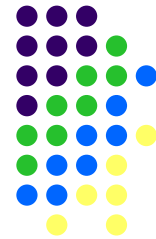


Back to the Future: Oil and Natural Gas Markets in Transition (Again)

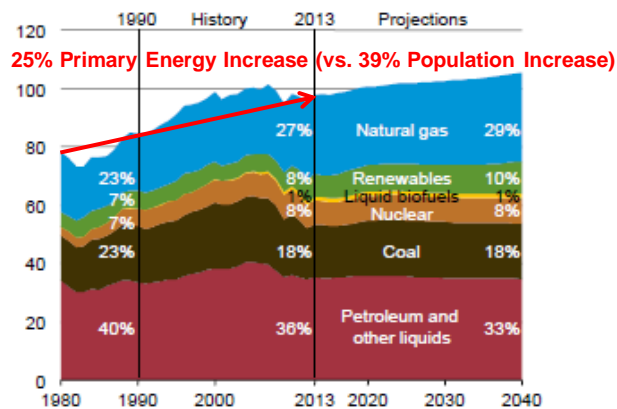
Center for the New Energy Economy
2015 Annual Natural Gas Conference
Fort Collins, Colorado
28 October 2015

Lori Smith Schell, Ph.D., ERP
Empowered Energy
LSchell@EmpoweredEnergy.com
(970) 247-8181



U.S. Energy Mix Is a Large, Slow-Moving Ship with Inertia

Figure 18. Primary energy consumption by fuel in the Reference case, 1980-2040 (quadrillion Btu)



Source: EIA, 2015 Annual Energy Outlook, p. 15, <http://www.eia.gov/forecasts/aeo/pdf/0383/282015%29.pdf>.
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Oil Is an International Market; Natural Gas Is More Regional

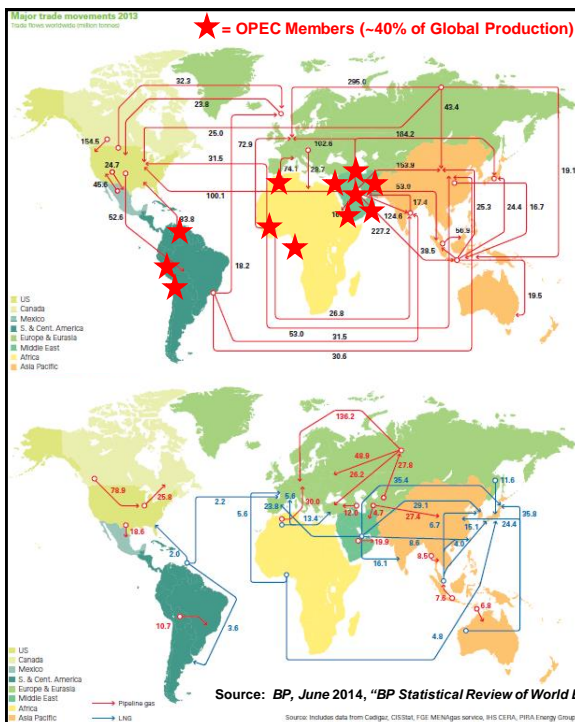


- As a liquid, oil is readily transportable
 - Pipelines, waterborne tankers, trucks
- As a gas, natural gas is mostly transported regionally via land-based pipelines
- Liquefied natural gas (“LNG”) enables marine transport in international markets
 - Requires extensive, costly facilities on both ends, for liquefaction (exporter) & regasification (importer)
 - Long-term contracts historically tied to oil prices
 - Spot market transactions becoming more prevalent

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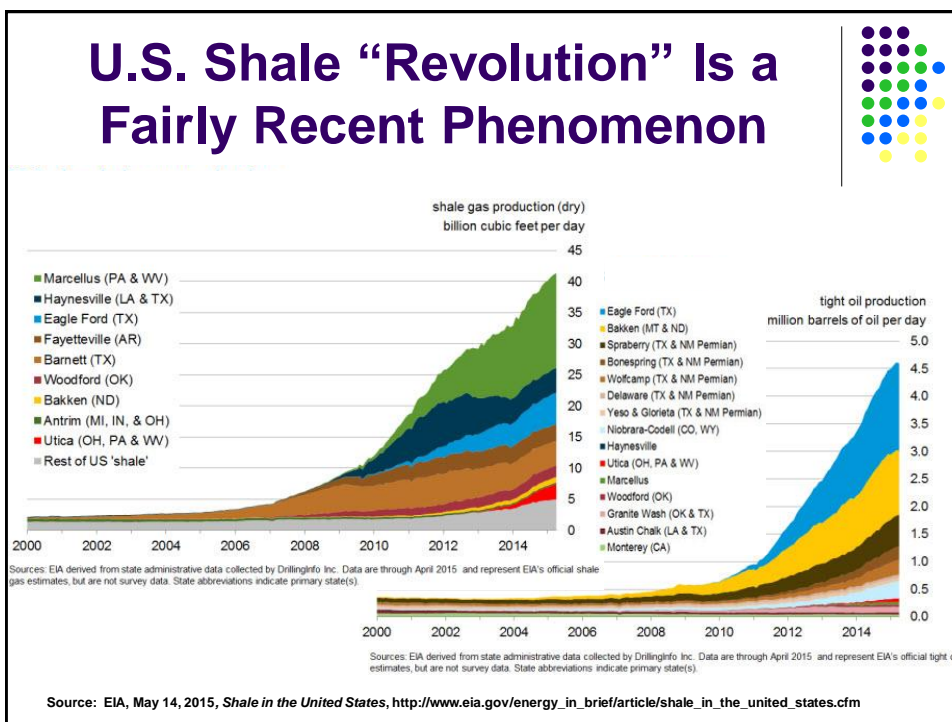
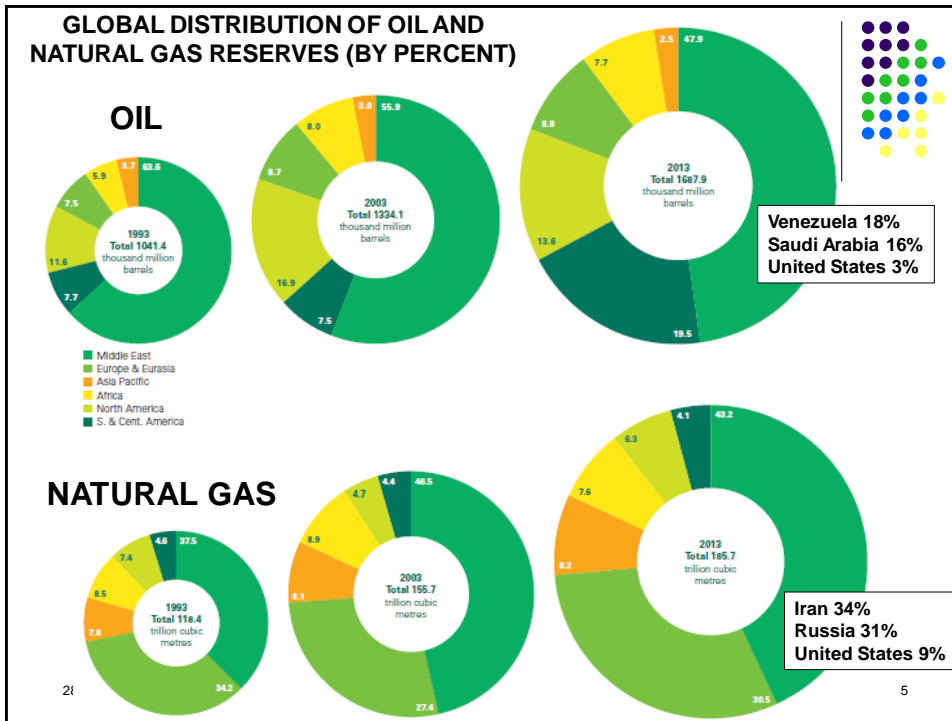
3



- Oil is an international commodity, with widely heterogeneous qualities (sulfur content, weight, product yield)
- Natural gas is homogeneous and traded more regionally, with international LNG trade increasing



4

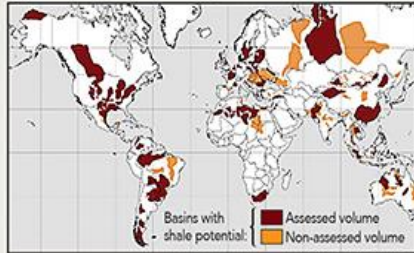


Can the U.S. Shale Experience Be Replicated Elsewhere?



F1: SHALE GAS RESOURCES ESTIMATES AND PRODUCTION

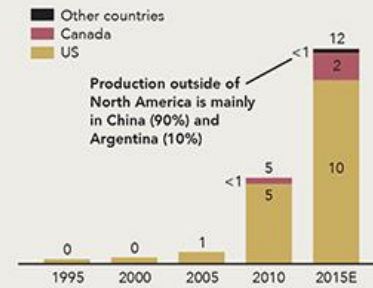
Many regions outside of the US are expected to hold significant amounts of shale gas resources...



Estimated technically recoverable resources of 7,201 tcf worldwide (6,634 tcf, >90%, outside of the US)

... but these countries have not yet translated this potential into significant production

Shale gas production; tcf/yr



Source: EIA, Rystad, SBC Analysis

Source: Oil & Gas Financial Journal, April 2015, *Global Shale Lagging – Here's Why*, p. 41.

