

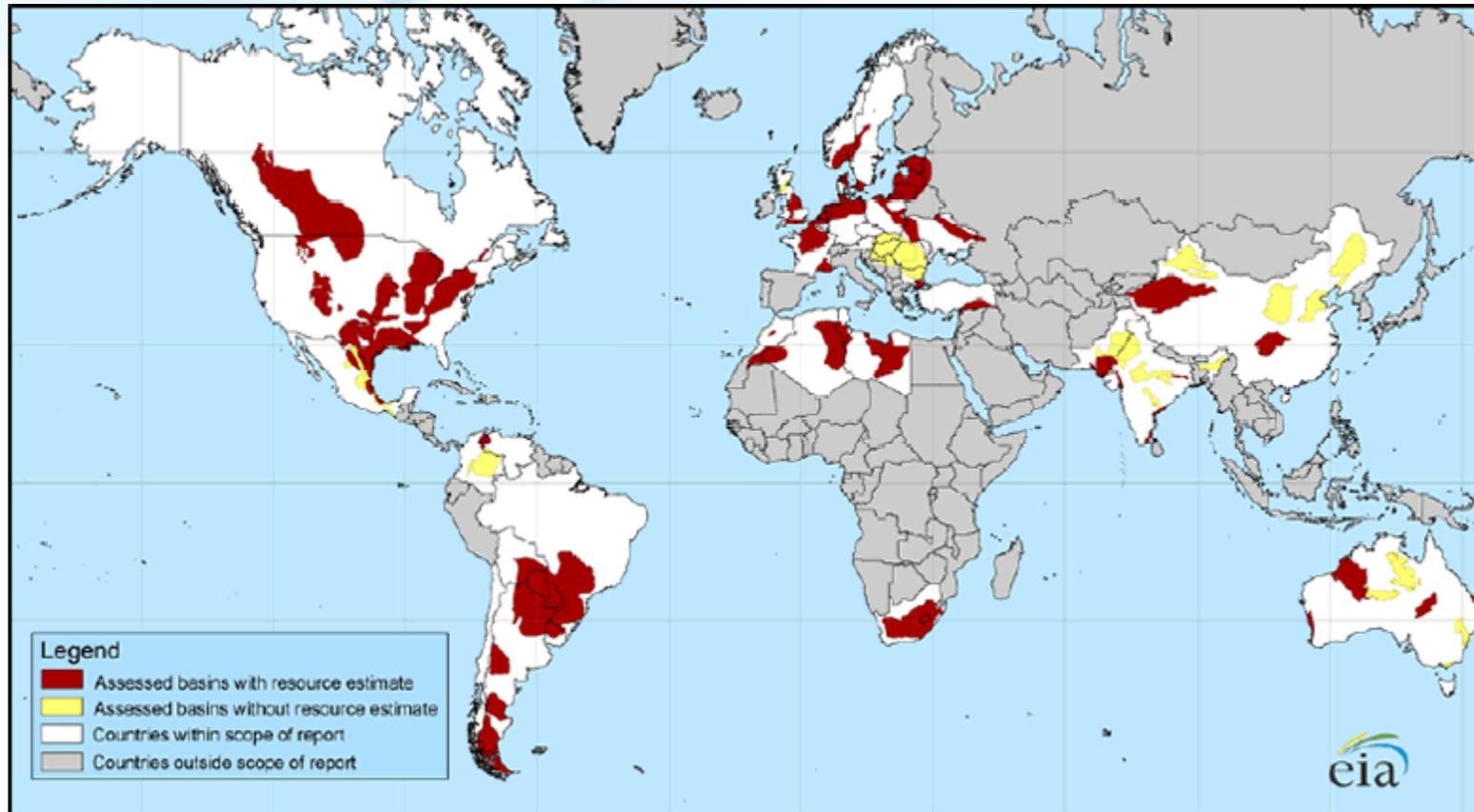


Polymer Consulting International, Inc.

Impact of Shale Gas on the U. S. Petrochemical Industry

CMR FLEXPO, Houston
March 29, 2012

Shale gas is a global phenomenon.....



....with nothing in the Middle East



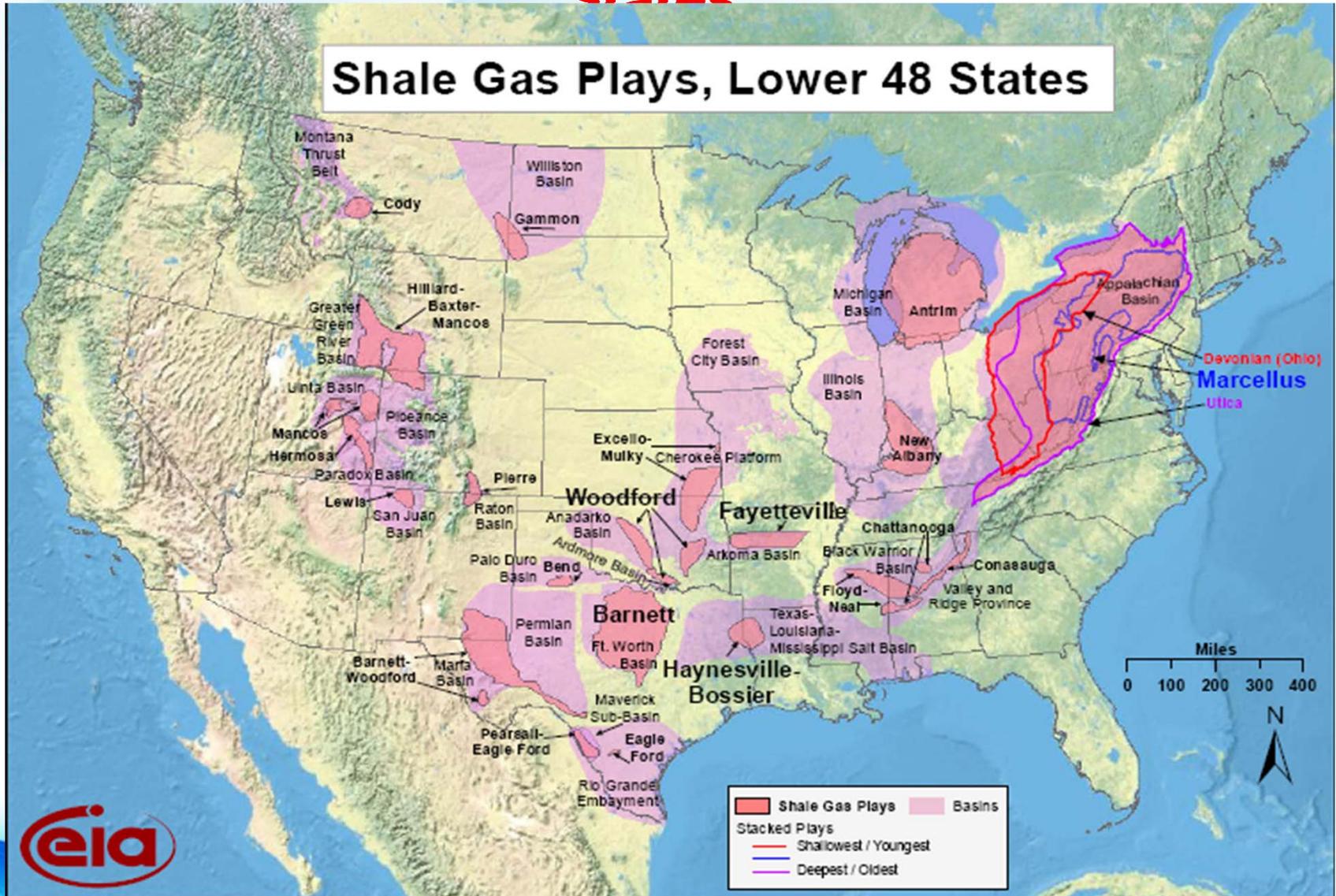


Investments are occurring in many countries

- Countries that are now actively developing shale gas include:
 - Argentina (Chevron Phillips/Apache)
 - China (ExxonMobil)
 - Poland
- Depending upon logistics, government policies and the product portfolio of the developers, petrochemicals could also be produced
- There are significant opportunities in other countries that have large shale gas plays but investments will depend primarily on government priorities and policies. Finding a foreign company to make or share in an investment will be easy



Shale gas is particularly abundant in the United States



Marcellus is one of the world's largest plays

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Why are they called **Plays**?

