



Louisiana State University Center for Energy Studies
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Shale Gas and the Manufacturing Renaissance




Dr. T.K. Swift
Chief Economist & Managing Director



Chemistry in Louisiana



- One of largest industries in US and Louisiana with \$45.9 billion in revenues (#2 in USA)
 - America's #1 exporter, with Louisiana exports of \$6.3 billion
 - Innovative and knowledge intensive
 - #1 in Private R&D
 - 1 out of 9 Patents
 - A solutions provider and enabler, making life healthier, safer and more productive
 - Nationwide 780,000 good jobs (22,500 in Louisiana supporting a total of 181,000)
 - Over 10,000 companies operating nearly 13,800 facilities (226 of which are in Louisiana)
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Shale Gas: A Game Changer

"A renewed U.S. ethane advantage has lifted the fortunes of North American petrochemical makers. A surge in supply from unconventional gas sources has increased the availability and reduced the cost of ethane and other natural gas liquid (NGL) feedstocks."

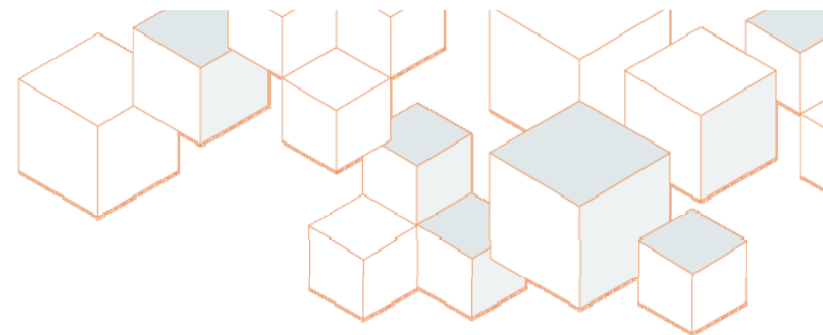
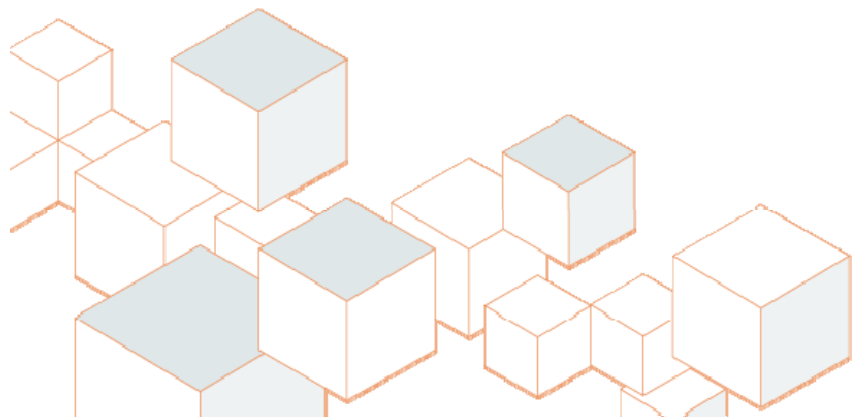
--Chemical Week [Cover Story](#), March 18, 2011

"Some believe the potentially tremendous economic impact of the Marcellus shale will be a 'game-changer' for a state long dependent on the coal industry."

--[Times-Herald](#), Charleston, WV, March 3, 2011

"Cheap U.S. shale gas production could deliver massive spill-over benefits to the U.S. chemicals industry. ... Cheap natural gas will make U.S. chemicals companies cost competitive against just about everyone except the Middle East."

--Citi, "Shale Gas: [A Game Changer](#) for the Chemical Industry?," P.J. Juvekar, March 11, 2010