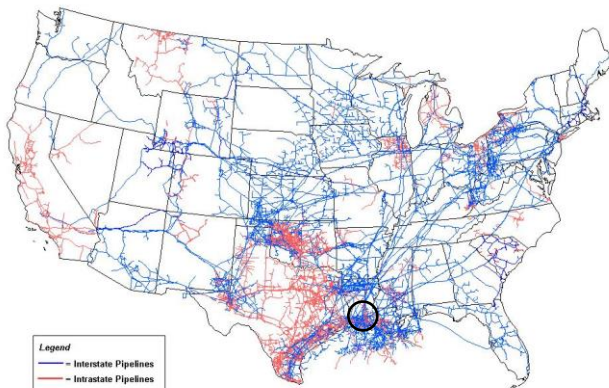
<http://www.ogfj.com/articles/print/volume-12/issue-4/features/global-shale-lagging-here-s-why.html>

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Extensive Natural Gas Pipeline Network, Various Regulators



Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System

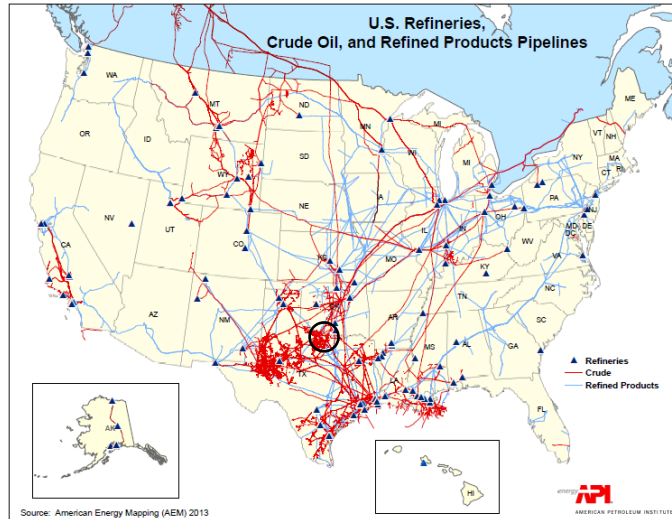
- Interstate
- Intrastate
- Hinshaw
- “LDC” = Local Distribution Company
- “Muni” = Municipality (Self-Regulated)

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8

Oil Pipelines More Limited Since Other Transport Exists



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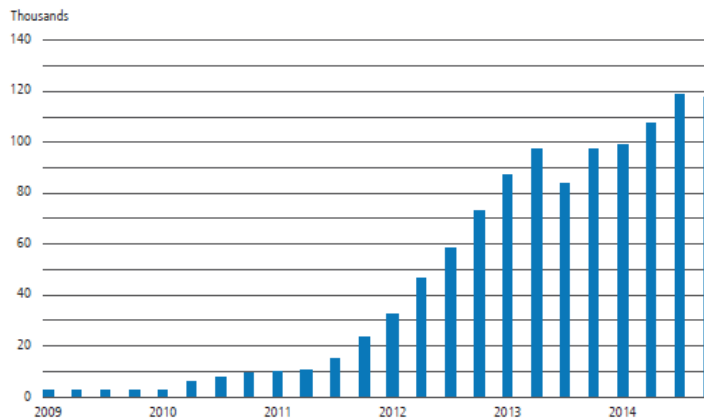
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9

“Crude by Rail” as New Fields Developed Beyond Pipelines



Figure 5-1. Originated Class I Railcars of U.S. Crude Oil (2009–2014, Quarterly)¹⁴



The rapid increase in crude by rail is a function of the growth in new source of new oil production, particularly in North Dakota, as well as limited pipeline capacity for moving this oil to refiners on the East and West Coasts.

Source: U.S. Department of Energy, Quadrennial Energy Report, April 2015, p. 5-4. <http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report>

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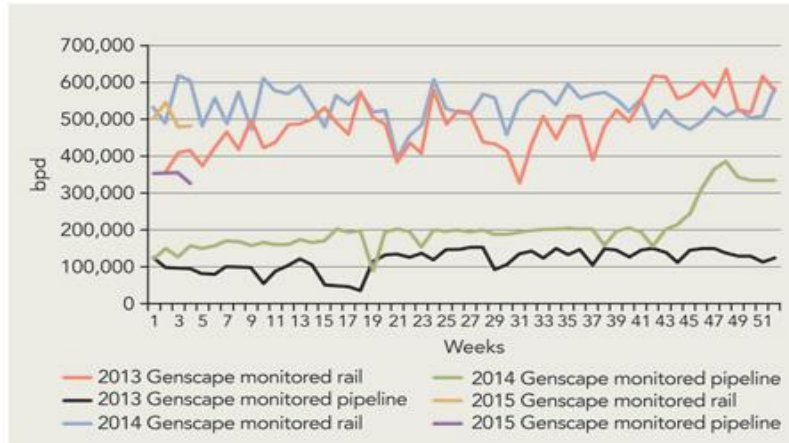
www.EmpoweredEnergy.com

10

At Least Until Sufficient Pipeline Infrastructure Is Developed



F1: BAKKEN TRANSPORTATION FLOWS YEAR OVER YEAR



Source: Oil & Gas Financial Journal, March 2015, *Will the Bakken Boom Go Bust?*, p. 30.
<http://www.ogfj.com/articles/print/volume-12/issue-3/features/will-the-bakken-boom-go-bust.html>

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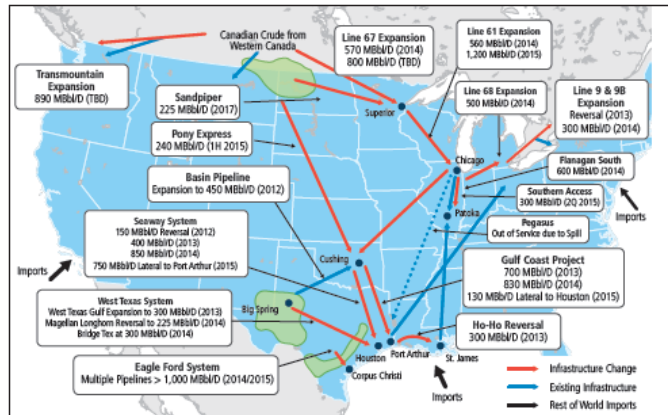
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11

Shale Oil & Gas Is Changing Pipeline Flows & Pricing



Figure 4-2. Highlighted Pipeline Reversals and Expansions Accommodating Increased Domestic and Canadian Supply⁷



There have been substantial pipeline additions and some reversals of pipeline product flows to accommodate the changes in domestic production regions and the volumes of product that are being transported.

Source: U.S. Department of Energy, Quadrennial Energy Report, April 2015, p. 4-5. <http://energy.gov/epsa/downloads/quadrennial-energy-review-full-report>

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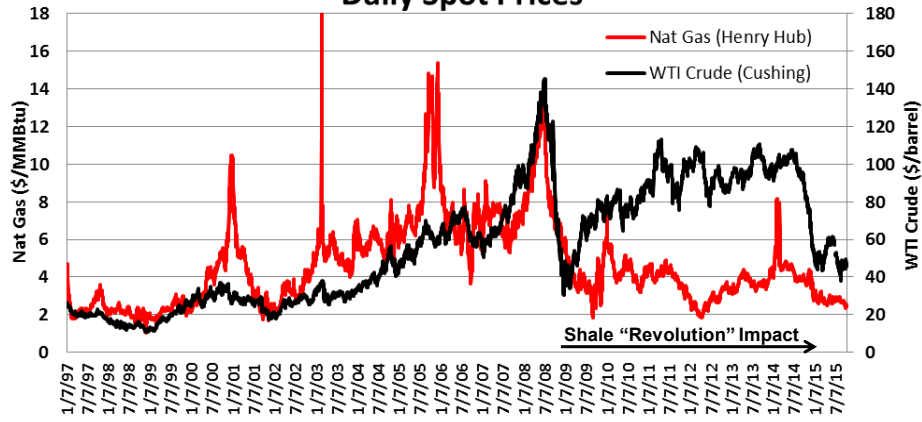
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12

Natural Gas & Oil Prices – Both Volatile, No Direct Linkage Now



Henry Hub Natural Gas vs. WTI Crude Oil
Daily Spot Prices



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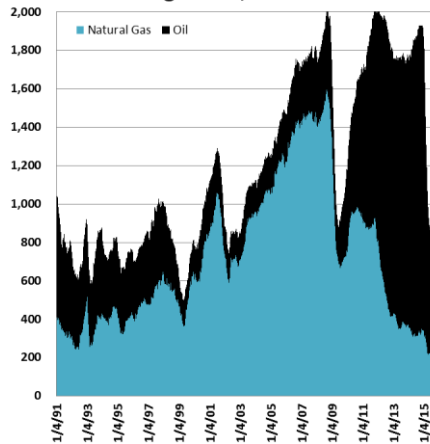
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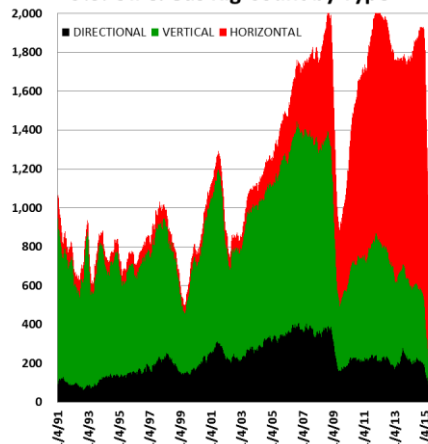
Low Rig Count?? We've Been Here Before...