Because the Petrochemical Industry is a Drama!

And we are either in the audience.....

.....or in the Cast!

**Remember: All the world is a stage,
and all the men and women mere players
William Shakespeare, first petrochemical
reporter (“As you like it”)**





Now Playing

**Shale Gas:
The New Frontier**

aka

The “Game Changer





Setting the Stage

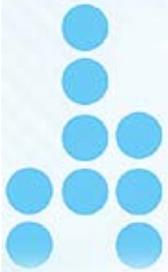


Shale gas: The New Frontier

- ❖ Shale formations are fine grained rock formations that trap natural gas. Shale rock has small pores that are relatively impermeable to natural gas flow unless they are naturally or artificially fractured to create channels connecting the pores so the gas can flow (Sponge)
- ❖ Shale gas is present across much of North America in basins of both extreme and moderate size (referred to as “plays”)
- ❖ Currently most shale development is concentrated in Marcellus (Appalachia), Barnett (Texas), Haynesville (Louisiana), Fayetteville (Arkansas), Eagle Ford (Texas) and Woodford (Oklahoma)
- ❖ The process of setting up the rig, drilling, fracturing, stimulating, and installing operational equipment for a single shale well takes approximately two to eight weeks



Shale gas composition varies between/within plays



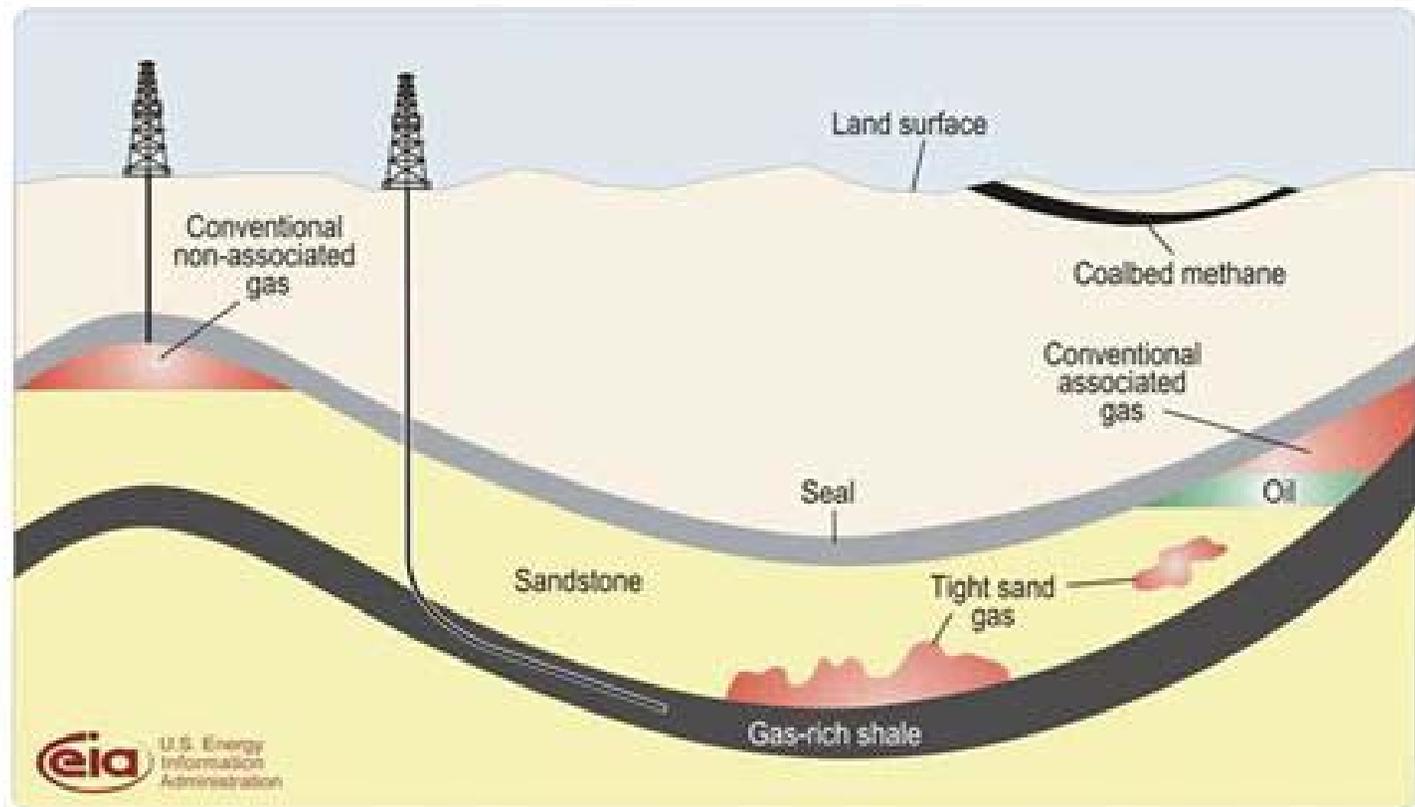
- The ethane content varies from a dry gas (<5%) to a wet gas (6 – 16%)
- The maximum content for heavies for transporting the natural gas is 12% (condensation). The ethane content is so high at some locations that it MUST be extracted prior to shipping
- Western Marcellus is an example of a very rich gas:

Composition	Share, %
Methane	74.22
Ethane*	15.62
Propane*	5.46
Butane*	1.40
Pentanes*	1.00
Hexanes*	1.00
inerts/other	1.30
Total	100.00
* heavies	

Due to low natural gas prices, developers have been shutting down dry gas wells in favor of wet gas wells to capture the ethane and other NGLs



Geology of shale gas and conventional natural gas



Shale deposits are well below the drinking water table; proper drilling procedures should not have drinking water contamination problems

Fracturing (fracking) is used to make the hard shale rock porous to allow the gas to flow to the wellbore

- ❖ Drill 6,000-10,000 feet
- ❖ Steel casings
- ❖ Cement to stabilize the well and prevent any leakage.
- ❖ Drill more
- ❖ Explode
- ❖ Pump 3 to 4 million gallons of water, mixed with sand and fractional amounts of chemical additives at high pressure, creating cracks in the shale rock beds
- ❖ Wellhead



There are some strong environmental concerns

- ❖ These include:
 - ❖ environmental safety of the hydraulic fracturing process and the management of the volumes of water used to fracture shale
 - ❖ Chemicals used during the fracking process
 - ❖ Environmental issues will not stop shale gas development in the key states: PA, LA, TX, WV, et al.

