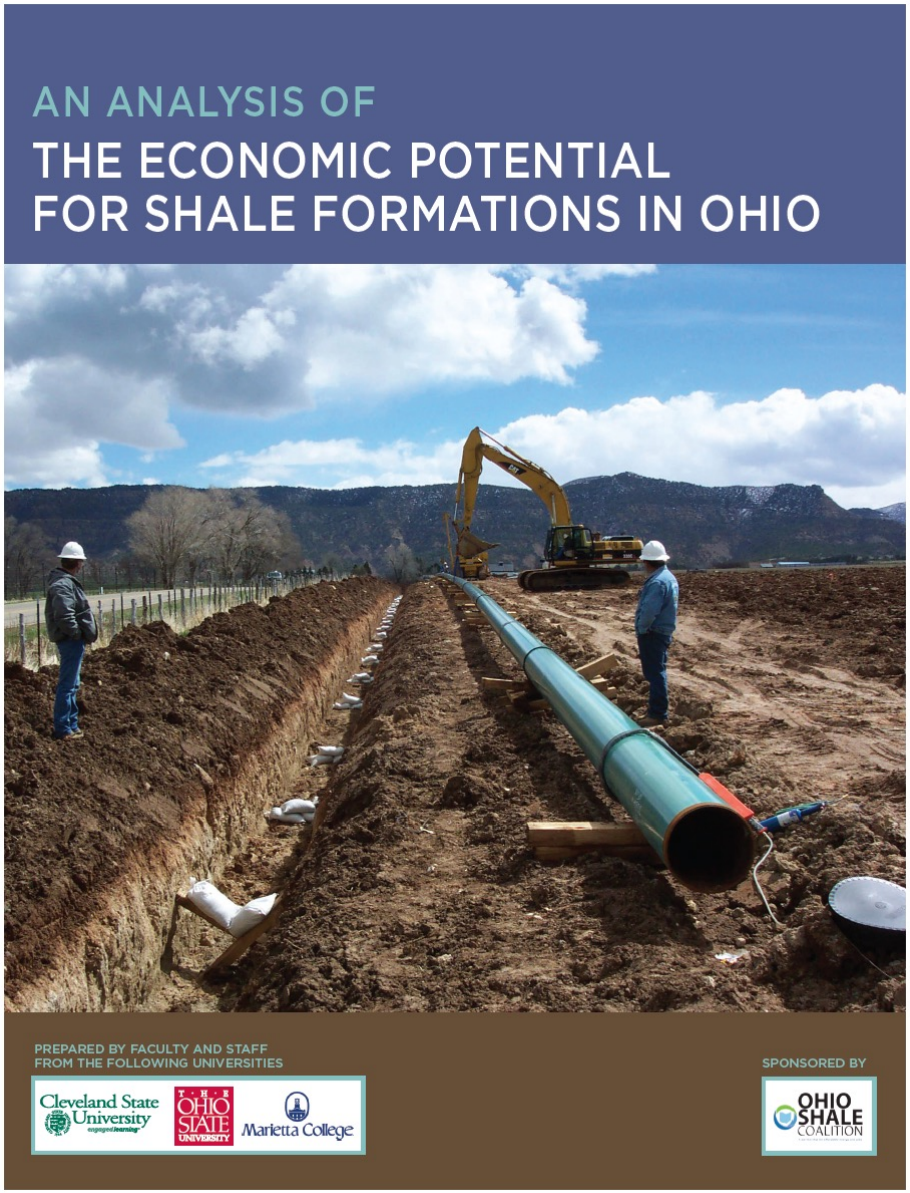

Geopolitical and Economic Trends in Response to Shale Development

Andrew R. Thomas
Energy Policy Center
Cleveland State University

Energy Law & Policy
November 2013

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November

- 11/4 Oil and Gas Policy/Ken Alfred
- **11/6 Shale Revolution**
- 11/11 Fuel Cells/Pat Valente
- 11/13 Transportation Policy/Jim Halloran
- 11/18 Alternative Fuels/Joe Degenfelder
- 11/20 Nuclear Power and Energy Storage
- **11/25 Economic Development/Iryna Lendel**
- 11/27 Individual Meetings on Research –
  - » **Please Schedule in advance**

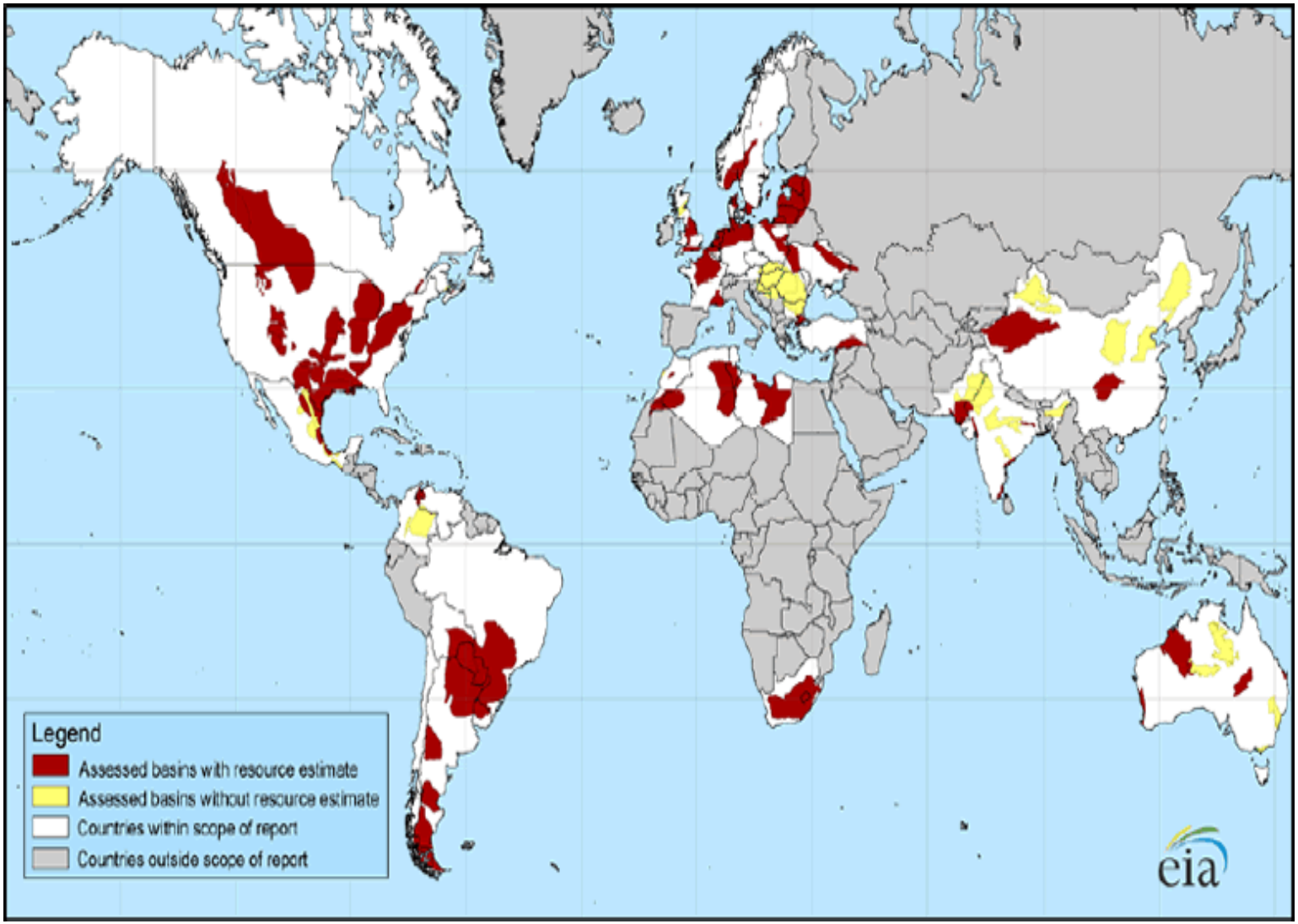
December

- 12/2 Student Presentations
  - Elizabeth, Terence
  - All research papers due
- 12/4 Student Presentations
  - Candace, Allan & Christine
- Dec 9 Make up date
- Dec 14 Grades Due

The Shale Gale

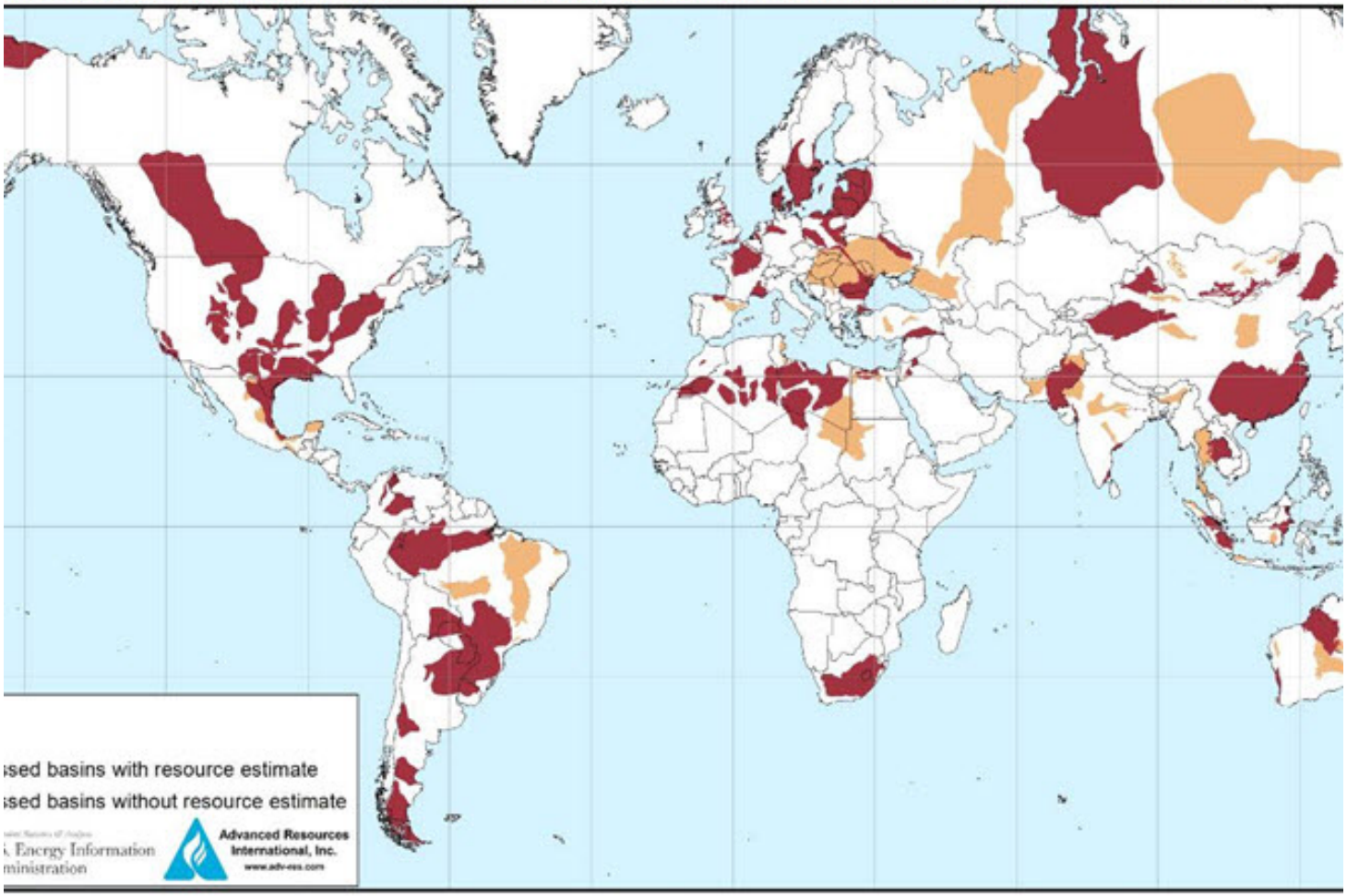
- Estimated US Shale gas reserves: 862 TCF
  - Energy Information Agency 2012
- Locally: Marcellus 50 TCF; Utica 15 TCF
  - Shale gas creates surge in NG supplies
  - Electricity: shift from coal to natural gas
  - Transportation and home heating: shift from oil to natural gas
- Geopolitical shift of wealth
  - Toward N. America
  - But for how long? Where else?
    - Driver of value is natural gas infrastructure
    - But organic shale available in all oil and gas regions -- and markets are emerging.

