

The Shale Gas Resource: *What are the Trends, Where is it Headed?*

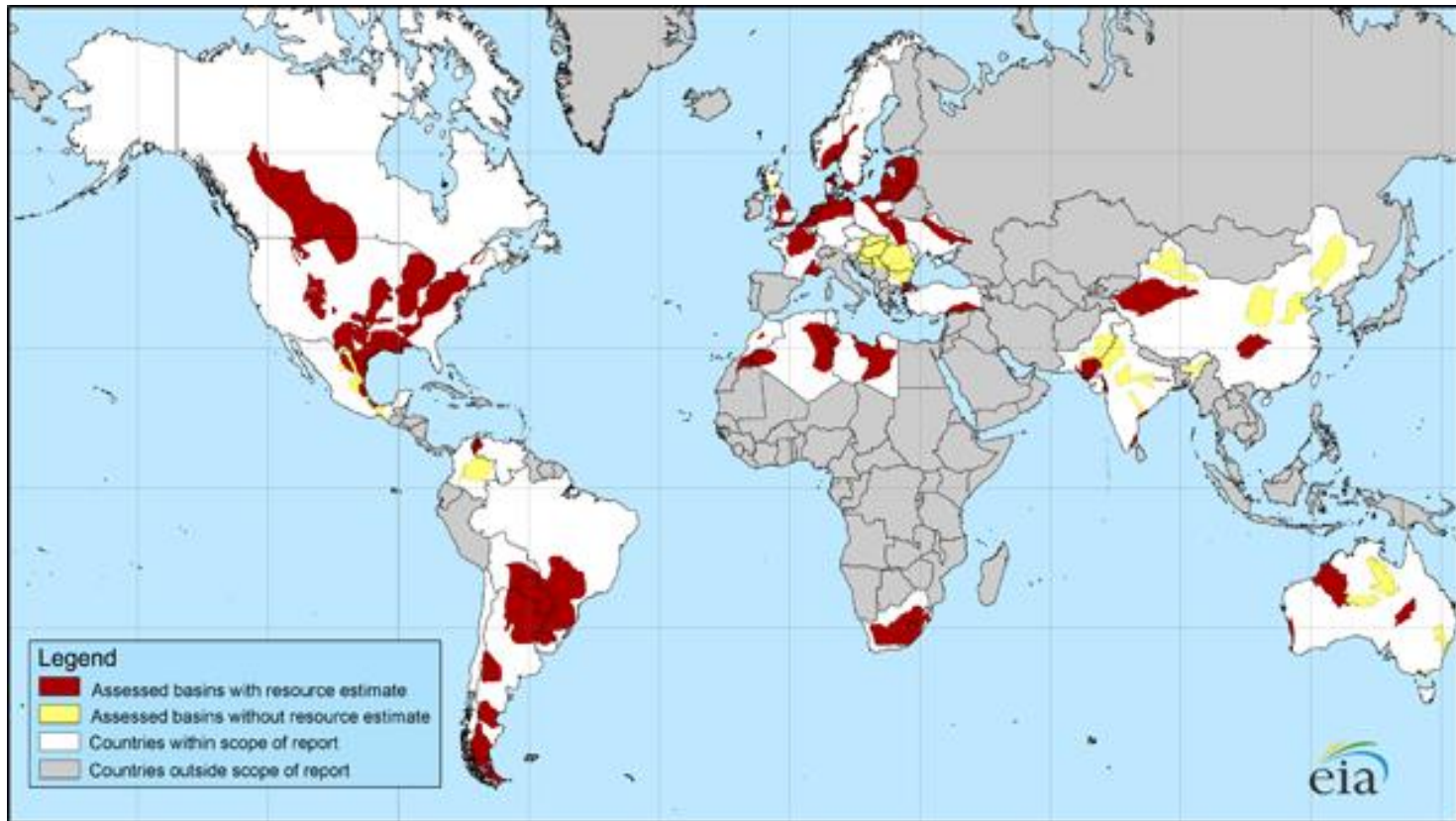




Global Shale Gas Reserves

U.S. Department of Energy released an assessment of 48 shale gas basins in 32 countries, containing almost 70 shale gas formations around the world.

<http://www.eia.gov/analysis/studies/worldshalegas>

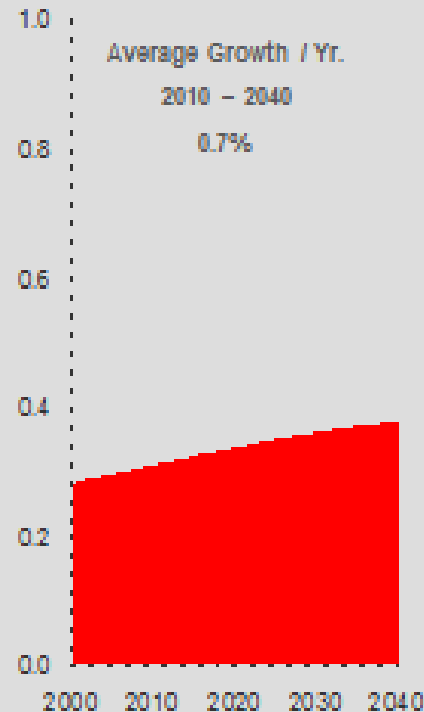


Global Energy Demand up 30% but...