A documentary movie (“Gasland”) has been recently made reporting on the environmental problems associated with shale gas developments (visit You Tube for more information)

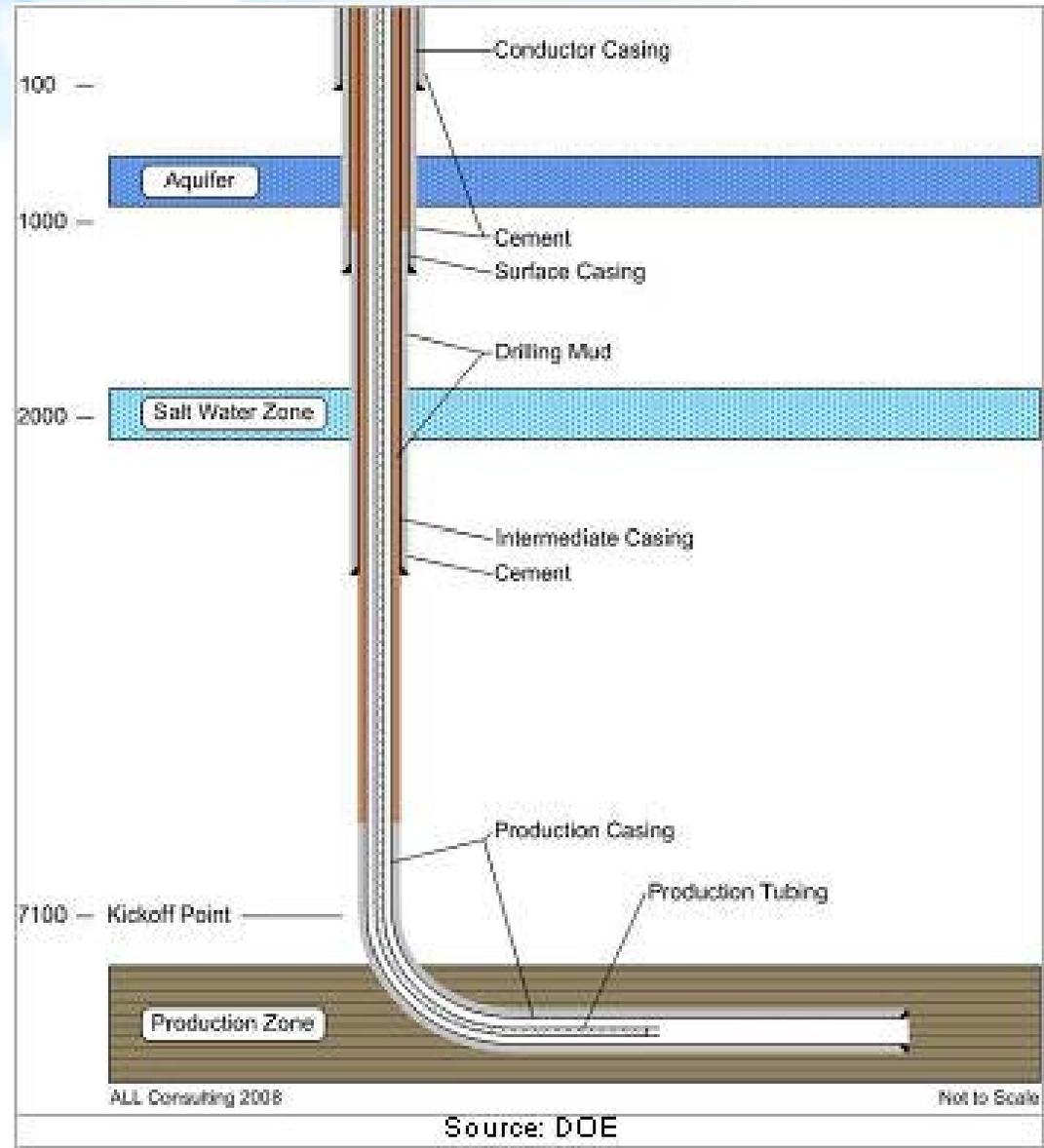




The Scenery

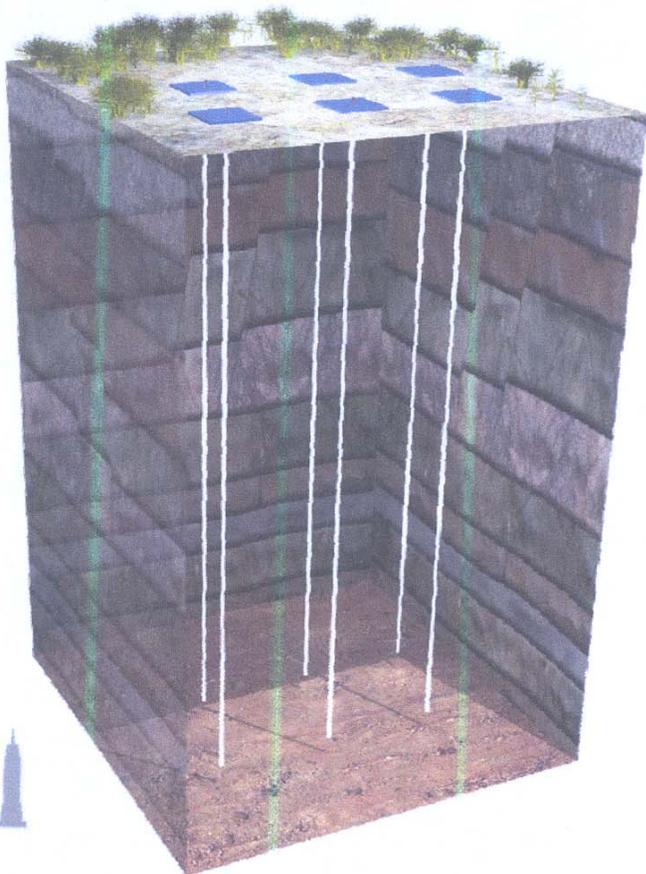


The key developments have been the ability to drill horizontally and to fracture the shale rock



Horizontal Drilling reduces the environmental footprint

Traditional development with vertical wells requiring one pad site per well



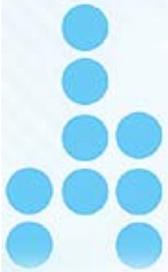
Multi-well development minimizing surface use with 6-12 wells drilled from a single pad site (surface disturbance <2%)



Empire State Building
1,250 ft.