U.S. Rig Count, Oil vs. Gas



U.S. Oil & Gas Rig Count by Type



Source of Data: Baker Hughes, <http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother>

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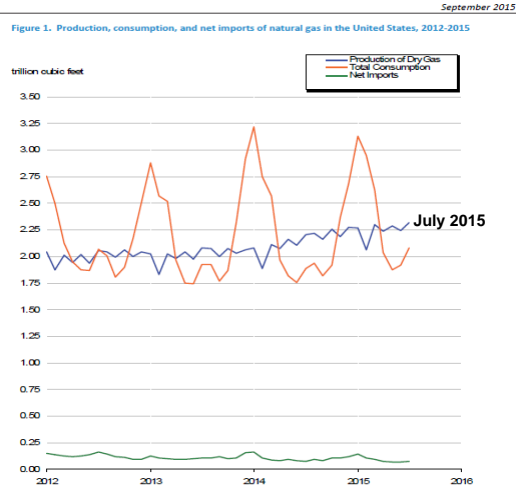
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Natural Gas Production Levels Slowing but Still Growing



Figure 1



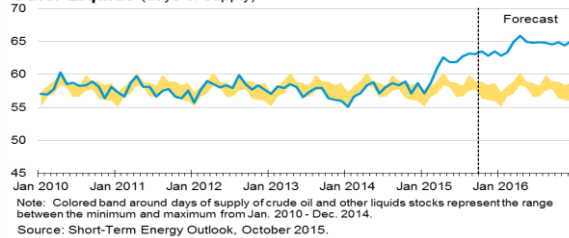
Source: U.S. Energy Information Administration, Natural Gas Monthly, September 2015, p. 4.
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15

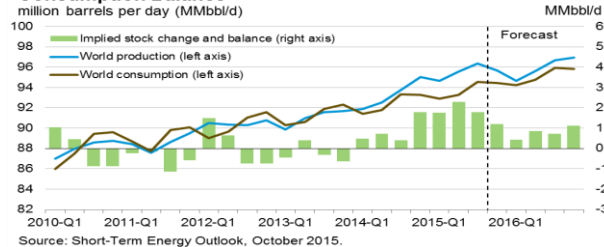
Current Oil Markets Driven By Large Storage Overhang



OECD Commercial Stocks of Crude Oil and Other Liquids (days of supply)



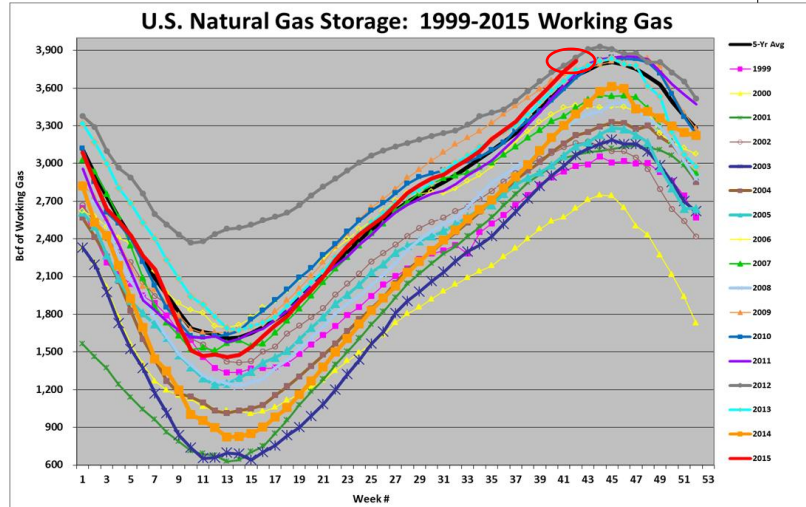
World Liquid Fuels Production and Consumption Balance



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U.S. Natural Gas Storage Also Approaching Record Level

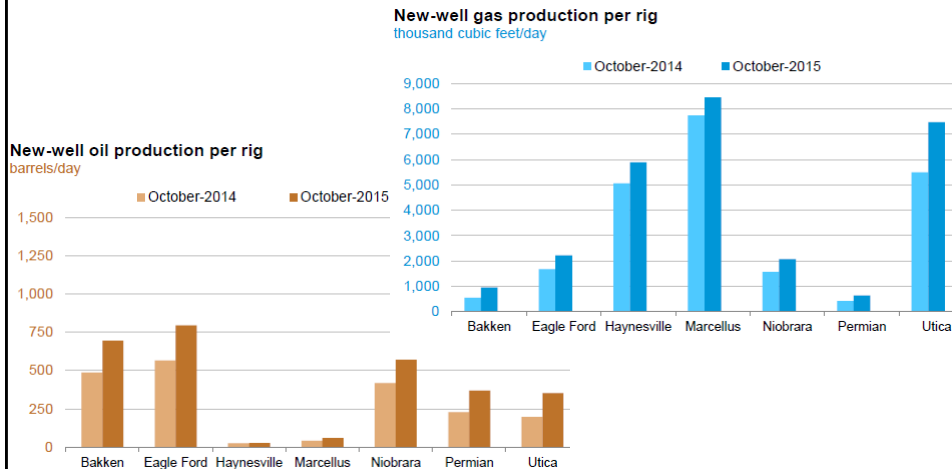


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Rig Count Is Down But Production Per Rig Is Up



Source: EIA, September 2015, *Drilling Productivity Report*, p. 2, <http://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf>

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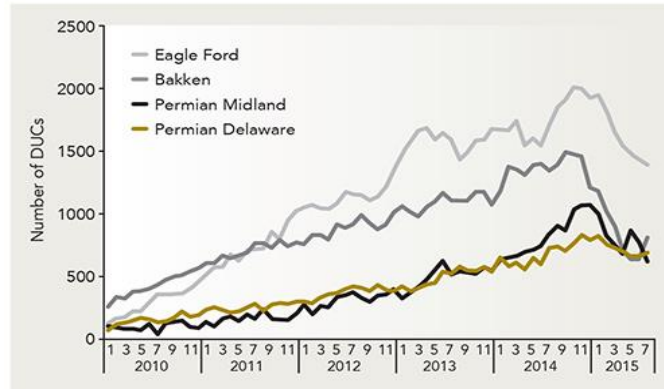
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18

“Frack-log” of Drilled and Uncompleted Wells Is Falling



F1: DUC FOR BAKKEN, EAGLE FORD, PERMIAN
FROM 2010 TO 2015 (AS OF JULY 2015)



Source: Rystad Energy NASWellData and Rystad Energy analysis

Source: OGFJ, October 2015, *North American Shale Update*, p. 20. <http://www.ogfj.com/articles/print/volume-12/issue-10/features/north-american-shale-update.html>

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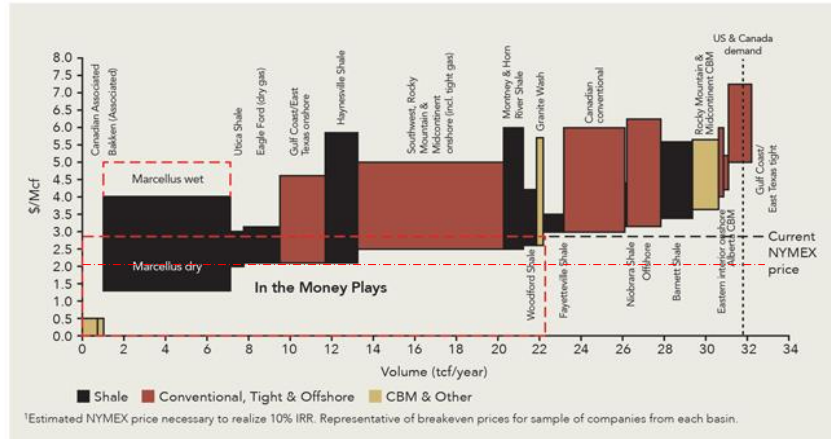
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Amount of Economic Natural Gas Declines as Prices Decline



F3: 2015 US & CANADA NATURAL GAS SUPPLY CURVE



Estimated NYMEX price necessary to realize 10% IRR. Representative of breakeven prices for sample of companies from each basin.