United States Energy Trends

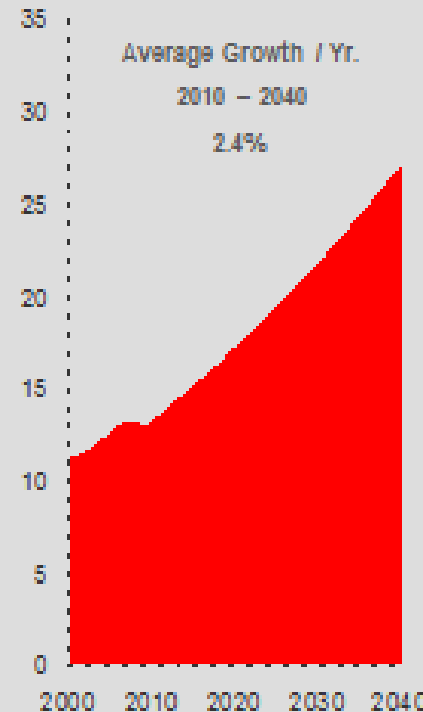
Population

Billion



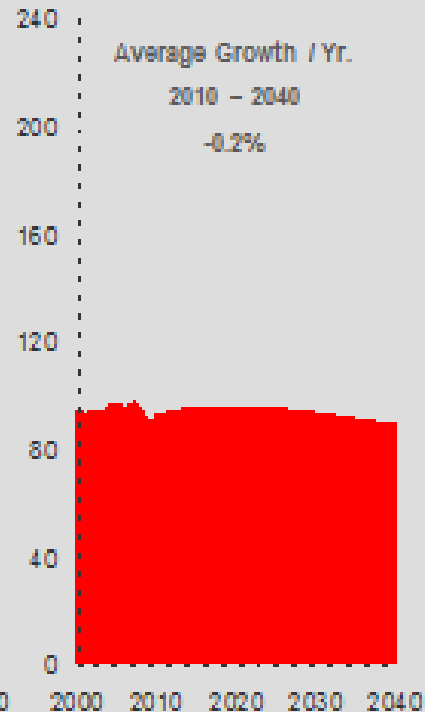
GDP

Trillion 2005\$



Energy Demand

Quadrillion BTUs

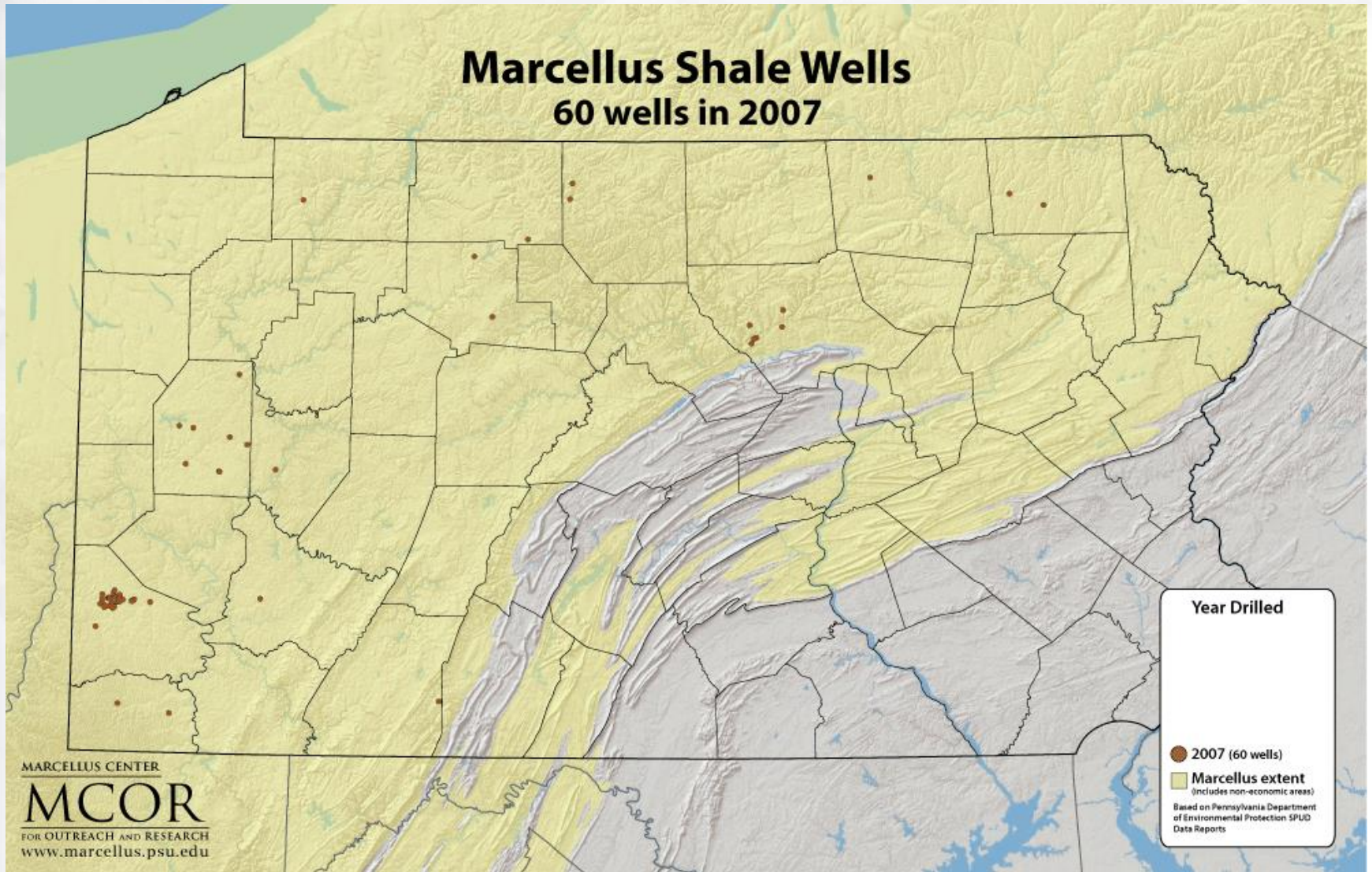


ExxonMobil 2012 Outlook for Energy

ExxonMobil

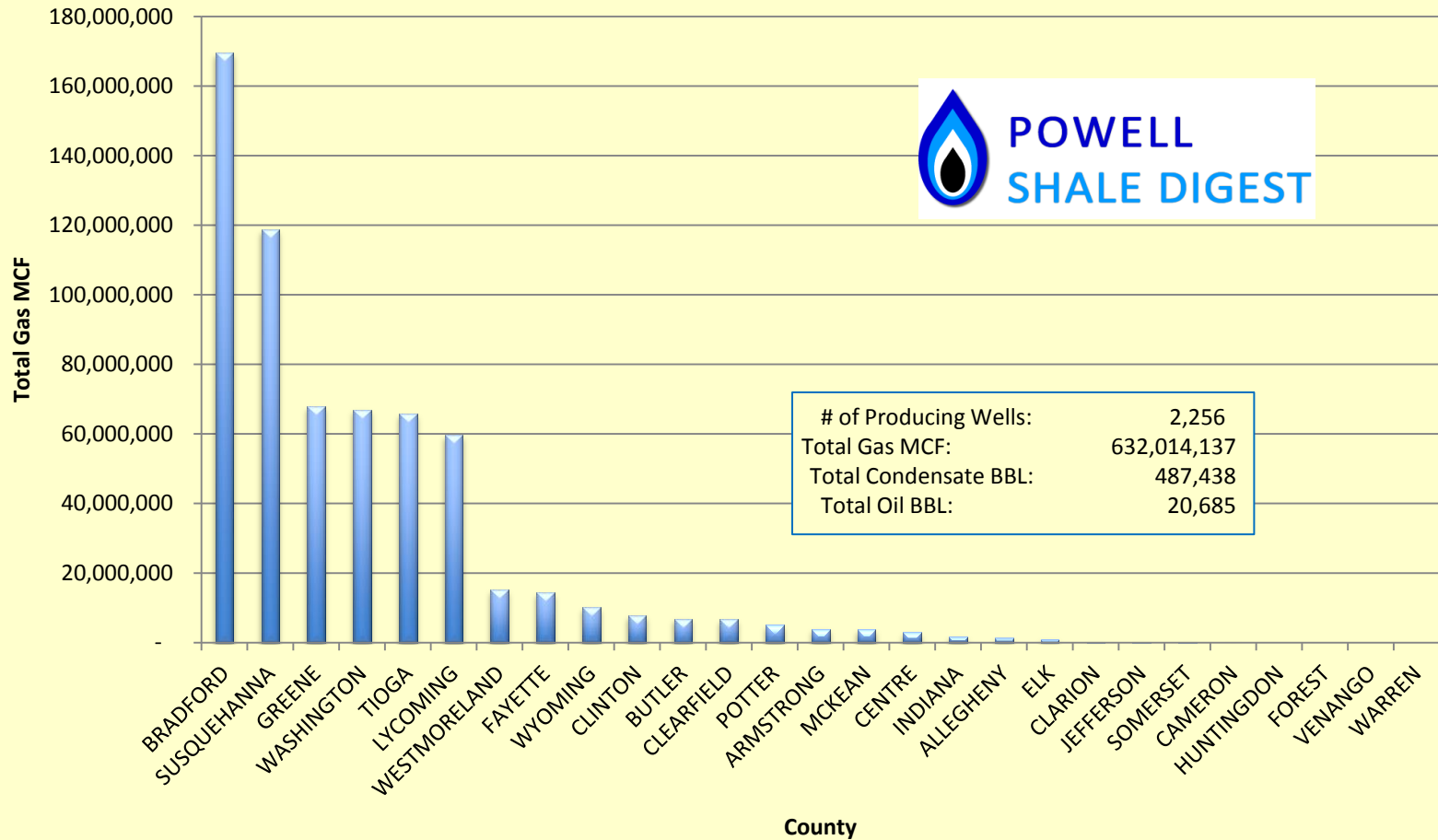


Marcellus Wells Drilled



Pennsylvania Marcellus Shale Production July 1 - Dec. 31, 2011

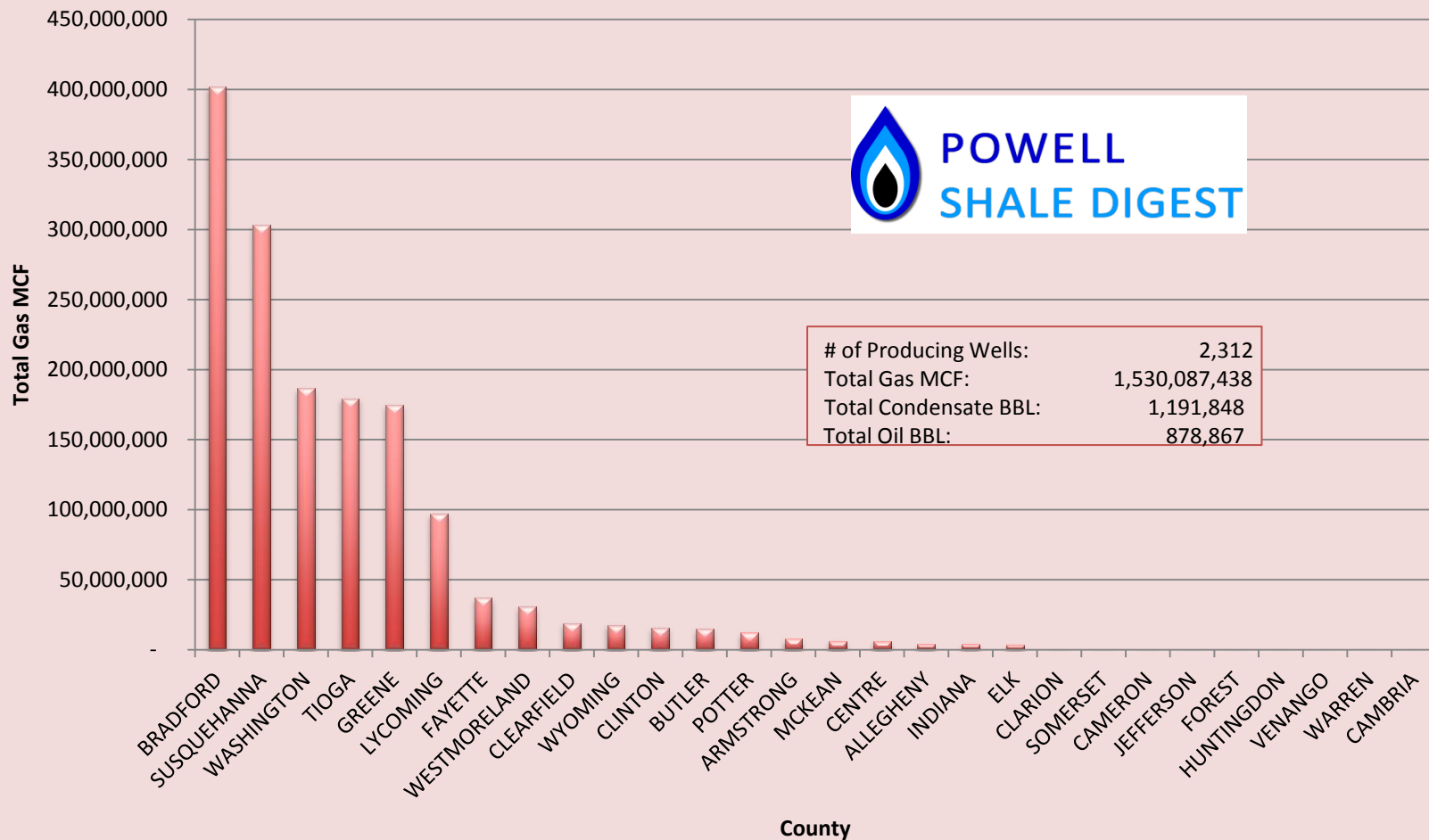
Counties Sorted by Total Gas MCF



Source: Pennsylvania Department of Environmental Protection

Powell Shale Digest, April 16, 2012

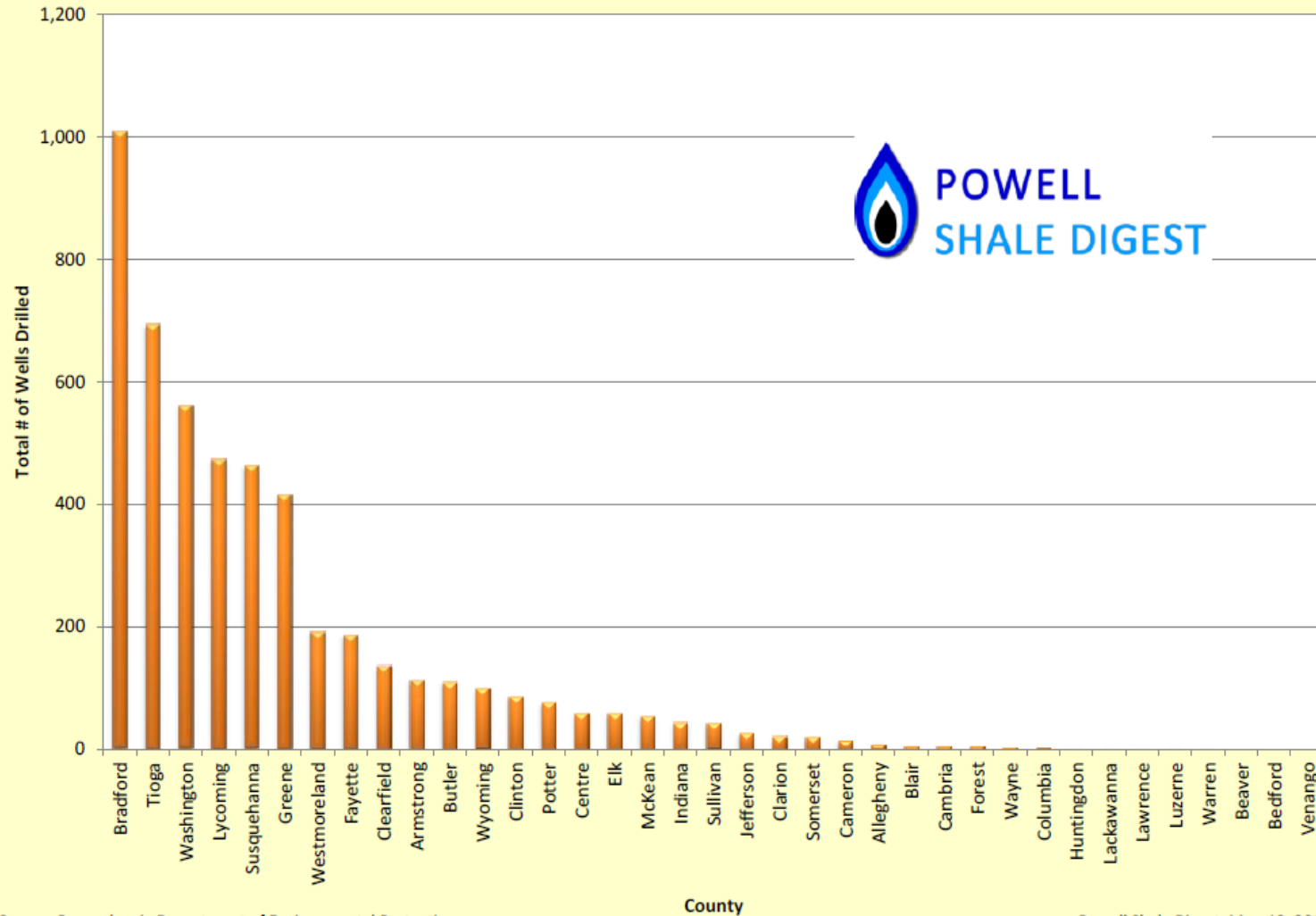
Pennsylvania Marcellus Shale Production July 1, 2009 - Dec. 31, 2011 Counties Sorted by Total Gas MCF



Source: Pennsylvania Department of Environmental Protection

Powell Shale Digest, April 23, 2011

Pennsylvania Marcellus Shale Total # of Wells Drilled 2003 - 2011



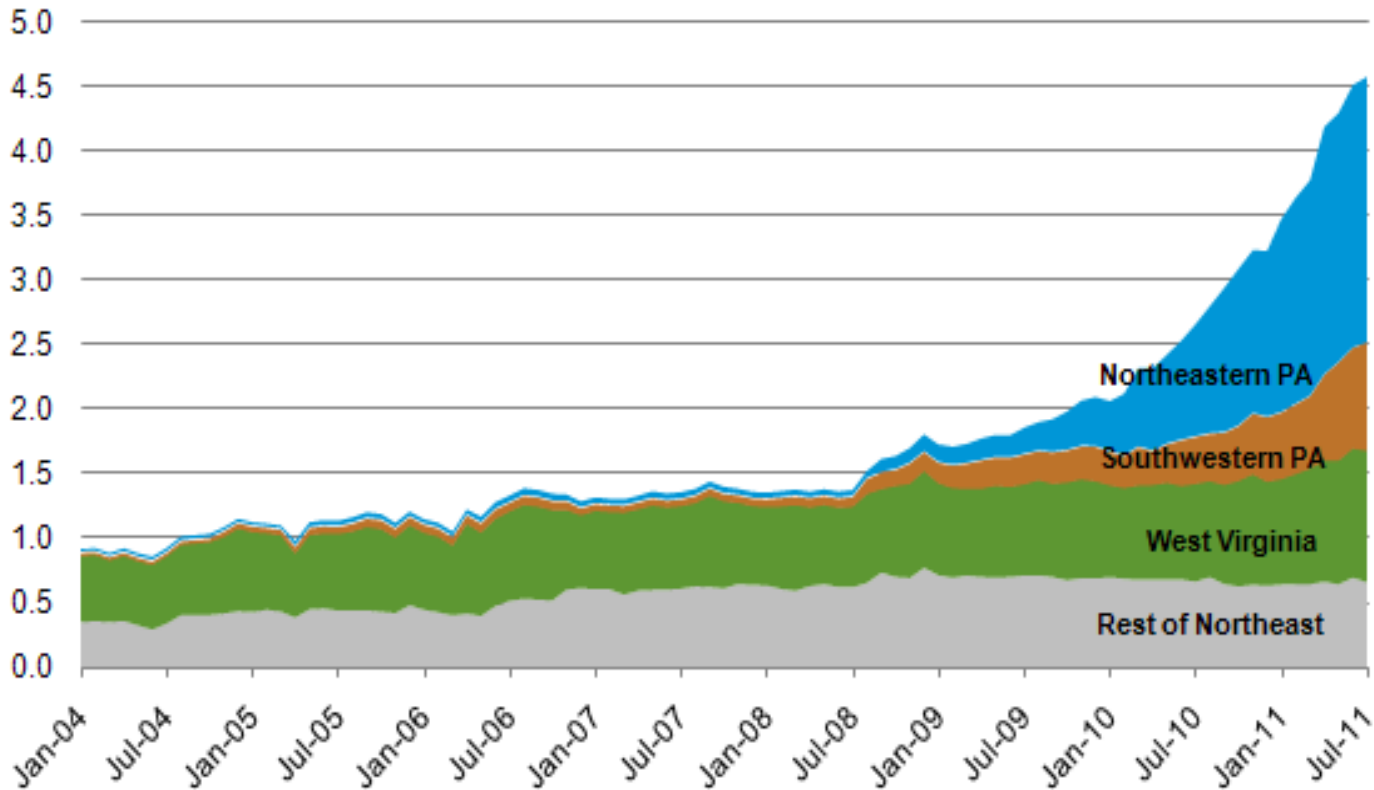
Source: Pennsylvania Department of Environmental Protection

Powell Shale Digest, Mar. 12, 2012



PA Production

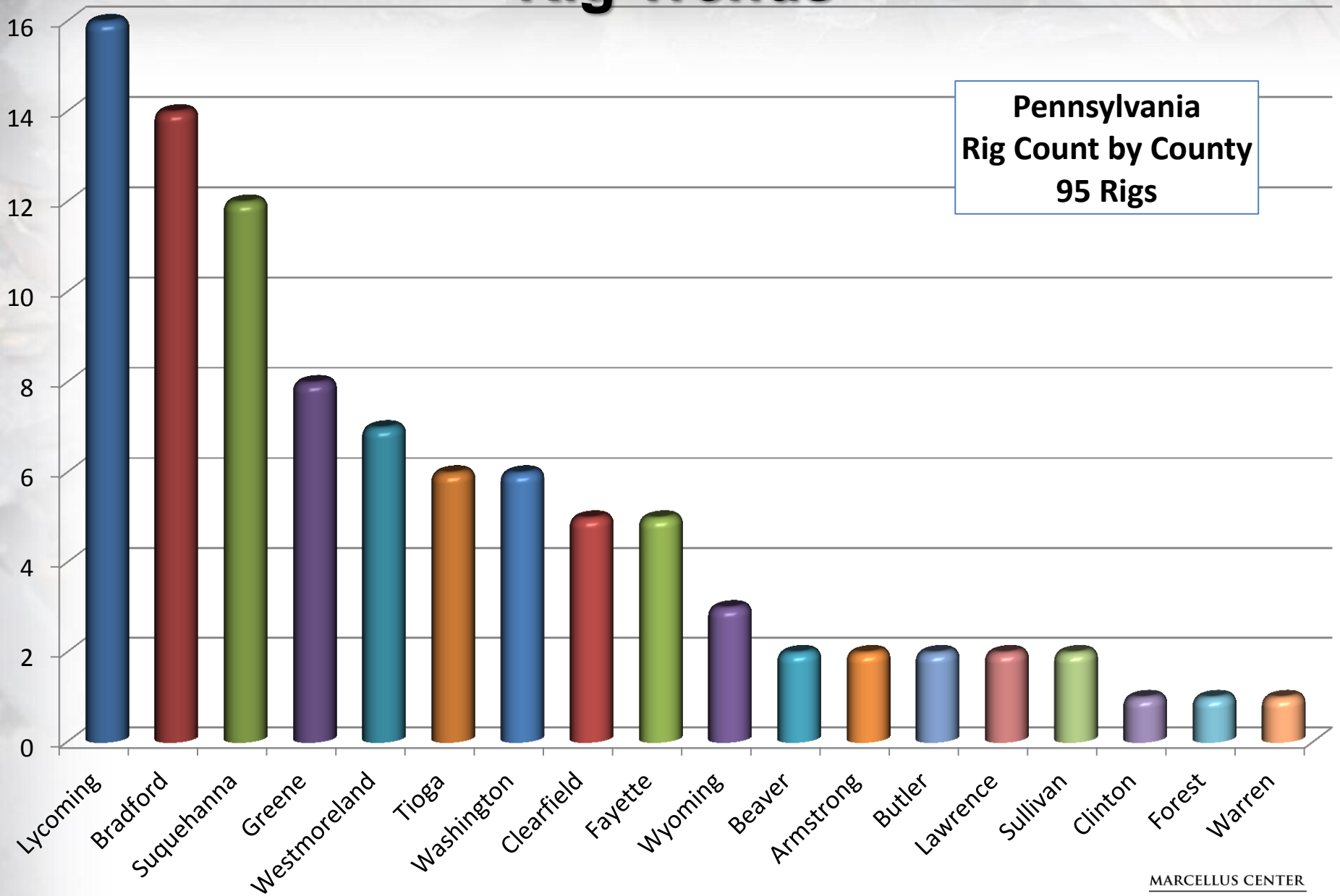
Average monthly natural gas production
billion cubic feet per day



Source: U.S. Energy Information Administration based on Bentek Energy, LLC.