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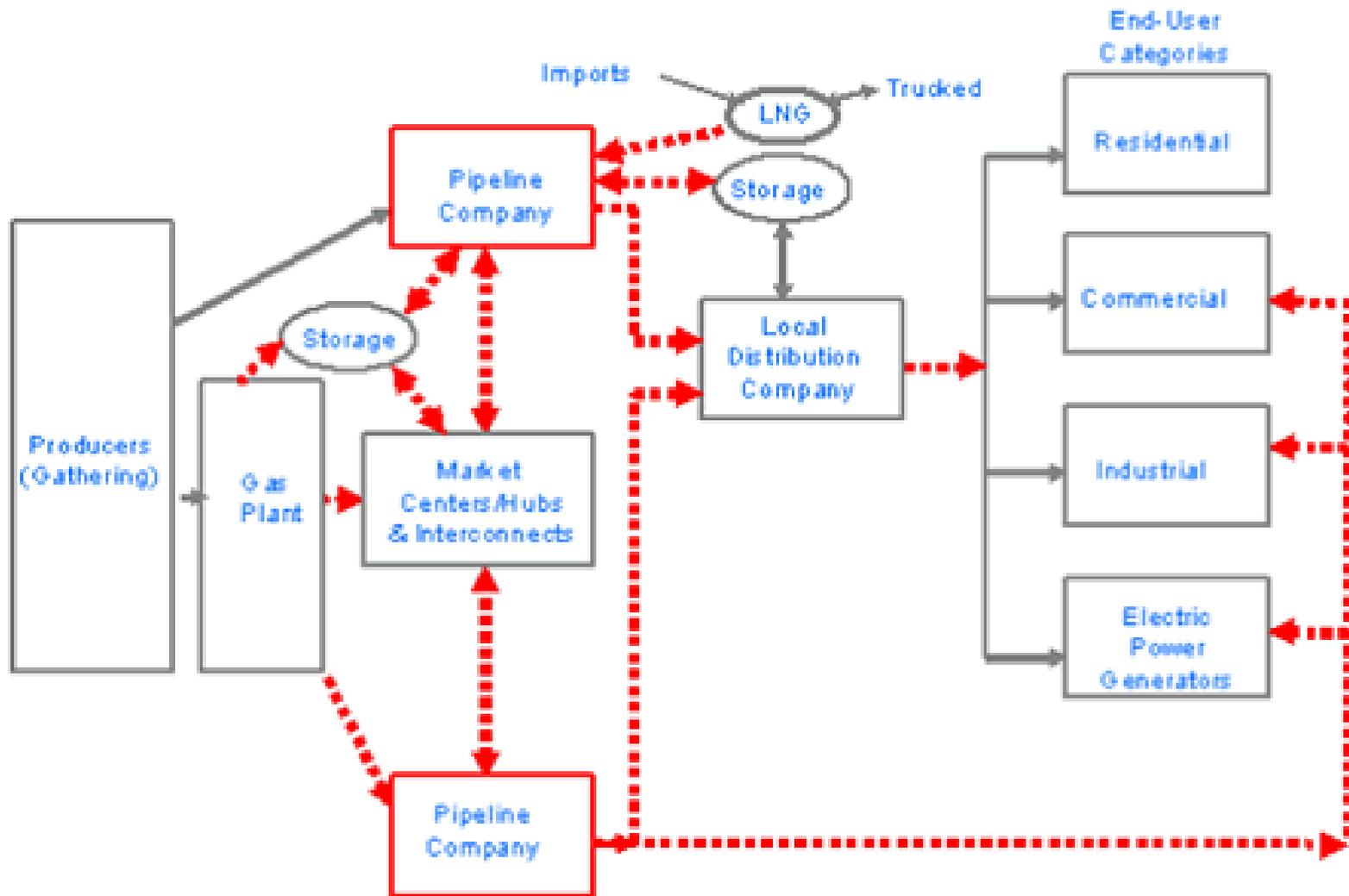
The shale gas landscape footprint is small



source: University of Pennsylvania study, 6/24/09



The shale gas process



Source: EIA

-----> = Larger Diameter Pipeline

————> = Smaller Diameter Pipeline

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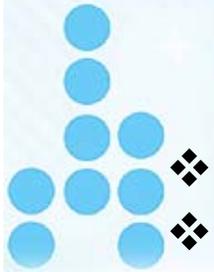




Act One: A Star is Reborn



The North American petrochemical industry has undergone a dramatic rebirth

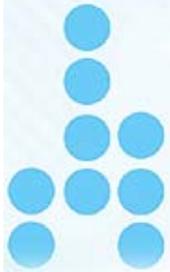


- ❖ New wave of cracker announcements
- ❖ American Chemistry Council Study, “*Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs and US Manufacturing*”:
 - ❖ \$16.2 billion in capital investment
 - ❖ 17,000 new jobs in the U.S. chemical industry
 - ❖ 395,000 additional jobs outside the chemical industry
 - ❖ \$4.4 billion more in federal, state, and local tax revenue annually (\$43.9 billion over 10 years)
 - ❖ A \$32.8 billion increase in U.S. chemical production
 - ❖ \$132.4 billion in U.S. economic output



Shale gas has increased natural gas reserves (and petrochemical feedstocks) to more than 100 years (23 MM ft³ current annual consumption vs. reserves of 2.4 trillion ft³)

Ethane has been the favored cracker feedstock



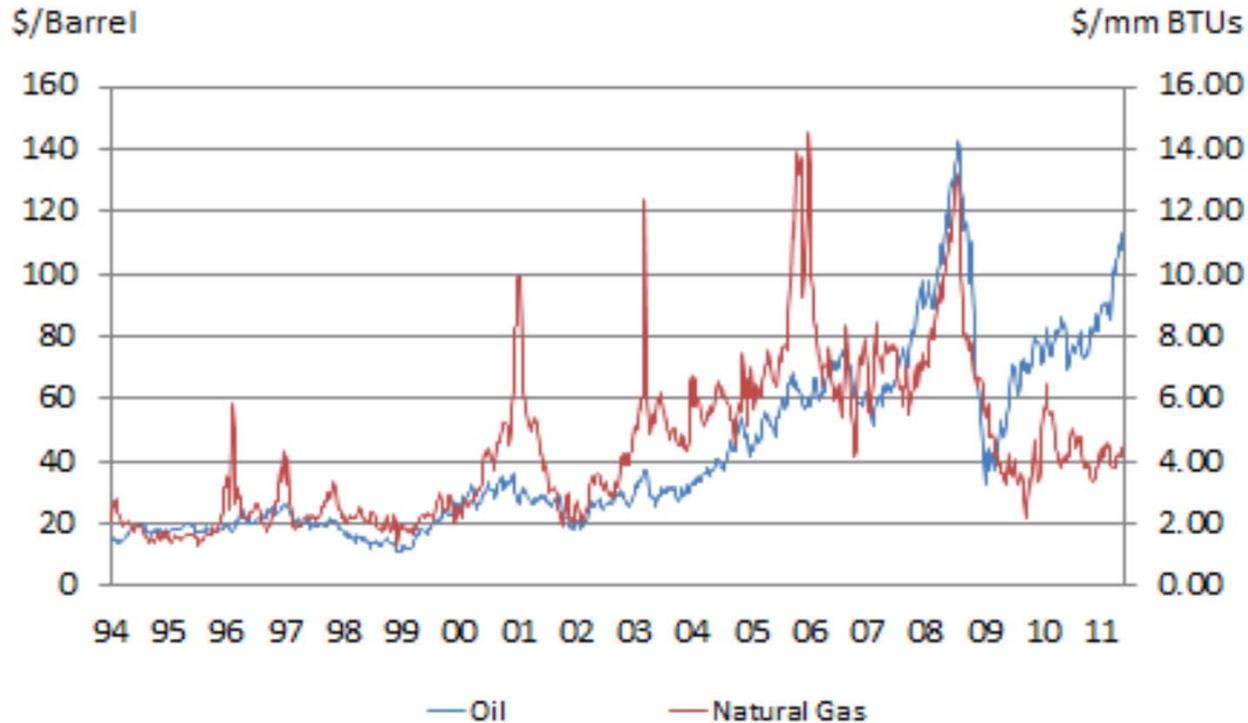
- ❖ Shale gas is rich in ethane mainly with propane and butane
- ❖ Historically, U. S. crackers were based on 70 percent ethane (NGLs) and 30 percent naphtha (liquids)
- ❖ As a result of shale gas and its impact on ethane prices, the ratio has now changed to 87 percent ethane (NGLs) and 13 percent naphtha (liquids). This has dramatically impacted propylene, C₄s and aromatics



