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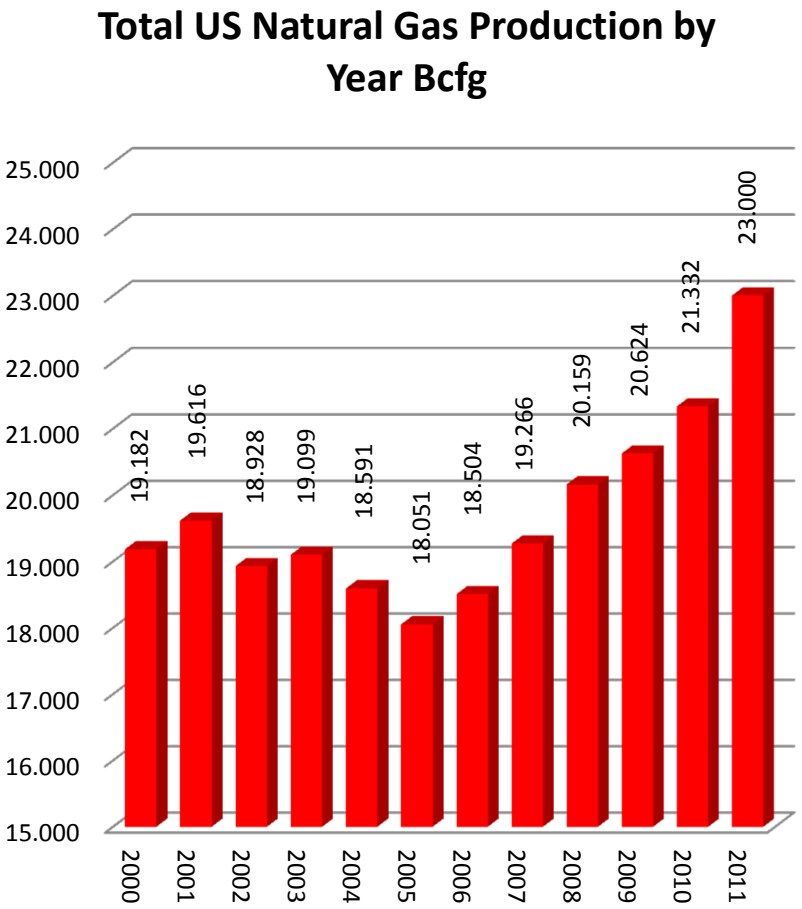
The American Shale Gas Revolution

Outline

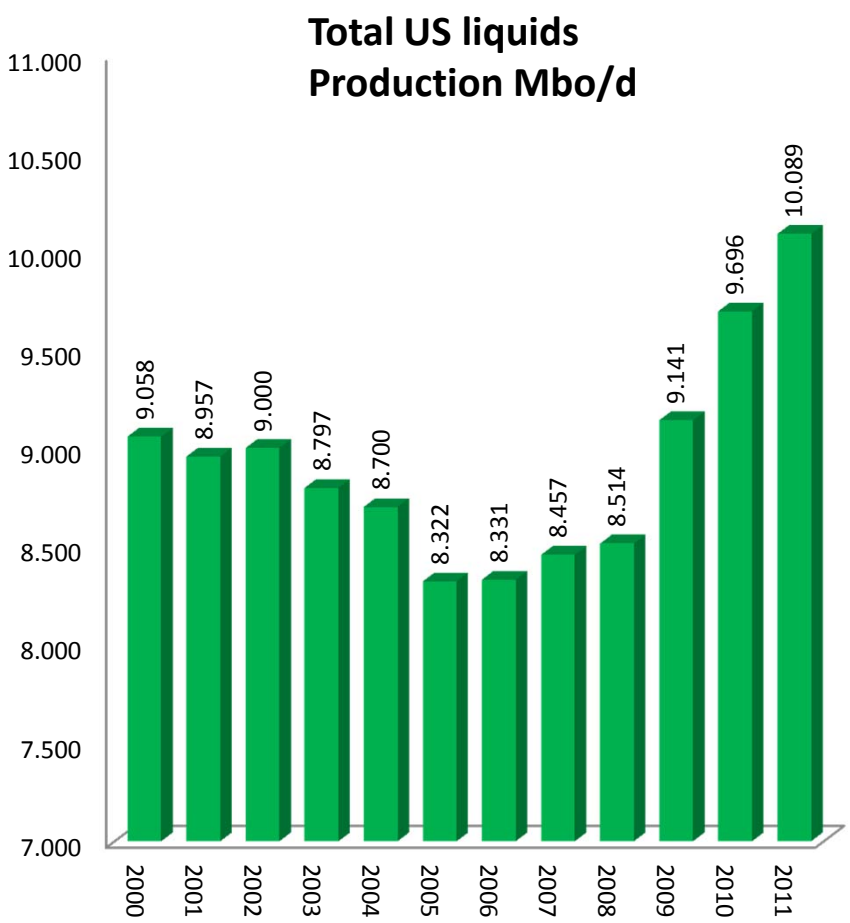
- US oil & gas - production & pricing 2000-2011
- Shale gas E & P technology
- US unconventional play overview
- Role of data in success & failure
- Current status, pricing, cost and activity
- Commercial impact
- Look to future
- Latin American activity & other countries