Note: Rest of Northeast includes KY, MD, NY, OH, TN, VA.

Rig Trends

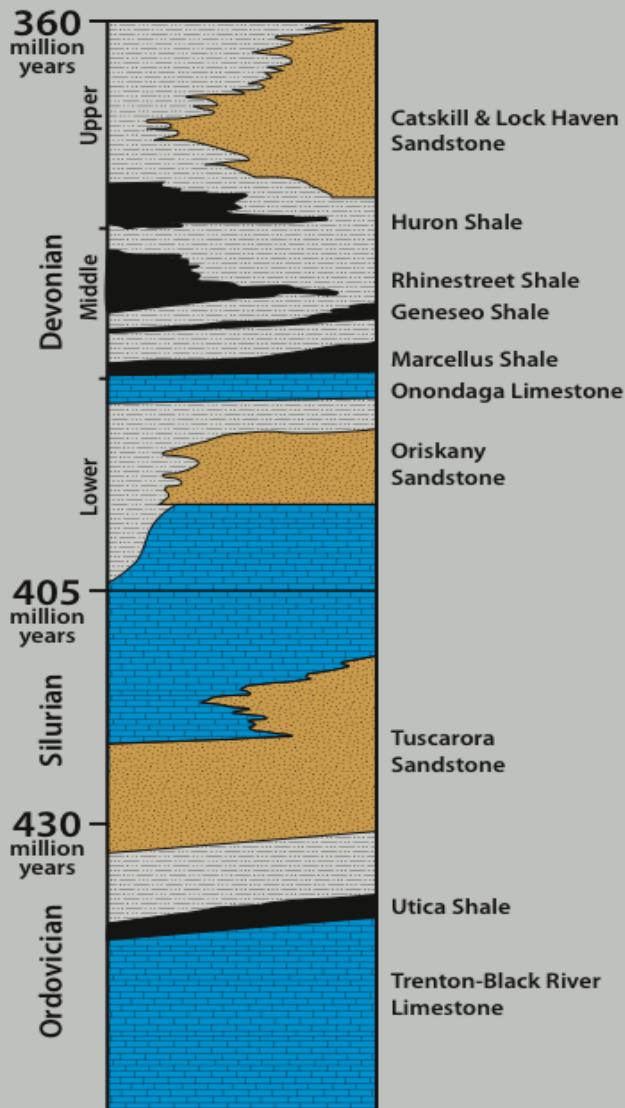


Sources: [Baker-Hughes Investor Relations](#) (May 11, 2012)

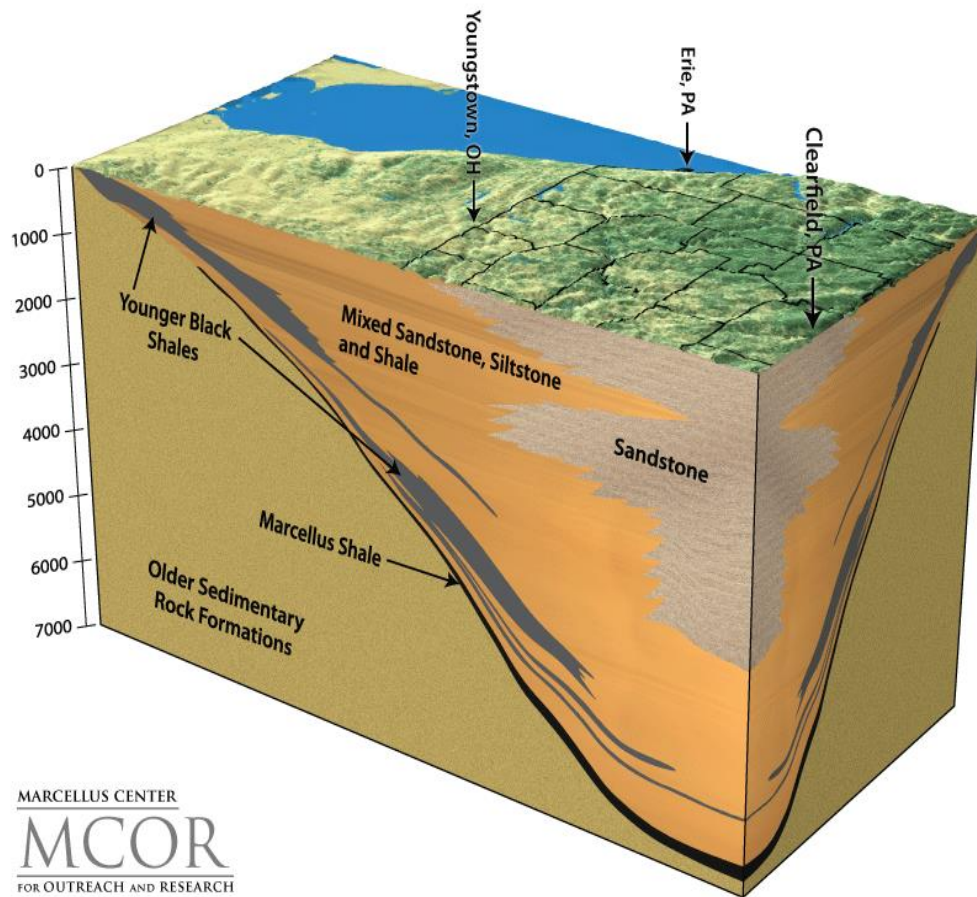


Other Shale Targets

Key Gas-Producing Formations in Pennsylvania



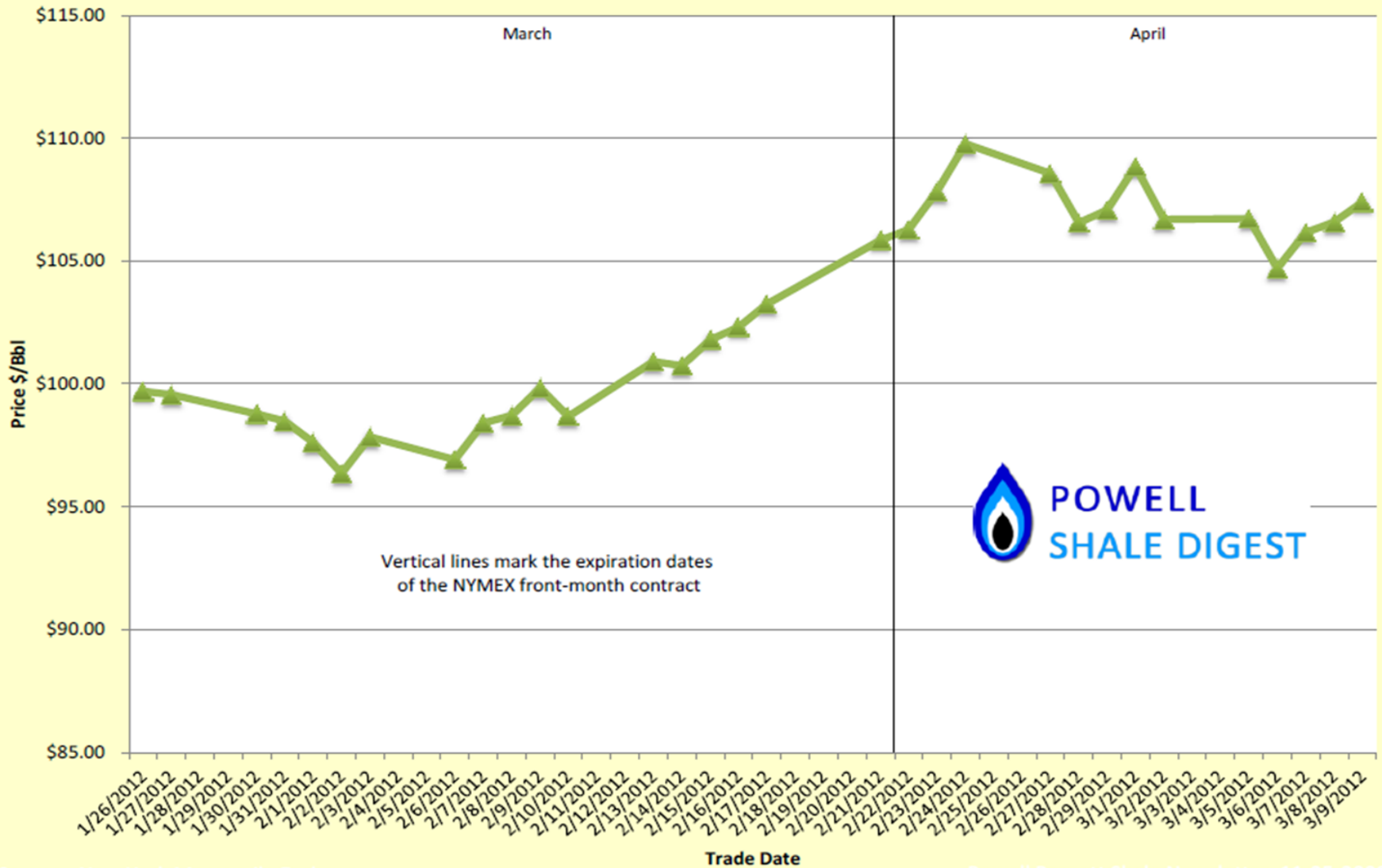
Generalized Geologic Cross Section Showing Marcellus Shale in Western Pennsylvania



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NYMEX Light Sweet Crude Oil Futures Recent Price History