World Shale Formations 2011

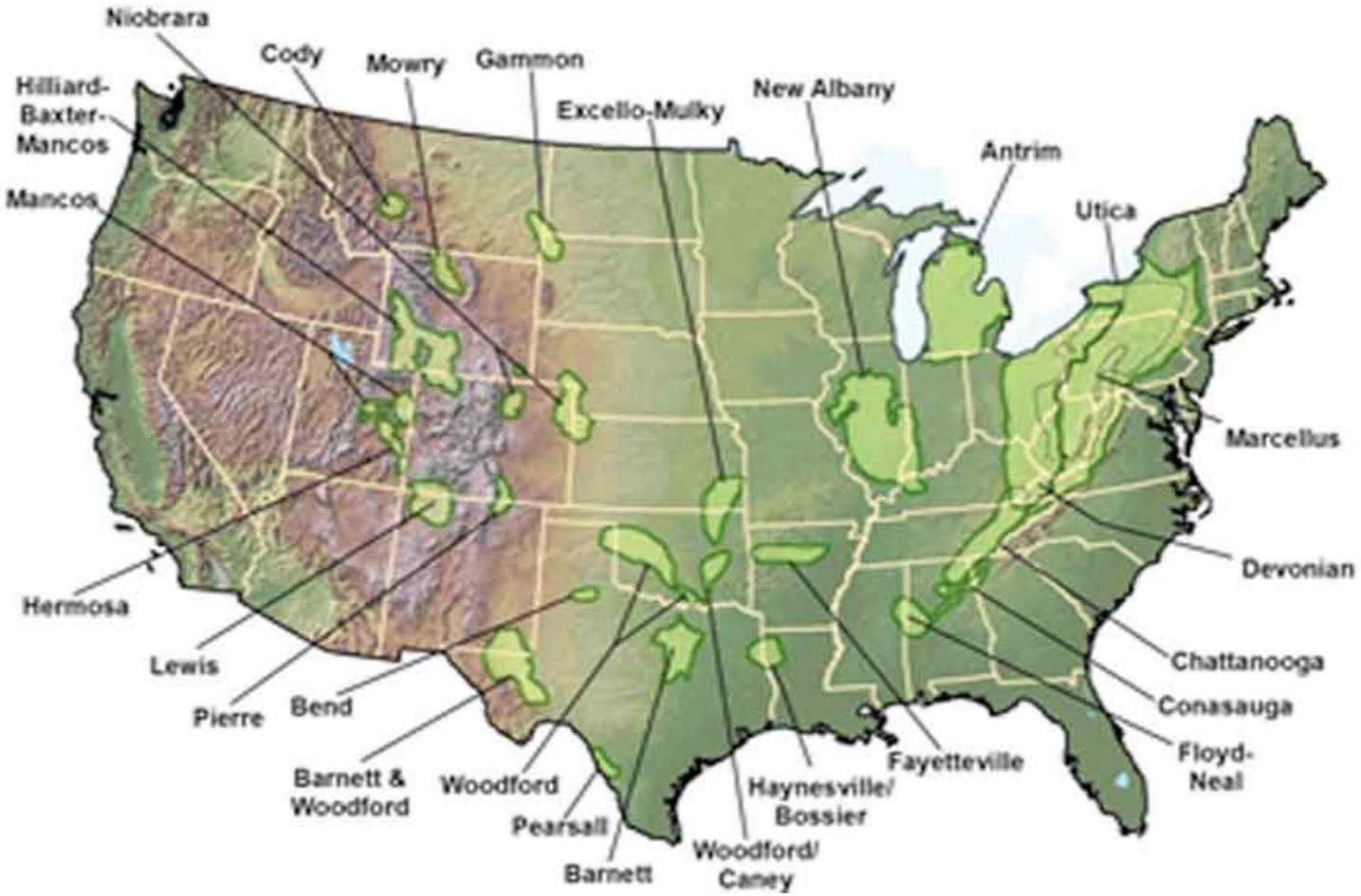


World Shale Formations -- 2013

.. Map of basins with assessed shale oil and shale gas formations, as of May 2013



ited States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on dat
blished studies.



Location of Gas Shale Plays (Source: DOE)

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Marcellus and Utica

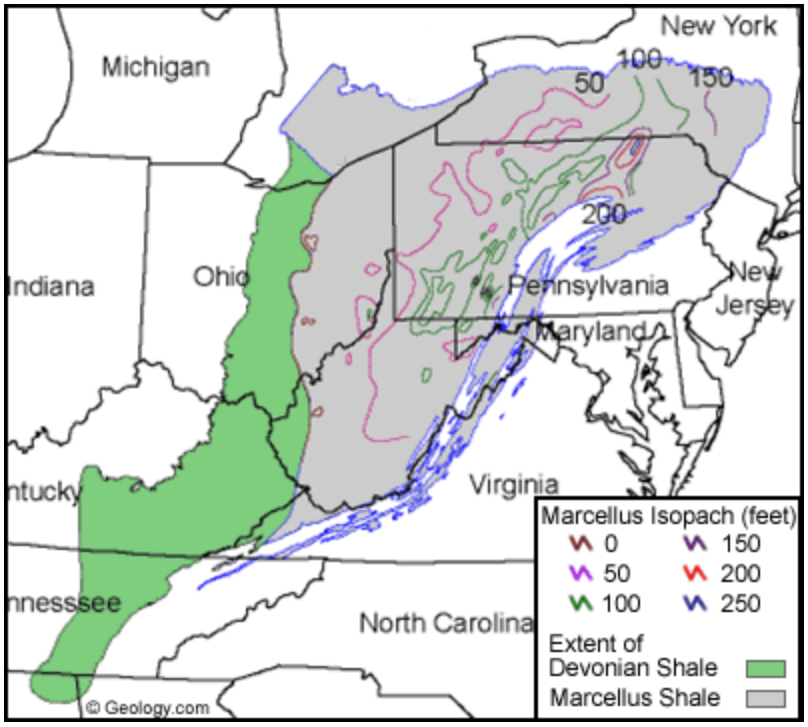

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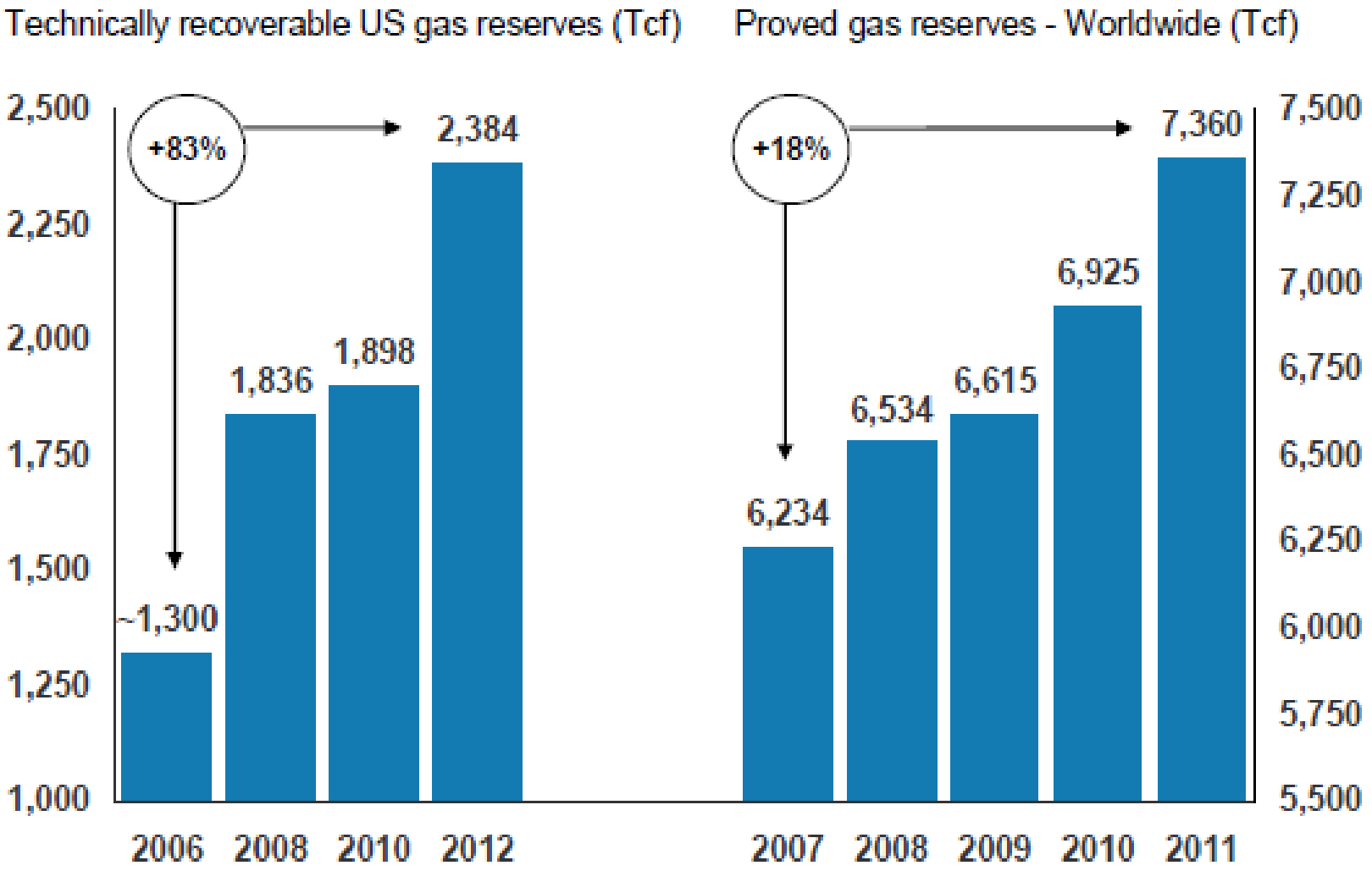
Exhibit 1