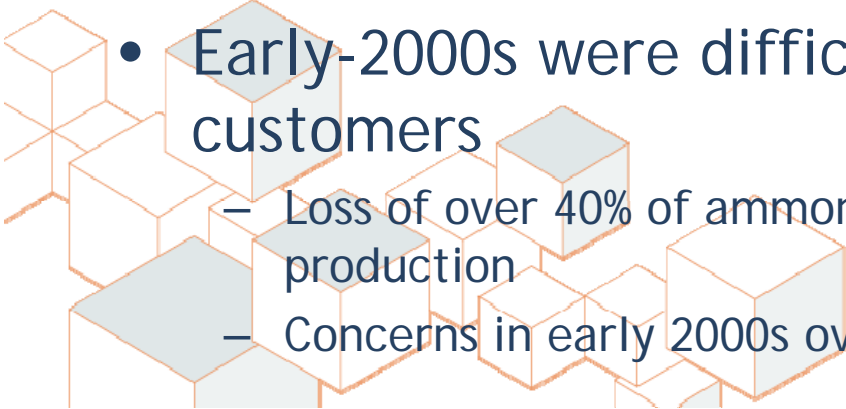


Shale Gas Developments

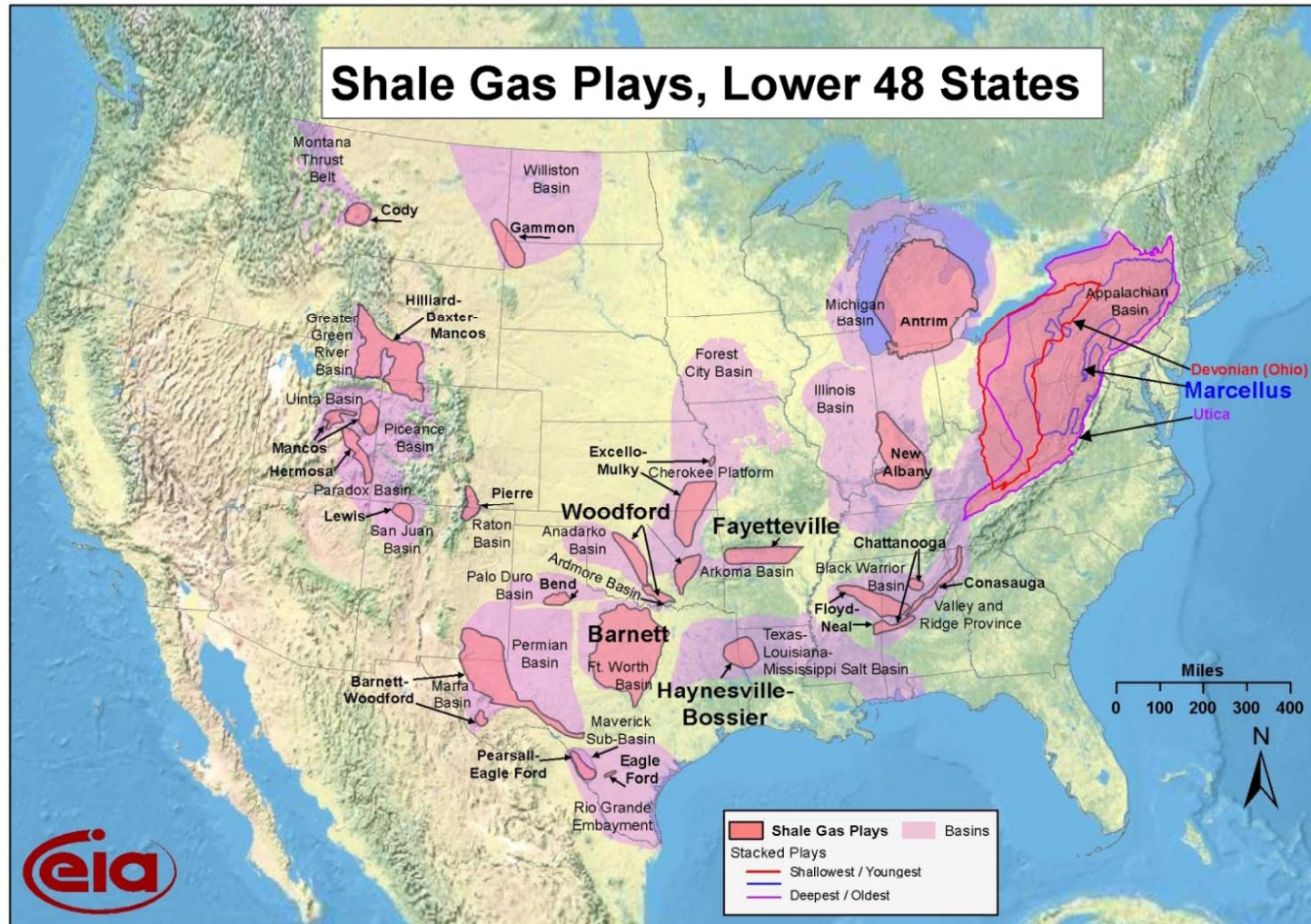
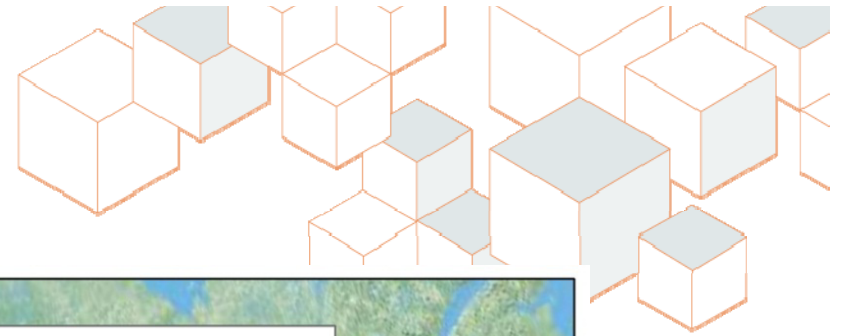


Background on Shale Gas



- Shale and other non-conventional gas always present, just not economically feasible to extract
 - Fixed natural gas supply and rising demand from electric utilities in 1990s combine with supply constraints
 - Prices rise from average of \$1.92 per thousand cubic feet in the 1990s to \$5.46 in 2004 and with the hurricanes an average of \$7.33 in 2005
 - Natural gas production in the USA was supposed to end
 - Early-2000s were difficult period for industrial gas customers
 - Loss of over 40% of ammonia capacity and decimation of US methanol production
 - Concerns in early 2000s over long-term viability of US petrochemicals
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Shale Gas Resources

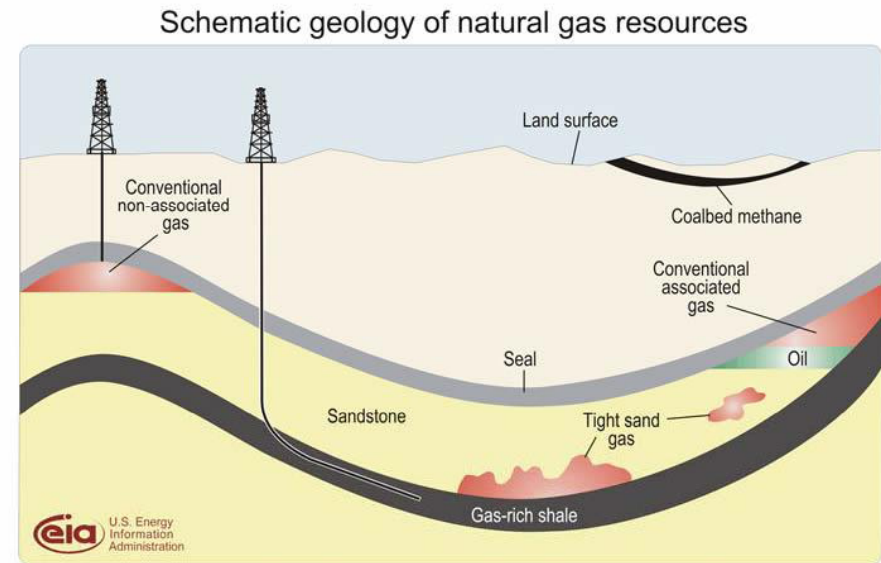


Source: Energy Information Administration based on data from various published studies.
Updated: March 10, 2010

Two Enabling Technologies

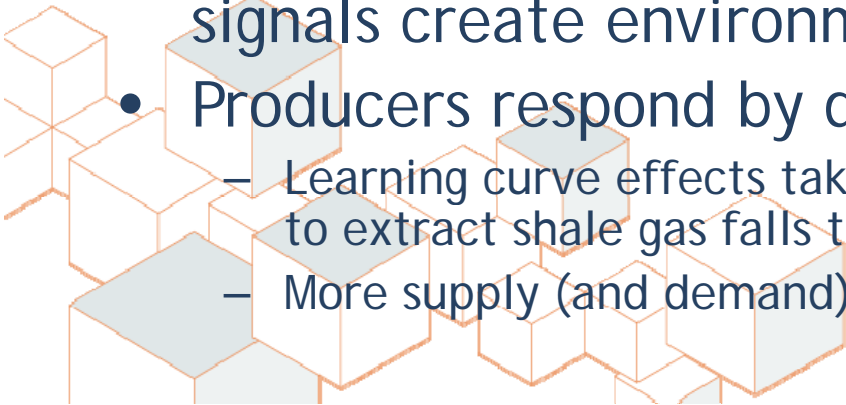


- New way of gathering natural gas from tight-rock deposits of organic shale
- Horizontal Drilling
 - Drill horizontal wells 1 ½ miles beneath the surface
 - And lateral lengths of 10,000 feet
- Hydraulic Fracturing
 - Fracture the rock by using water pressure aided by chemistry (polymers, gelling agents, foaming agents, etc.)
 - Typical well requires 2 to 3 million gallons of water and 1.5 million pounds of sand for just one well
 - About 99.5% of mixture is sand and water