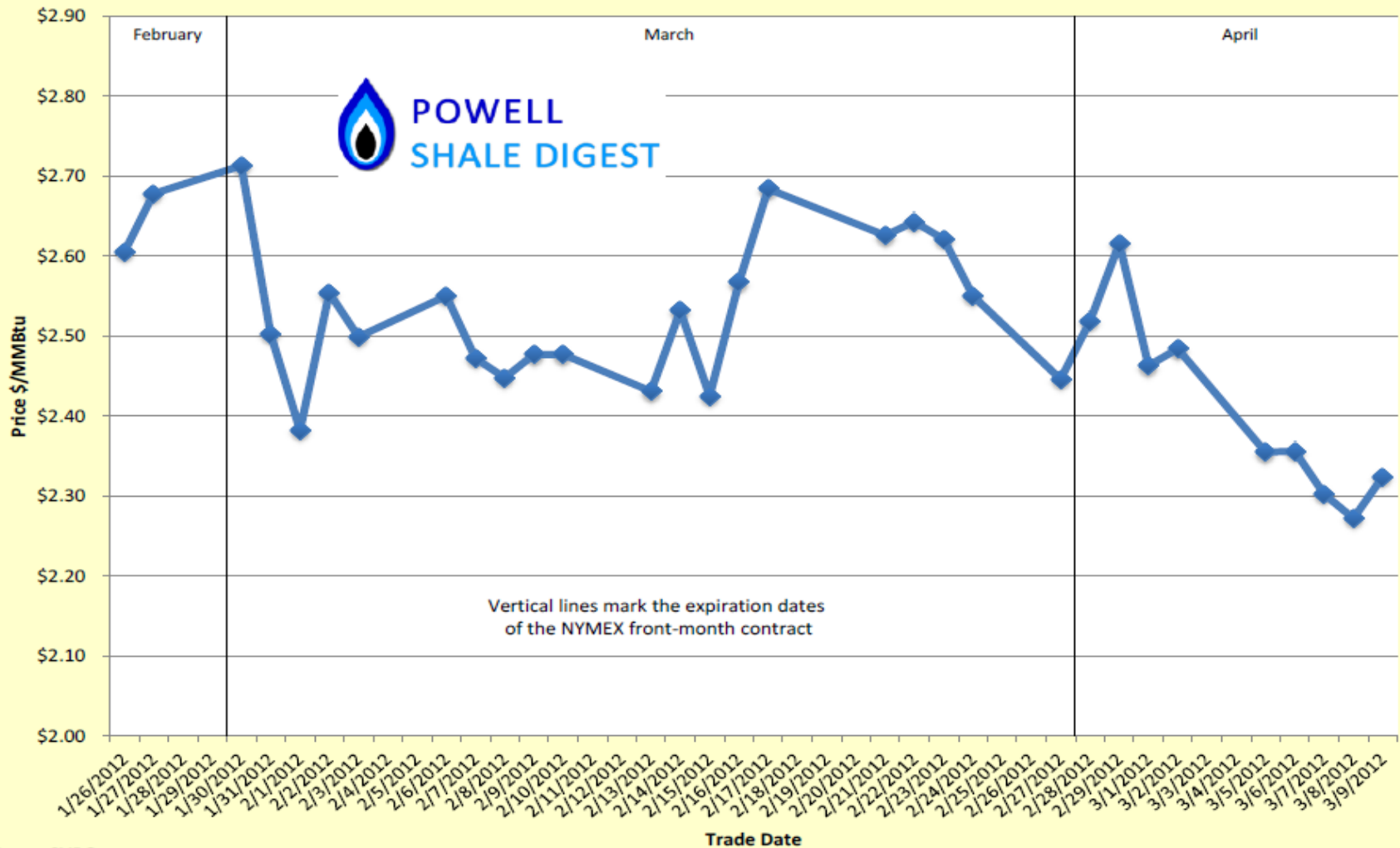
**POWELL
SHALE DIGEST**

Source: CME Group, Light Sweet Crude Oil Futures

Powell Barnett Shale Powell Shale Digest, Mar. 9, 2012

U.S. Natural Gas Prices

NYMEX Henry Hub Natural Gas Futures Settlement Prices Recent History



Source: CME Group

Powell Shale Digest, Mar. 9, 2012

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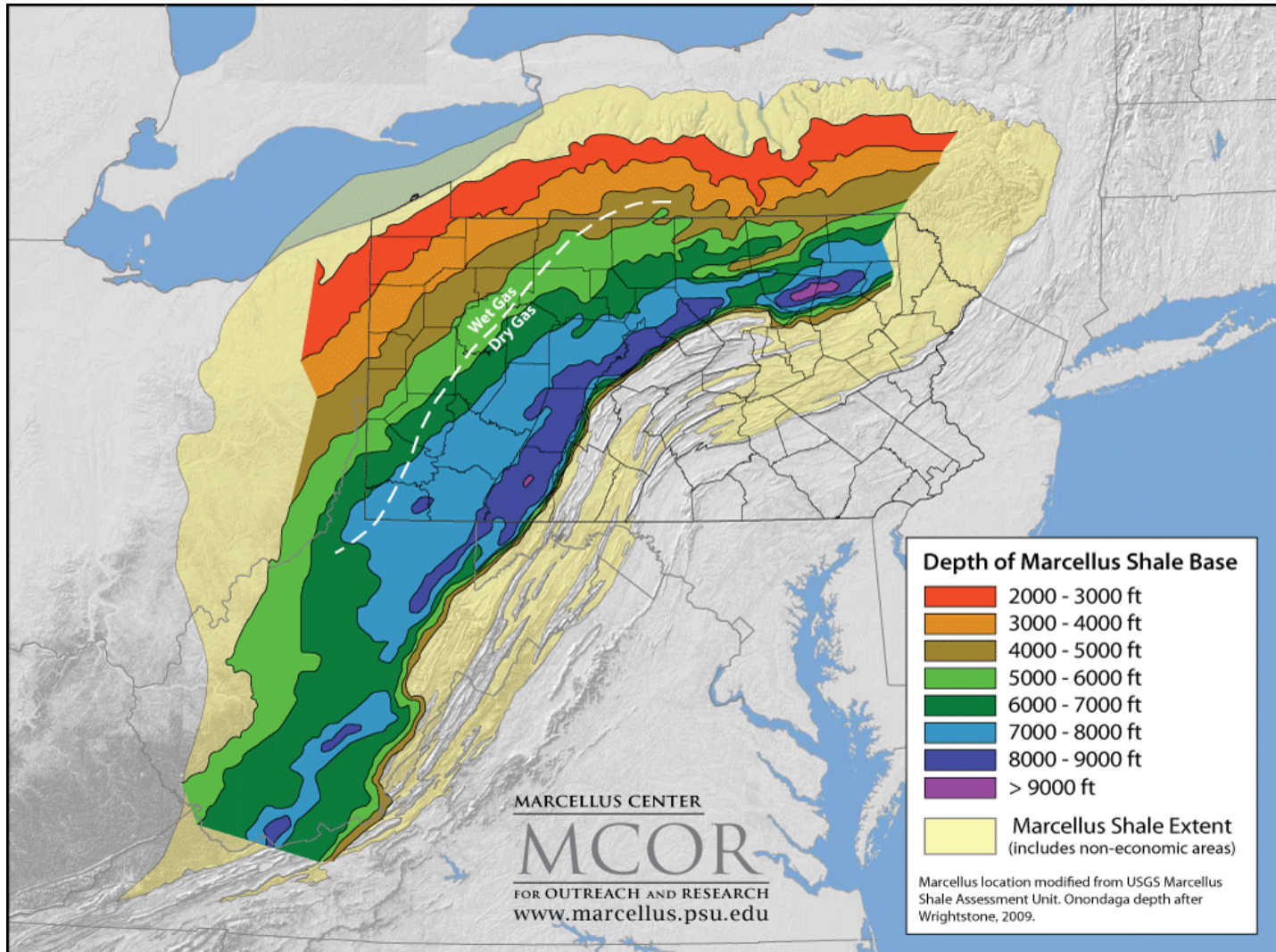
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Producing Wells

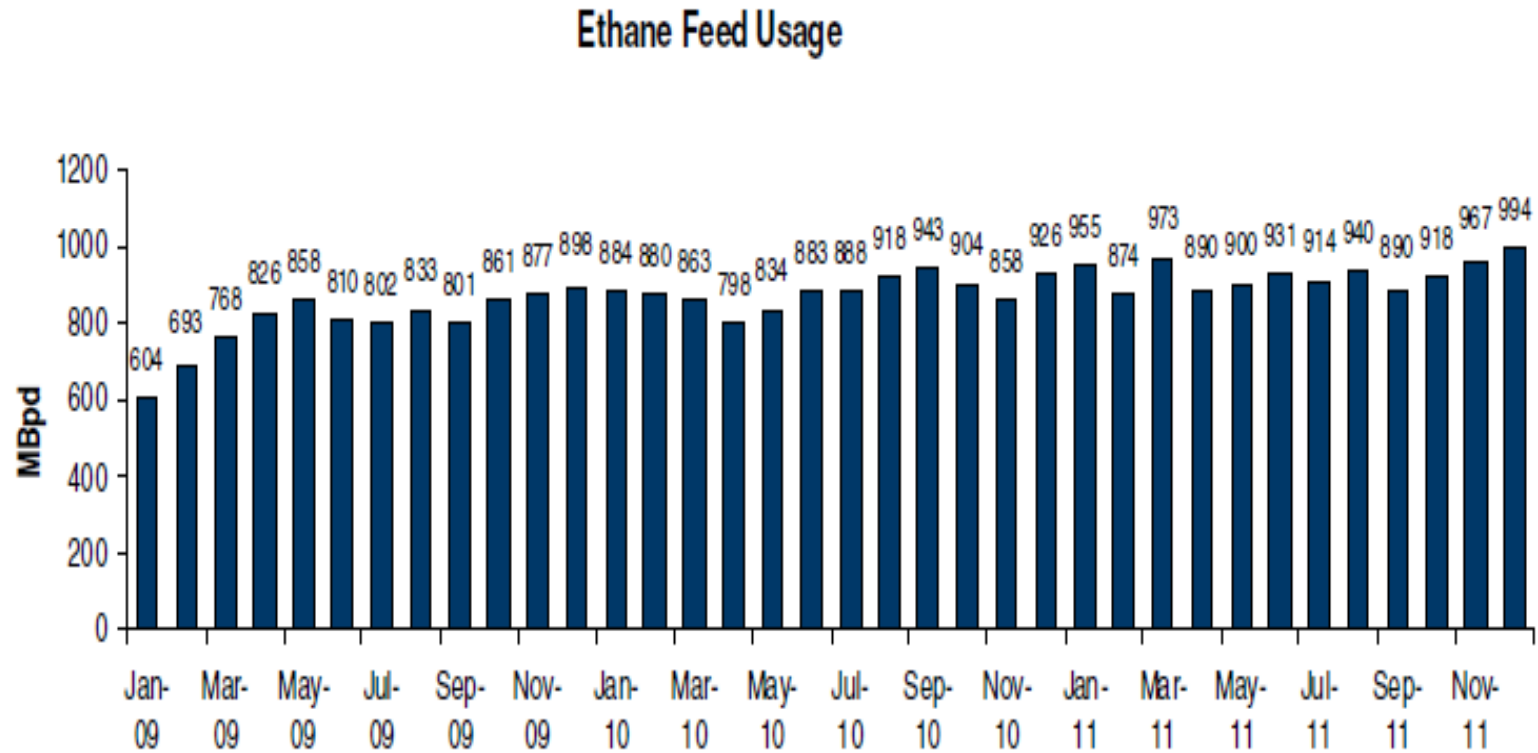
- 95 drill rigs running in PA
 - 116 last year at this time
 - 19 currently in OH
- As of June '11
 - ~3200 drilled in PA
 - 1697 reported producing
 - 52% producing in PA
 - Estimated to be 2250 on 1/1/12

Natural Gas Liquids (NGLs)