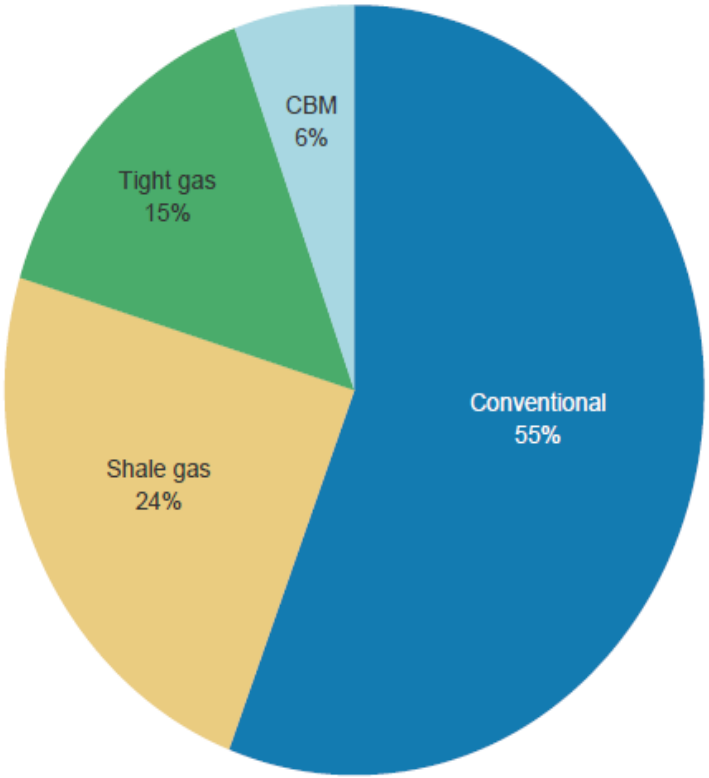
Global gas reserves have risen sharply …

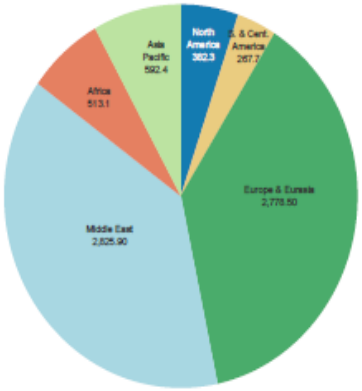


Source: Potential Gas Committee, BP Statistical Review of World Energy

Natural gas reserves and consumption - worldwide

Tcf





Technically recoverable

~28,000 tcf

Proved reserves

~7,360 tcf

Annual consumption

~114 tcf

Source: Wood Mackenzie, BP Statistical Review

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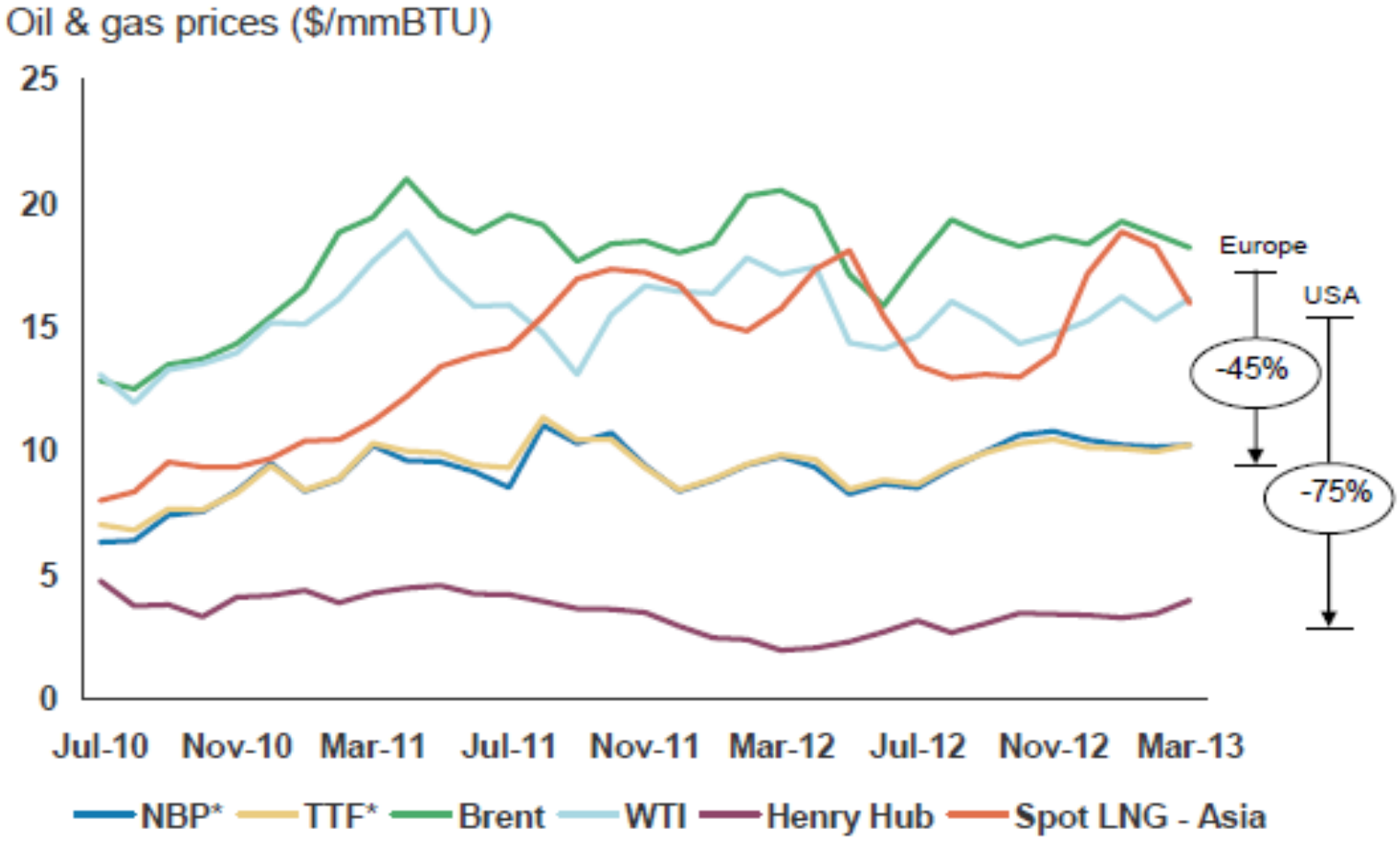
Exhibit 2

… leaving gas at a discount in Europe and the US



* Month ahead

Source: Thomson Reuters, Datastream

Science Saves the Oil Industry

- New technology in exploration
  - Advent of 3D seismic acquisition
    - Reduce risk of failure by 50%
    - Direct detection of hydrocarbons
  - Deep water platform technology
  - New drilling techniques
    - Real time drilling
    - High pressure and subsalt drilling
    - **Horizontal drilling**
  - Improved/advanced recovery techniques
- New Recovery Strategies
  - **Fracturing impermeable reservoirs**
  - *Hydraulic fracturing is not a new technology*
    - But how it is being used is new.

Challenges for Shale Production

- Expensive
  - Victim of own success – depressed natural gas prices
- Takes long time to drill and produce
- Steep decline rates
- Requires large volumes of fresh water
  - Around 5 mm gallons per well
- Fracturing has become controversial
    - Alleged groundwater contamination.
      - Fracturing and drilling chemicals
      - Natural gas leaks
    - Surface pits, flow back water storage, disposal.
    - Increased seismic events?

Advantages to Shale Production

- Predictable costs
- Success rate is extremely high – around 98%
- Shale basins located close to markets
- More environmentally benign than coal mining or tar sand development

Legal Issues

- Regulatory
  - Senate Bill 315 – May 2012
    - Chemical disclosure for fracking fluids.
    - Appeal procedure for mandatory pooling.
    - Road Use & Maintenance Agreements.
- Litigation
  - Strict Liability – pending case law.
    - Abnormally dangerous/ultra-hazardous activity
  - Implied Covenants
  - Methane emissions.
    - EPA setting rules in 2015
    - Some states mounting legal challenge to delay

Tax Issues

- Severance taxes
  - Current: $0.03/mcf; $0.20/bbl; NGL's: ??
  - Current proposal from Kasich:
    - 4% of value on gross proceeds (1.5% first year)
    - Specifically includes natural gas liquids
    - Horizontal wells only
- Commercial Activity Taxes
  - Applies only if production sold or consumed intrastate. Effect on midstream activity?
- Property taxes
  - Ad valorem – based on reserves in ground
  - Surface & Buildings – no direct tax increase
    - But can increase be avoided?

Environmental Issues

- Drawdown on aquifers – *not issue for Ohio*
- Handling and Disposal of Wastewater
  - Produced Brine and flow back fracturing fluids
  - Spills – spotty industry record
  - Injection – earthquakes?
- Migration of Fluids Into Water Table
  - 2/3 of hydraulic fracturing fluids do not return
    - What do we know about migration paths?
  - Gasland Problem: Natural gas in water table separate issue
- Air Emissions
- Handling and Disposal of Hazardous Solids
  - Problem of Naturally Occurring Radioactive Materials (NORM) and TENORM

"World Class Oil Field on a Collision Course with World Class Farmfields"
Western Reserve Land Conservancy

- Less concerned about:
  - Well pads – better than traditional drilling
  - Fracking process – well known and regulated
  - Acquifer contamination – too deep
- More concerned about:
  - Hapharzard infrastructure construction
  - Mancamps
  - Reduced appreciation for the land

Ohio Senate Bill 59 – 9/2013

- Quarterly production statements
- TENORM regulation
- Prohibits spreading of brine from horizontal wells on roads
- Permitting process for
  - Treatment, storage of brine
  - Recycling facilities for brine
    - Effective January 1, 2014

Federal Regulation

- Scope of 2012 EPA Study
  - Covering the entire fracking process from obtaining water through injection to recovery and disposal
  - Case studies: gather data from fracking sites
    - Cement logs/completion details
    - Logs and production data
    - Well design, location and size
    - Revisit completed sites
    - Monitoring wells/flow modeling
  - Initial results due by the end of 2012
- Resistance by some states—North Dakota, Texas
- Question: if states address concerns, will EPA still act?