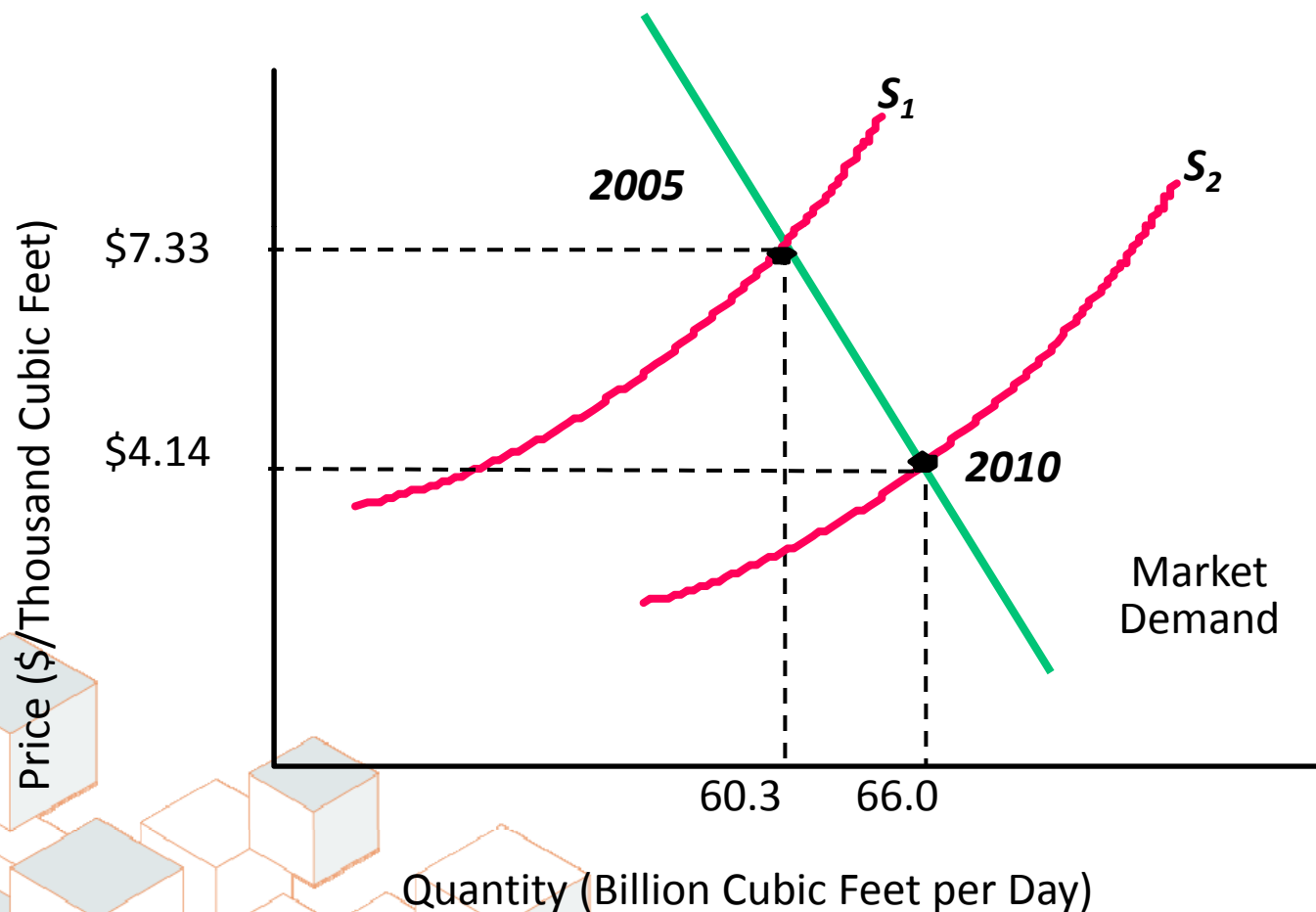


Technological Developments and High Prices Spur Shale Gas



- Technological developments to exploit shale gas
 - Horizontal drilling
 - Hydraulic fracturing (or fracking)
 - However, technologies are expensive and viable at about \$7.00 per thousand cubic feet
 - Hurricanes Katrina and Rita push prices above \$12.00 per thousand cubic feet in 2005 by shutting down Gulf supply
 - Combination of technological innovation and price signals create environment for shale gas development
 - Producers respond by drilling
 - Learning curve effects take hold and cost (including return on capital) to extract shale gas falls to less than \$4.00 per thousand cubic feet
 - More supply (and demand) available
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Entry of New Technology (and Firms) into US Natural Gas Market






Shale Gas Boosts US Resources

- New technical discoveries have vastly expanded reserves and will offset declines in other production.
- Estimates of technically recoverable shale gas were first assessed by National Petroleum Council (NPC) at 38 trillion cubic feet (TCF) in 2003, with 2009 estimates by Potential Gas Committee (PGC) of 615-680 TCF.
- Some estimates of over 900 TCF?
- In less than two years, the US has gone from a gas importing nation to a gas surplus nation.



Shale Gas: A Game Changer



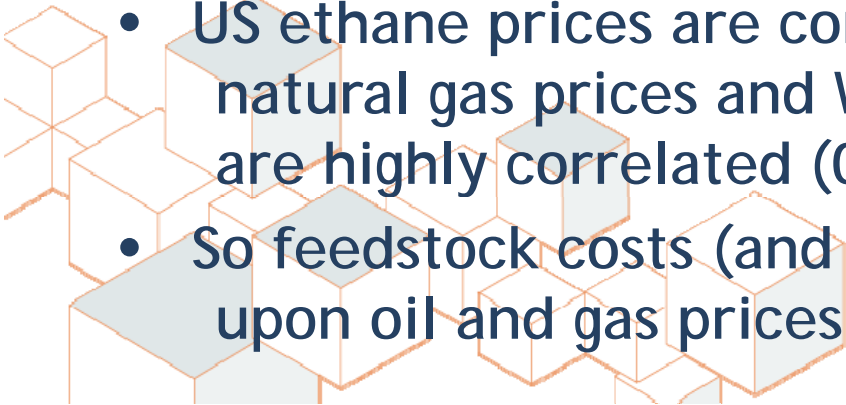
- Increased availability of shale gas could threaten the position of oil in many applications
 - Last month, gas could be purchased for the equivalent of \$23 per barrel while oil sold for more than \$85 per barrel
 - Forward natural gas prices have declined even as forward oil prices have increased
 - Shale gas is a game changer; could provide well over 25% of US needs compared to 8% in 2008
 - Availability of very low priced natural gas (and ethane) could improve US chemical industry competitiveness
 - Other countries, particularly China, can be expected to aggressively apply the technology
 - Potential reserves in Europe could rival those of the US
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Implications for Chemicals



