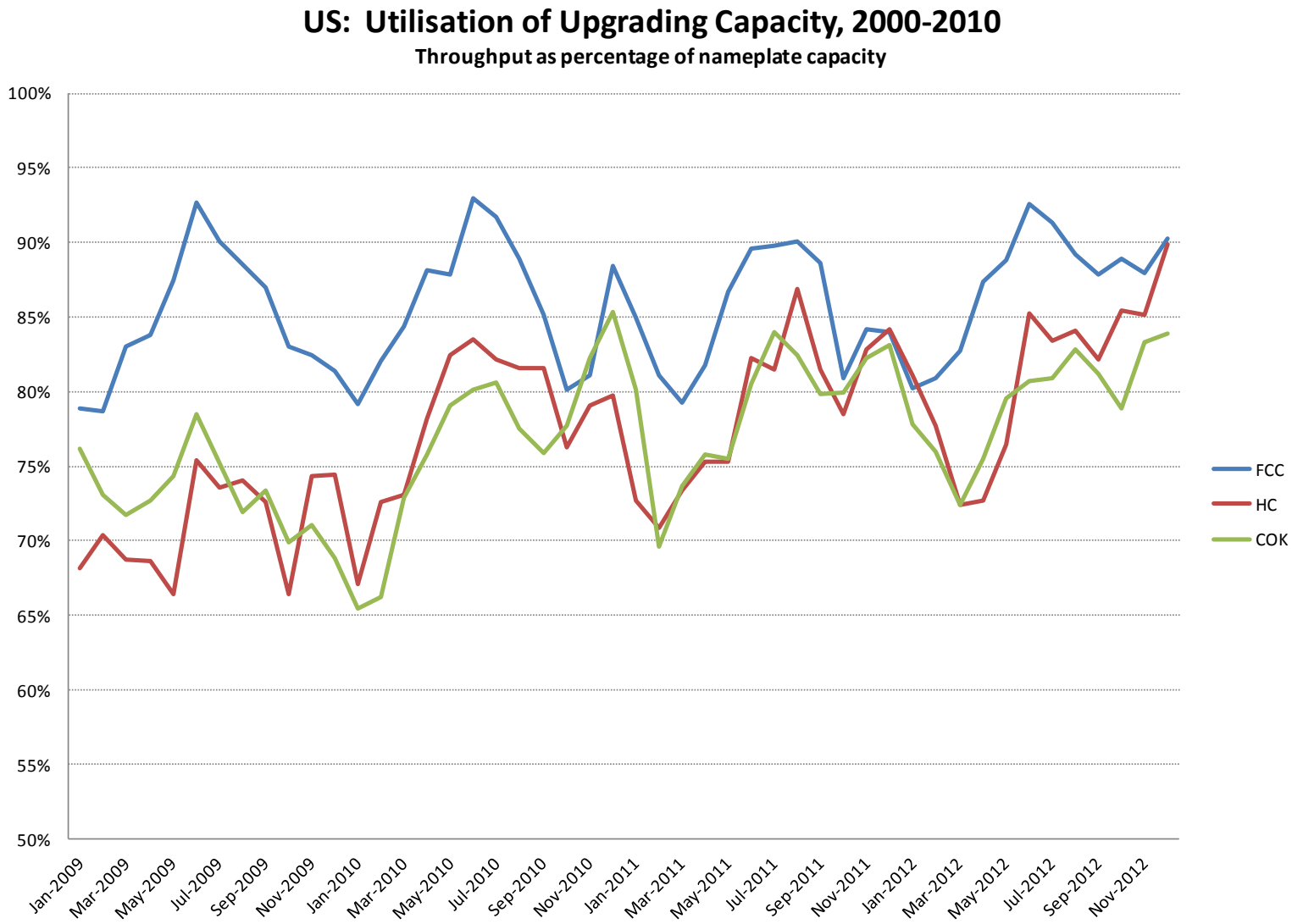