"The Truth About Fracking"

- Single fracturing of deep shale formations should be benign.
- Well sites with multiple factures has increasing risk for contamination of drinking water with each fracturing event.
- Advanced tests, such as tracer chemicals in the well, could prove definitely whether fracturing is safe.
  - C. Mooney, *Scientific American*, November 2011

John Hanger – PA EPA Chief – Advice to Other States

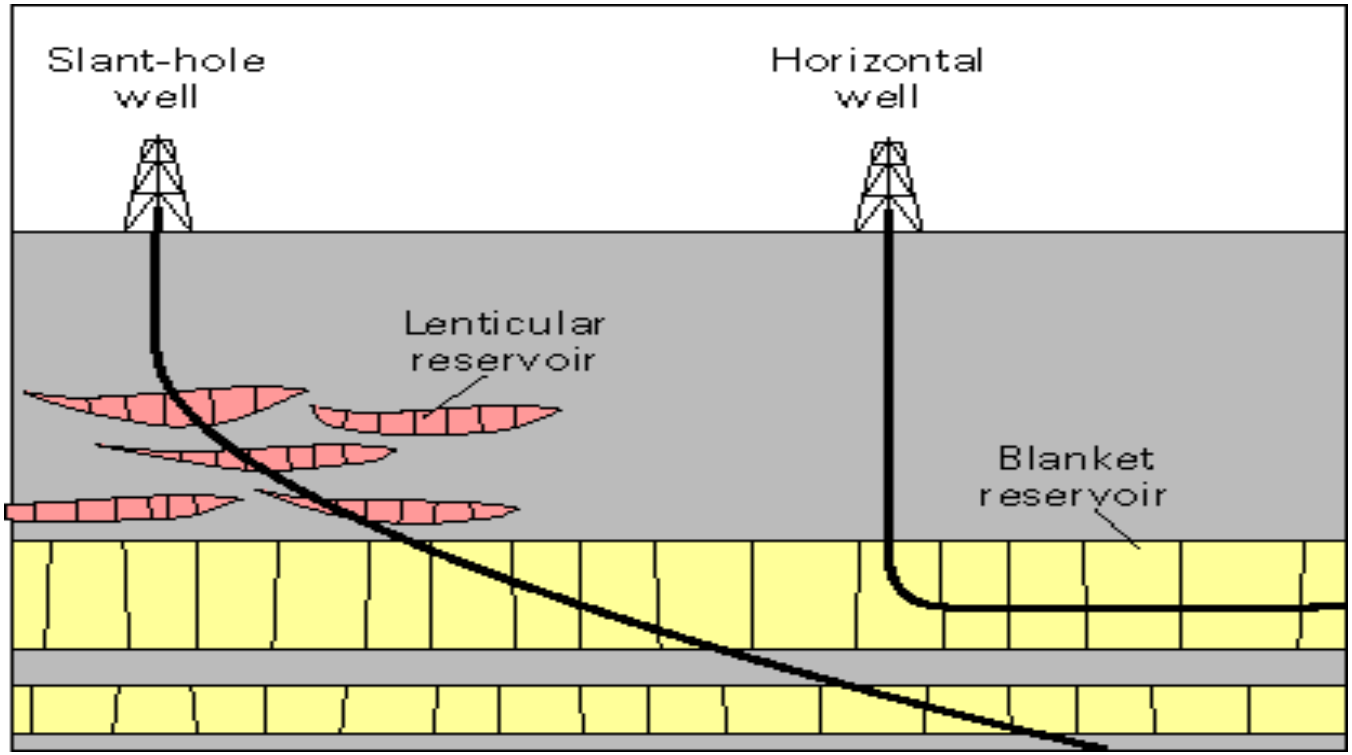
Believes that regulations in place can control problem of fracturing. But States with Shale plays must:

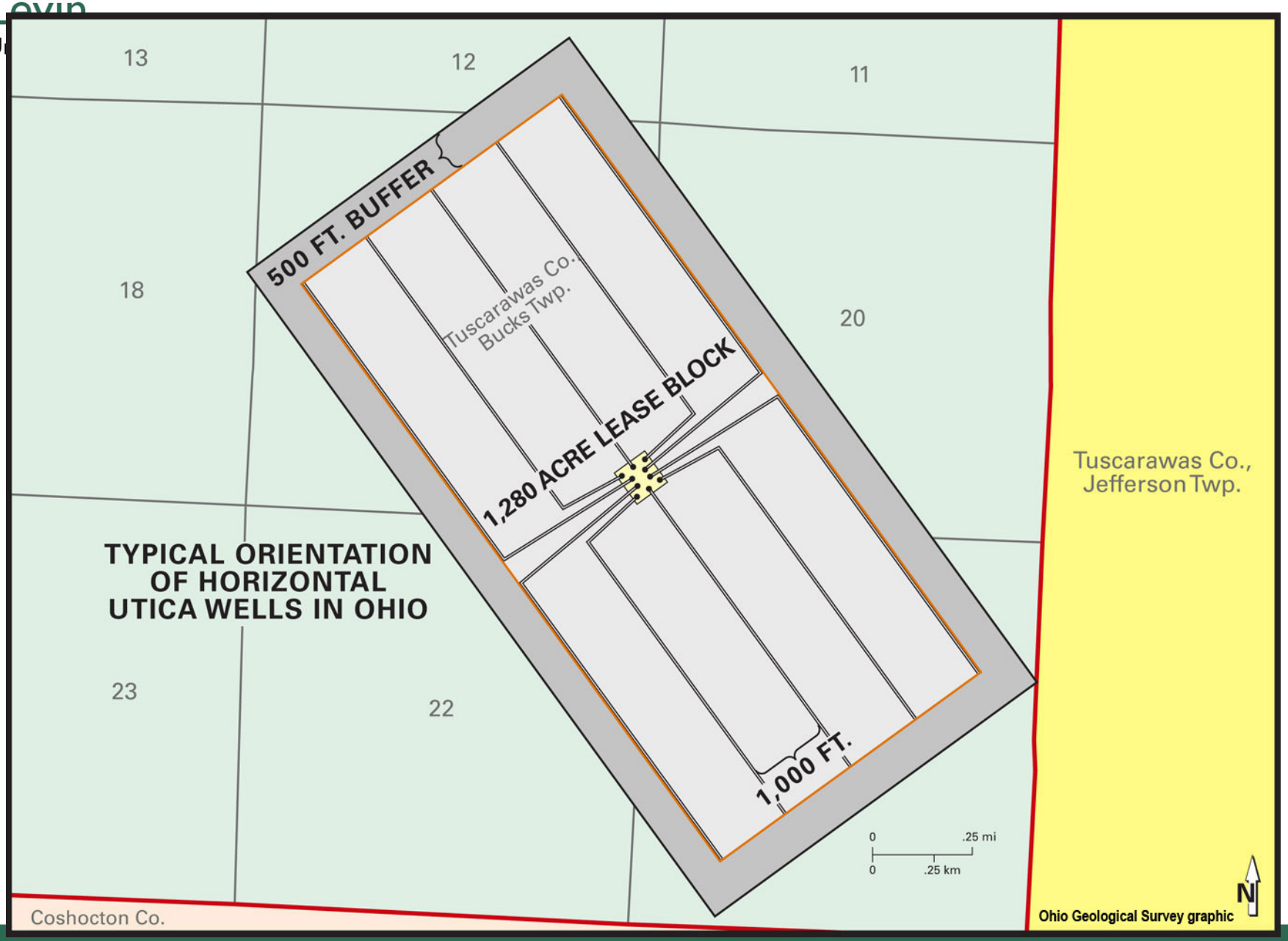
- Have adequate staff.
- Enforce your rules.
- Send message from political leadership to Industry that rules will be enforced.
- No cozy relationships between regulators and regulated.

John Hanger on the MMS

- **Should the federal government regulate fracturing?**
- "I laugh when people ask that question because, basically, if the BP oil spill showed anything, it's that you can't rely on the federal government to regulate the oil and gas industry. The Minerals Management Service was completely captured by the industry."

Horizontal Drilling




13
12
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22
500 FT. BUFFER
Tuscarawas Co.,
Bucks Twp.
1,280 ACRE LEASE BLOCK
1,000 FT.
TYPICAL ORIENTATION
OF HORIZONTAL
UTICA WELLS IN OHIO
Tuscarawas Co.,
Jefferson Twp.
Coshocton Co.
0 .25 mi
0 .25 km
N
Ohio Geological Survey graphic

Hydraulic Fracturing – the Basics

- Problem: some rock formations are "tight"
  - Filled with oil and gas but neither flows to a well
  - Typically shale—lots of porosity/no permeability
  - Hydrocarbons flow along cracks in the rock
- Solution: artificially-created cracks to let gas flow
  - Horizontal drilling in target formation
  - Charges set in drainpipe create initial fractures
  - Injection of fracing fluid/proppants at high pressure
  - Fluid pumped out – proppants hold open cracks

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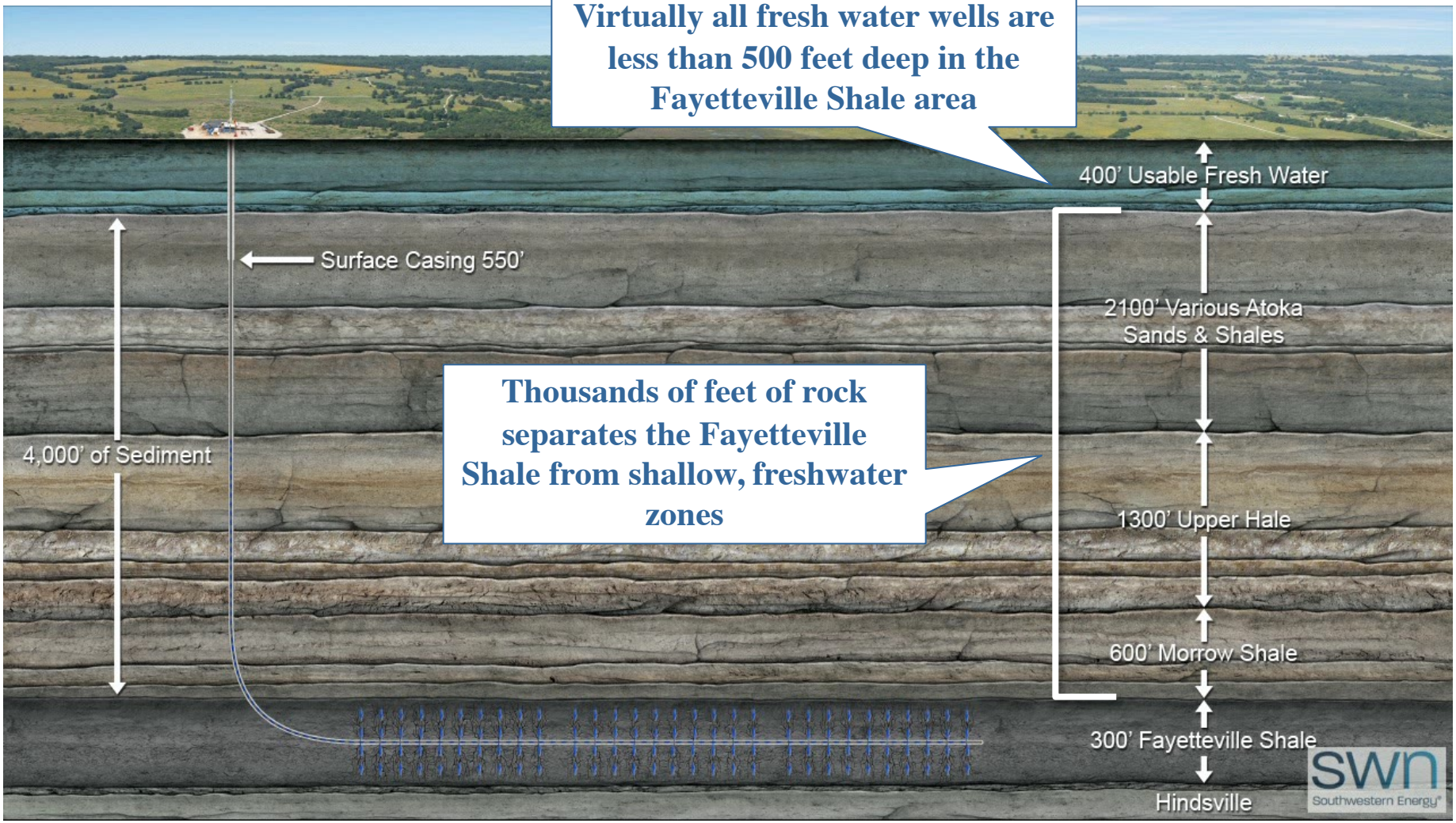
Evaluating Stratigraphic Confinement