Background on Petrochemical Feedstocks



- In the USA and Canada, historically cheaper to crack ethane, propane and other natural gas liquids (from natural gas)
 - Process is simpler
 - The hardware is less expensive
 - Over 85% of ethylene derived from natural gas liquids
 - In Western Europe and NE Asia, naphtha (from oil refining) is primarily used
 - Must take into account yields, by-product values, etc.
 - US ethane prices are correlated (0.82) with Henry Hub natural gas prices and Western European naphtha prices are highly correlated (0.97) with Brent oil price
 - So feedstock costs (and competitiveness) are dependent upon oil and gas prices
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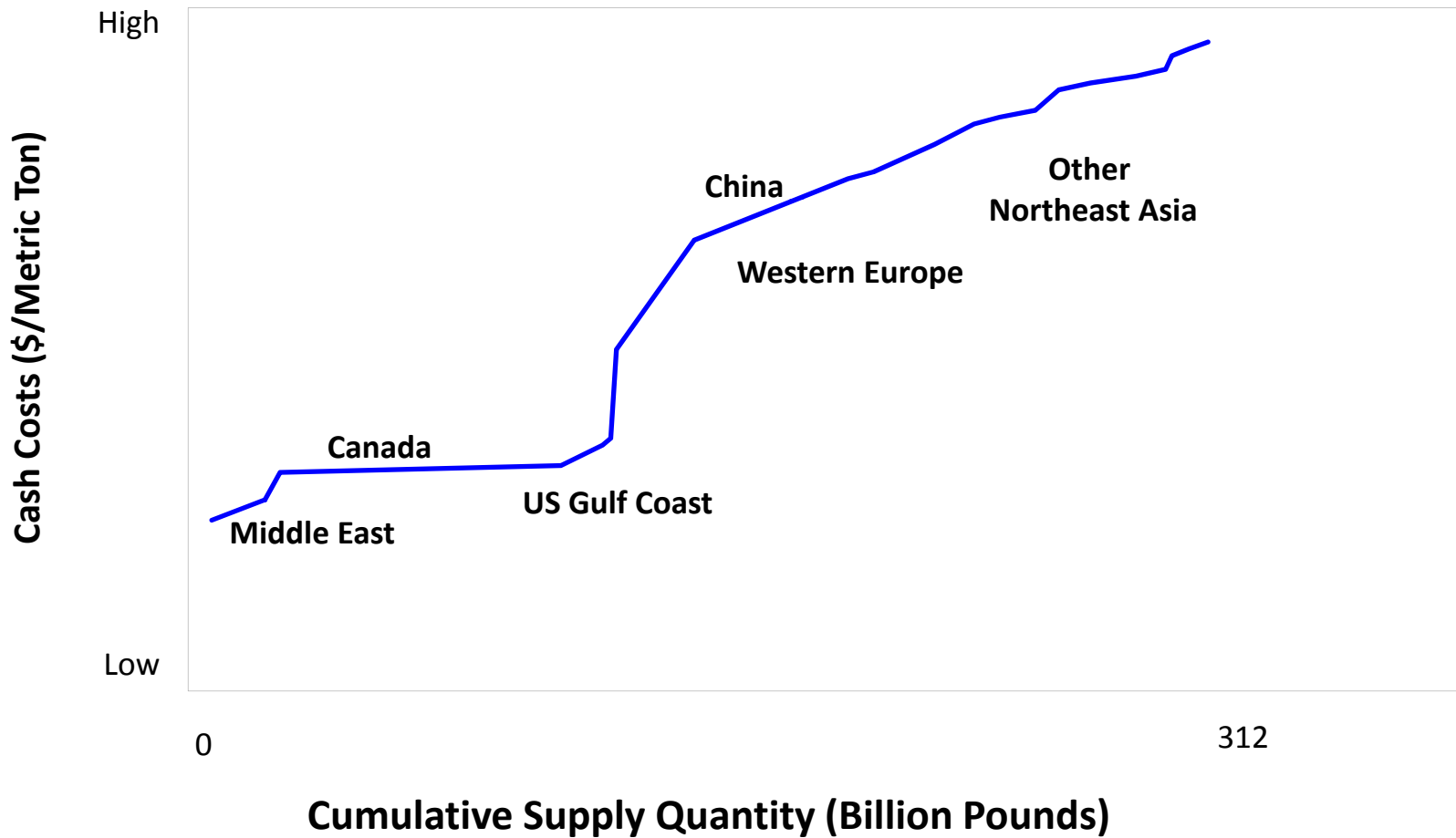
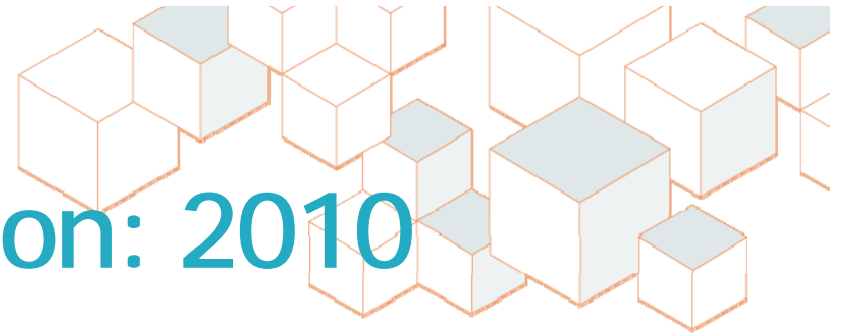


Petrochemical Competitiveness

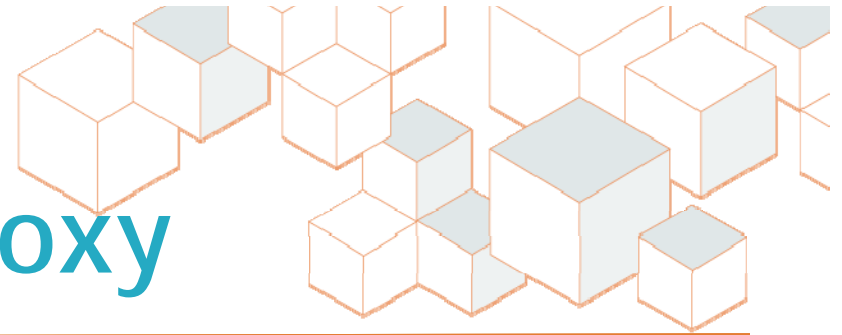
- Eight to 10 years ago, US Gulf Coast (USGC) petrochemicals were being written off
- Position near top of cost curve and in a worse position than Western Europe and Northeast Asia
- The wave of capacity in the Middle East (ME)
- In 2010, USGC cost position had improved that region follows Middle East with boost to US plastic exports
- Canada is in even better shape
- Ethane supplies are tightening in Middle East and are constrained - era of low-cost feedstocks is over and some producing nations may ride up the cost curve



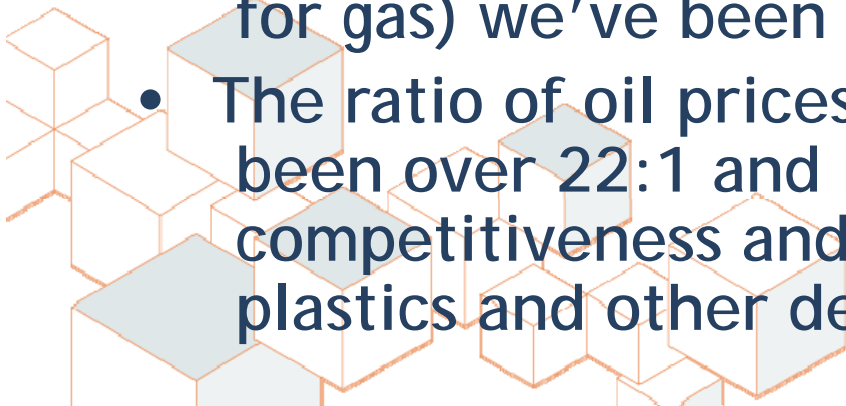
Typical Petrochemical Costs by Country/Region: 2010