Oil and natural gas prices have decoupled since 2009



Oil and Natural Gas Prices

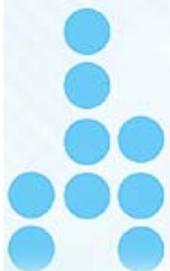


Source: Energy Information Administration



The spread will likely widen in the future

Ratio of oil prices to natural gas prices (7 is the magic number for export competitiveness)



Crude oil-to-natural gas price ratio



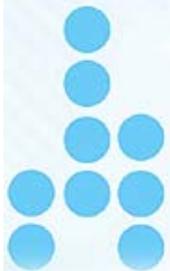
Source: [U.S. Energy Information Administration](#) based on data from Thomson Reuters

Note: The crude oil-to-natural gas price ratio is calculated by dividing the spot price of Brent crude oil (\$/barrel) by the spot price of natural gas at the Henry Hub (\$/MMBtu.) In the past, the crude oil price most utilized for this calculation was West Texas Intermediate (WTI). Due to the significant current discount of WTI relative to Brent and other crude benchmarks, we use the Brent price here.



The U. S. is at a competitive advantage not seen for the past 20 years

Impact of shale gas on natural gas prices



Natural Gas Spot
Henry Hub



Feb 1, 2011 - Mar 2, 2012

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— Close





The availability of low-cost ethylene will also change the type of derivative produced

- Before shale gas, many industry experts have said that the production of certain derivatives such as methanol and EG were no longer economically viable for production in the United States
- This is changing
 - Ineos has announced a 500 KTA EG expansion
 - Methanex and Eastman are re-starting methanol plants that have been closed for more than five years due to poor economics
 - Shell will produce EO/EG in its PA cracker

Shale gas has changed the North American petrochemical industry beyond olefins and polyolefins