Source: EIA, NEB, Credit Suisse, Wood Mackenzie, RBAC, DI Desktop Company Reports, Client Interviews, and Strategy& analysis

Source: OGFJ, September 2015, *Time to Tack Towards Gas*, p. 48. <http://www.ogfj.com/articles/print/volume-12/issue-9/features/time-to-tack-towards-gas.html>

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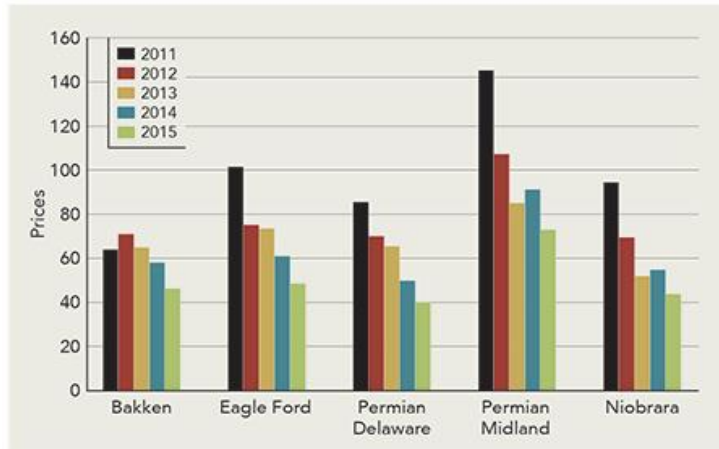
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20

Similarly as Oil Prices Decline...



F3: WTI BREAKEVEN PRICES FOR MAIN SHALE PLAYS FROM 2011-2015



Source: NASWellData and Rystad Energy analysis

Source: OGFJ, July 2015, *Unconventional Resources*, p. 17. <http://www.ogfj.com/articles/print/volume-12/issue-7/features/unconventional-resources.html>

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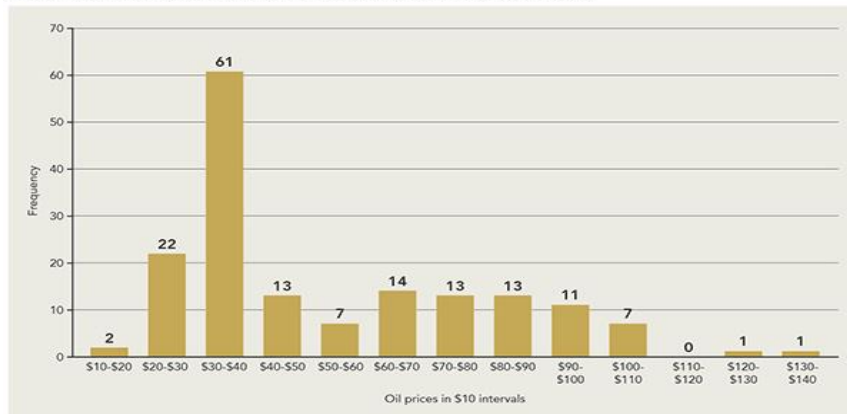
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“Bucketed” Oil Prices Suggest Current Prices Not Abnormal



F3: QUARTERLY OCCURRENCES OF INFLATION ADJ. OIL PRICES 1Q74-1Q15



Source: EIA and EnerCom analysis

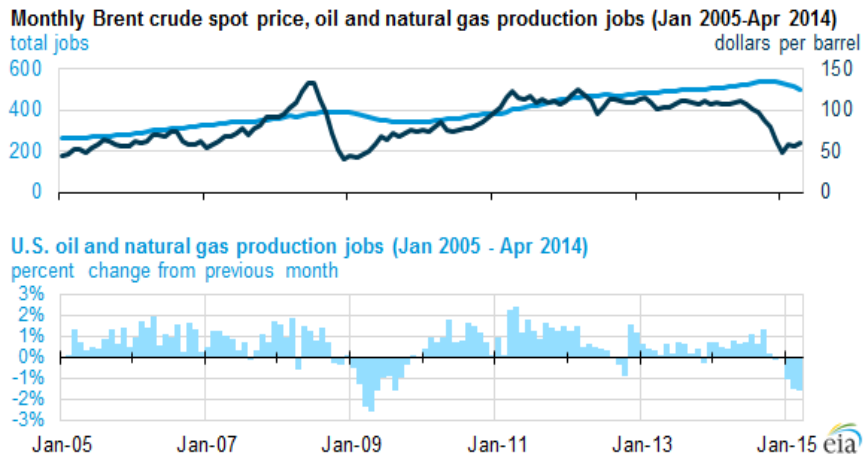
Source: OGFJ, *A Look at Key E&P Metrics*, July 2015, p. 28. <http://www.ogfj.com/articles/print/volume-12/issue-7/features/a-look-at-key-e-p-metrics.html>

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Oil & Gas Employment Has Declined with Low Prices...



Source: EIA, *Today in Energy*, June 23, 2015, <http://www.eia.gov/todayinenergy/detail.cfm?id=21772>

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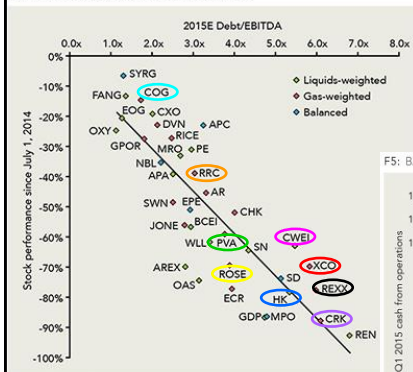
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23

And Overleveraged Companies May Fall to “Consolidation”



F8: STOCK PERFORMANCE VS. LEVERAGE

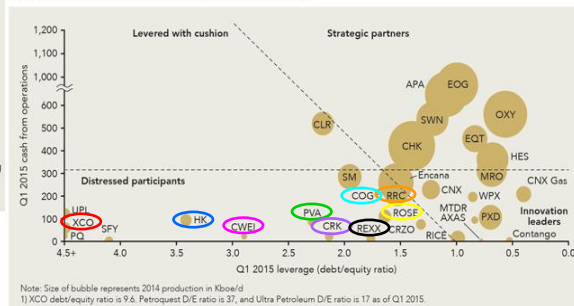


Source: RBC Capital, 2015.

Source: OGFJ, June 2015, *Capital Availability for E&Ps*, p. 38. <http://www.ogfj.com/articles/print/volume-12/issue-6/features/capital-availability-for-e-ps.html>

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F5: BALANCE SHEET STRENGTH OF SELECT PRODUCERS



Source: Capital IQ, company reports, Strategy& analysis

Source: OGFJ, September 2015, *Time to Tack Towards Gas*, p. 49.

<http://www.ogfj.com/articles/print/volume-12/issue-9/features/time-to-tack-towards-gas.html>

Some Shale Gas is Rich in Natural Gas Liquids (“NGLs”)

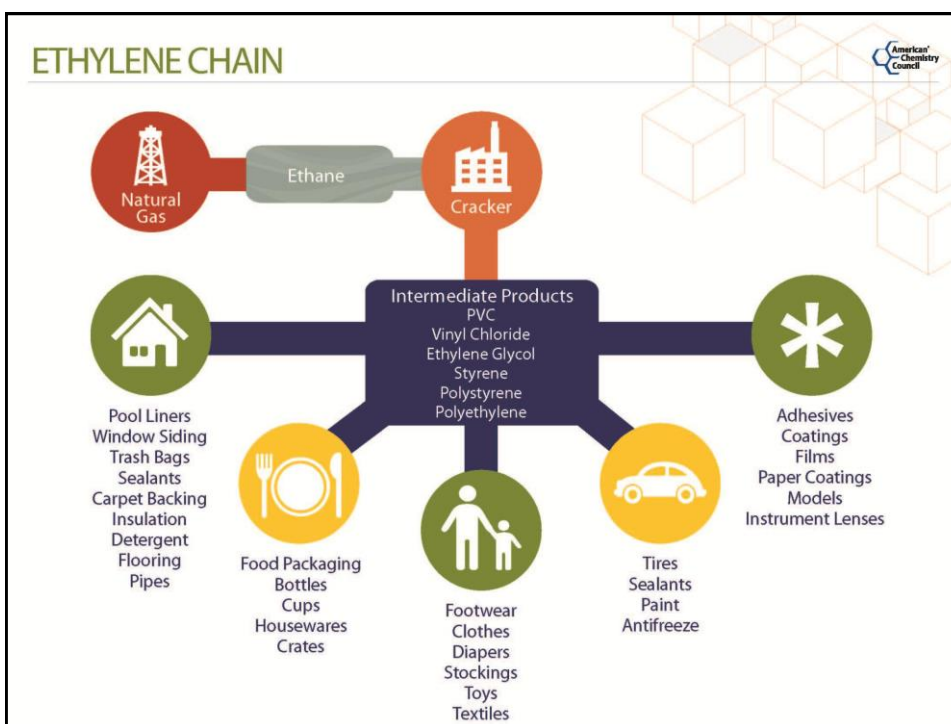


- NGLs must be removed to meet interstate pipeline specifications
- Amount of NGLs removed depends in part on relative prices of natural gas vs. NGLs
- Ethane rejection has led to low ethane prices in U.S. and increased global competitiveness
- Return of ammonia, fertilizer, and methanol production to U.S.

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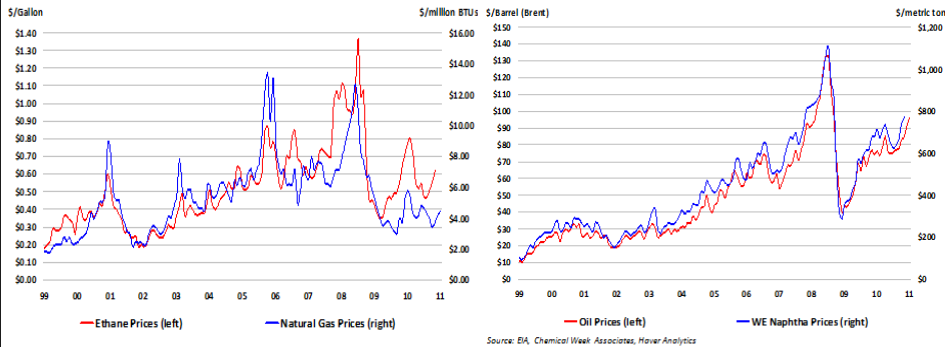


Chemical Feedstock Price Drivers Differs by Continent



US: Ethane Price Tied to Natural Gas

Europe: Ethane Price Tied to Naphtha



Source: American Chemistry Council, March 2012, "Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and US Manufacturing", pp. 13-14.