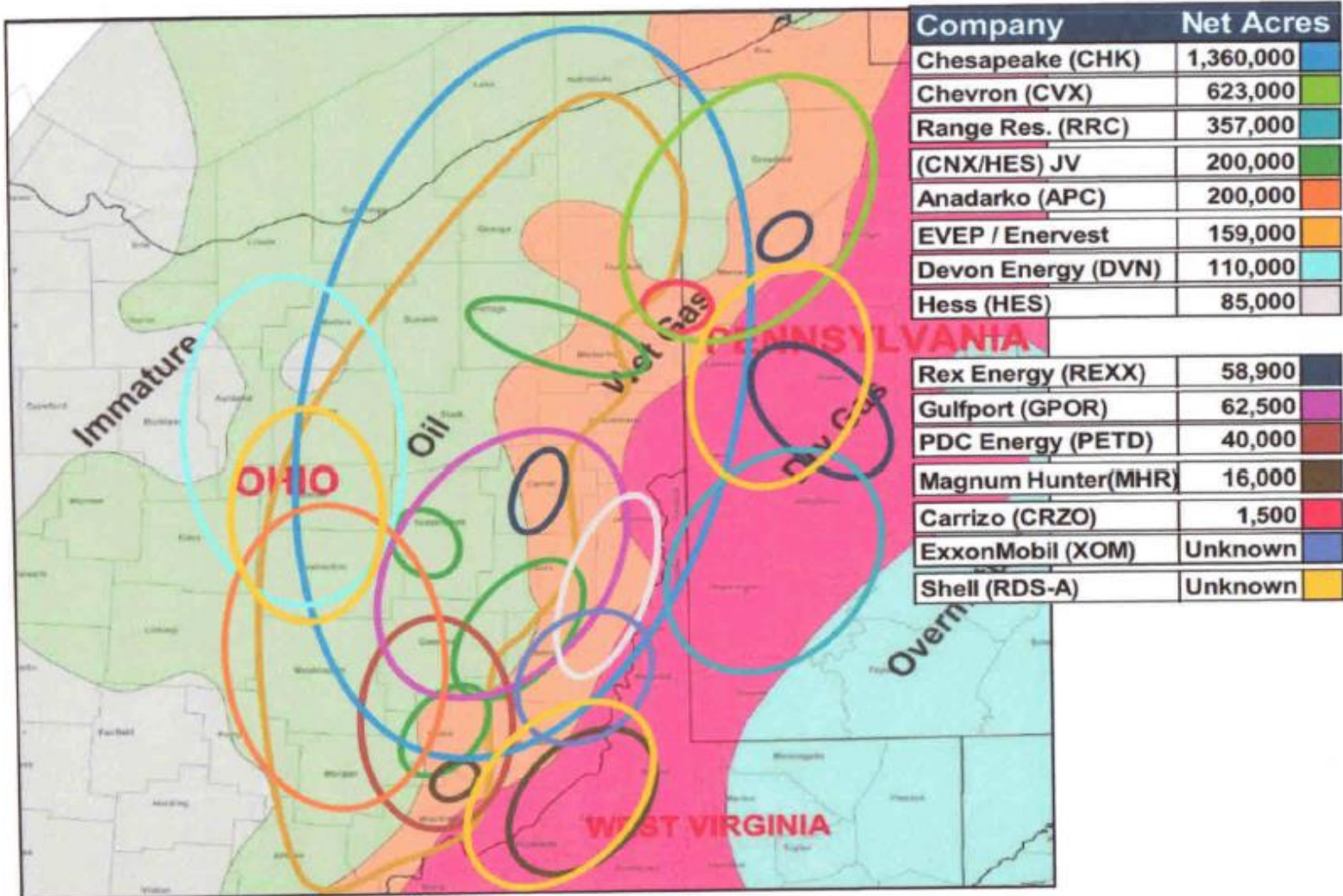
Demand for NGL's Rising

Exhibit 7: Ethane Feed Usage from NGLs



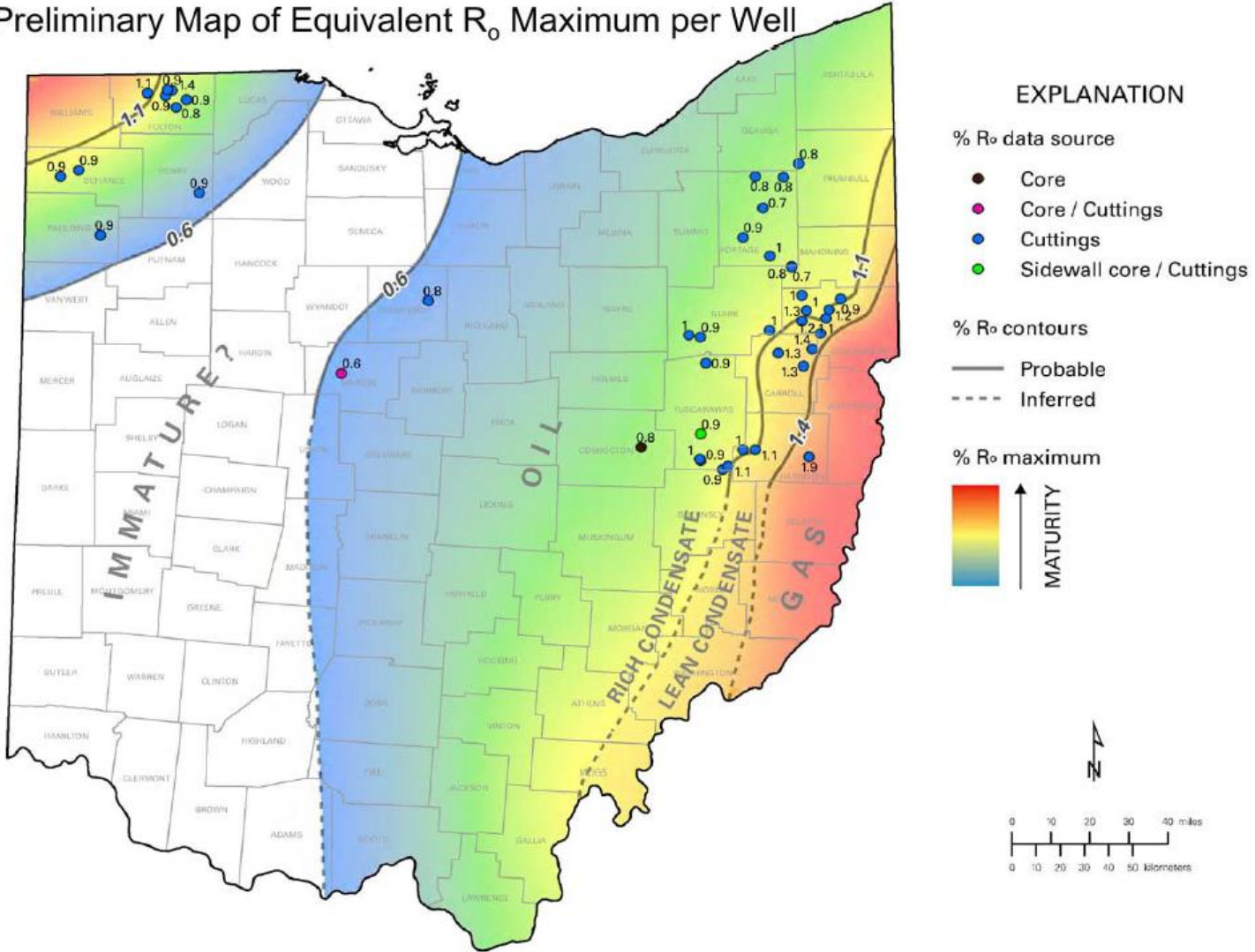
Source: Hodson Reports, Credit Suisse

Utica Development

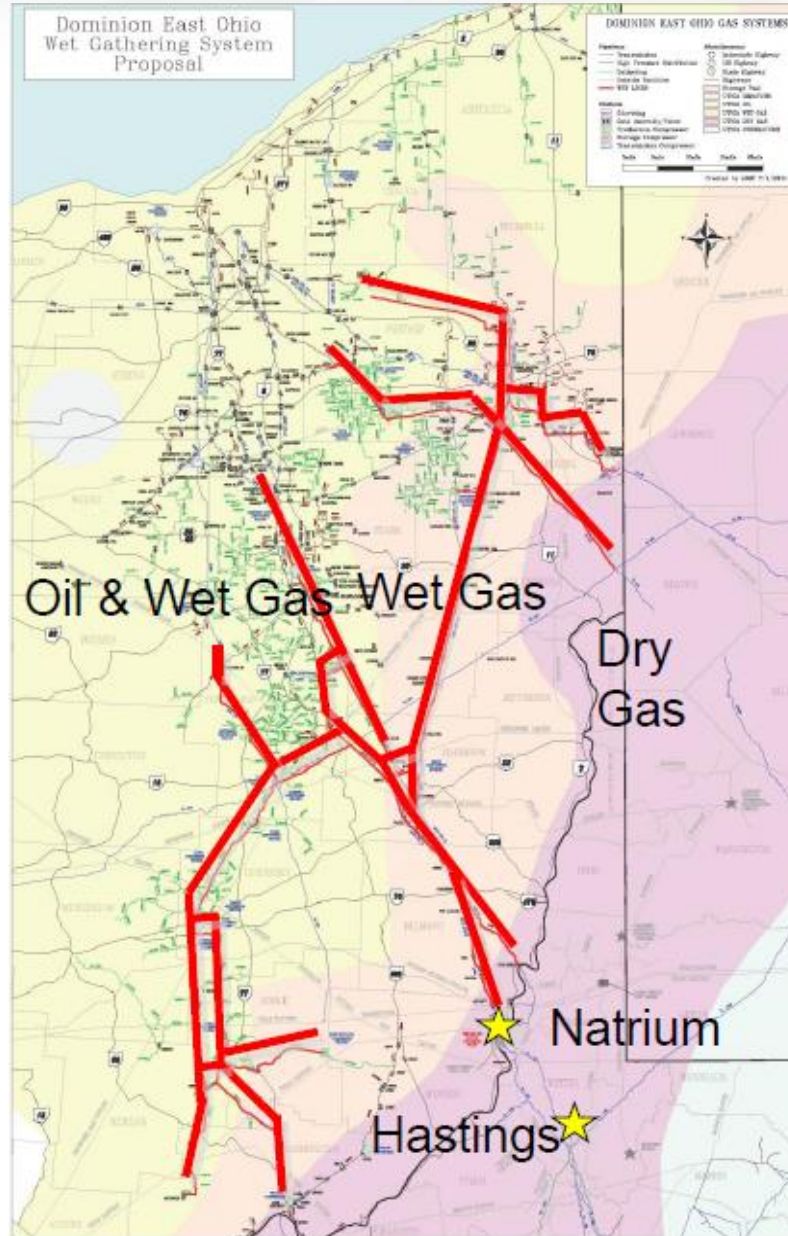


Source: Company Data, modified Gulfport map, GHS Research

Preliminary Map of Equivalent R_o Maximum per Well



Utica Midstream Buildout



ETHYLENE CHAIN



Ethane



Pool Liners
Window Siding
Trash Bags
Sealants
Carpet Backing
Insulation
Detergent
Flooring
Pipes



Food Packaging
Bottles
Cups
Housewares
Crates



Footwear
Clothes
Diapers
Stockings
Toys
Textiles



Tires
Sealants
Paint
Antifreeze



Adhesives
Coatings
Films
Paper Coatings
Models
Instrument Lenses

Intermediate Products
PVC
Vinyl Chloride
Ethylene Glycol
Styrene
Polystyrene

NGL Attribute Summary



Natural Gas Liquid	Chemical Formula	Applications	End Use Products	Primary Sectors
Ethane	C_2H_6 	Ethylene for plastics production; petrochemical feedstock	Plastic bags; plastics; anti-freeze; detergent	Industrial
Propane	C_3H_8 	Residential and commercial heating; cooking fuel; petrochemical feedstock	Home heating; small stoves and barbeques; LPG	Industrial, Residential, Commercial
Butane	C_4H_{10} 	Petrochemical feedstock; blending with propane or gasoline	Synthetic rubber for tires; LPG; lighter fuel	Industrial, Transportation
Isobutane	C_4H_{10} 	Refinery feedstock; petrochemical feedstock	Alkylate for gasoline; aerosols; refrigerant	Industrial
Pentane	C_5H_{12} 	Natural gasoline; blowing agent for polystyrene foam	Gasoline; polystyrene; solvent	Transportation
Pentanes Plus*	Mix of C_5H_{12} and heavier	Blending with vehicle fuel; exported for bitumen production in oil sands	Gasoline; ethanol blends; oil sands production	Transportation

C indicates carbon, H indicates hydrogen; Ethane contains two carbon atoms and six hydrogen atoms

*Pentanes plus is also known as "natural gasoline." Contains pentane and heavier hydrocarbons.

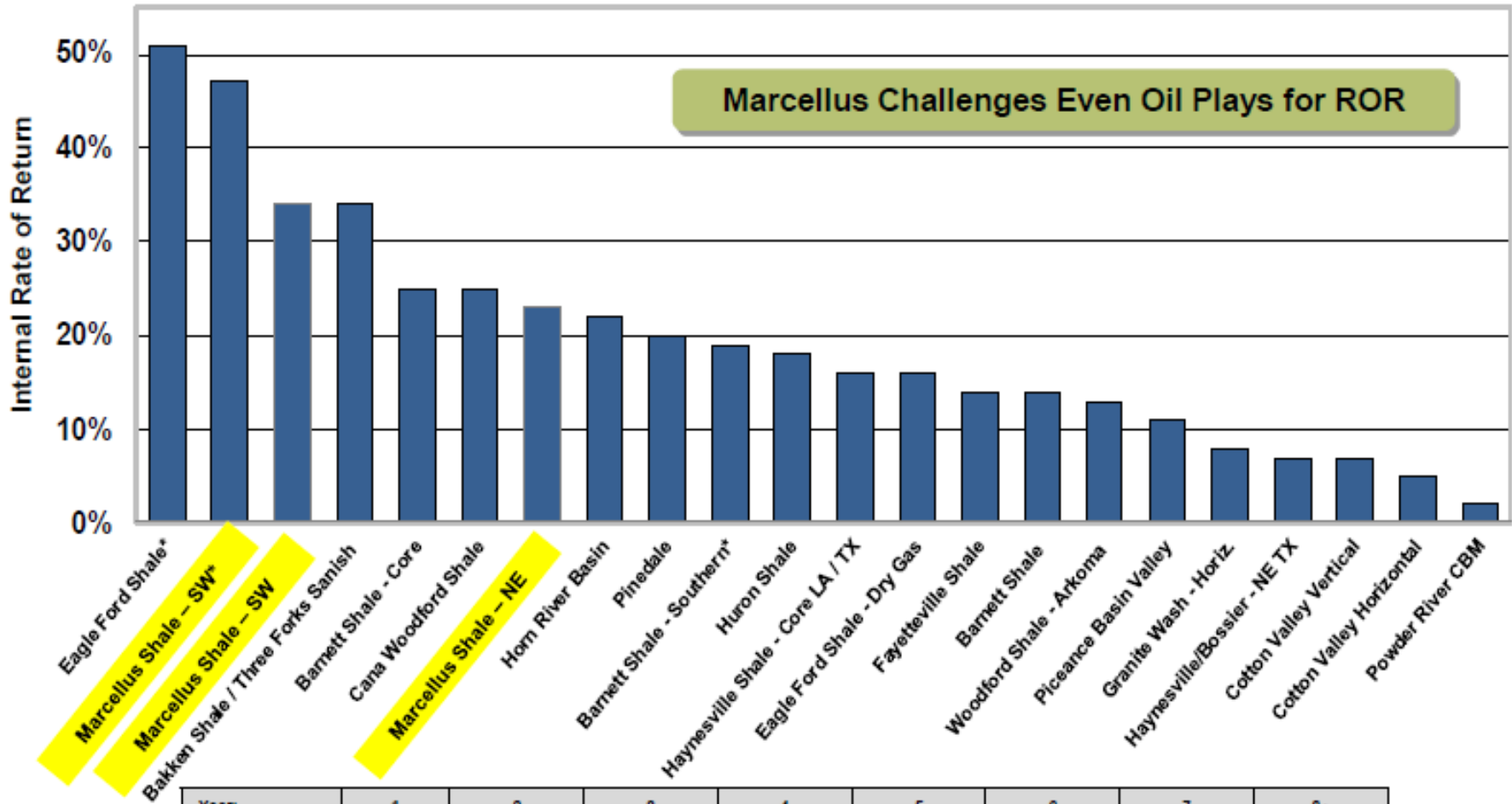
Source: EIA, Bentek Energy LLC

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Relative Profitability of Shale Plays



Year:	1	2	3	4	5	6	7	8+
WTI Oil:	\$93.18	\$87.55	\$88.76	\$89.20	\$89.81	\$90.57	\$90.57	\$90.57
NYMEX Gas:	\$4.09	\$4.15	\$4.69	\$5.00	\$5.22	\$5.47	\$5.47	\$5.47

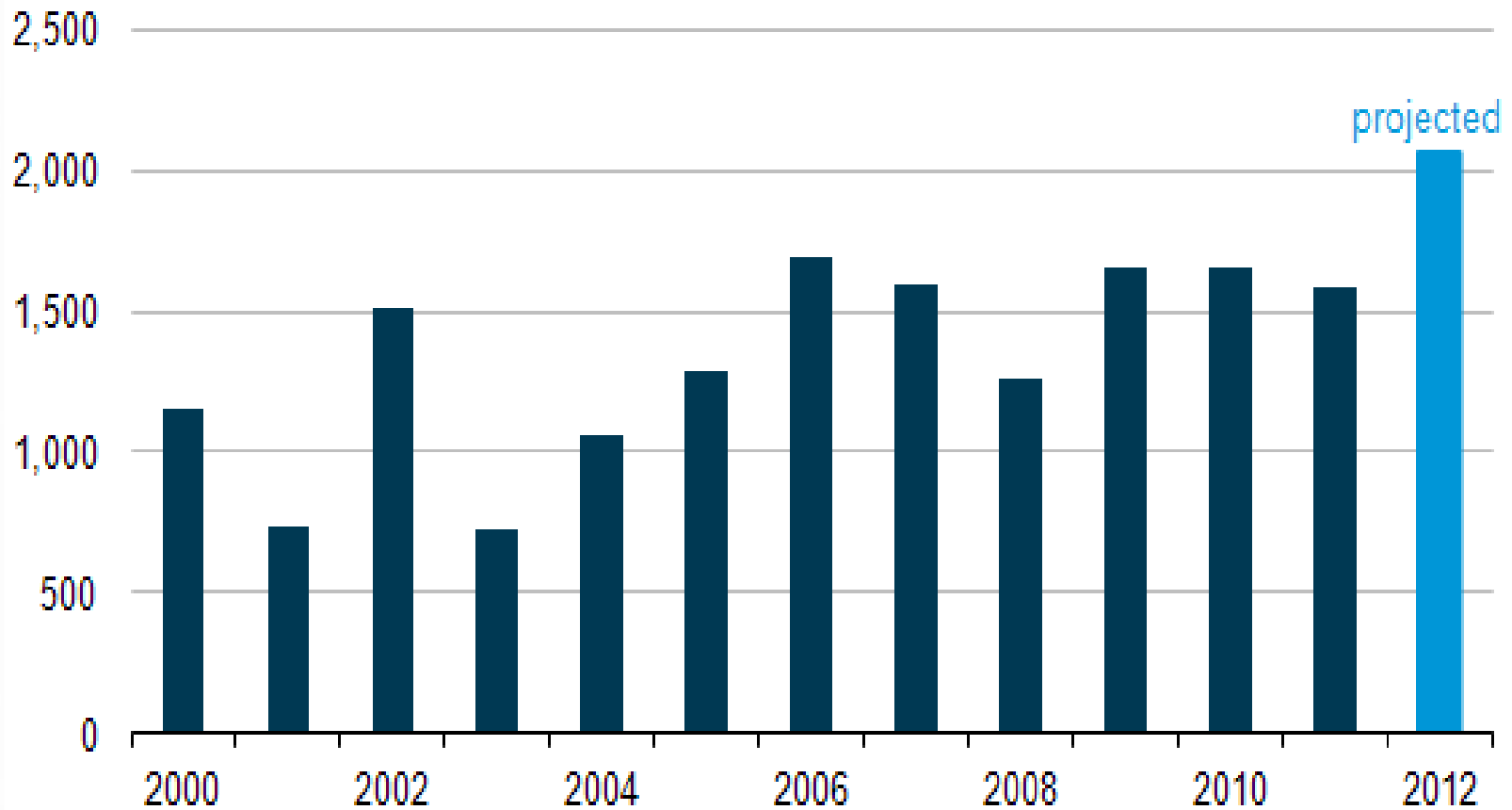
Source: Credit Suisse Research Report – October 18, 2011

*Liquids Rich



Gas Storage

U.S. working natural gas in underground storage at end of first quarter
billion cubic feet



New Energy Picture?