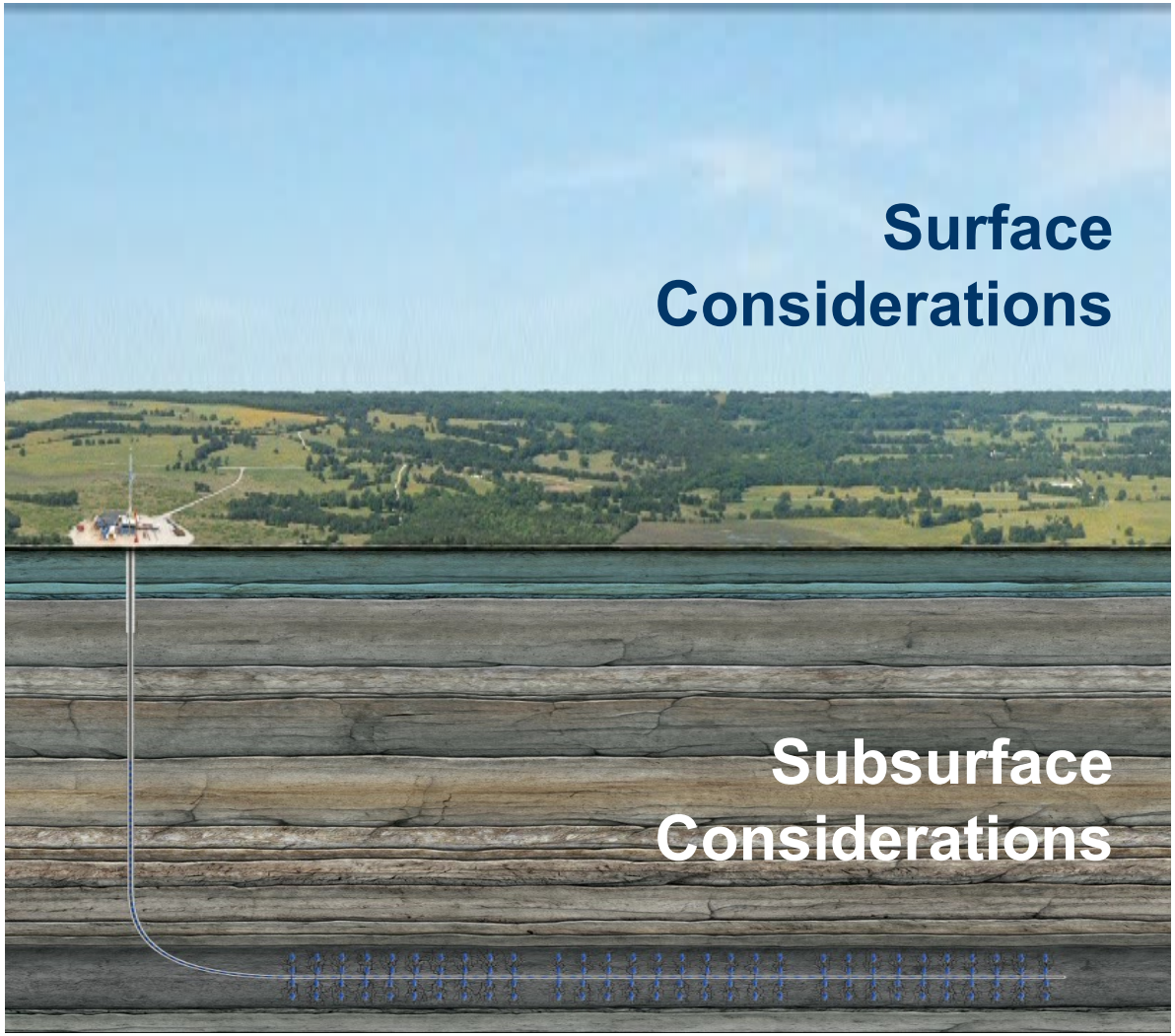
Cross sectional view

Fracking Operations

Basic procedure:

- Hydraulic fluid, sans proppant, pumped into target formation
  - Pumped at about 100 bbl/minute; Pressure: around 14,000 psi
  - Pressure tests conducted to check for leakage into neighboring formations
- Proppant added to mix
  - Proppant—sand, ceramics, wire mesh, sintered bauxite
  - Proppant carried into fractures—designed to hold the fractures open for flow
- Flushing the reservoir
  - 20-50% return—although anecdotal data from industry says 80% or more
- Produce the gas normally thereafter
- Total amount of fracking fluid use per well in the Marcellus: 1-5 million gallons (Michele Rogers, PSU College of Ag. Science)

Environmental Considerations



- Air Emissions
- Water Supply/Water Handling/Water Disposal
- Surface Impact
  - Drilling Locations (Pit Construction; Chemical Storage; Erosion Control)
  - Infrastructure (Roads; Compressors; Pipelines; Water Treatment Facilities)
  - Truck Traffic and Road Damage
- Protecting Underground Water Resources
- Frac Fluid Disclosure

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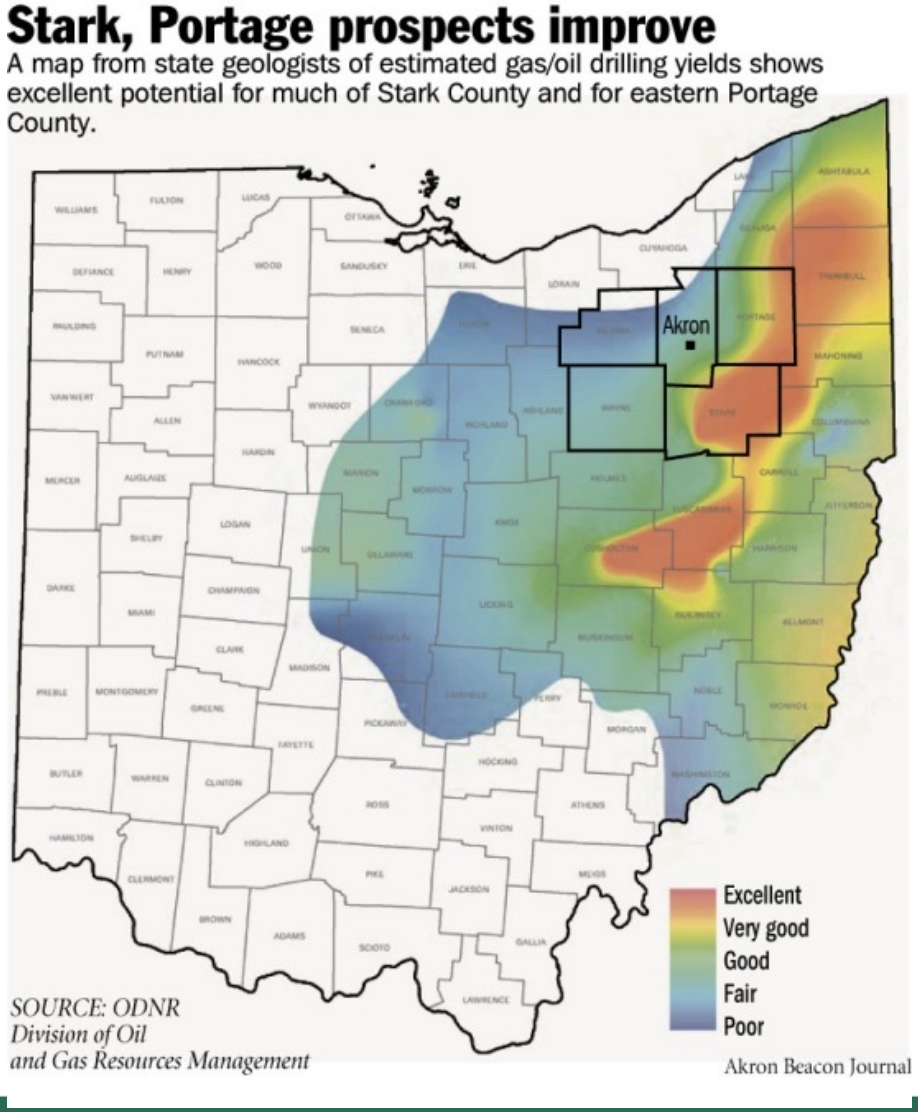
Utica Shale Recoverable Reserve Projections in Ohio

- USGS:
  - 940 million barrels of oil
  - 208 million barrels of natural gas liquids
  - 38 Trillion cubic feet of gas
    - Source: USGS October 2012
- ODNR:
  - 5 Billion barrels of oil
  - 15 Trillion cubic feet of gas
    - Source: Ohio Geological Survey January 2012

Ohio Geological Survey Shale Map



Gulfport Energy Corp. Results

- Well in Harrison County
- Flow test results (daily production)
  - 432 barrels condensate
  - 110 barrels
  - 17 MMCFD natural gas
- Estimated anticipated production rates
  - 10 MMCFD (8.2 MMCFD with 18% shrinkage)
  - 65 Barrels NGLs
  - 254 Barrels condensate
    - Source: Gulfport 8/7 Earnings Statement
- First Year projection (assuming no decline)
  - 2.99 BCF
  - 23 MB NGLs
  - 92 MB Condensate

Current ODNR Projections 11-21-13 – Mike McCormac

- Permits
  - To date: 988
  - Through 2015: 2573
- Wells Drilled
  - To date: 606
  - Through 2015: 1830
- Wells Operating
  - To date: 184
  - Through 2015: 750

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Expected Path of Development 2011 to 2014