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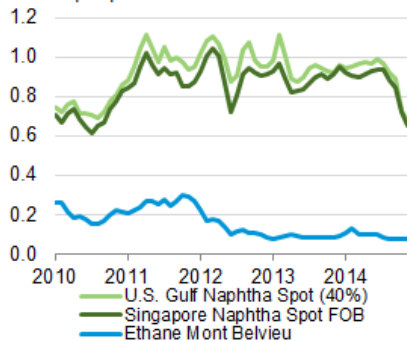
27

Low Natural-Gas Tied Ethane Prices Drive Investment



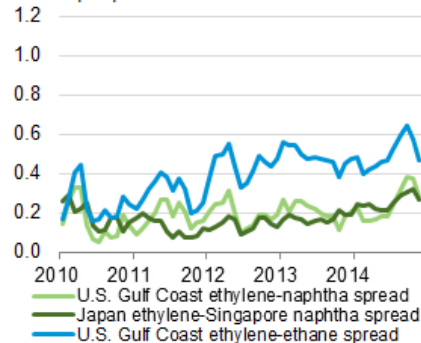
Average monthly ethane and naphtha spot prices

January 2010-November 2014
dollars per pound



Average monthly ethylene spot price spreads over ethane and naphtha spot prices

January 2010-November 2014
dollars per pound



Source: Energy Information Administration, *Today in Energy*, January 29, 2015, "Growing U.S. HGL Production Spurs Petrochemical Industry Investment", <http://www.eia.gov/todayinenergy/detail.cfm?id=19771>

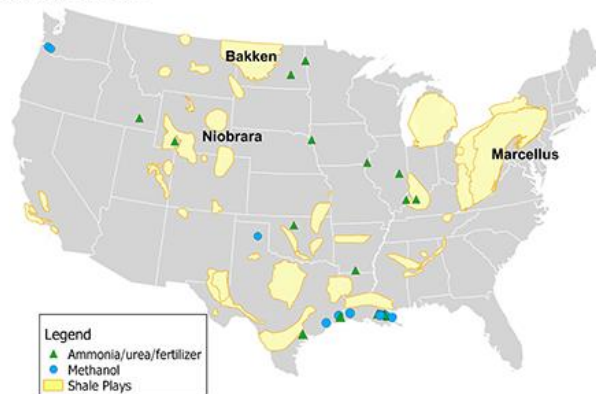
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Increased U.S. Competitiveness Elicits New Manufacturing

Major proposed methanol and ammonia-based fertilizer plants, 2015-18



Source: U.S. Energy Information Administration based on Bentek Energy and industry reports. http://www.eia.gov/naturalgas/weekly/archive/2015/05_21/index.cfm

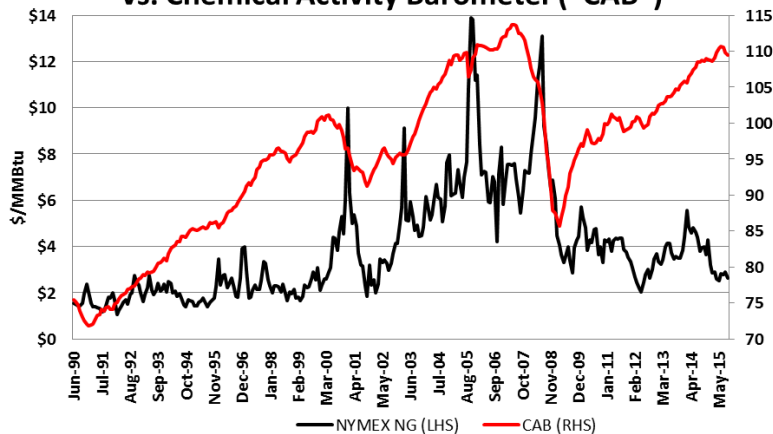
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New Chemicals Manufacturing Impact Is Reflected in CAB

NYMEX Natural Gas Futures Prices
vs. Chemical Activity Barometer ("CAB")



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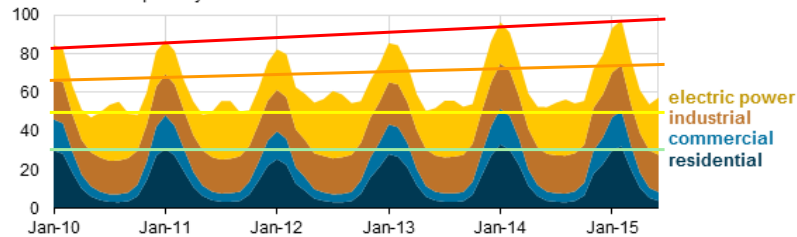
30

U.S. Shale Gas “Revolution” – The Demand Side

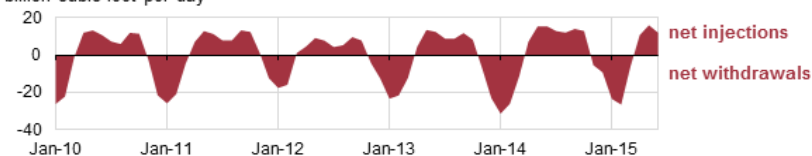


cia

Natural gas deliveries to customers by end use, Jan 2010 - Jun 2015
billion cubic feet per day



Natural gas storage withdrawals and injections, Jan 2010 - Jun 2015
billion cubic feet per day



Source: U.S. Energy Information Administration, Today in Energy, September 11, 2015, *Natural Gas Use Features Two Seasonal Peaks Per Year*. <http://www.eia.gov/todayinenergy/detail.cfm?id=22892>

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Oil Remains Transportation King Pin...But for How Long??



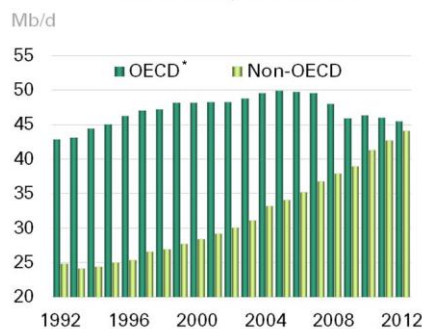
The competition is coming.....

Oil consumption and mobility

- Plug-In Electric Vehicles
- Hybrid Vehicles
- CNG/LNG Vehicles
- H₂ Fuel Cell Vehicles



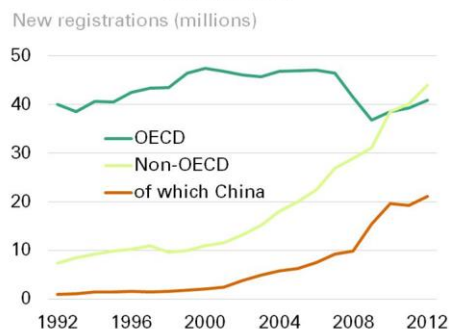
Oil consumption trends



Source: Includes data from R. L. Polk & Co.

* OECD = Organisation for Economic Co-operation and Development

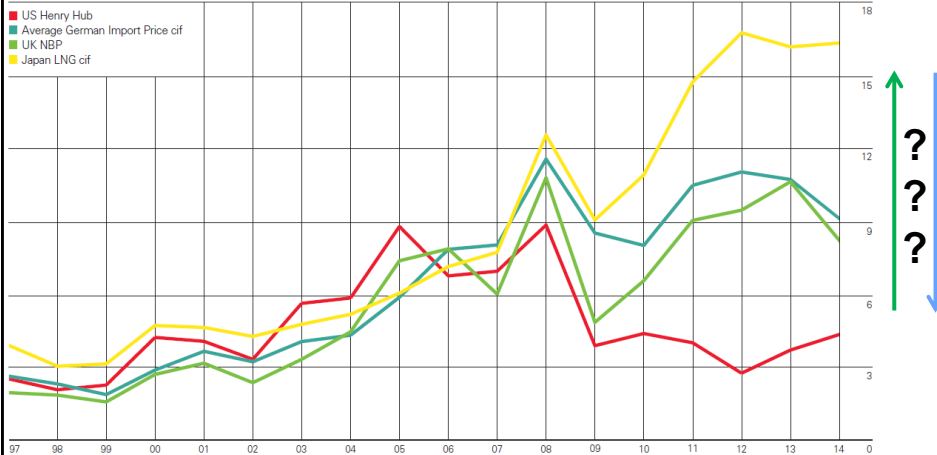
Vehicle sales



BP Statistical Review of World Energy

© BP 2013

Global Nat Gas Price Disparity: OPPORTUNITY, but Whose?