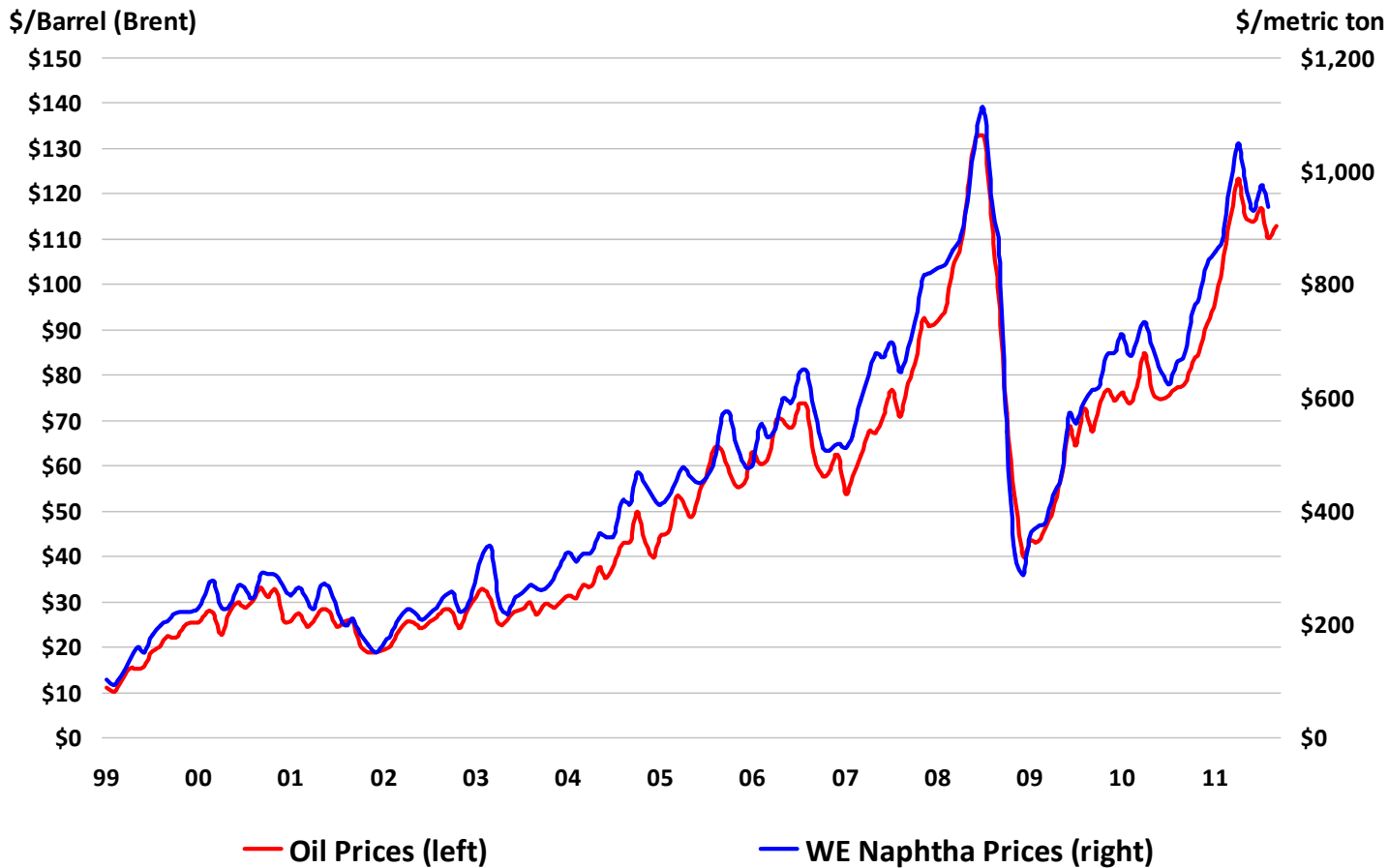
Oil - Gas Ratio: A Proxy



- As a rough rule of thumb, when the ratio of the WTI divided by the Henry Hub is above a band between 6:1 and 7:1, the competitiveness of Gulf Coast-based petrochemicals and derivatives vis-à-vis other major producing regions is enhanced
- Other factors (co-product prices, exchange rates, capacity utilization, etc.) have played a role in competitiveness as well
- As a result of shale gas (and weak industrial demand for gas) we've been above 7:1 for several years
- The ratio of oil prices to natural gas has recently been over 22:1 and is very favorable for US competitiveness and exports of petrochemicals, plastics and other derivatives