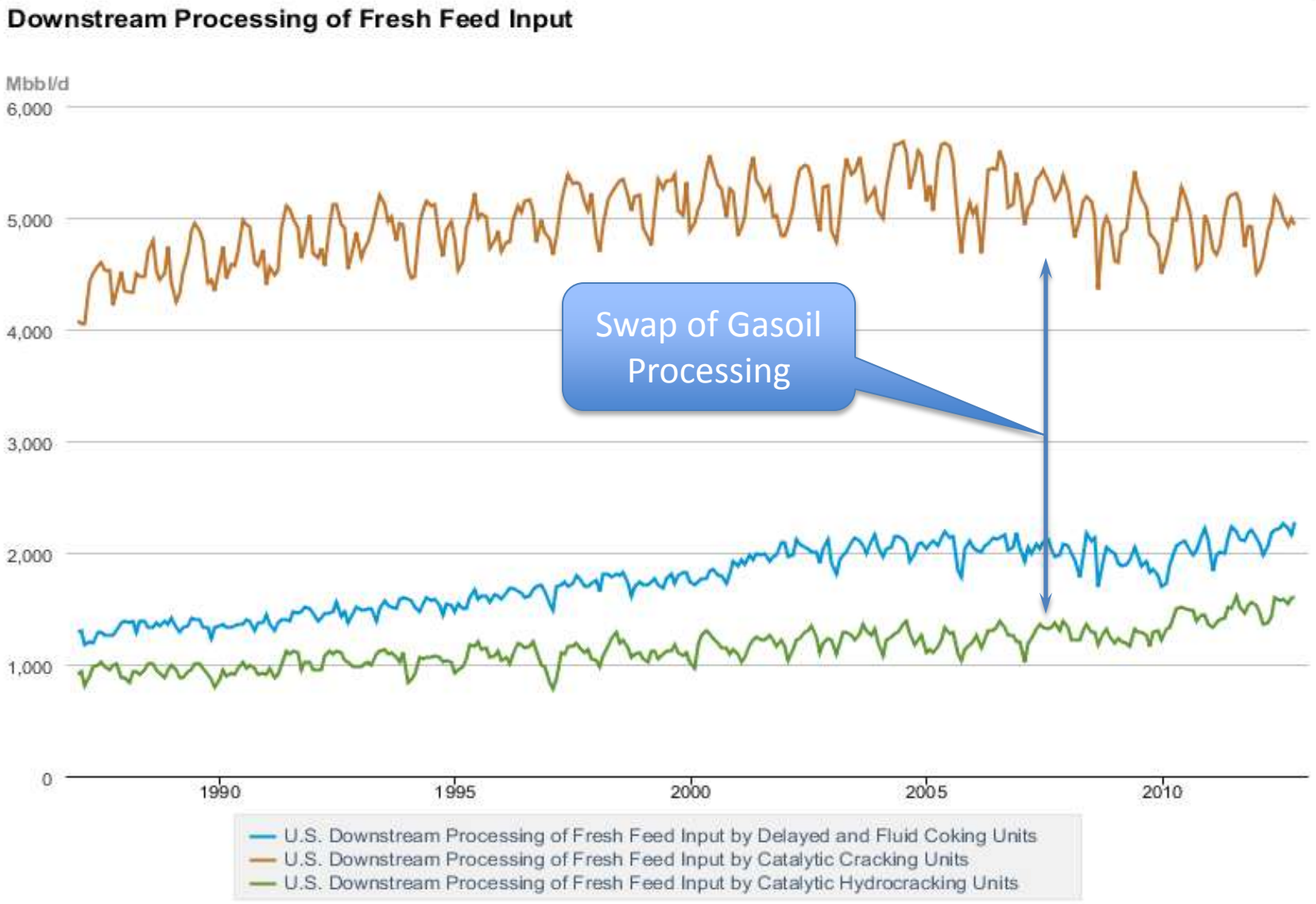
FCC Unit
What is Next