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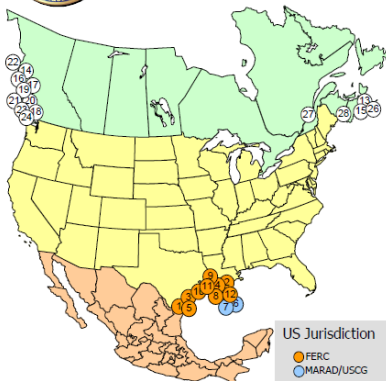
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Today's Expectations: U.S. to Become Net Overall Exporter *



North American LNG Export Terminals
Potential



Export Terminal

POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS

1. Brownsville, TX: 2.8 Bcfd (Gulf Coast LNG Export)
2. Cameron Parish, LA: 0.16 Bcfd (Waller LNG Services)
3. Ingleside, TX: 1.09 Bcfd (Pangea LNG (North America))
4. Cameron Parish, LA: 0.20 Bcfd (Gasfin Development)
5. Brownsville, TX: 3.2 Bcfd (Eos LNG & Barca LNG)
6. Gulf of Mexico: 3.22 Bcfd (Main Pass - Freeport-McMoRan)
7. Gulf of Mexico: 1.8 Bcfd (Delfin LNG)
8. Cameron Parish, LA: 1.60 Bcfd (SCT&E LNG)
9. Port Arthur, TX: 0.2 Bcfd (WesPac/GulfGate Terminal)
10. Galveston, TX: 0.77 Bcfd (NextDecade)
11. Calcasieu Parish, LA: 0.64 Bcfd (Live Oak LNG-Parallax Energy)
12. Cameron Parish, LA: 1.94 Bcfd (G2 LNG)

POTENTIAL CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

13. Goldboro, NS: 1.4 Bcfd (Pieridae Energy Canada)
14. Prince Rupert Island, BC: 2.91 Bcfd (BG Group)
15. Melford, NS: 1.8 Bcfd (H-Energy)
16. Prince Rupert Island, BC: 2.74 Bcfd (Pacific Northwest LNG)
17. Prince Rupert Island, BC: 4.0 Bcfd (ExxonMobil - Imperial)
18. Squamish, BC: 0.29 Bcfd (Woodfibre LNG Export)
19. Kitimat/Prince Rupert, BC: 0.32 Bcfd (Triton LNG)
20. Prince Rupert, BC: 3.12 Bcfd (Aurora LNG)
21. Kitimat, BC: 2.7 Bcfd (Kitimat Energy)
22. Stewart, BC: 4.1 Bcfd (Canada Stewart Energy Group)
23. Delta, BC: 0.4 Bcfd (WesPac Midstream Vancouver)
24. Vancouver Island, BC: 0.11 Bcfd (Steelhead LNG)
25. Prince Rupert Island, BC: 4.2 Bcfd (Ovca LNG)
26. Port Hawkesbury, NS: 0.5 Bcfd (Bear Head LNG)
27. Saguenay, Quebec: 1.6 Bcfd (GNL Quebec)
28. Saint John, NB: 0.67 Bcfd (Saint John LNG Development)

* Source: EIA, Annual Energy Outlook 2015, Reference Case; Net Exporter by 2017.

As of April 14, 2015

Source: <http://ferc.gov/industries/gas/indus-act/lng/LNG-proposed-potential.pdf>

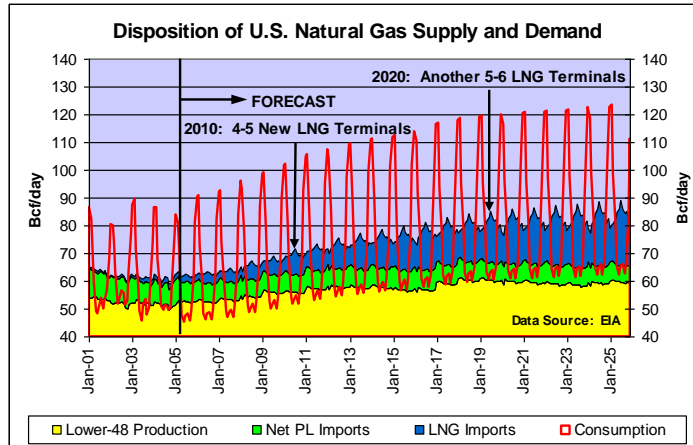
Office of Energy Projects

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Pre-Shale Gas “Revolution” Anticipated More LNG Imports



PRESENTATION MADE BY LORI SMITH SCHELL, Ph.D.,
TO THE 18TH WORLD PETROLEUM CONGRESS,
JOHANNESBURG, SOUTH AFRICA, SEPTEMBER 27, 2005

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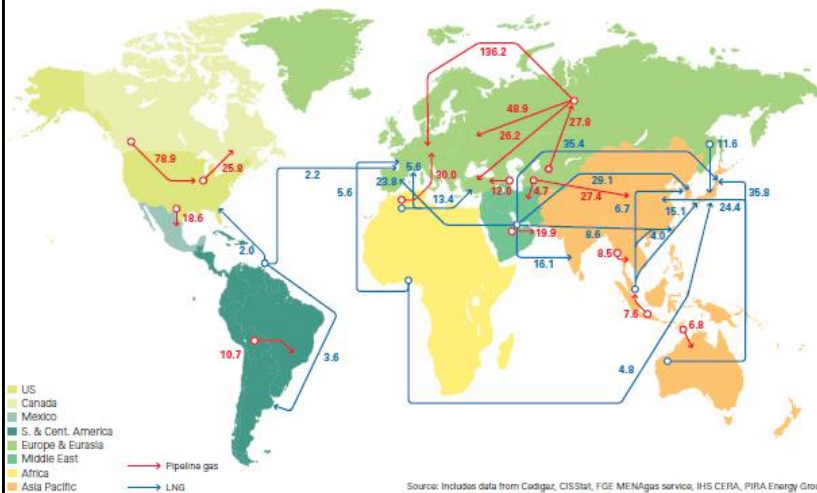
35

U.S. LNG Exports Would Shift Global LNG Flows and Markets



Major trade movements 2013
Trade flows worldwide (billion cubic meters)

Source: BP, June 2014, “BP Statistical Review of World Energy”, p. 29.

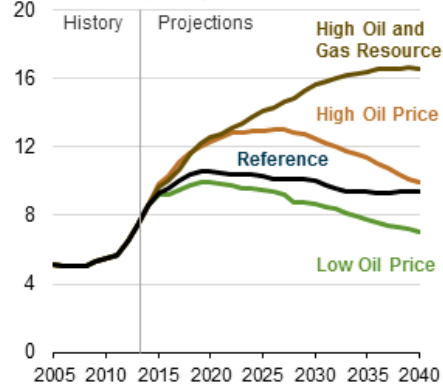


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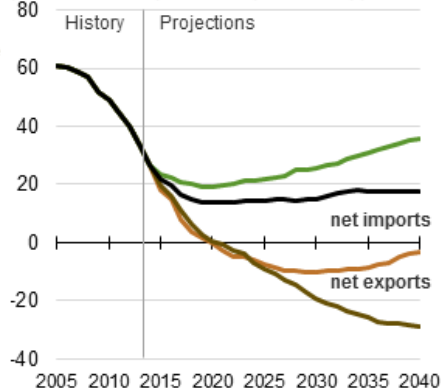
Despite Shale Oil Boom, U.S. Likely to Remain Net Importer



U.S. crude oil production, 2005-40
million barrels per day



U.S. net petroleum product imports
percent of U.S. petroleum product supplied



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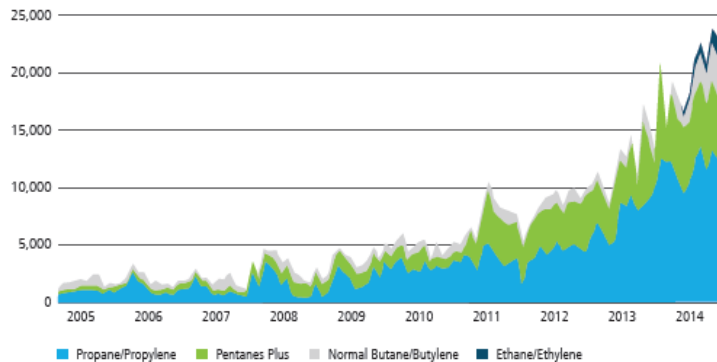
37

U.S. Crude Oil Export Ban? Export Petroleum Products!



Figure 4-3. U.S. Hydrocarbon Gas Liquid Exports^{13,14}

Thousand Barrels/Month



Since 2009, U.S. hydrocarbon gas liquid exports have risen substantially due to increased domestic production and wide international price spreads.