Evolution of US Gas production since 2000



- First extracted in Fredonia NY in 1825
- Active R&D in 1970s & 80s
- 2006 – 1.1 Tcfg shale gas or 5.9% of production, start of trend
- 4,185 shale gas wells completed in 2007
- Production increase 27.4% since 2005
- Many considered it impossible
- Conventional production peaked years ago

Liquids Production Increase Mirrors Gas Trend



- Increase since 2005 is 21.2%
- Unconventional oil leads the charge
- Operators drilling liquids portion of acreage due to low gas prices
- US oil production reaches 23-year high in June 2012 for lower 48
- US projected to pass Saudi Arabia & Russia this decade
- Texas and North Dakota are fastest growing oil producers.
- Onshore production was up 10% in 2011
- Oil imports are declining

Unconventional Hydrocarbon Production Growth

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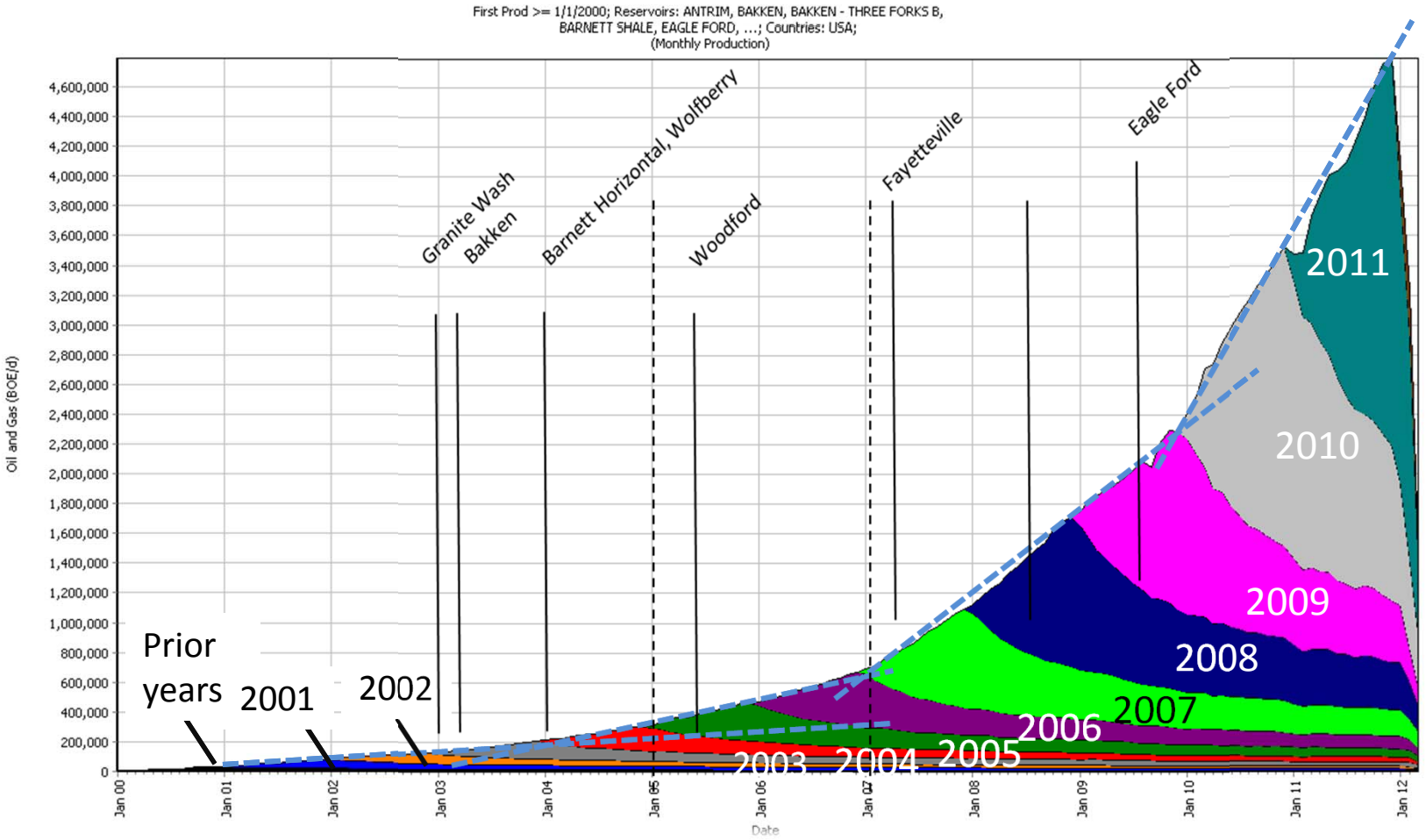
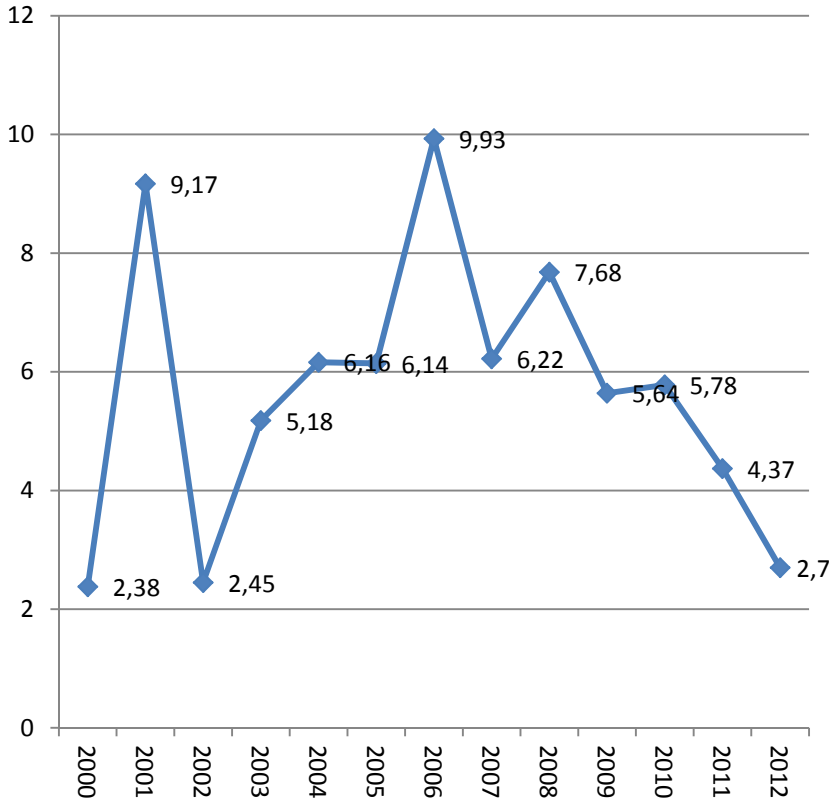
Monthly US Production