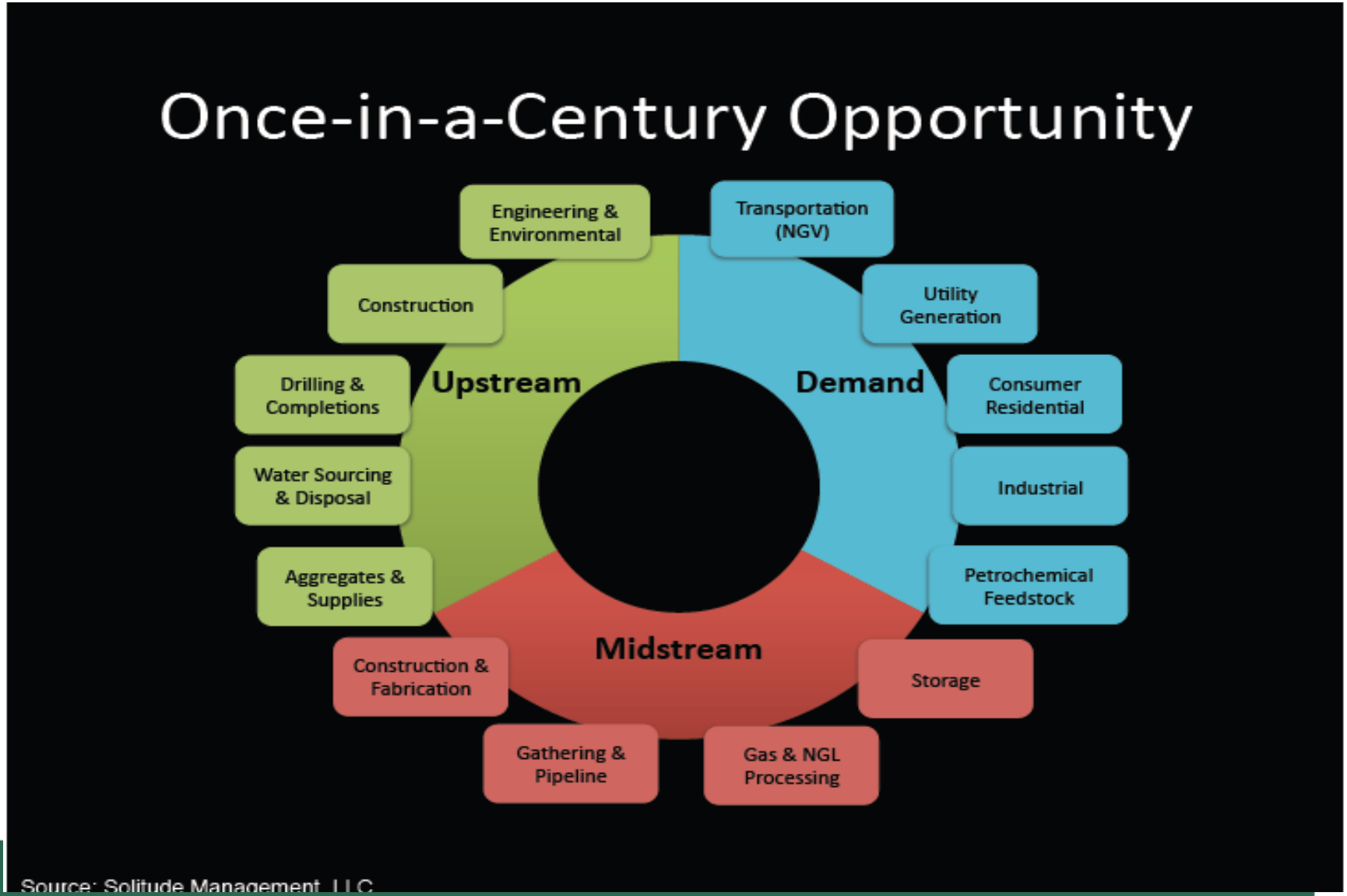
Returns from Increased Demand in Ohio Due to Utica Shale Development in 2012 dollars

	2011	2012	2013	2014
Value Added	$162,030,036	$878,982,133	$2,980,378,198	$4,857,632,095
Employment	2,275	12,150	40,606	65,680
Labor Income	$99,758,497	$571,543,463	$1,994,216,405	$3,298,757,195
Output	$291,574,770	$1,667,574,417	$5,823,268,396	$9,642,544,988
Total State and Local Taxes	$16,522,865	$73,422,148	$271,539,607	$433,528,922
Average labor income	$43,850	$47,041	$49,111	$50,225

Impact of the Utica Shale Development on Ohio's Economy

- Gross State (or Domestic) Product is expected to increase by **$4.9 billion** in 2014 due to the development of the Utica formation as an energy resource.
- This is equal to a **1%** increase in the real value of Ohio's Gross State Product – greater than the average annual growth rate in Ohio for the past 13 years (0.6%).

The Value Chain



Upstream Spending

- Drilling and Completion
  - $5.75 million per well
  - 58% of labor and material from Ohio, improving to 70% in 2014
- Road Improvements: $1.1 million per pad location.
- Lease Bonuses: $2500/acre
  - 1 million acres in 2012; 500,000 acres in 2014
- Royalties: 15%
  - $65/bbl; $3.60/mcf
  - Throughput 1 BCFD by 2014
    - Natural gas: $500,000/day in royalties!

Midstream Spending

- Post production infrastructure build out
  - Gathering pipelines – over $1 mm/mile
  - Compressors – over $300,000 each
  - Processing plants – $400,000/mmcfd
  - Fractionation plants – 36 Mbbl/d – $100 mm
  - Storage facilities – 1BCFD – $120 mm
  - Railroad terminals – 1 BCFD – $40 mm

Midstream Infrastructure

- Gathering/processing agreements
  - MarkWest agreements with Gulfport, Antero – Harrison and Noble Counties.
  - M3/Chesapeake agreement – 800 BCFD throughput.
  - Dominion/Caimen -- $1.5 B joint venture
  - NiSource/Hilcorp $300 mm joint venture
  - Spectra-DTE plans for $1.9 B pipeline
- Fast enough to keep pace with drilling?
- Northeast will have infrastructure constraints by 2015 – Oil & Gas Journal

Gathering Line

Compressor

Processing Plants

Opportunities for Ohio Industries

- Pad construction – location liners, limestone, pits, dikes, roads, etc.
- Water – for drilling and fracturing
- Mud – bentonite and barite clay
- Steel pipe (casing)
- Cement (conventional cements not acceptable)
- Sand – clean, well-sorted 20-40 mesh in particular
- Steel tanks, separators, metering equipment, production equipment, etc.
- Compressors
- Pipelines
- Treatment facilities for NGL's, water, and impurity removal

Near Term Development Strategy: Wet Gas Corridor

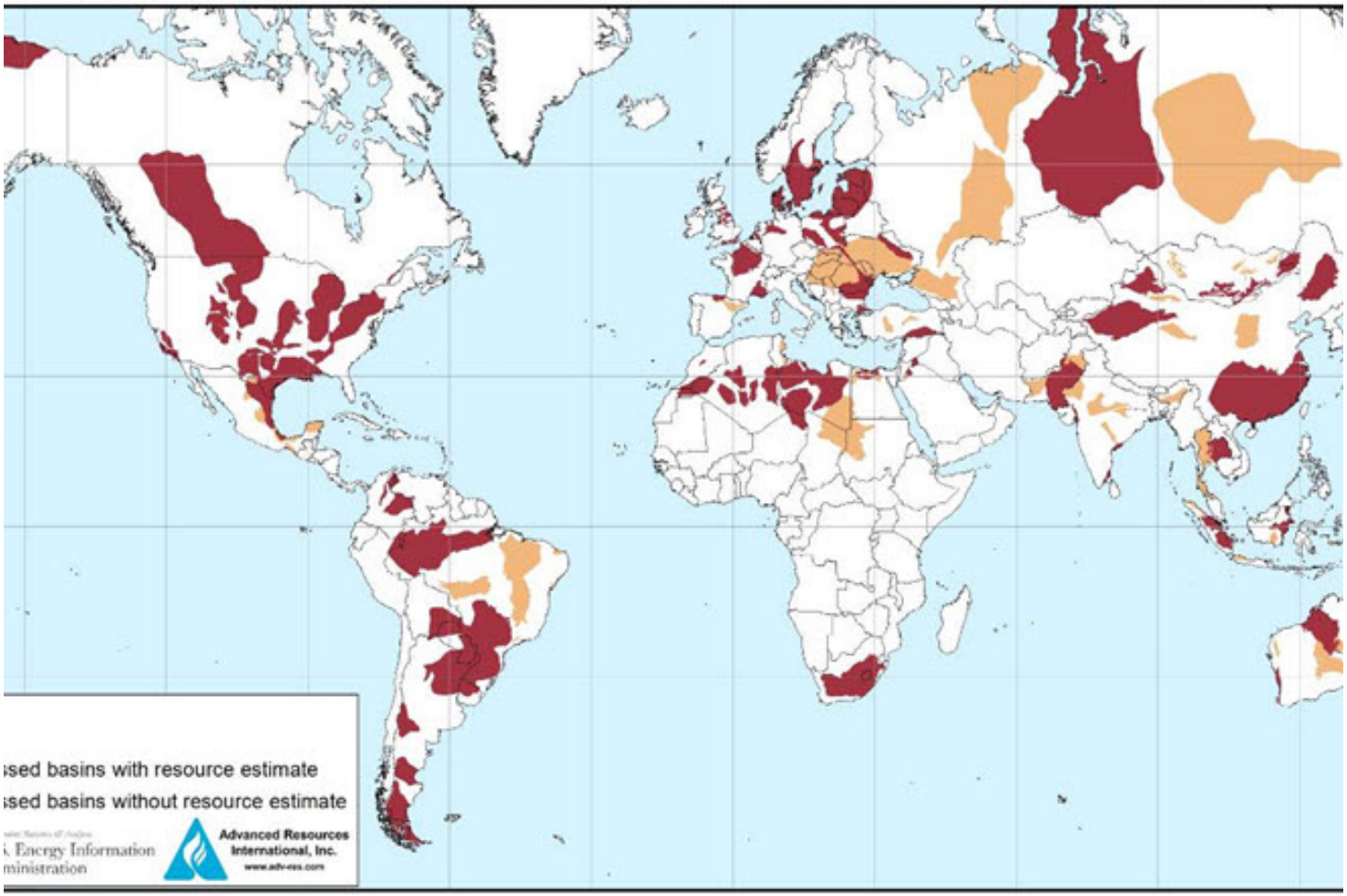
- M3 Midstream: 90% Internal Rate of Return in "wet" portion of Utica.
  - Best rate of return of any shale play in the United States.
- "[W]ith results from each well we test, it's becoming increasingly apparent that the Utica is a prolific shale play…."
  - James D. Palm, Chief Executive Officer, Gulfport Energy Corporation, 11/7/2012

Shale and Pipeline Politics

- Historical stranglehold Russia has on eastern Europe is threatened
- But is Siberia the next shale giant:
  - 570 mm acres – 80 times larger than Bakken
  - Early wells: 400 barrels/day – comparable to Bakken
  - Current estimates are between 18 and 2000 billion barrels of oil.
    - Forbes Magazine June 2012
- Comparison: N. Dakota (Bakken) – up to 24 billion barrels of oil.
  - 500 MB/day is currently being produced
  - Only 60 MB/day five years ago

World Shale Formations -- 2013

.. Map of basins with assessed shale oil and shale gas formations, as of May 2013



ited States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on dat
blished studies.

China Shale Gas Reserves

- Estimated to be 50% higher than in US.
  - EIA estimate: 1275 TCF
  - 80% of electricity currently from coal.
- Challenges to recovery
  - Different geology. (Deeper, clay mix)
  - China lacks extensive pipeline network needed to quickly bring gas bounty to market.
  - Water-intensive energy development strains irrigation-dependent agriculture.

    - National Geographic Daily News – August 2012

United States Trends in Natural Gas

- Consumption
  - US – 21 TCF/yr -- Dropped by 2.2% worldwide in 2010 – a record decrease.
  - Consumption up 4% in 2011.
  - EIA – projects 20% increase by 2035.
- Production:
  - 2000 – 2% of natural gas came from shale
  - 2012 – 37% comes from shale
- Pricing:
  - 2008 -- $15/mcf; 2012 -- $2.50/mcf
  - Decoupled from oil – now tracks peak power.
  - Byproduct of oil and NGL production?
  - EIA projects $6.50/mcf by 2035.