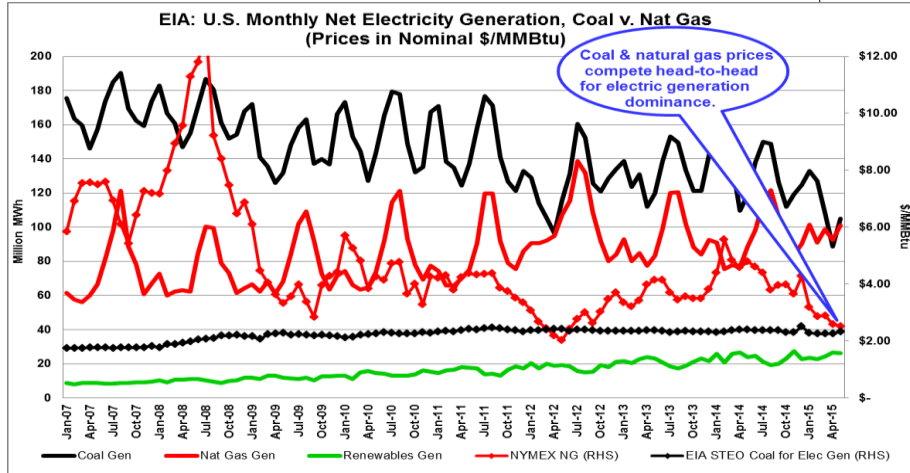
Source: U.S. Department of Energy, Quadrennial Energy Report, April 2015, p. 4-10.
<http://energy.gov/epa/downloads/quadrennial-energy-review-full-report>

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Renewables on the Rise, but... Coal & Nat Gas Still Dominate



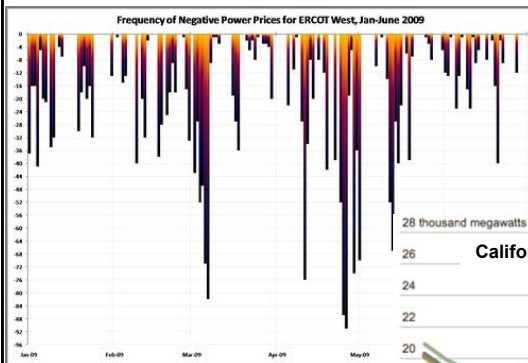
Source of Data: U.S. Energy Information Administration and New York Mercantile Exchange (NYMEX).

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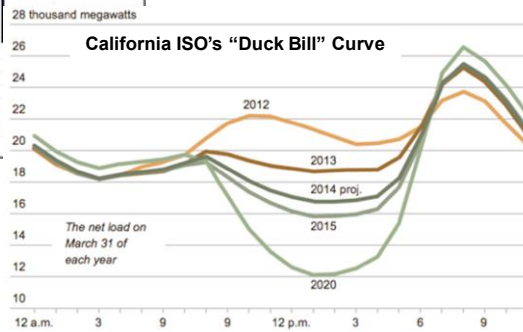
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Renewables Are Impacting Both Electric Grid Flows & Pricing...



Source: <http://knowledgeproblem.com/2009/07/22/negative-power-prices-in-ercot-west-charts-for-jan-june-2009/>



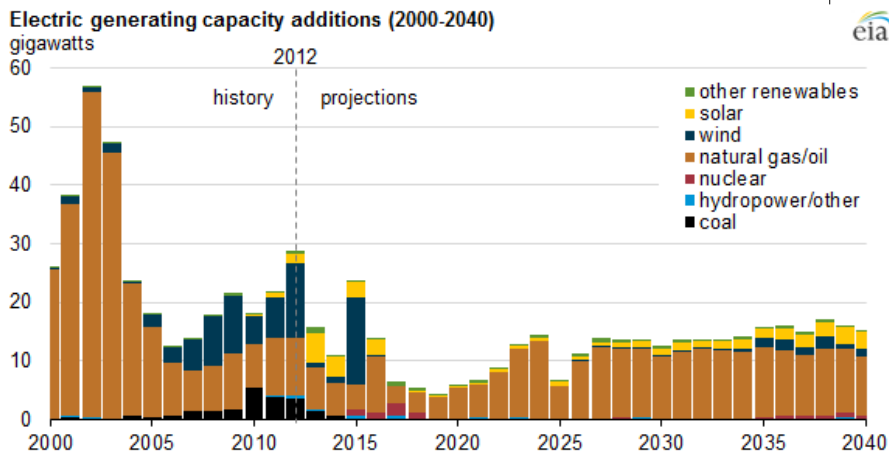
Source: CalISO

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With Increased Electrification Seen as the Best Solution



eia



Source: Form Eia-860 and Annual Energy Outlook 2014, <http://www.eia.gov/todayinenergy/detail.cfm?id=17131>

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EPA Issued Final Clean Power Plan (“CPP”) August 3, 2015



- End: Cut power sector CO₂ emissions 32% by 2030 (2012 base) via state-specific targets
 - Rate-based: Reduce CO₂/MWh generated
 - Mass-based: Reduce absolute quantity emitted
- Means: “Building blocks” of (i) increased coal plant efficiency, (i) swapping gas for coal, and (iii) swapping renewables for fossil fuel
- Final Rule: Increased reduction requirements for states with coal-fired generation vs. draft.

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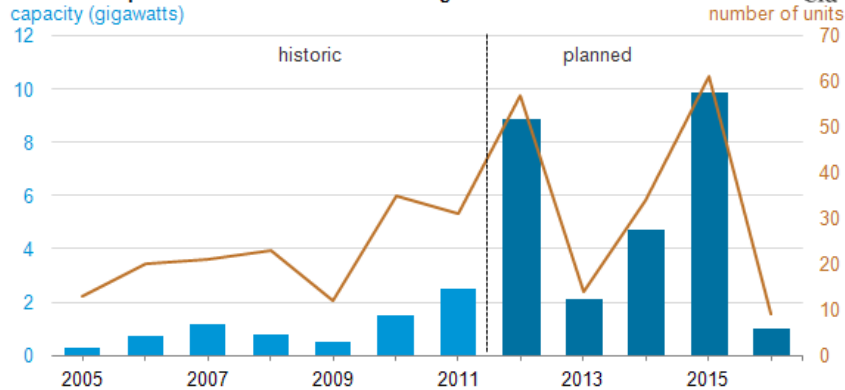
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Many Coal-Fired Generators Closed *Before* the Final CPP



Historic and planned retirements of coal-fired generators



Source: U.S. Energy Information Administration, Form EIA-860, "Annual Electric Generator Report."

Note: Data for 2005 through 2011 represent actual retirements. Data for 2012 through 2016 represent planned retirements, as reported to EIA. Data for 2011 through 2016 are early-release data and not fully vetted. Capacity values represent net summer capacity.

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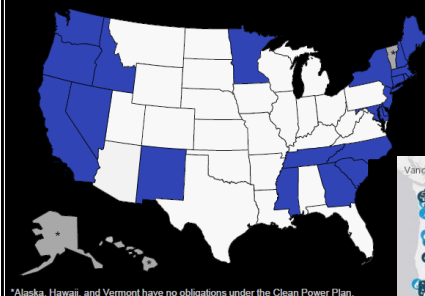
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UCS' Assessment of States' Readiness for CPP Compliance



21 States are Already on Track to Surpass Their 2022 Clean Power Plan Benchmarks (Rate-Based Compliance)



Source: Union of Concerned Scientists, August 13, 2015, *States of Progress Update: Existing Clean Energy Commitments Put Most States in Strong Position to Meet the EPA's Final Clean Power Plan*, pp. 12-13, <http://www.ucsusa.org/sites/default/files/attach/2015/08/States-of-Progress-Update-Slidedeck.pdf>

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Climate Change – It's Not Just About the Carbon...



- GHG = Greenhouse Gas
- GWP = Global Warming Potential

GHG	GWP (100 Yr)	
• Carbon Dioxide – CO ₂	1	
• Methane – CH ₄	21	
• Nitrous Oxide – N ₂ O	310	
• SF ₆ – Sulfur Hexafluoride	23,900	
• Hydrofluorocarbons (13) – HFCs	140-11,700	} “F-gases”
• Perfluorocarbons (6) – PFCs	6,500-9,200	

- CO₂e = Carbon dioxide-equivalents
- MT = metric tonne = 2,200 pounds
- MMTCO₂e = Million metric tonnes of CO₂-equivalents (x 1000 = Giga tonnes)

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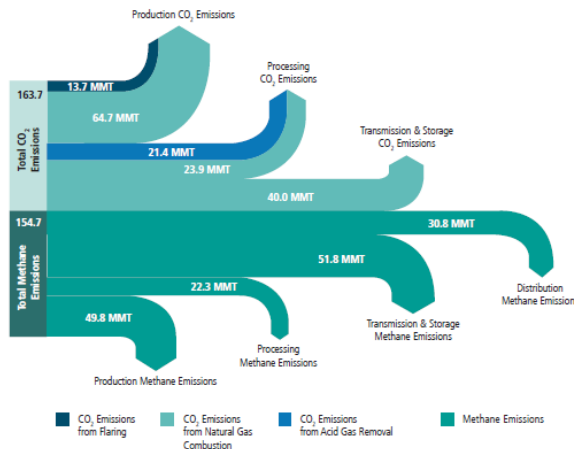
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Natural Gas GHG Emissions Half Those of Coal, But Still...