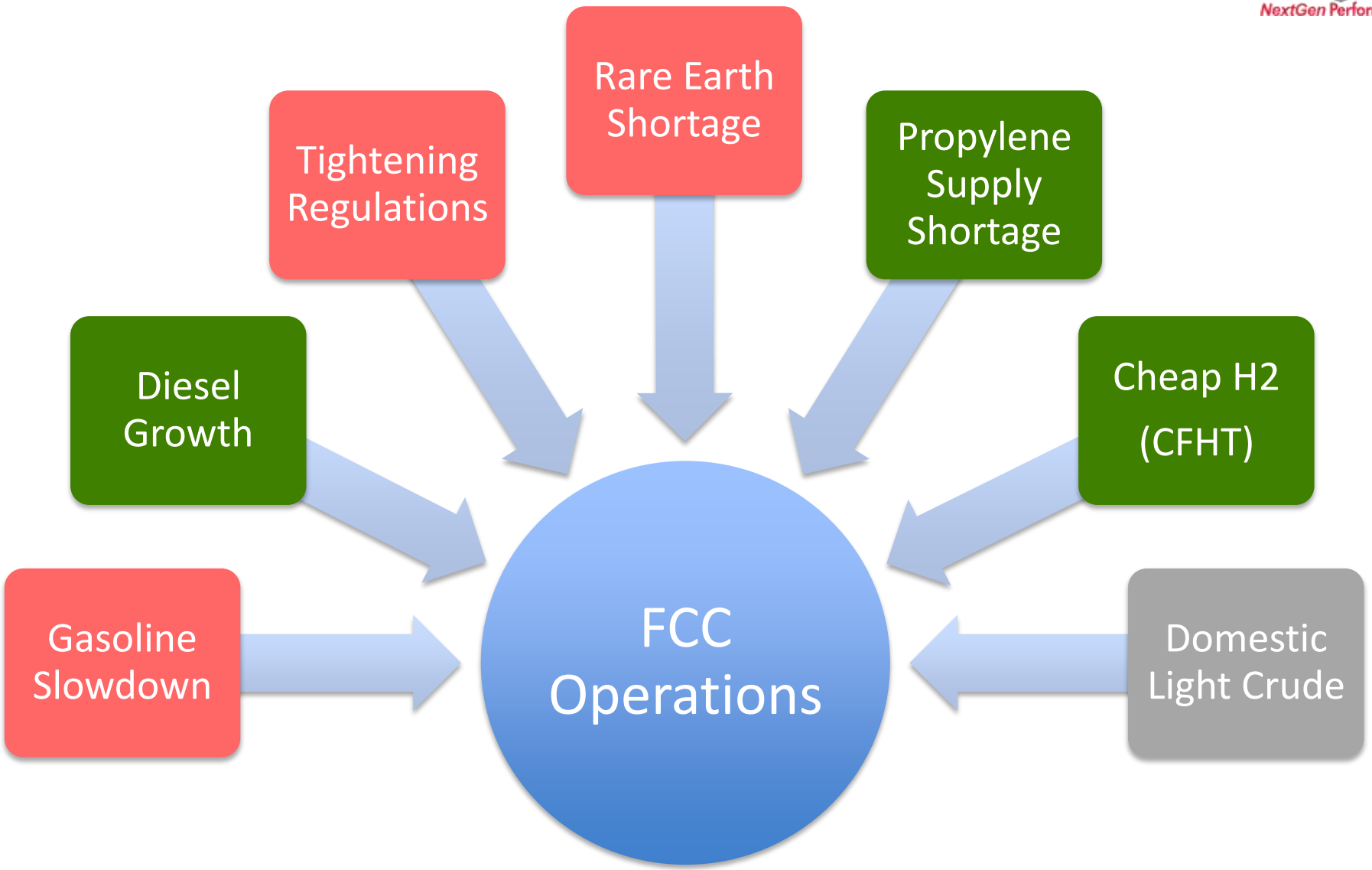
Upgrading Utilization



Gasoil + Resid Processing



Key Factors Influencing FCC



FCC Market Pressure

- Increase in cheaper, light oils for Petrochemical system
  - Feedstocks for Ethylene / Propylene cheaper
  - Short term propylene demand might raise FCC conversion
- Native crude Gasoline / Middle Distillate yields higher
  - Lower Gasoil / Residua of Shale Oil
    - How much deep conversion capacity is required to meet fuels demand?
- FCC continues to contribute 40-60% of finished gasoline
  - FCC Naphtha + Alkylation

Comparison of Gasoil Cut

Gasoil Quality	WTI	Maya blend	Bakken Core	Tx Shale	Cold Lake	Peace River5	Wabasca
API Gravity	26.3	21.0	24.5	31.9	14.9	24.4	13.4
Specific Gravity	0.897	0.928	0.907	0.866	0.966	0.908	0.976
Sulfur wt%	0.46	2.05	0.27	0.18	3.56	2.29	4.31
Acidity mg KOH/g	0.095	0.085	0.053	0.049	1.279	0.522	1.658
Nitrogen wt%	0.13	0.18	0.11	0.01	0.12	0.13	0.16
Refractive Index_67 C	1.4759	1.4980	1.4824	1.4588	1.5257	1.4832	1.5351
Nickel ppm wt	0.00	0.64	0.47	0.09	1.80	0.07	3.79
Vanadium ppm wt	0.00	4.48	0.14	0.08	5.18	0.28	5.10
Con Carbon wt%	0.01	0.47	0.68	0.03	1.69	0.07	1.41
Distillation							
1	489	496	489	481	509	497	514
5	587	594	589	578	609	596	615
10	635	641	637	626	662	644	669
30	742	751	746	734	769	748	777
50	814	829	814	798	845	815	872
70	904	908	896	874	943	891	967
90	1,007	1,041	1,007	989	1,059	1,007	1,063
95	1,059	1,065	1,060	1,049	1,077	1,061	1,107
99	1,167	1,173	1,168	1,159	1,175	1,156	1,176
Relative Conversion x base	Base	85%	97%	113%	70%	95%	63%