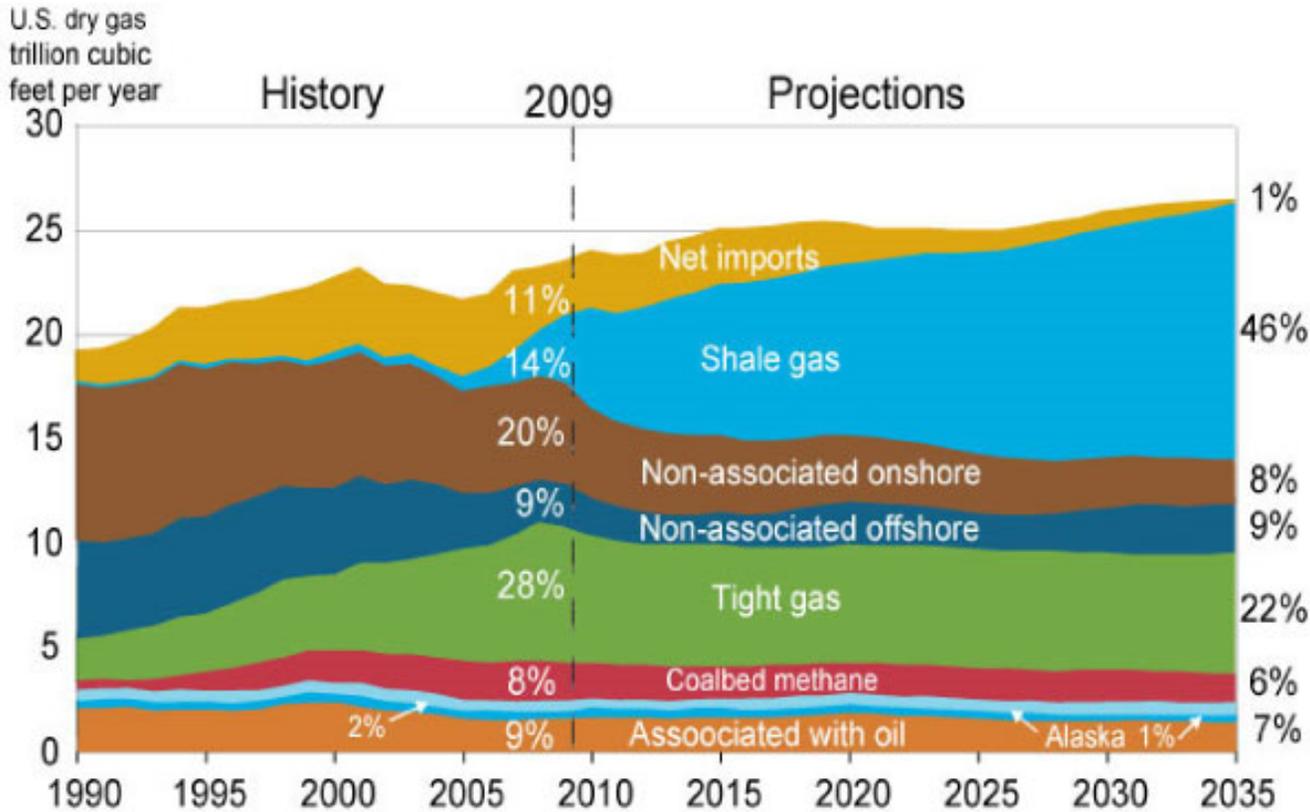
Act Two: Domination



Shale gas will be the major source for ethane



U.S. Natural Gas Supply, 1990-2035



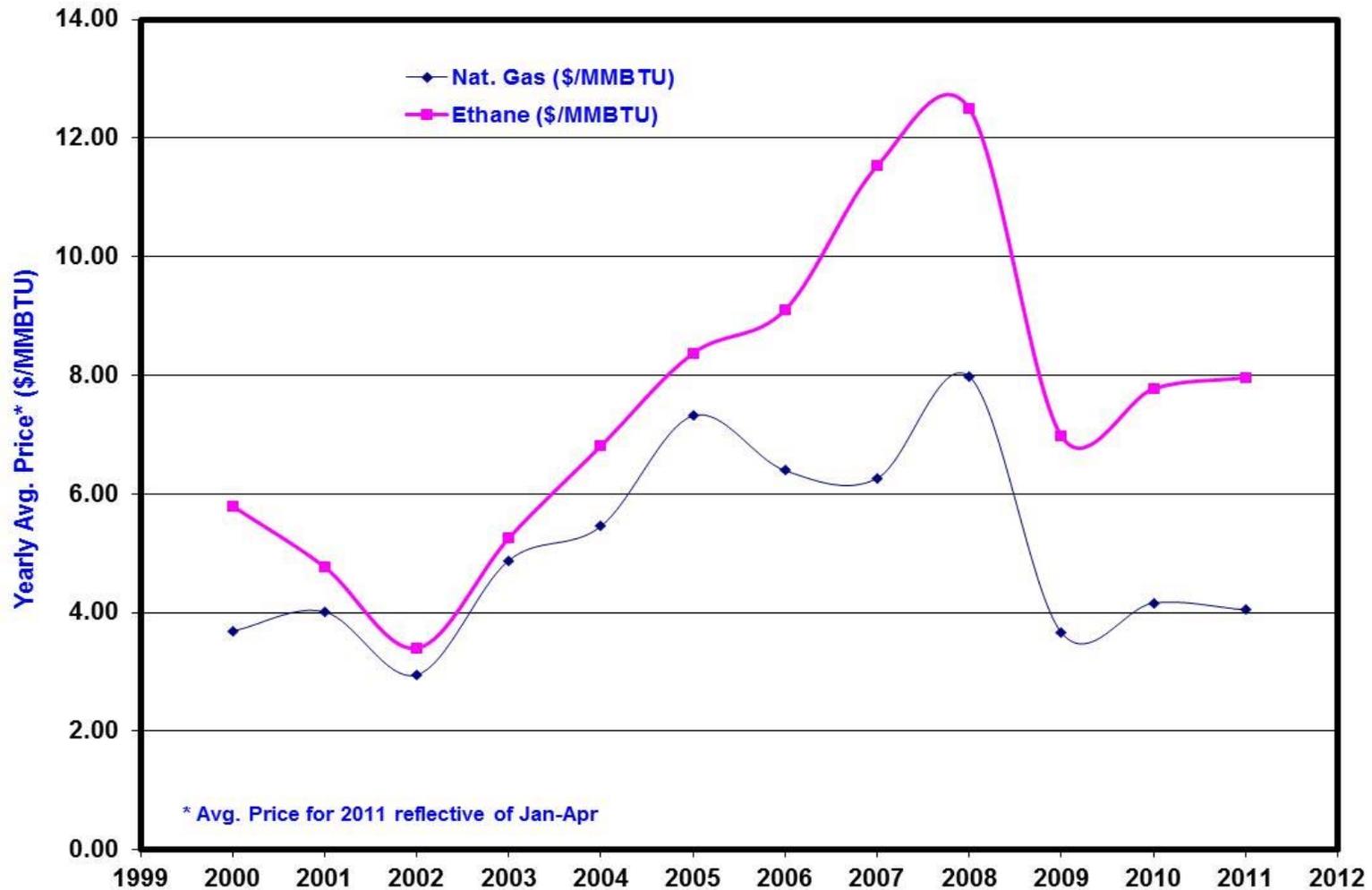
Source: EIA, *Annual Energy Outlook 2011*



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The U. S. will become a large net LNG exporter as supply will likely exceed demand

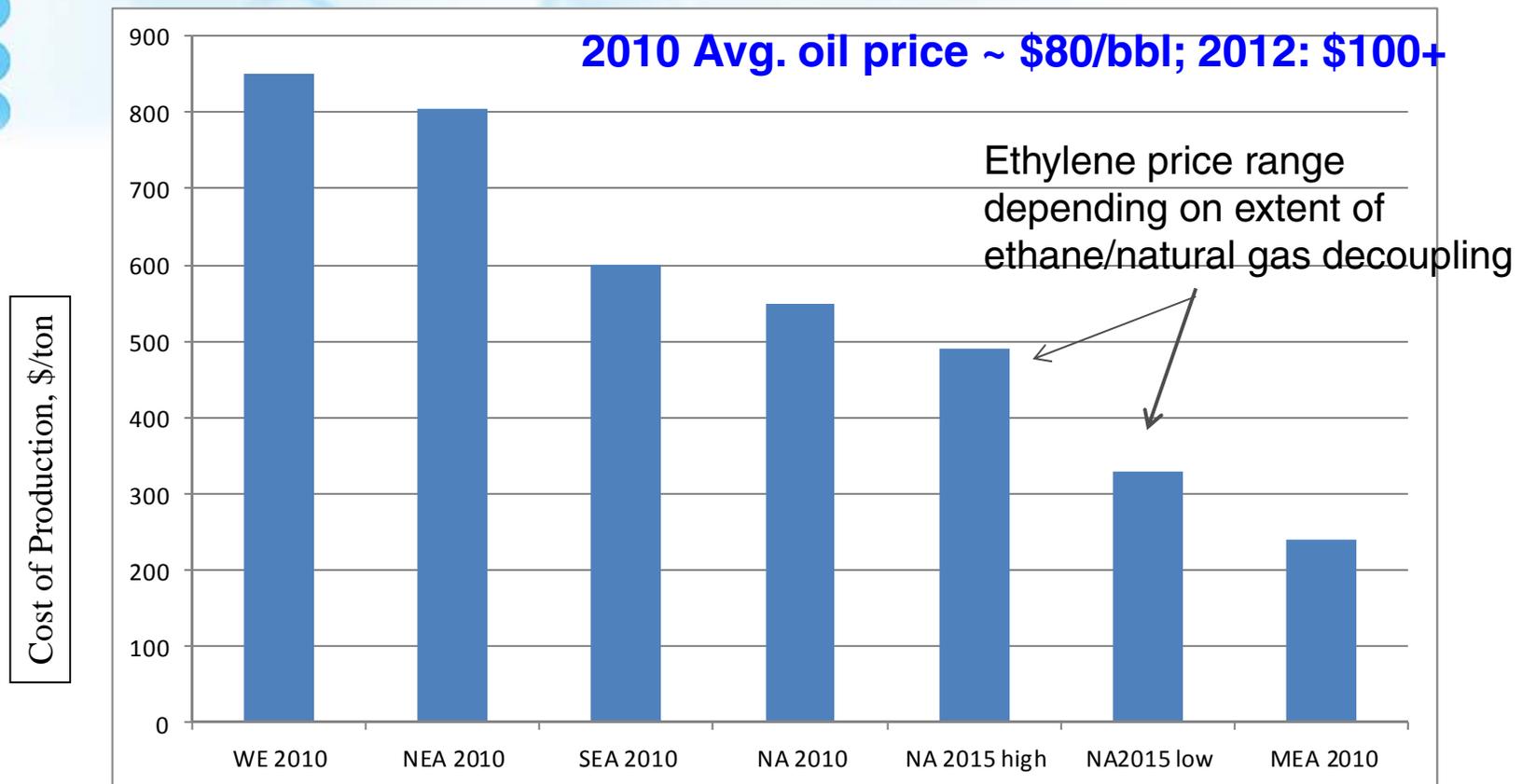
Ethane demand has exceeded supply resulting in price divergence



If this continues, the spread could widen further

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Impact of shale gas on US polyethylene competitiveness



Source: Chemical Market Resources, Polymer Consulting International



North America becomes the second lowest cost producer in the world in either scenario



The Cast



Shale gas has led to many new olefins expansion announcements (KTA)

NA=not Announced

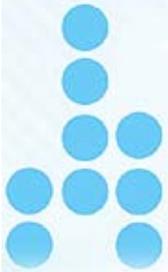
Companies	Announcement	Ethylene	Propylene	Timing
Bayer	Promoting investing at its site			
Braskem-IDEA	New cracker/PE in Mexico	1,000	0	2015
Chevron Phillips	Studying new cracker	1,500	-	NA
Cunningham Energy	Announced new cracker (WV)	NA	-	NA
Dow	Restart St. James cracker	300	-	2014
Dow	Increase flexibility	NA	-	2014
Dow	New cracker	1,100+	-	2017
Dow	PDH	-	~350+	2015
ExxonMobil*	Incremental expansions	NA	NA	NA
Formosa Plastics*	Expansion	800	600	2017
Ineos*	EO/EG : 500 KTA	NA	NA	NA
LyondellBasell	Debottlenecks	NA	NA	NA
LyondellBasell*	Studying new JV cracker	NA	-	2015+
NOVA	Shale gas to Canada	~900+**	-	2014-17
Shell	New cracker (JV?)	NA	-	NA
Sasol	New cracker	NA	-	2016-18
Westlake	Debottleneck	110	-	2012-13
Total		5410***	950+	