Figure 7-1. 2012 GHG Emissions from Natural Gas Production, Processing, Transmission, Storage, and Distribution¹⁸

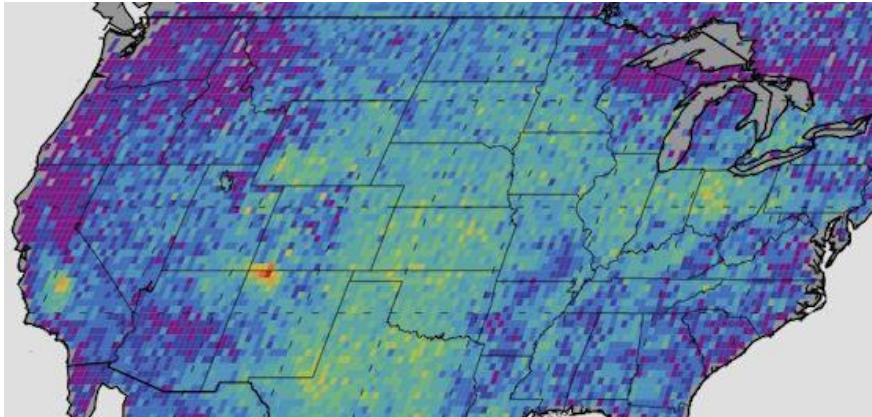


Both CO₂ (top of diagram) and methane (bottom of diagram) are emitted in roughly equal amounts from various sources and processes upstream of end-use consumers. Eighty percent of the GHG emissions from the natural gas system result from consumer end use of natural gas. However, these emissions are omitted from this figure to enable a more detailed picture of emissions from natural gas infrastructure.

Source: U.S. Department of Energy, Quadrennial Energy Report, April 2015, p. 7-8. <http://energy.gov/epa/downloads/quadrennial-energy-review-full-report>
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Recent Discovery of Regional Methane Cloud Is Troubling...



Source: NASA, October 9, 2014, U.S. Methane Hot Spot Bigger Than Expected,
http://science.nasa.gov/science-news/science-at-nasa/2014/09oct_methanehotspot/

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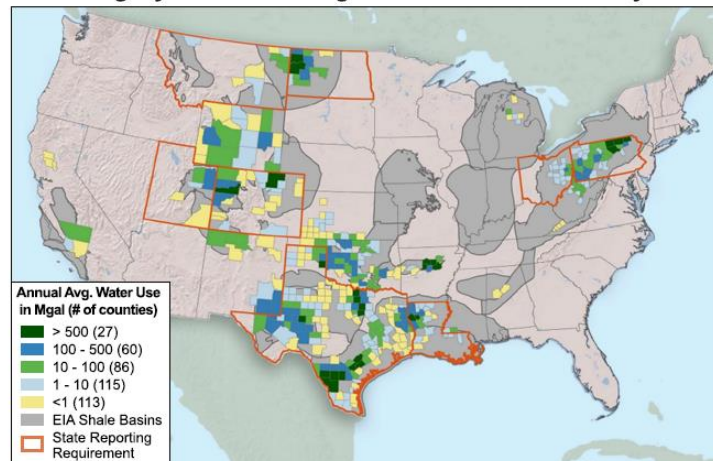
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Water Use for Fracking Tracks Major Shale Field Development



Annual Avg. Hydraulic Fracturing Water Use In 2011 & 2012 By County



Source: EPA, EIA

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Recent EPA Analysis of Fracking Water Issues Found:



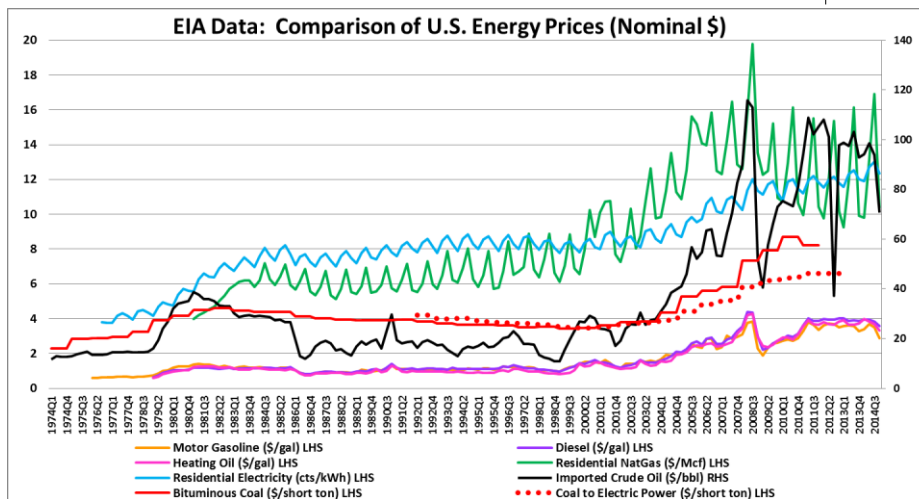
- No *systematic* impacts to-date to drinking water, but “potential vulnerabilities” *do* exist
 - Water withdrawals in low water availability areas
 - Fracking conducted directly into formations containing drinking water resources
 - Inadequately cased or cemented wells resulting in below-ground migration of gases and liquids
 - Inadequately treated wastewater discharged into drinking water resources
 - Spills of hydraulic fluids and fracking wastewater, including flowback and produced water.

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Energy Prices Never Conform to “Hockey Stick” Forecasts...

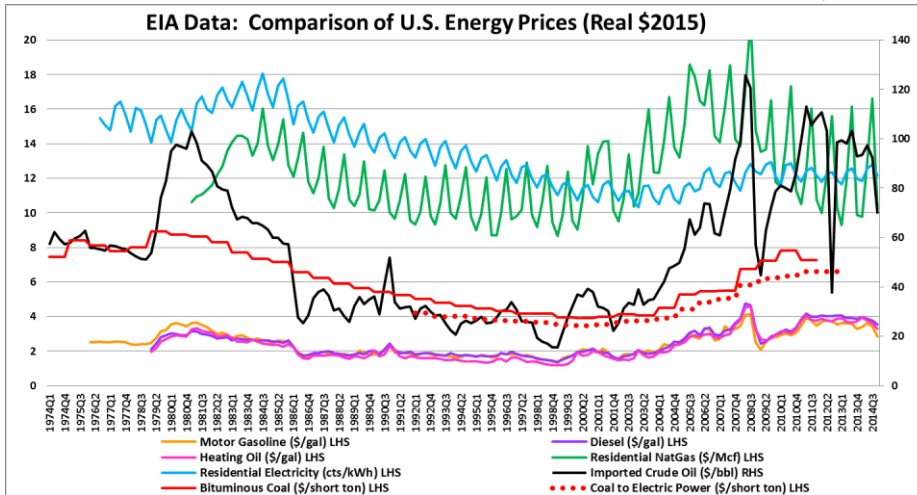


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...In Either Nominal or Real (Inflation-Adjusted) Dollars



Back to the Future: What Comes Around Goes Around



- What we **do** know volatility is here to stay
 - Prices go up and prices go down
 - Current *prices* are back to past price levels, though geography and flows differ
- What we **don't** know with certainty: *Timing*
- Advice in light of that uncertainty?
 - Consumers: Hedge your bets (lock in low prices)
 - Producers: Lock in ~~market share~~ efficiencies
- Bottom Line: The more things change, the more they stay the same.

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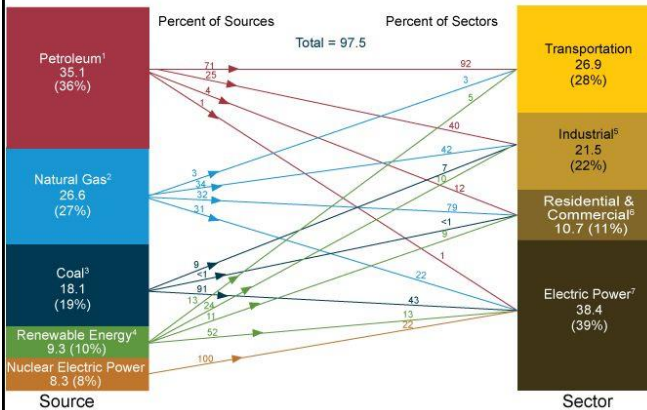
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Primary energy consumption by source and sector, 2013

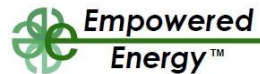
quadrillion Btu

Source: U.S. Energy Information Administration,
http://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2013_energy.pdf.



Thank you!
Questions?

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Backup Slides

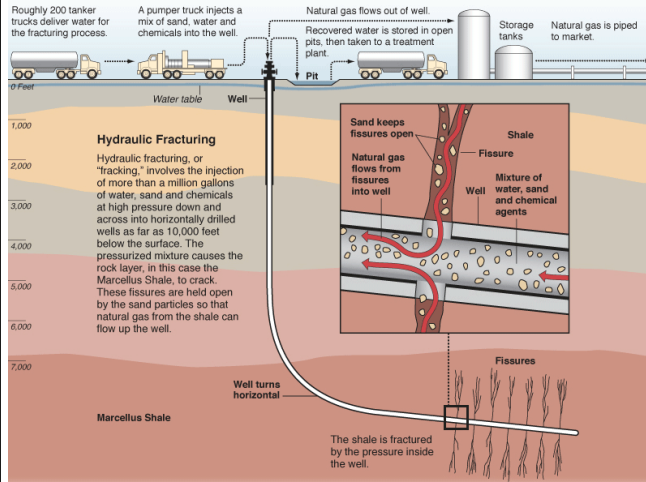


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Water in the West – Huge Issue in Hydraulic Fracturing of Shale



Source: <http://www.propublica.org/special/hydraulic-fracturing-national>

Graphic by Al Granberg

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- Major Issues:
 - 1.2-3.5 million gallons of water per well
 - Fracking fluid chemicals
 - Produced water disposal
 - Groundwater issues?

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