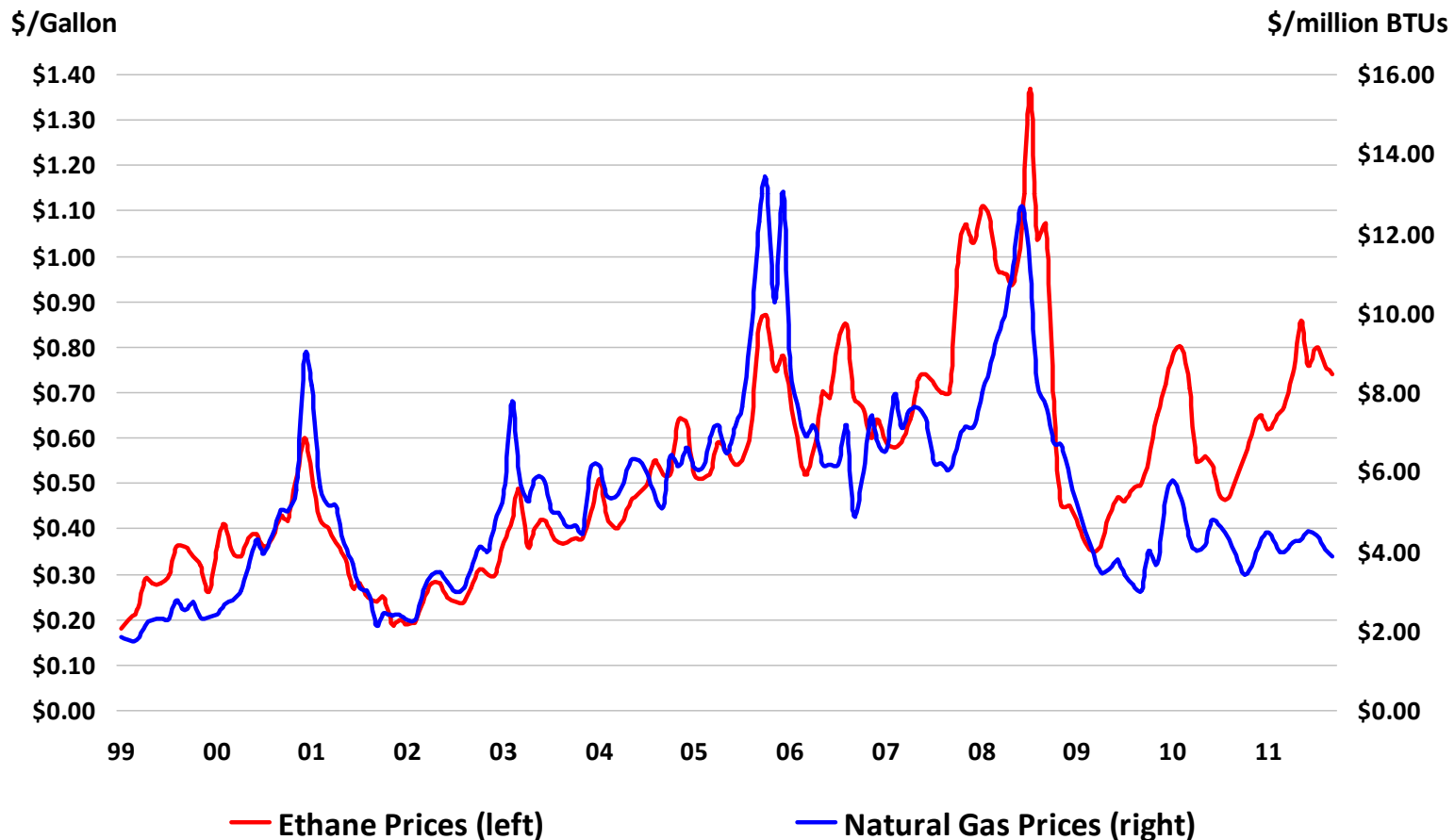


Strong Correlation: Price of Oil and Western European Naphtha



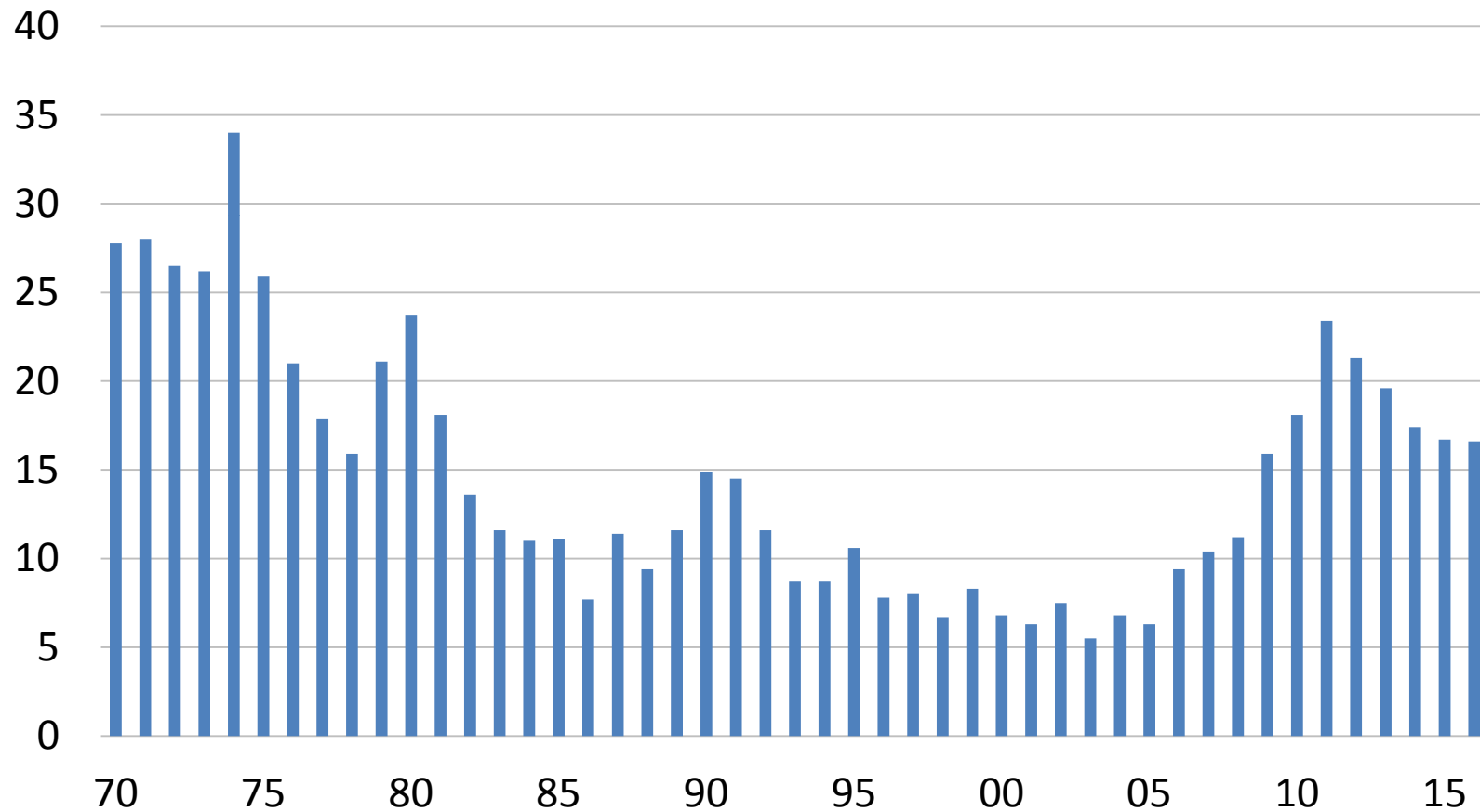
Source: EIA, Chemical Week Associates, Haver Analytics

Price of U.S. Ethane and Natural Gas Also Correlated (but Decoupling)



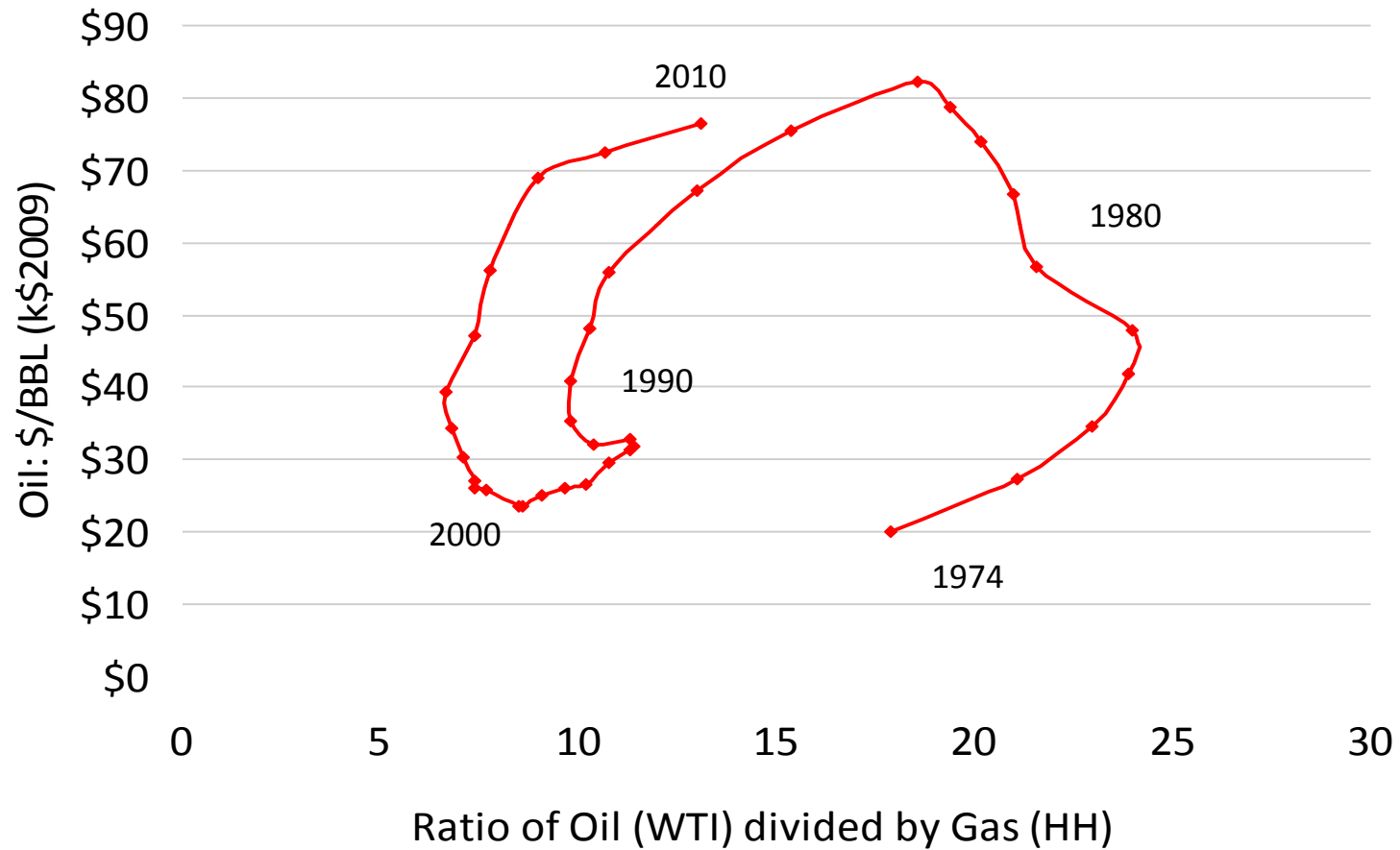
Source: EIA, Chemical Week Associates, Haver Analytics