FCC Matrix of Responses

- Challenge on FCC
  - Potential feed rate reduction
    - Reduce diesel in gasoil feed
    - Hydrocrackers competing with FCC feed
  - Heat balance Reactor / Regenerator
    - Lower carbon producing feed
  - Severity vs yield distribution
    - Temperature vs Cat/Oil revisited
    - Catalyst to make MORE coke ~! Say it ain't so~!!
  - Utilizing the total asset of reaction/fractionation and recovery to maximize value

FCC – Environmental Considerations

- Shale Oil impacts not just yield but has secondary values
  - Fuel quality / Contaminant
  - Emissions compliance
- Environmental Considerations
  - Tier 3 Gasoline
  - FCC Flue Gas Emissions
    - FCC Flue is becoming a target for more stringent and restrictive pollutant controls
    - Lower Particulate allowances
    - Lower SOx tolerances
    - Lower NOx values

FCC Feed Change and Response

- Less Feed overall to FCC (under-utilized asset)
  - Increase HVGO Cutpoint (if possible)
  - Consider processing VDU overflash in feed
  - Consider small amount of atmospheric residua
  - Recycle HCO / Slurry for both heat balance and destruction of low quality oils
  - Consider processing heavy slops in FCC
- Same feed rate but feed concarbon is lower
  - Increase Riser Severity
  - Lower steam to feed nozzles (additive carbon)
  - Consider HCO recycle first (above)
  - Change catalyst and/or apply additives

FCC – Heat / Pressure Balance

- Heat balance considerations
  - Recycle HCO or Slurry
    - Regenerator running cooler (not cold) 1325^{o}F down to 1280^{o}F
  - Recycle and crack Naphtha for upgrading
    - Can reduce cost of ZSM-5
- Pressure Balance considerations
  - Lower carbon feed will reduce regenerator temperatures and catalyst circulation increases (C/O going up)
    - Consider balance of Slidevalve ΔP and increased cat circulation from lower coke yield
    - Review shutdown system and instruments to pinch out last ounce of operations
  - If it makes sense increase regenerator pressure to back blower up on curve for stable operations

Operational Boundaries - Tier 3

- Refiners with CFHT (easiest option)
  - Lower CFHT severity to maintain same feed quality
  - **Or increase CFHT severity to meet Tier 3 specifications without post-treating of naphtha**
- Refiners without CFHT
  - Feed quality will improve with lower sulfur / nitrogen contaminants, most may have naphtha post treatment and thus may have less octane loss
- Refiners without CFHT, and processing residua
  - This will be a greater challenge as:
    - Shale Oil is less coke intensive
    - Refinery without CFHT and Residua will have substantial challenge in meeting Tier 3 gasoline without investment
    - What is the refinery reliance on FCC Steam if catalyst cooler is present?

FCC Feed Change and Response

- Long-Term
  - Consider refinery-wide Naphtha position
    - Shift to maximizing LCO with added Hydrotreating capacity / severity
      - Dependent upon cetane in pool
    - Recycle Cat Naphtha to FCC Riser to convert to more valuable C_3/C_4 olefins
      - Increased octane and lower sulfur may be a fit for Tier 3
  - Using “wide-range” HCO recycle to Riser
    - Defining heat balance requirement and Naphtha yield will be key in using this stream to manage the FCC operation
    - Prefer a less catalyst contaminated stream to minimize feed nozzle erosion

Maximizing Asset Usage

- Catalyst Adjustments
  - If not using CO Promoter, maybe add to keep regenerator bed hot
  - Catalyst to Maximize LCO
  - ZSM-5

- Mechanical Improvements
  - Fractionator and heavy product system modifications
  - Gas plant modifications
  - Feed injection system upgrades
  - Riser termination device upgrades
  - Review catalyst piping or valving

Fractionator and Gas Plant

- Max Propylene mode / severity on existing gas plant capacity
  - Wet gas compression capacity
  - Propylene recovery optimization
  - Depropanizer loading
- Max Diesel mode can stretch LCO product system
  - Potential for large downgrade of LCO into DCO
  - Monitor Fractionator overhead temperature and salting issues
- Slurry product circuit turndown could be an issue with high conversion and DCO Recycle rates

Wrap Up

- Short Term 3-7 yrs
  - The US will continue to be an exporter of product
  - Keystone XL pipeline will provide an economic advantage for lower cost crude with the domestic crudes in USA
  - Delayed Coker operation from an economic view should remain fully utilized
    - Market demand continues to be stable and strong
    - Pressure from Asia in coke production and metals smeltering will determine demand.
  - FCC operation will be less defined
    - Overall octane increases with Tier 3 will on average lower FCC octane contribution
    - Tier 3 gasoline sulfur compliance more attainable with Shale gasoil
    - Upcoming FCC Flue Gas emissions tightened will negatively impact unit