US Trends in Oil

- Consumption
  - Gasoline consumption 8% lower than in 2006.
  - Fuel economy standards, decreased driving will continue this trend.
- Production:
  - 2009: Half of US trade deficit from oil imports
  - US production up by 25% since 2008; imports down from 60% to 42% since 2006.
  - North Dakota 2nd leading oil producing state.
  - Other shale oil plays?
- Pricing:
  - 2011 -- $85-$110/bbl
  - EIA projects $150/bbl by 2035.

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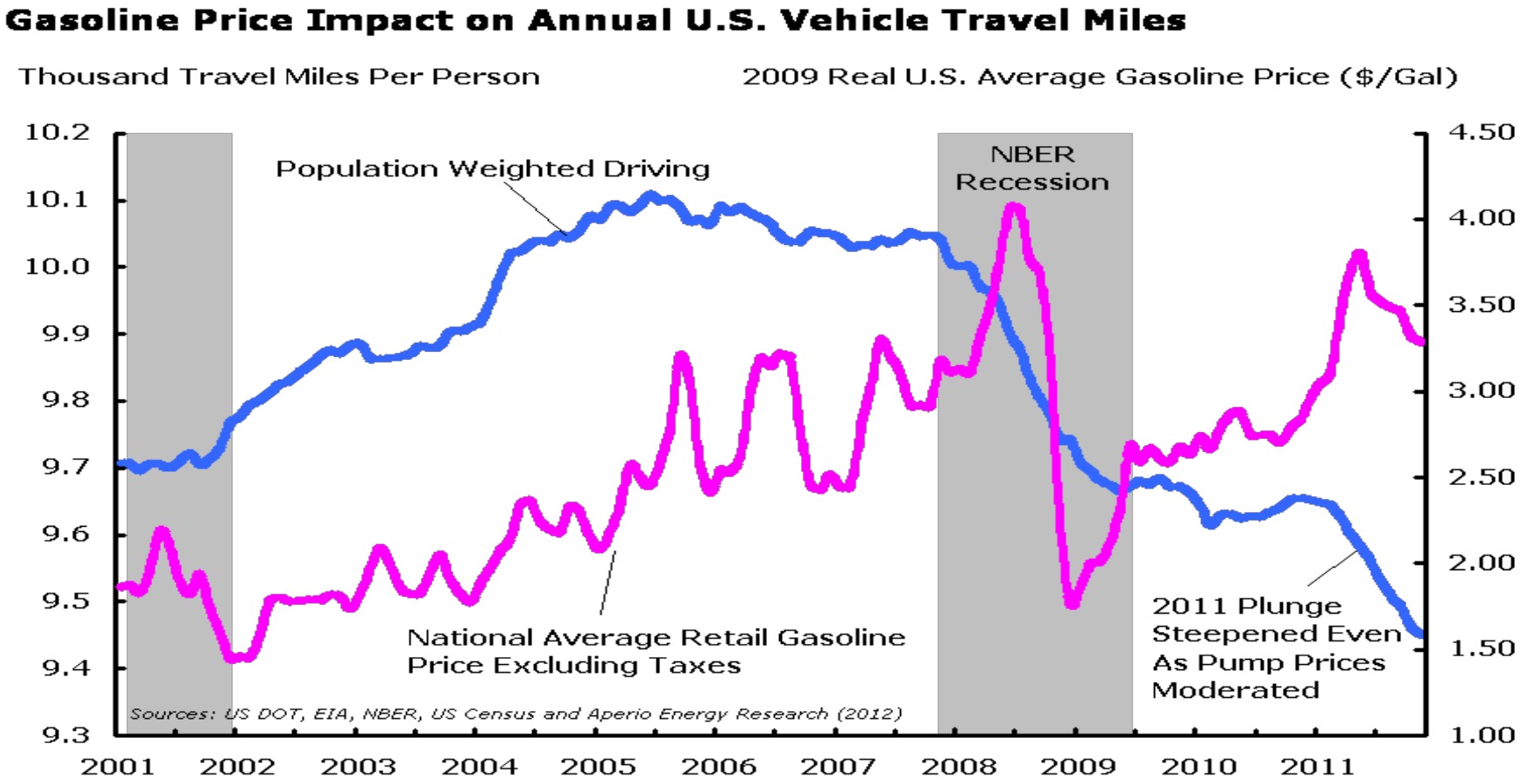
Driving Habits Change



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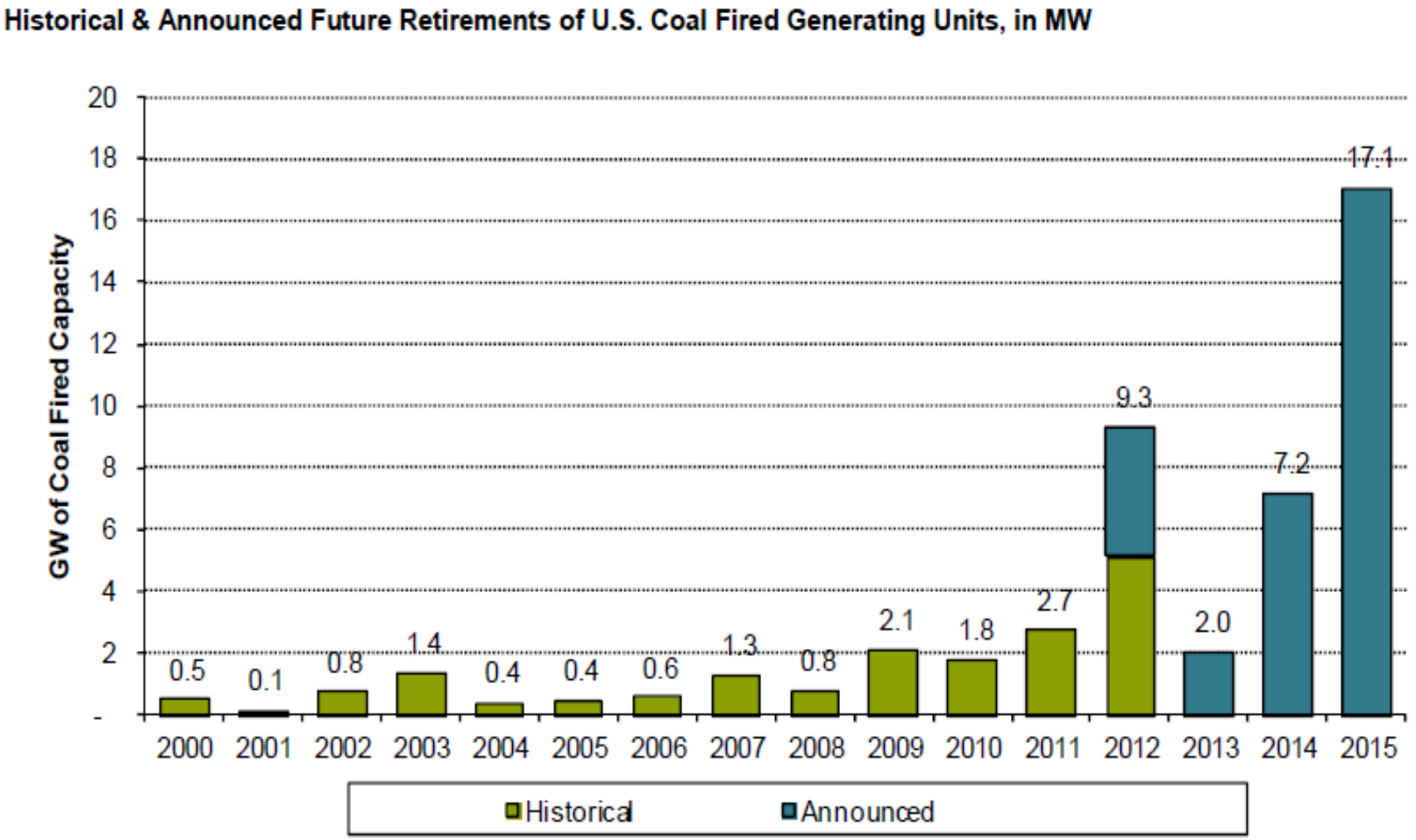
The Shale Drilling Treadmill

- Average Decline Rate 2001: 23%
- Average Decline Rate 2011: 32%
  - New Shale plays may be masking decline rates as high as 90%.
- Capital Requirements to Maintain Natural Gas at Current Replacement Rate of 22 BCF/Day:
  - $88 Billion/yr for top 34 producers
    - » Source: PNC Bank Wealth Management
- But new data supports economics
  - University of Texas study: $4.00/mcf threshold
  - Shale as manufacturing technology
    - Cost reduction/production increase

Gas Replacing Coal

- Coal-Fired Plants Mothballed by Gas Glut
  - $3/mmbtu gas equals $0.02/kw-hr power
  - Coal around $0.04/kw-hr
    - Source: Wall Street Journal 9/12/2012
- Coal's share of U.S. electricity production has dropped from almost 50 percent to 34 percent in just three years.
  - The United States is on track for its energy-related carbon dioxide emissions in 2012 to be 11 percent lower than in 2005.
    - » Source: Energy Information Agency

Coal Generating Unit Retirements



Source: ABB Ventyx Global Energy, EIA, Bernstein analysis

Electricity Market Drivers

- Natural Gas reduces GHG emissions by 50% -- even with a 17% life cycle carbon increase for hydraulic fracturing.
- Long term natural gas price outlook favors gas fired combined heat and power.
- EPA BoilerMACT rules require capital investment in new heat generation.
- Northern Ohio grid congestion favors distributed generation.
  - PJM capacity charges – 1-4 cents kw-hr by 2015.