Oil-to-Gas Ratio: A Proxy for U.S. Gulf Coast Competitiveness



Source: EIA, CMAI, EIU, Global Insight

Competitiveness is Returning

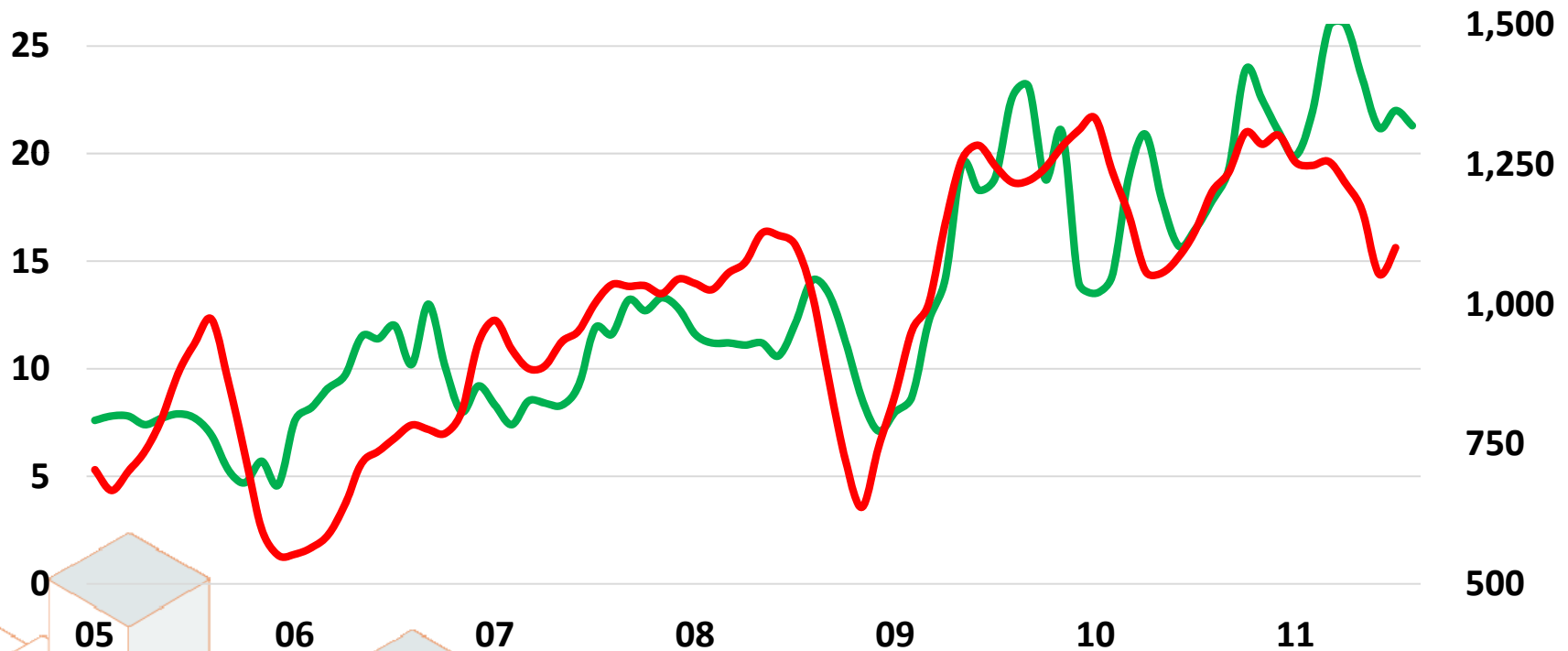


Note: Used a five-year moving average of prices and ratio to smooth long-term trends

NA Plastics Exports and Oil-to-Gas Ratio are Highly-Correlated

Ratio: Oil-to-Gas

Exports (Millions of Pounds – 3MMA)



Oil to Gas Ratio

Exports (right)

Note: Thermoplastics includes LDPE, LLDPE, HDPE, PP, PS and PVC

Shale Gas Boosts US Petrochemical Investment

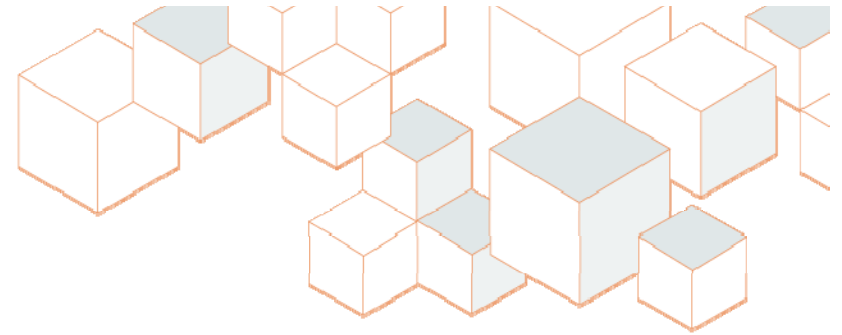
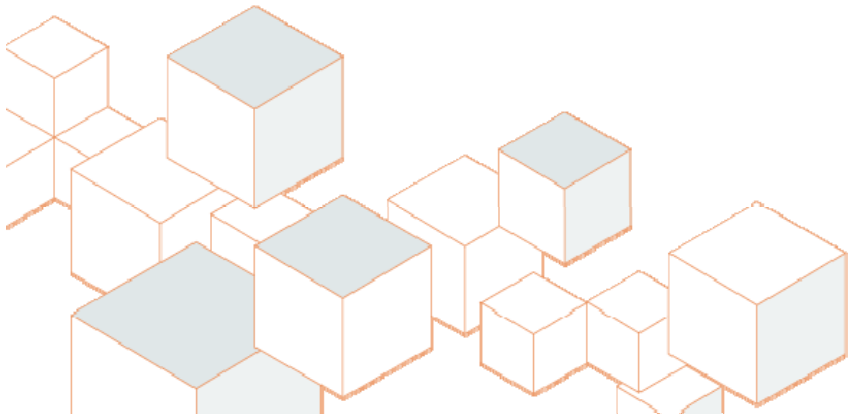
- March ACC report analyzed impact of a 25% increase in US petrochemicals supply