*needs propylene, **supplemental ethane from Alberta, ****Does not include Shell or Sasol



Every cracker that proceeds must produce polyethylene; some may only produce polyethylene

Potential polyethylene expansions



Expansion status	LLDPE	LDPE	HDPE	Comments
Announced new cracker/study				
Chevron Phillips		X	XX	Possibly as a JV
Cumberland (Northeast)				Nothing announced on products
Dow	XX	X		with PDH
LyondellBasell (study)		X	XX	Possibly as a JV, PDH
NOVA	XX		X	Will build ~900 KTA AST & NOVAPOL
Shell (Northeast)				Likely to set up JV for polyethylene
Sasol				Could set up JV for polyethylene
Announced debottlenecking				
ExxonMobil	XX	X		Split/capacity not announced
Formosa	D	X	D	300 KTA LDPE, some debottlenecking, replace purchased ethylene
Westlake	X	XX	?	Split not announced (110+ KTA)
No ethylene announcement (yet)				
AT Plastics		XX		Not Likely to expand
DuPont		XX		Major expansion not likely
Ineos	?		XX	Only announced 500 KTA EO/EG
Total			XX	Likely to expand with recent shale gas investment
D=debottlenecking, XX=most likely, X=secondary focus				



There will be a LOT OF POLYETHYLENE!



The Understudies



There could be additional companies interested in ethylene from shale gas

Company	Comments
Other North American polyethylene producers	
DuPont	Major expansion not likely (Specialty LDPE)
Total	Expansion possible; JV with Chesapeake in WV
Potential new entrants in ethylene and derivatives	
Braskem, Brazil/USA	Purchased Sunoco; has expressed interest in ethylene derivatives in the US, needs propylene
Reliance, India	Has invested in three Shale Gas plays; tried to buy LyondellBasell, strong cash position
SABIC, Saudi Arabia	Major sales effort with polyolefins in the Americas; strong cash position



In addition, some large investments in shale gas have occurred with major foreign companies such as Sinopec



Act Three: War



These developments could also lead to new geographic investments in North America

- ❖ Due to the ethane in the Marcellus field, some companies are considering a new cracker in the northeast. Shell has selected Pennsylvania for its new cracker
- ❖ The alternative is to ship the ethane to the Gulf coast via pipeline or barge – both of which are expensive (new pipelines will be required for parts of the route, which may have environmental and other issues)
- ❖ NOVA will build a pipeline from Marcellus to Canada for its cracker

Pennsylvania is where the US oil industry developed in the 1850s. In 1900 Pennsylvania supplied more than 50% of the world's oil. New York is where the natural gas industry was developed in 1831 using hollow logs to transport the gas

There will be other pressures

- The ethylene merchant market could be a disaster for sellers and great for buyers
- Companies may over expand in other derivatives
- The “Market Share Wars” begin

There could be a major battle for market share between Gulf Coast and Northeast polyethylene producers

And the winner is.....



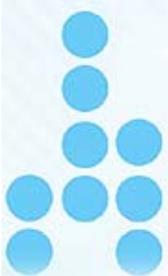
The Customer





Act Four: Collateral Damage



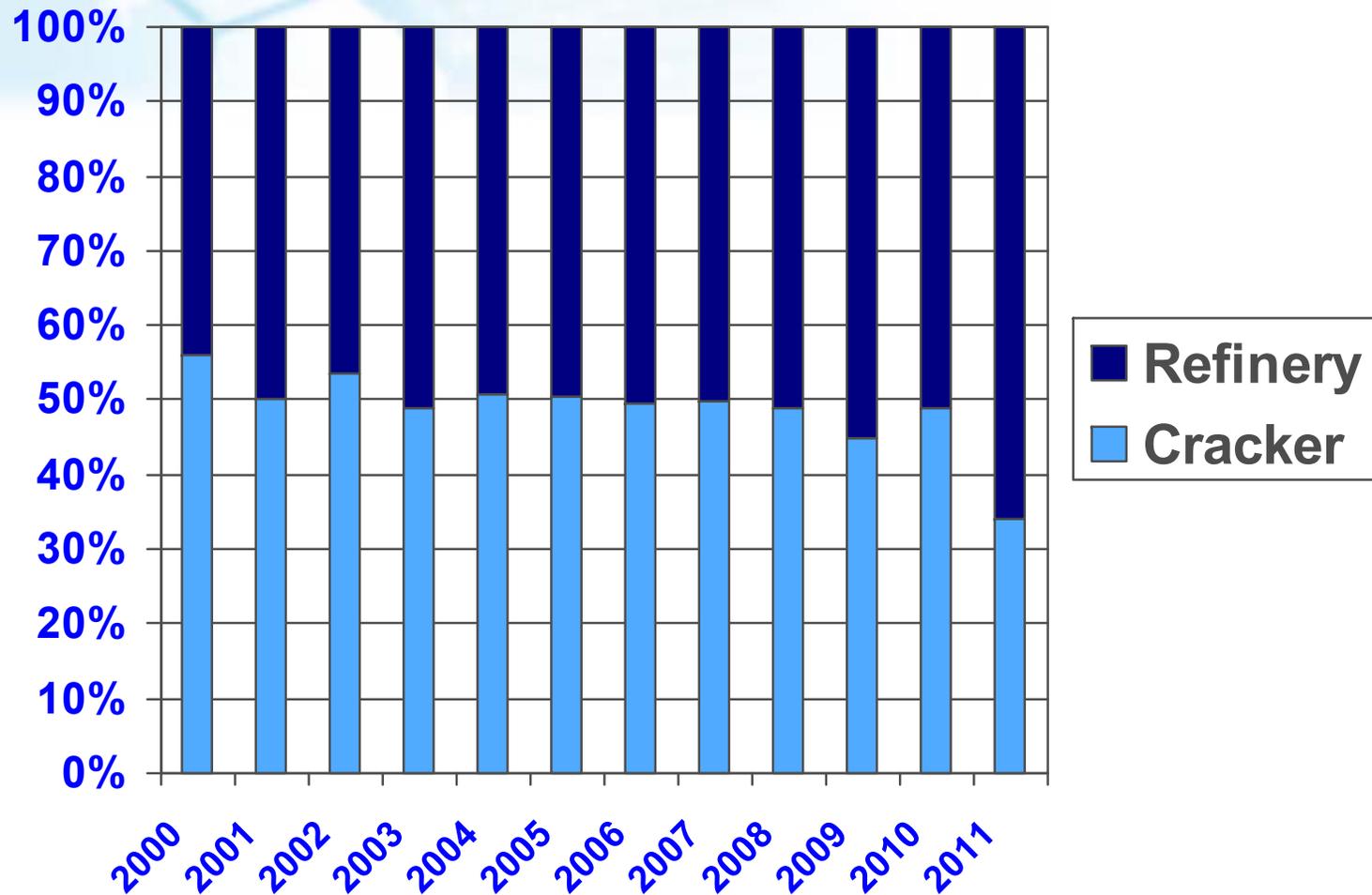


Shale gas has dramatically affected propylene, C₄s and Aromatics

- ❖ Liquid feedstocks such as naphtha have been increasingly replaced with natural gas liquids with more coming
- ❖ The change from 70% NGLs/30% liquids to 87% NGLs/13% liquids in 2011 has reduced propylene production in crackers by more than 50 percent
- ❖ Refineries, which account for about 50 percent of propylene production have remained at 2008 levels
 - ❖ Propylene is used in the gasoline pool which is more profitable
 - ❖ Would need to revamp refinery product slate to produce substantial quantities of propylene
 - ❖ Some additional propylene is likely – but not enough to replace current losses and meet future demand