» Source: Brakey Energy Company

CNG/LNG Transportation Market

Price per gallon equivalent (June 2012):

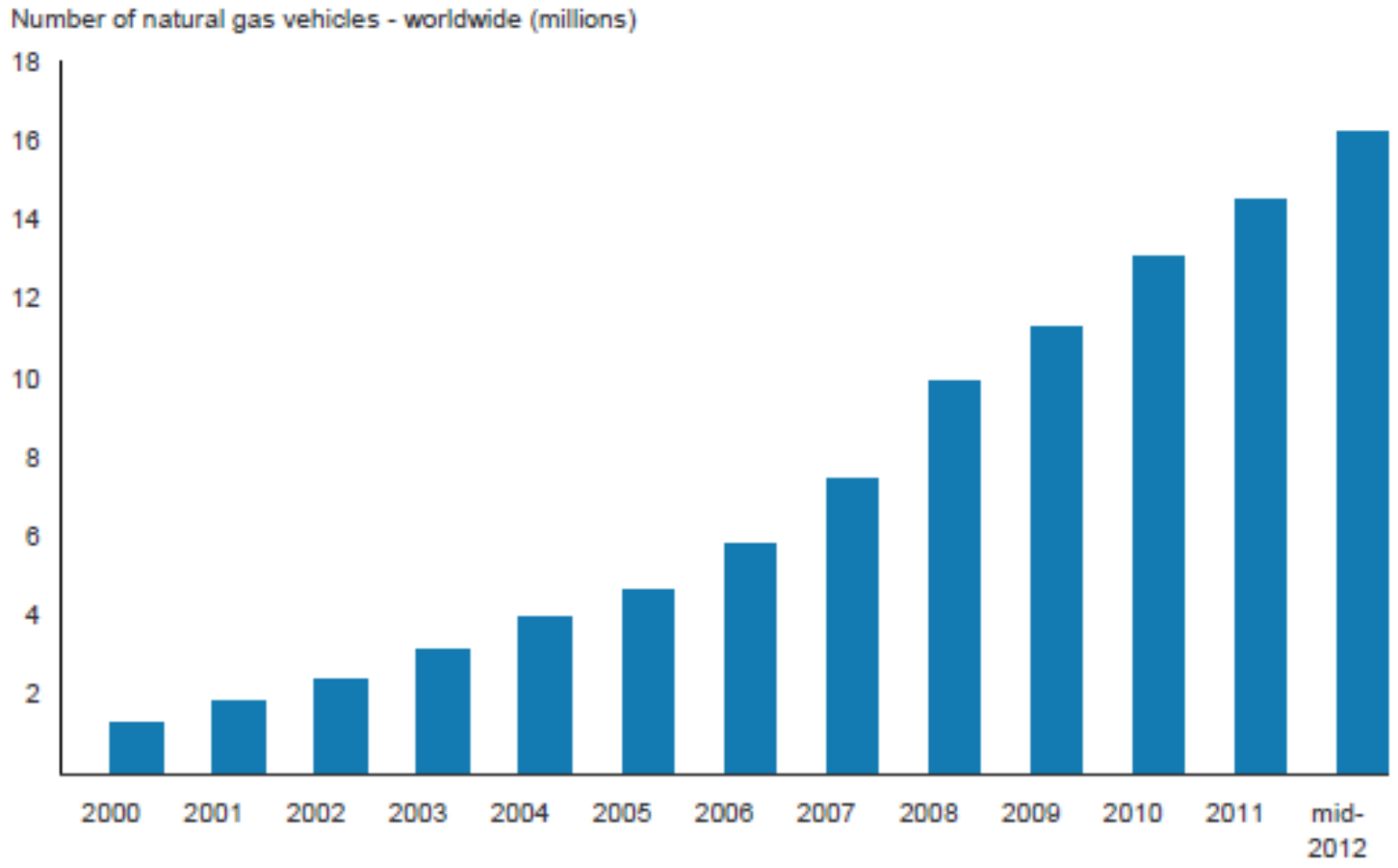
- Gasoline $3.57
- Diesel: $3.90
- CNG: $2.38
- LNG: $2.60

Shell Highway Natural Gas Network

- Shell will construct and TA Travel Centers will operate at least 200 natural gas fueling lanes on at least 100 TA locations.

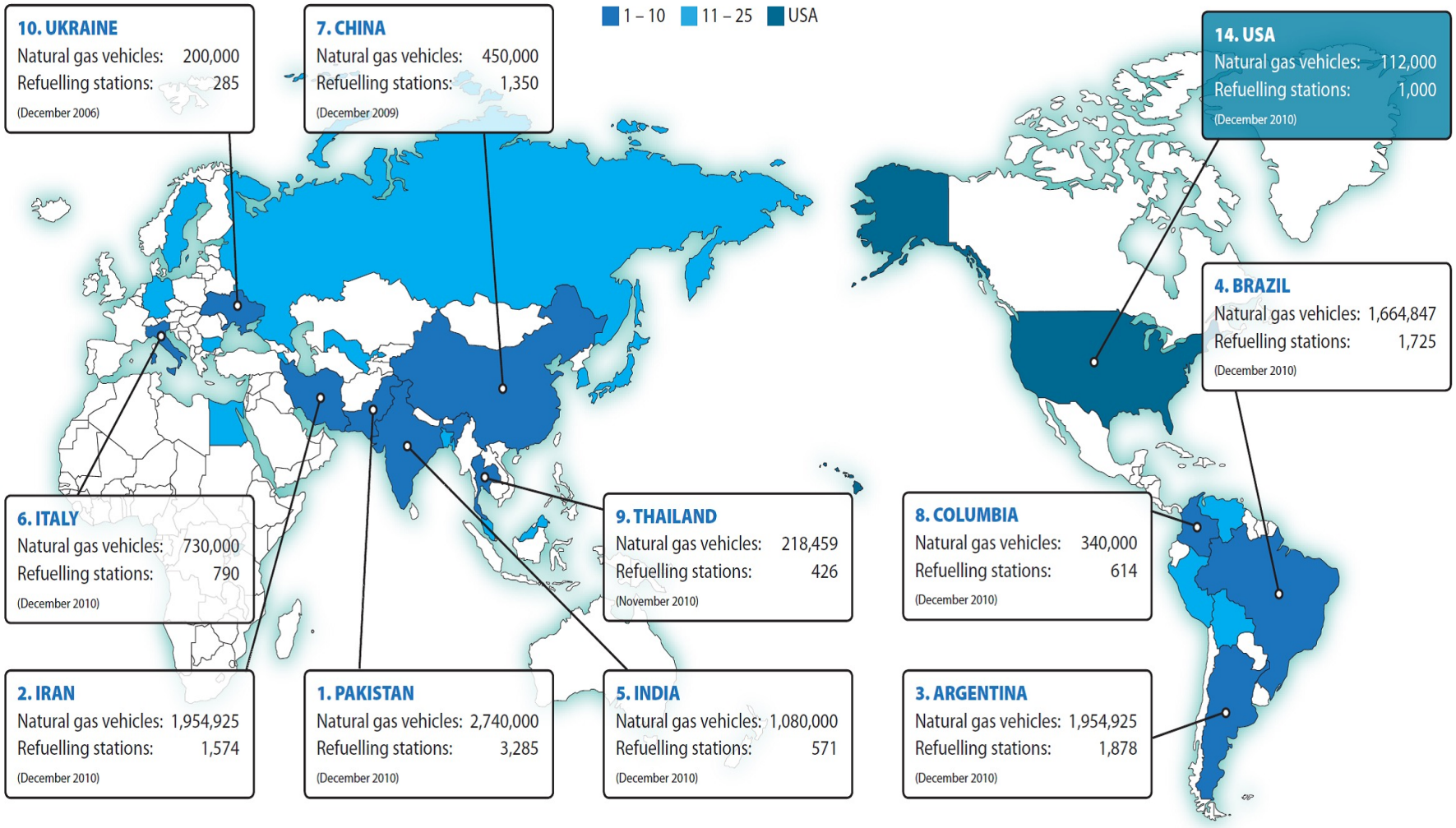
Exhibit 3

The NGV fleet has grown 15% p.a. since 2008 …



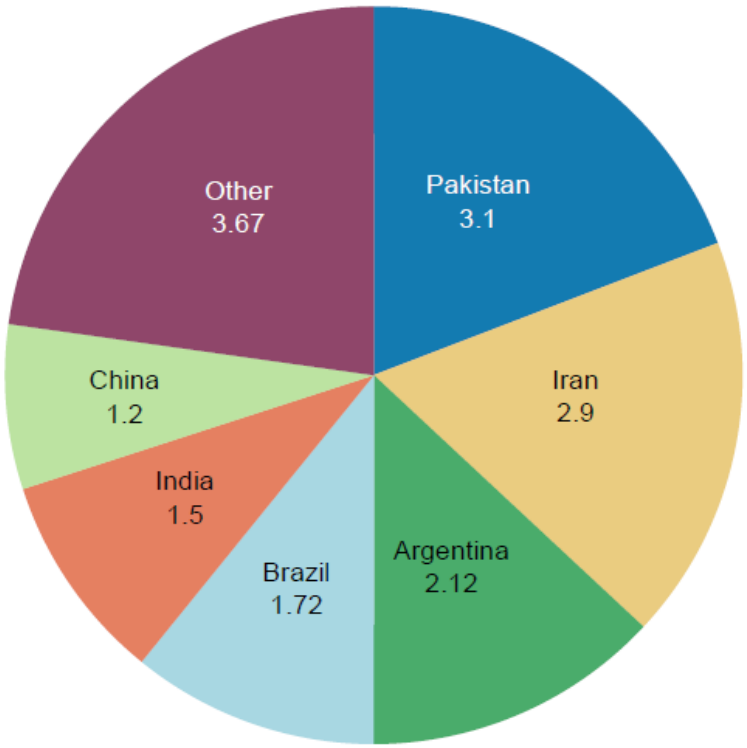
Source: NGVA Europe

Global NG Vehicles

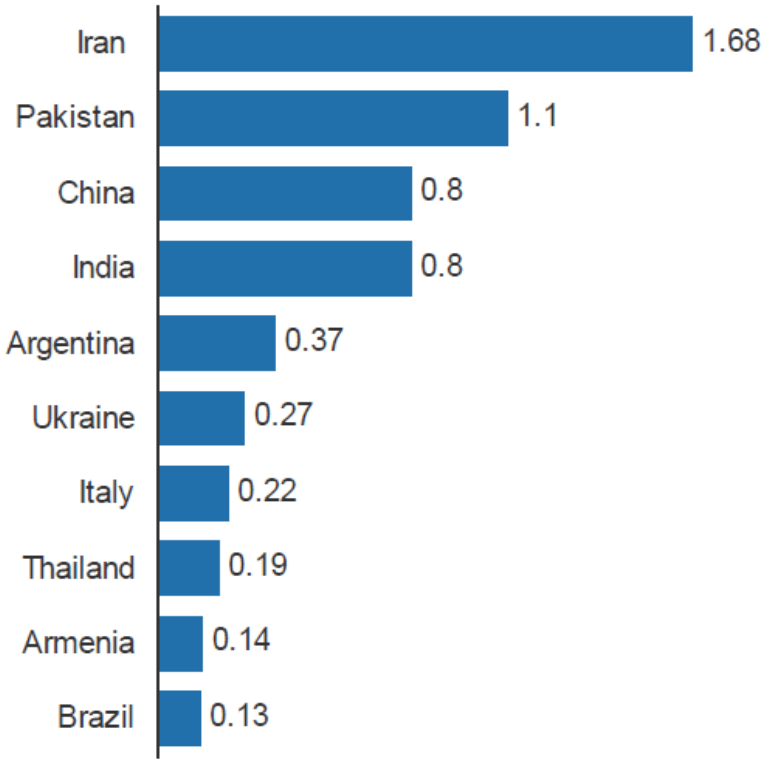


Source: http://iangv.org/tools-resources/statistics.html

Number of NGVs by country
Millions



Growth in NGV fleet by country
Between Dec-08 and Jun-12, in millions



Source: NGVA Europe, GVR

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Urbanism Limited

Typical Brazilian fuel station with a choice of four fuels available: diesel (B3), gasoline (E25), neat anhydrous ethanol (E100), and natural gas (CNG).
Piracicaba, São Paulo, Brazil

Natural Gas/NGLs and Petrochemicals

- Nitrogen Fertilizer
  - Natural gas is 80% of cost of manufacturing.
- Polymer Industry
  - Ethane used as feedstock - Polyethylene
  - 2400 polymer firms in Ohio
  - Employ 130,000
- Competitive advantage
  - Europeans use naptha, derived from oil – costs more.
  - No liquids rich natural gas yet developed in Europe.

CSU Energy Policy Center

Thank you!