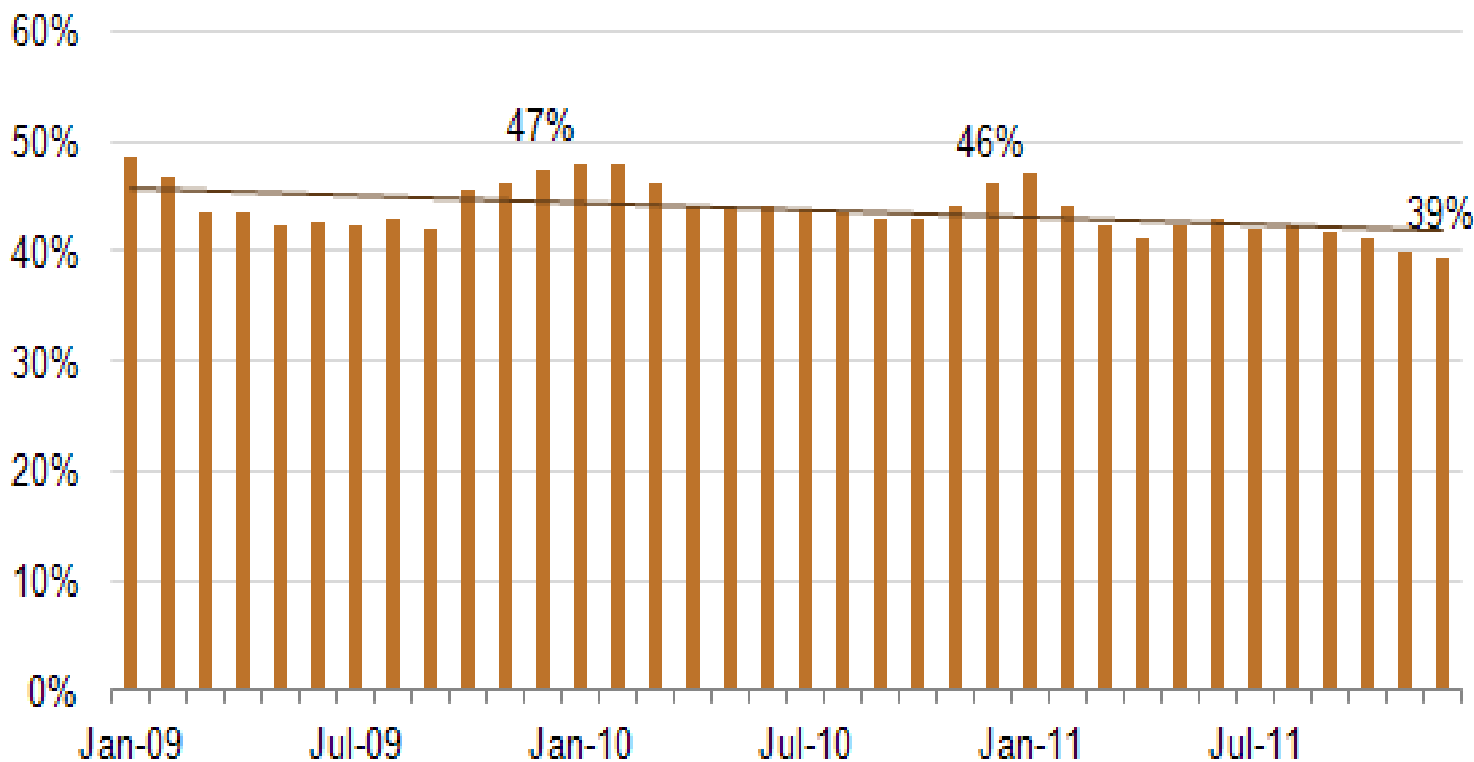
- Story is changing from production to utilization
- Adding value to the commodity
- Large energy consumers
 - Industrial
 - Power
 - Domestic/Cross-border
 - Transportation
- New workforce dynamics
- In-state manufacturing of key components
- New industrial renaissance?
- Reduces likelihood of “boom/bust”?



U.S. Electricity Production from Coal

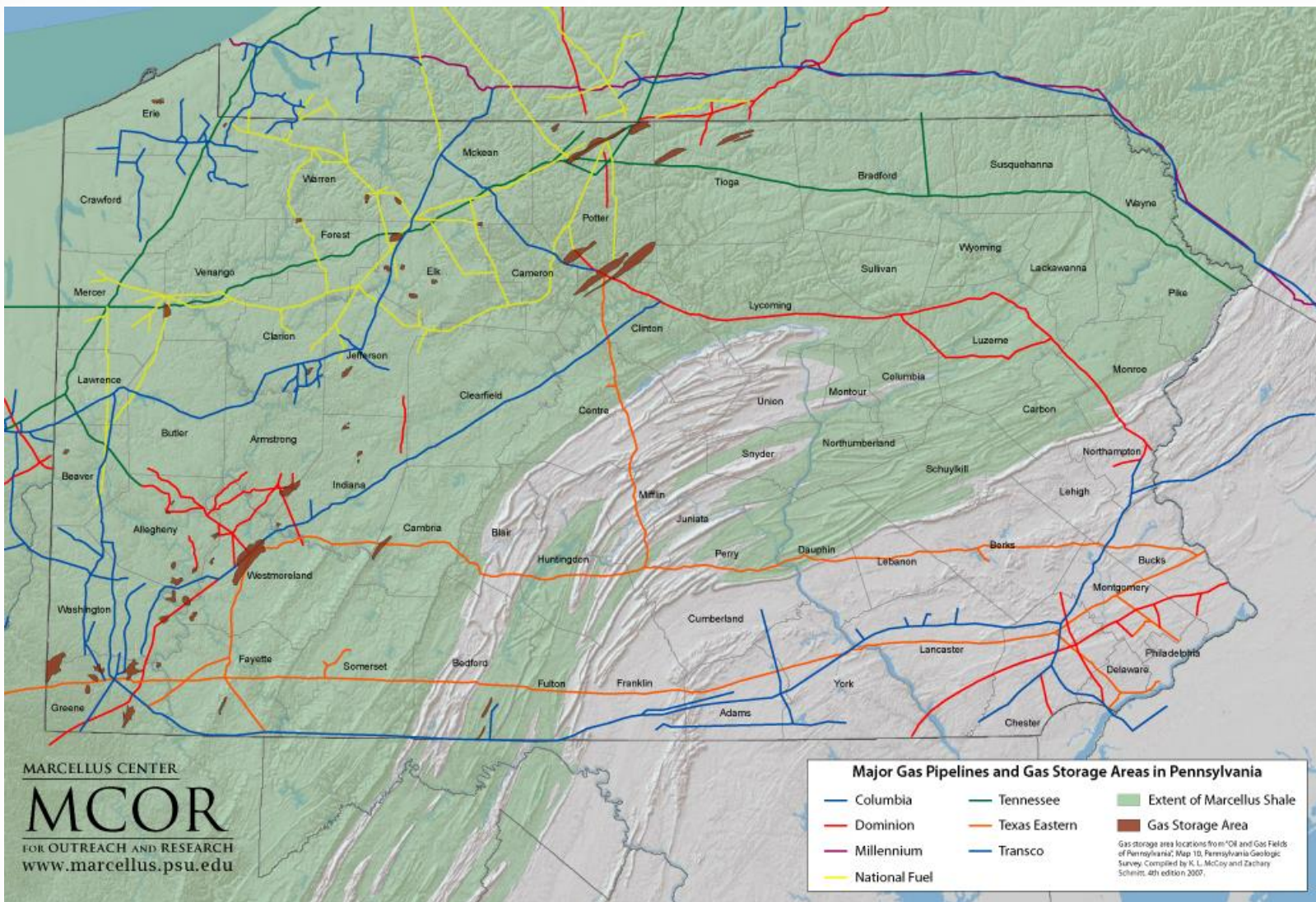
(lowest since '78)

Coal share of total electricity generation, January 2009 - December 2011
percent



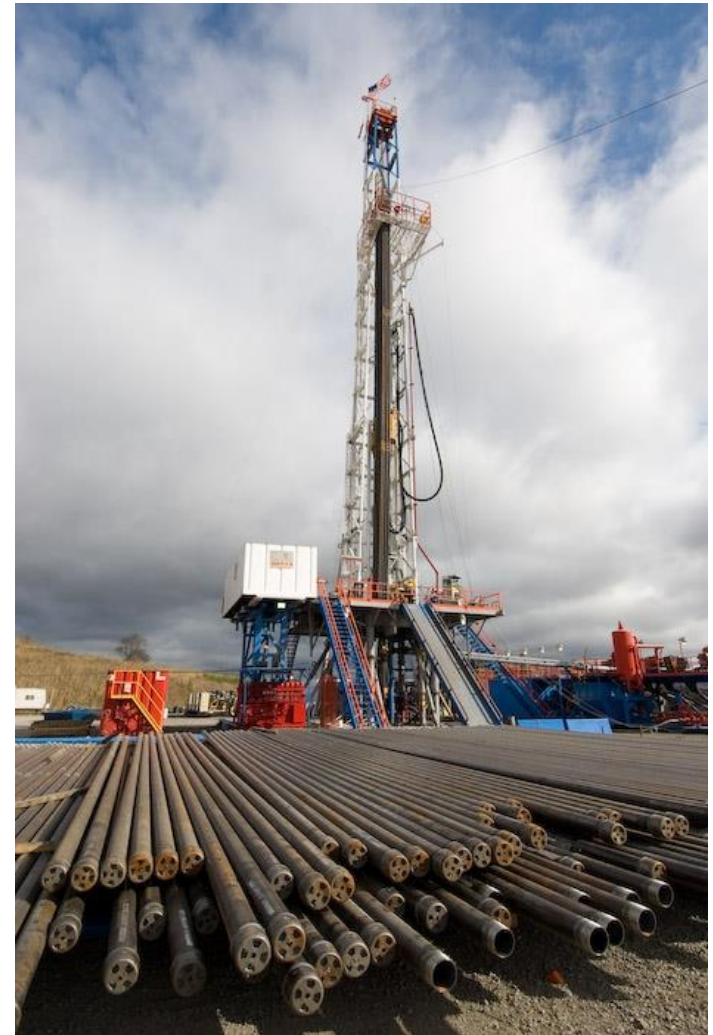


Interstate Pipeline and Storage



LNG Export

- Is there capacity to export the commodity?
 - Permit issued from the Gulf Coast
 - Alaska
 - Western Canada
 - Cove Point
- Are the economics favorable?
 - Long term contracts vs. spot pricing
 - Competitive environment - Africa, Australia, Qatar
- Is there political will to do so?
- Where would it go?
 - Asia
 - Europe