The propylene supply ratio (refinery versus cracker) has been affected by the price shift

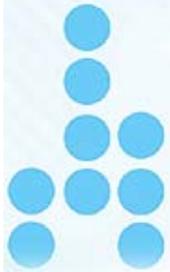


There has been a large percentage shift from crackers to refineries

Alternative propylene supply options

- ❖ Other options:
 - ❖ Cracking more propane and butane in flex crackers
 - ❖ Metathesis (ethylene trimerization with a C_4 – but C_4 s are also very tight). C_4 s could be produced via ethylene dimerization. Metathesis is being considered by at least one company (confidential)
 - ❖ Propane dehydrogenation (PDH) is an expensive process but low propane prices can support it (Dow, Formosa, others)
 - ❖ Methane-to-propylene (MTP) which has some issues such as producing major amounts of methanol and waste water (no known plans)
 - ❖ Key decision factor will be the relative economics



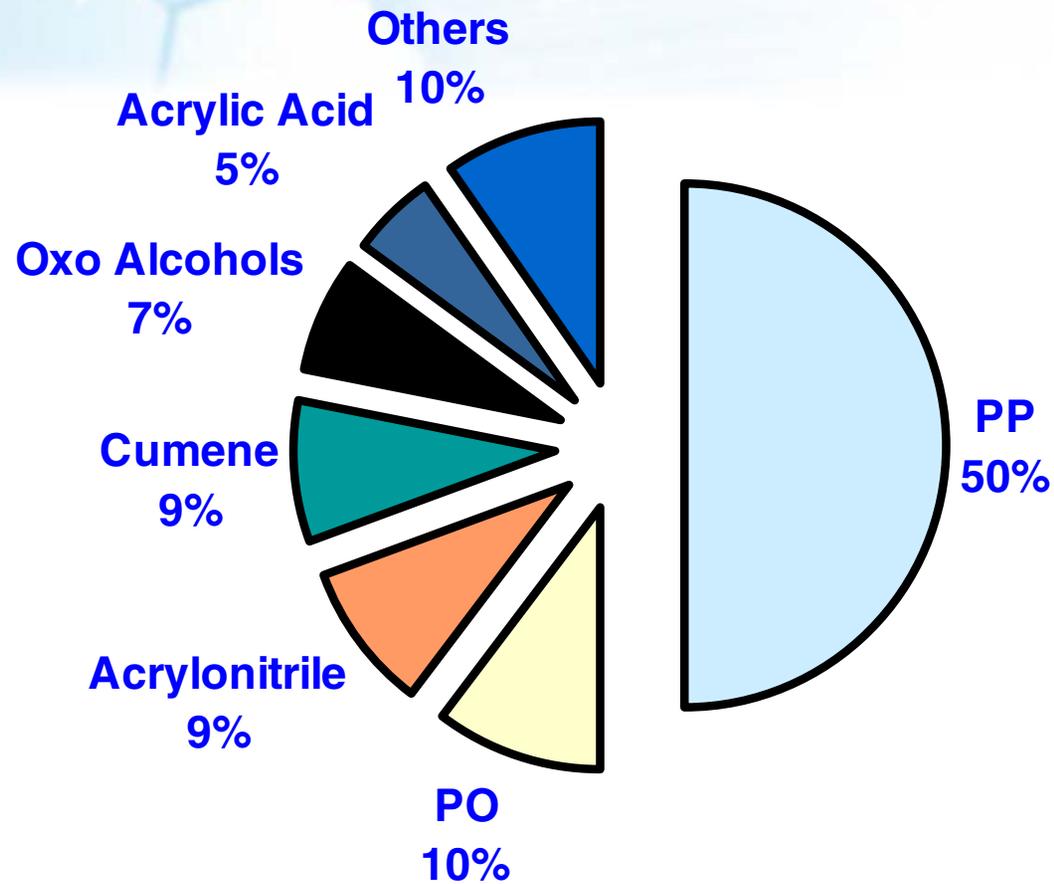


Outlook for North American propylene

- ❖ No propylene investments in Canada or Mexico
- ❖ Short-term, propylene in the United States
- ❖ Any outage in a liquids cracker or refinery will adversely impact propylene supply
- ❖ Announced on purpose capacity not enough
- ❖ About 1.5 million tons per year of new propylene capacity will be needed just to replace the capacity lost to the NGL shift. At a 3% growth rate for propylene derivatives, another 2 million tons per year of new propylene capacity will be needed to meet 2015 projected propylene derivative demand
- ❖ Refineries could supply some additional propylene but not enough



US Propylene Demand, By Derivative



Total Demand for Propylene in US, 2010 = 14,989 KT



Who gets the available propylene?

- ❖ Derivatives will compete for the available propylene
- ❖ Those using the least amount of propylene per ton of derivative production AND have the ability to pass through the higher cost will get the most propylene (maintain profitability)
- ❖ This would result in the following order of supply:
 - ❖ Acrylic acid
 - ❖ Oxo-Alcohols
 - ❖ Cumene
 - ❖ Acrylonitrile
 - ❖ Propylene Oxide
 - ❖ Polypropylene



Impact on polypropylene demand

- Polypropylene could lose about 12% of demand to HDPE, polystyrene/PET. A small amount could also be replaced by paper. Some applications “protected”
- Customers will have to pay higher prices and try to pass them on
- Reduction of U. S. polypropylene exports
- Possible U. S. imports of propylene and propylene derivatives
- Substitution of other derivatives is much more complex and is much more limited (e.g., SAP, specialties, etc.)





The Finale

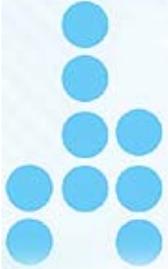


Summary

- Shale gas has revitalized the U. S. petrochemical industry with essentially every major ethylene/polyethylene producer planning some level of expansion (2012-2016)
- There could even be additional expansions driven by the natural gas companies, financial companies and other foreign companies
- Essentially all of the capacity will either be exported or replace existing production based on regional competitiveness
- Polyethylene demand growth could accelerate above current forecast levels, especially for LDPE (2 – 3 new LDPE plants could be built based on shale in addition to Mexico)
- The U. S. will have the second best regional export economic position and should dominate Latin America



First movers will have a significant advantage from procurement through construction and market entry



The United States will become a very large net exporter of polyethylene second only to the Middle East. This is a Structural Change that will require a different mindset!

So, are we ready for this or will companies first kill the domestic market trying to sell most of the production domestically (the proverbial Market Share Wars)?

حظاً سعيداً*



*** Good Luck**

Or should I say, "Break a Leg!"



The “Shale Gas Plays”

Is it a Comedy?

Is it a Tragedy?

Will it be a Broadway Hit?

Ask me during the intermission.....

.....in 2017!





Polymer Consulting
International, Inc.

Thank You!