- Using IMPLAN model report measured:
 - New U.S. chemistry output and jobs generated by increased chemistry investment (“direct impacts”)
 - New production and jobs created in chemistry’s supplier sectors (“indirect impacts”)
 - Increase in output and jobs in broader U.S. economy as a result of spending by new employees (“induced impacts”)

ACC Report Findings

A 25 percent increase in petrochemicals supply generates:

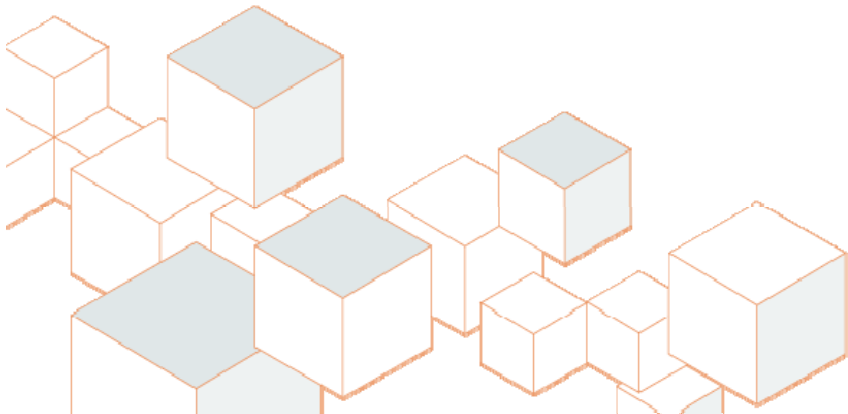
- 17,000 new jobs in the U.S. chemical industry
- \$32 billion increase in U.S. chemical production
- \$16.2 billion in new capital investment by the chemical industry
- 395,000 new jobs outside the chemical industry, including:
 - 165,000 jobs in supplier industries, as a result of increase in U.S. chemical production
 - 230,000 jobs from new capital investment by the chemical industry



Let's Assume Louisiana Captures One-Third of this Investment



- That's \$5.4 billion in capital spending; a mix of greenfield, brownfield and idled plant re-starts
- Why Louisiana?
 - Significant existing petrochemicals infrastructure
 - Access to deep-water ports and access to the interior via the Mississippi River
 - Excellent universities such as Louisiana State University
 - Shale gas deposits



Economic Impact of Added Petrochemicals Output in Louisiana



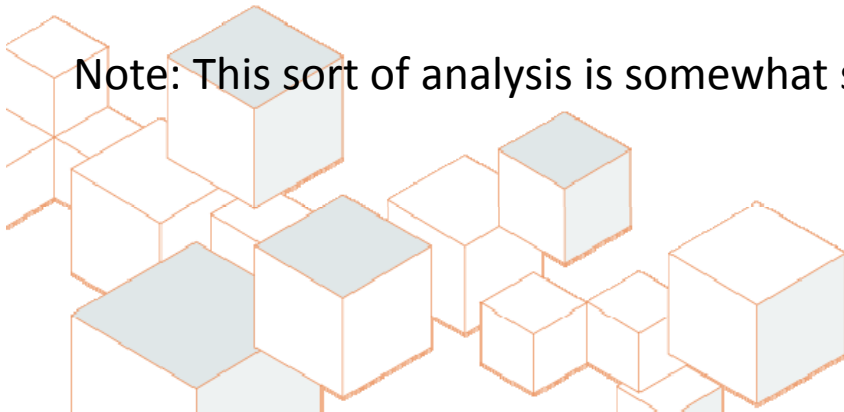
On-Going Economic Impact From Expanded Production of Petrochemical and Derivatives

Impact Type	Employment	Payroll (\$ Million)	Output (\$ Billion)
Direct Effect	5,490	\$730	\$10.9
Indirect Effect	18,092	\$1,089	6.9
Induced Effect	11,893	\$436	1.3
Total Effect	35,475	\$2,255	\$19.2

Economic Impact from New Investment in Plant and Equipment

Impact Type	Employment	Payroll (\$ Million)	Output (\$ Million)
Direct Effect	9,511	\$499	\$1240
Indirect Effect	2,070	\$111	\$1,346
Induced Effect	4,014	\$147	\$448
Total Effect	15,595	\$758	\$2,034

Note: This sort of analysis is somewhat static in nature and other effects are possible.



Tax Impact of Added Petrochemicals Output in Louisiana



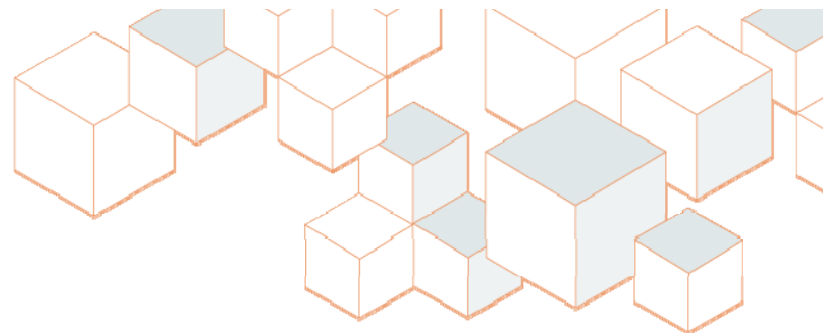
Tax Impact (in millions of dollars) from Expanded Production of Petrochemical and Derivatives

	Payroll	Households and Proprietors	Corporations and Indirect Business Taxes	Total
Federal	\$204	\$121	\$115	\$440
State and Local	\$6	\$39	\$355	\$399

Tax Impact (in millions of dollars) from New Investment in Plant and Equipment:

	Payroll	Households and Proprietors	Corporations and Indirect Business Taxes	Total
Federal	\$67	\$42	\$15	\$123
State and Local	\$2	\$13	\$45	\$60

Conclusion



- Shale gas has been a game changer in US natural gas markets
- Shale gas has improved the competitiveness of the US petrochemical sector
 - Boosting exports
 - Capital investment in US being reconsidered
 - Location of shale gas may foster new greenfield investment
 - Generating new business, jobs, and tax revenues
- **But challenges remain...**
 - Environmental concerns over hydraulic fracturing
 - Pending regulations will force utilities to retire many coal-fired power plants and replace much of the capacity with natural gas
 - Rising US economy will also promote US natural gas demand
 - Other trade, tax, and policy issues





Questions?

Telephone: 202.249.6180

Email: kevin_swift@americanchemistry.com