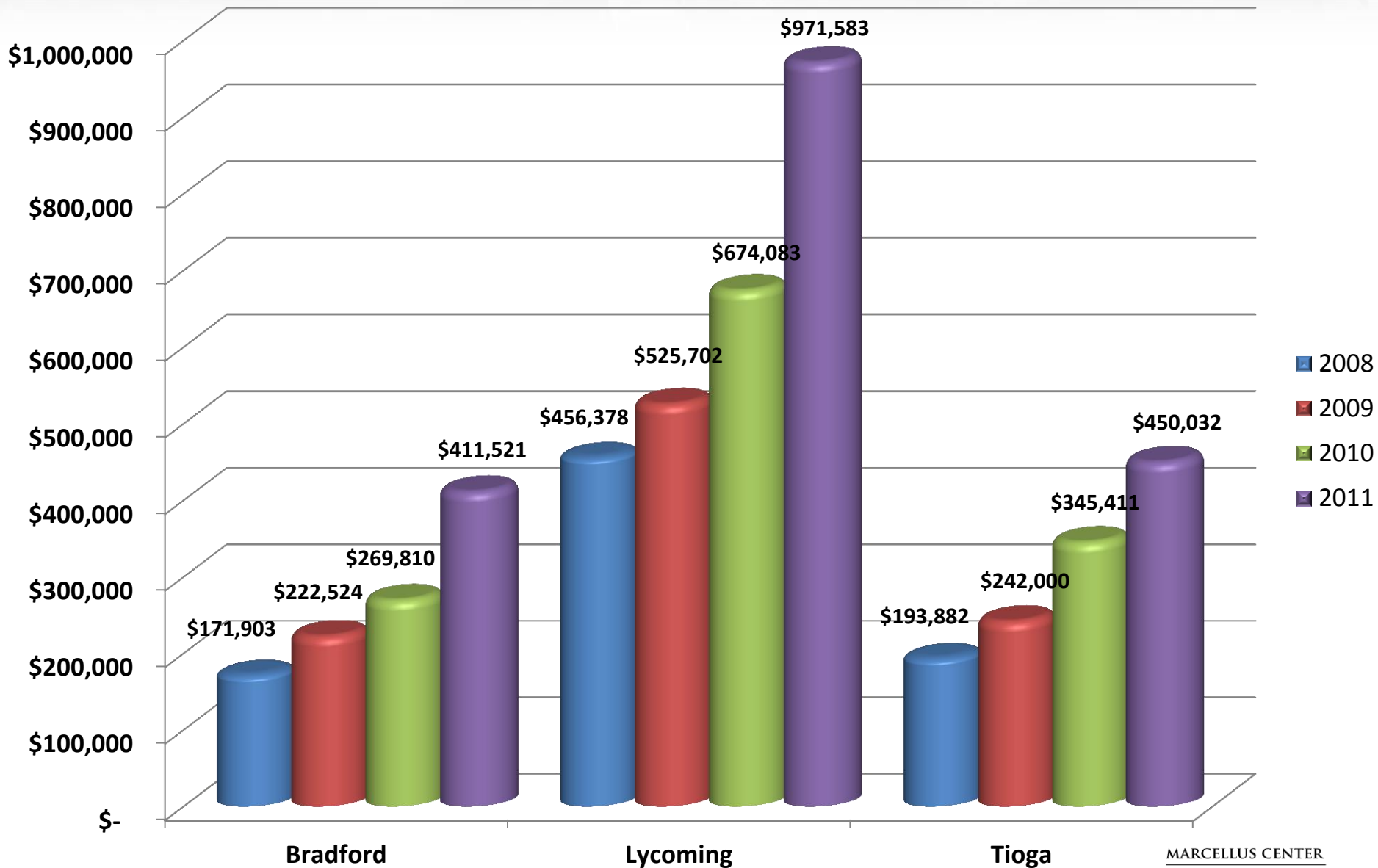


Land Use Changes

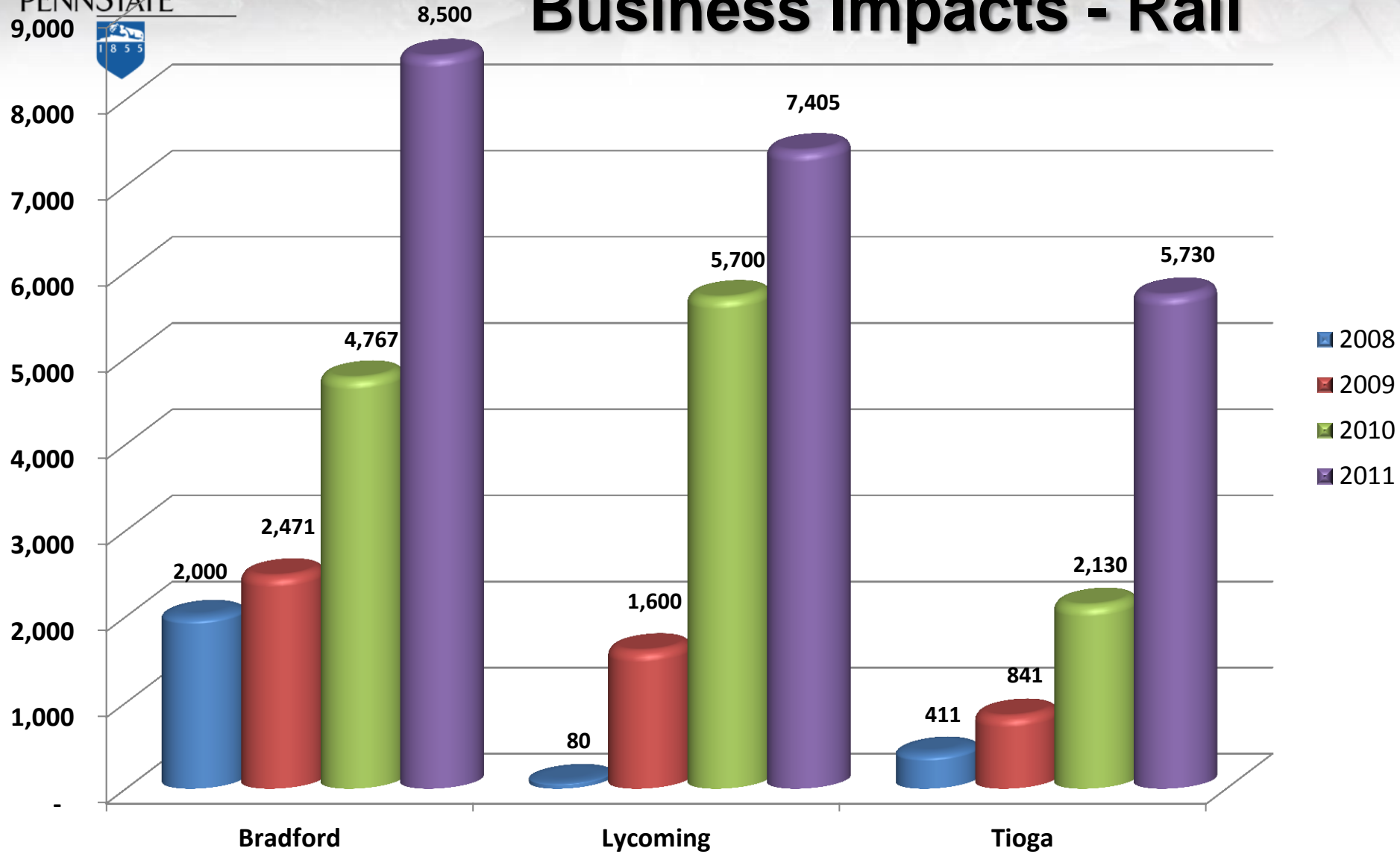


- Pipeline
 - 50K miles for gathering lines
- Agricultural use
 - workforce
- “Industrialization”
- Community wide planning
 - Sullivan
 - Westmoreland
- State Forest
 - Wild lands
 - Wildlife habitat
 - Timber resource
 - Certification
- Terminal use of property
- Aesthetics
 - Impact to tourism
- Traffic
 - Mitigation??

Business Impacts Hotel Tax

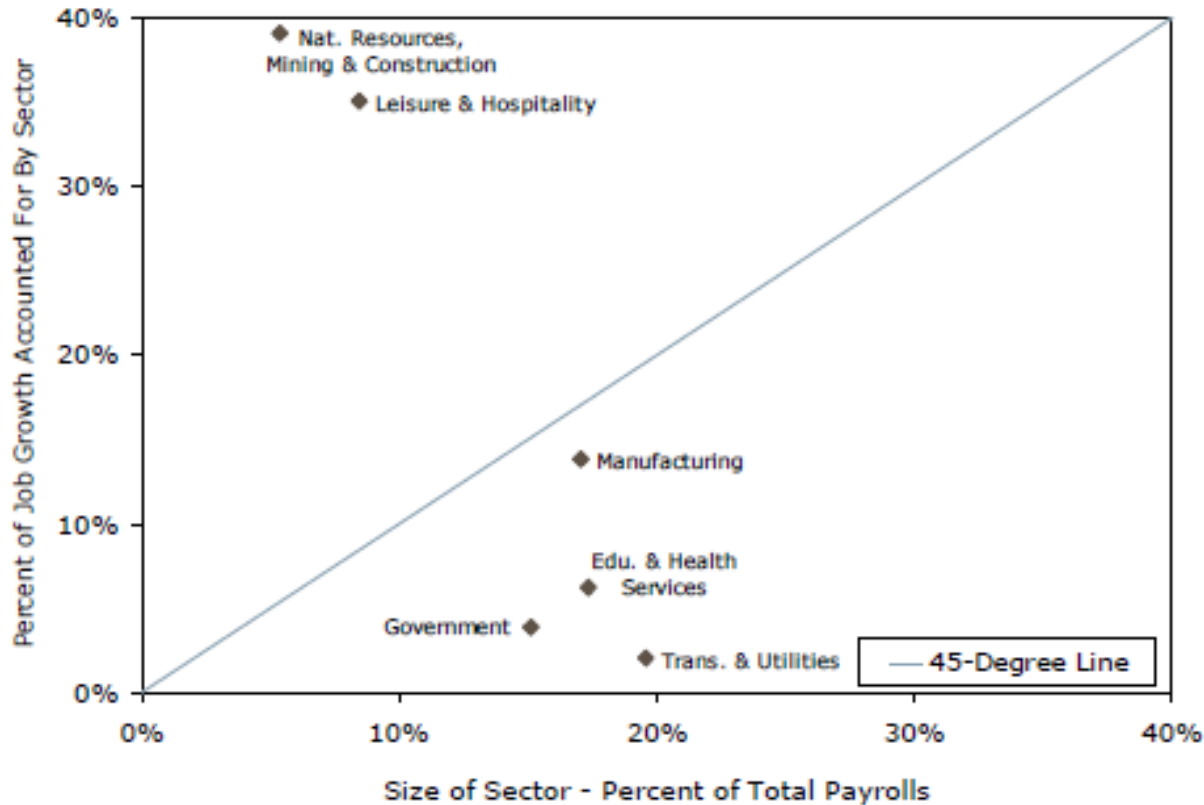


Business Impacts - Rail



Williamsport Employment Growth By Sector

Percent, Since Feb. 2010 Trough, As of Dec. 2011



Source: Wells Fargo
Economic Advisory 3/12



- **Web Resources:**

- www.marcellus.psu.edu
 - www.msetc.org
- www.naturalgas.psu.edu



Cross-Section of Typical Horizontal Marcellus Well

24" conductor casing (brown) is installed up to 50 feet deep and cemented (grey) to the surface.

20" casing is installed through the 24" casing and continuing up to 500 feet deep. This casing is cemented to surface to isolate and protect near-surface groundwater.

13 3/8" casing is installed through the 20" casing and continuing up to 1000 feet deep. This casing is also cemented to the surface to protect the groundwater aquifer from the gas well.

5 1/2" casing continues down and is turned laterally into the Marcellus formation at a depth of 5000 to 9000+ feet below the surface.

Fresh groundwater zone up to 1000 feet deep

Vertical portion of well

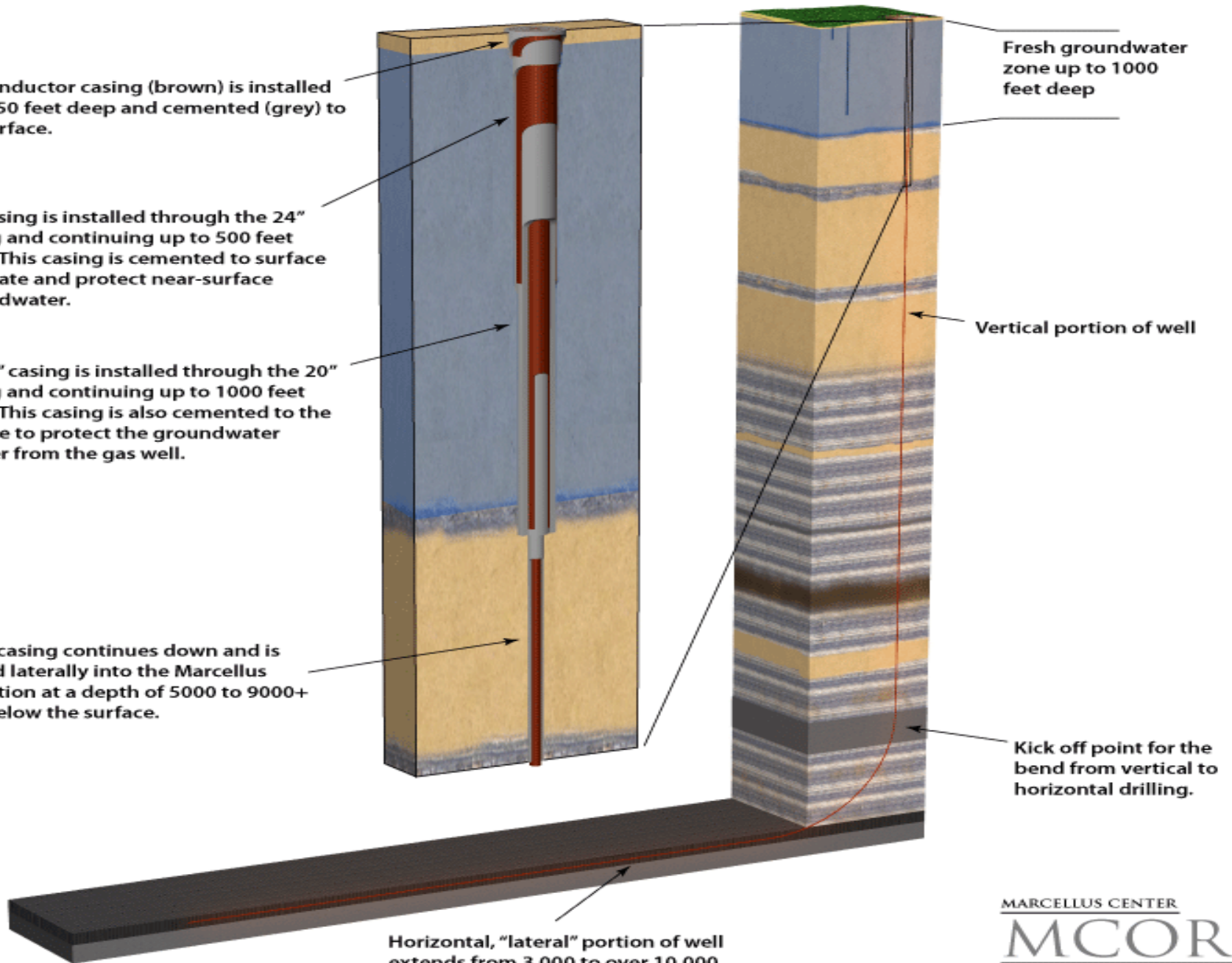
Kick off point for the bend from vertical to horizontal drilling.

Horizontal, "lateral" portion of well extends from 3,000 to over 10,000 feet within Marcellus formation.

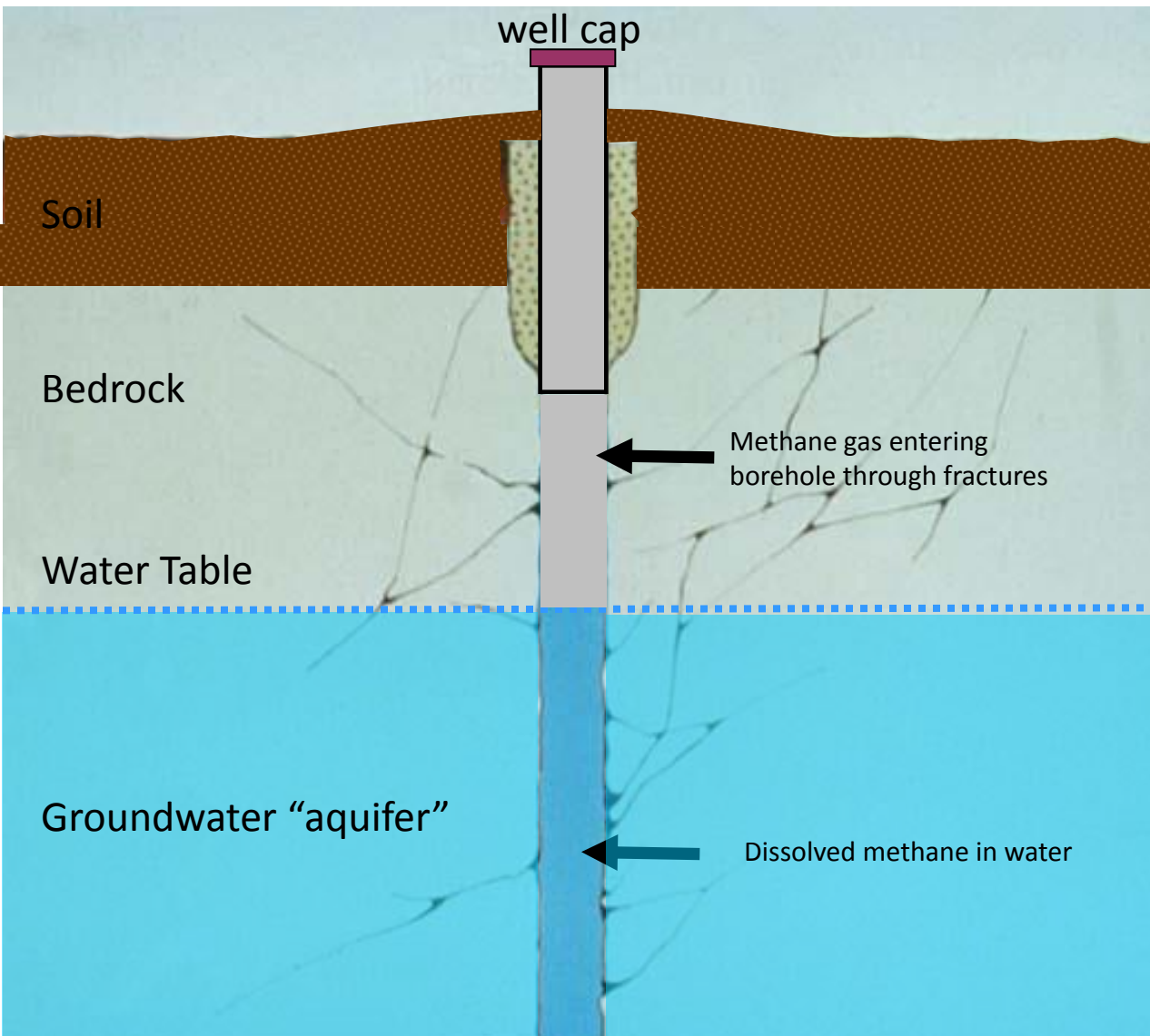
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Methane in Water Wells



- Can be naturally occurring or from gas drilling
- Pumping water can release dissolved methane by lowering pressure
- No drinking water standard or uniform testing method. Levels above 28 mg/L of great concern.
- Pre-existing detectable methane may occur in ~20% of water wells but most are below 1 mg/L.



Groundwater Protection





Groundwater/Pad Protections



Later Stages of Site Work





Start of Drilling





Well Site in Operation



Roughly 200 tanker trucks deliver water for the fracturing process.

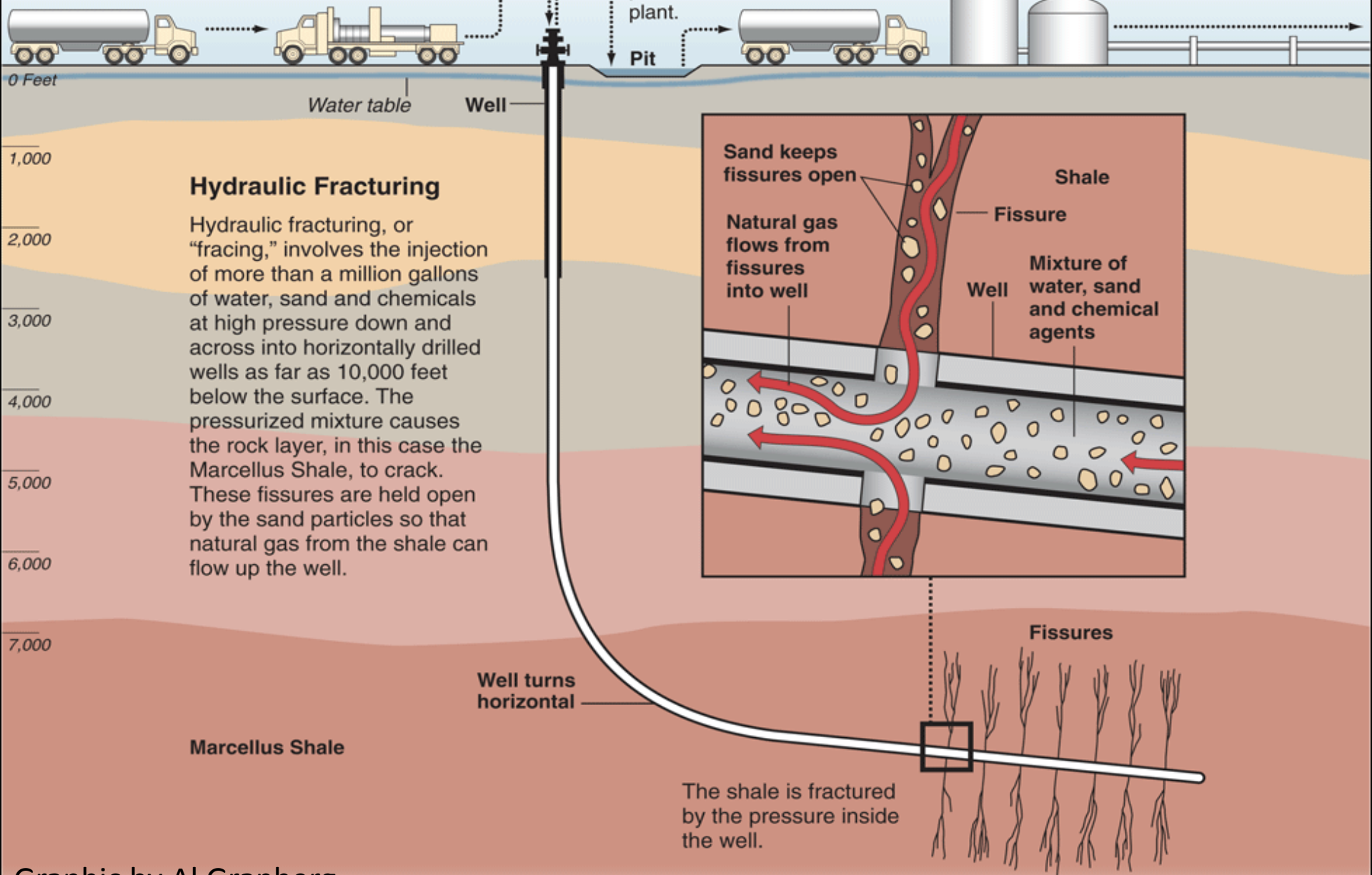
A pumper truck injects a mix of sand, water and chemicals into the well.

Natural gas flows out of well.

Recovered water is stored in open pits, then taken to a treatment plant.

Storage tanks

Natural gas is piped to market.



Hydraulic Fracturing

Hydraulic fracturing, or "fracing," involves the injection of more than a million gallons of water, sand and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.

Sand keeps fissures open

Natural gas flows from fissures into well

Shale

Fissure

Well

Mixture of water, sand and chemical agents

Well turns horizontal

Marcellus Shale

Fissures

The shale is fractured by the pressure inside the well.



Hydraulic Fracturing Process





Infrastructure Completion





Gathering Line Connection





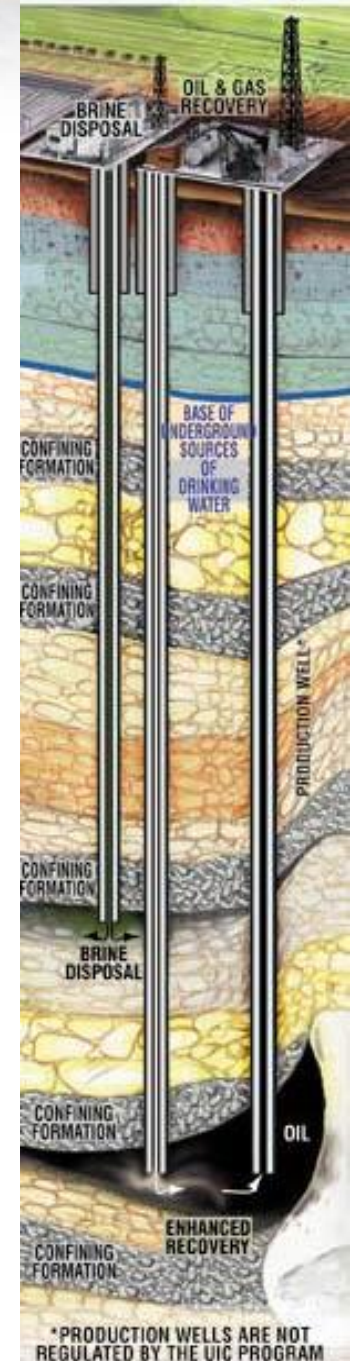
Site Renovation





Wastewater Options

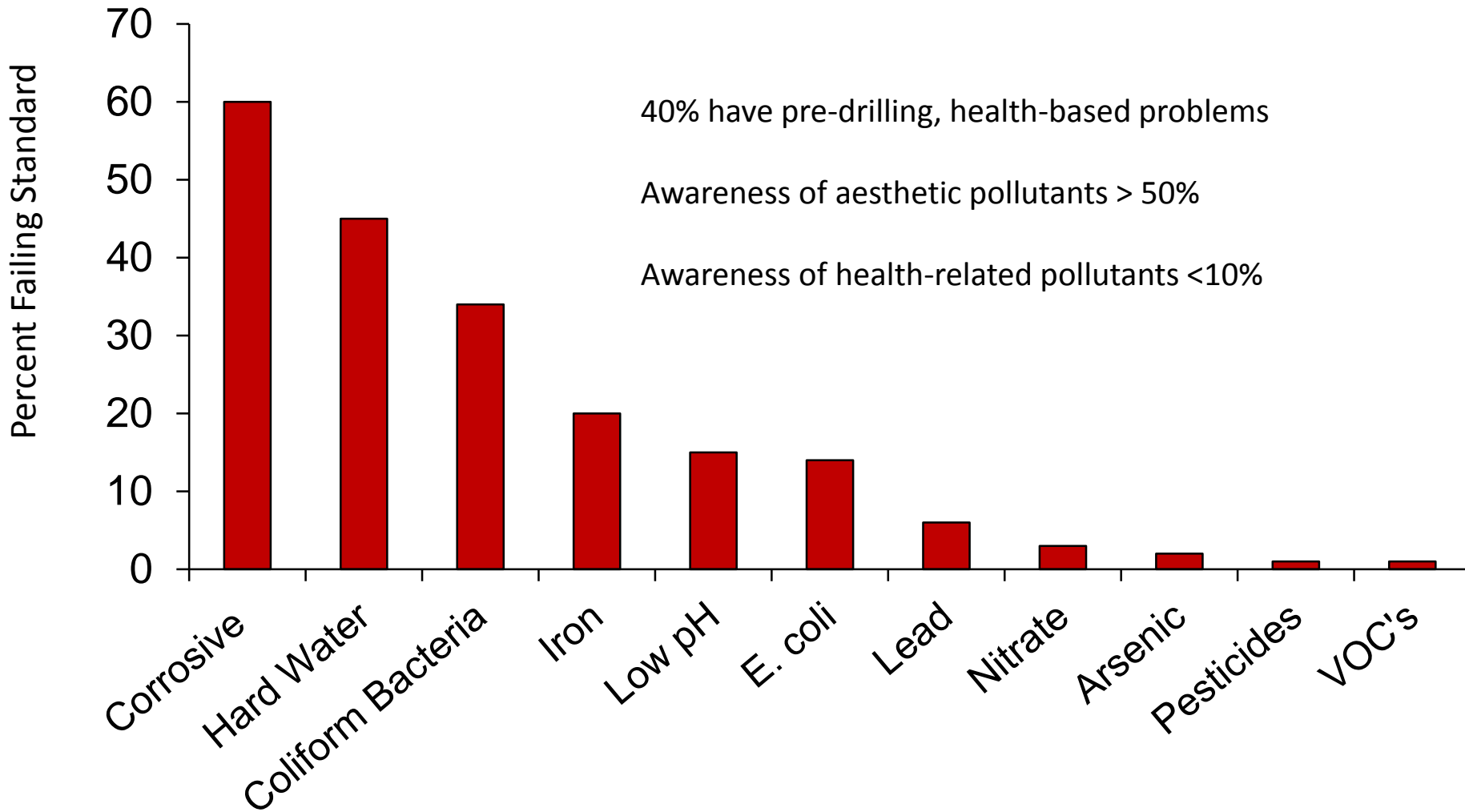
- 5 million gallons per well, 10% return
- Conventional treatment
 - Low cost, salt remains, limited in PA
- Deep injection wells (mostly OH and WV)
 - Limited by geology and orphan wells
- Advanced treatment (crystallization, membrane filtration, etc)
 - \$\$ but produces very clean water for re-use or discharge
- Reuse / recycling
 - Direct re-use of early flowback water
 - Re-use with dilution
 - Re-use with minimal treatment and dilution
 - Direct re-use after advance treatment





Pre-Drilling Problems are Common

(2006-07 survey of 701 water wells)



Impact of Marcellus Gas Drilling on Rural Drinking Water Supplies

- Five Penn State project coordinators
- Funded by the Center for Rural Pennsylvania (a legislative agency of the Pennsylvania General Assembly) and the Pennsylvania Water Resources Research Center at Penn State University

Objectives:

- Provide an unbiased and large scale study of water quality in private water wells both before and after the drilling of Marcellus gas wells nearby.
- Document both the enforcement of existing regulations and the utilization of voluntary measures by homeowners to protect water supplies.



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