Source: DI-Desktop

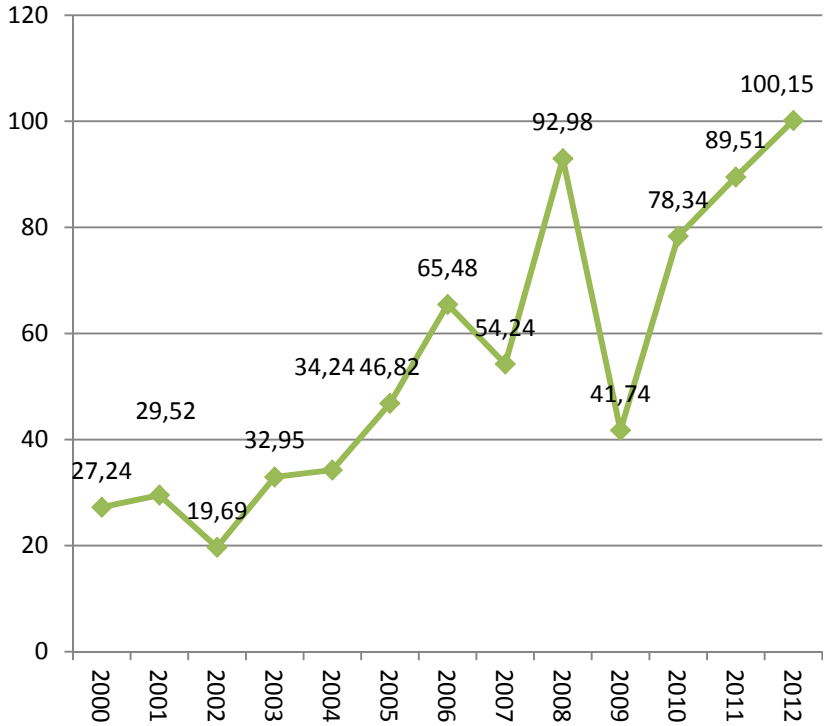
Henry Hub & WTI – General Price Trends

Henry Hub gas price US$
Per MMbtu start of year



Source: EIA

WTI price US$ per bbl start of year



Source: EIA

Pricing notes and Implications

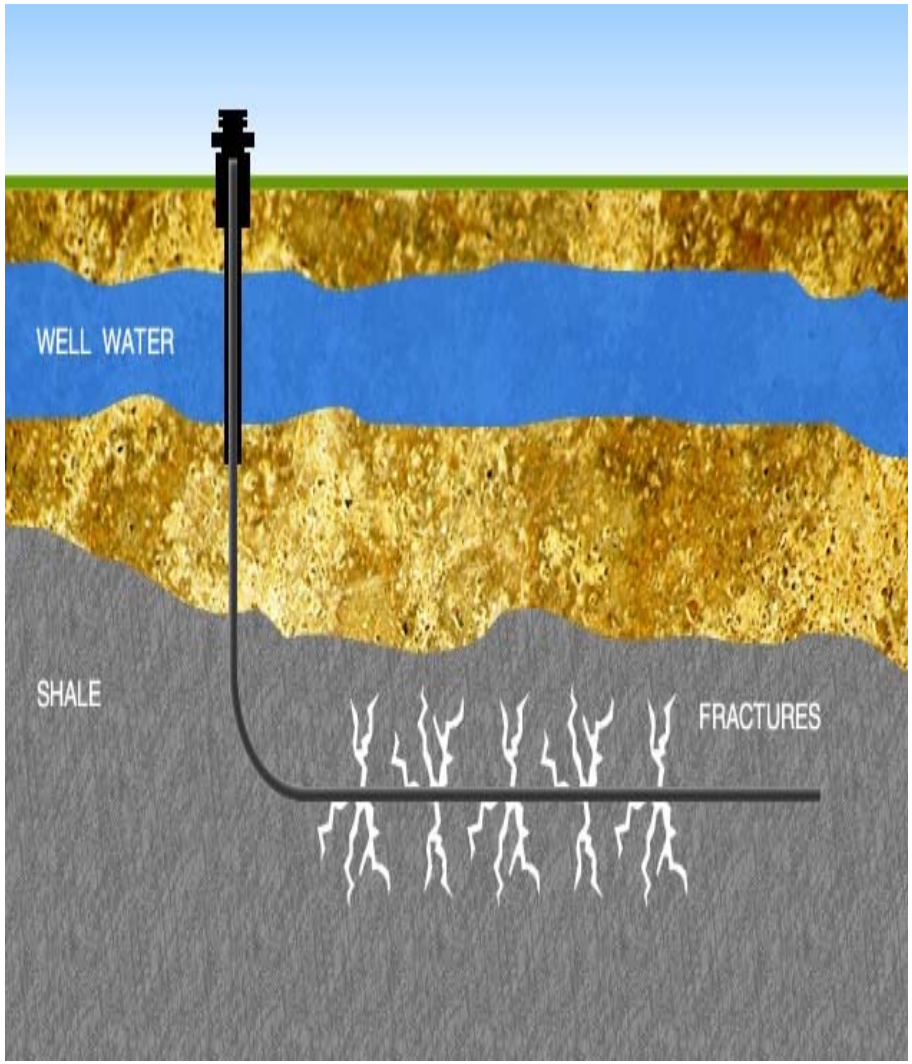
- Oil and natural gas pricing both historically volatile
- In long to medium term oil price trending upwards
- Natural gas price has plummeted
- Gas pricing increased from May 2012 low of $1.80 MMbtu.
- Current price around US$ 3.00 MMbtu

Current Status

- The US currently has an oversupply of natural gas
- US prices widely divergent from Asian/European/Intl markets
- Shale gas drilling at a minimum - operators switch to liquids
- Operators losing money/industry moves to consolidation phase

Shale Gas E&P Technology

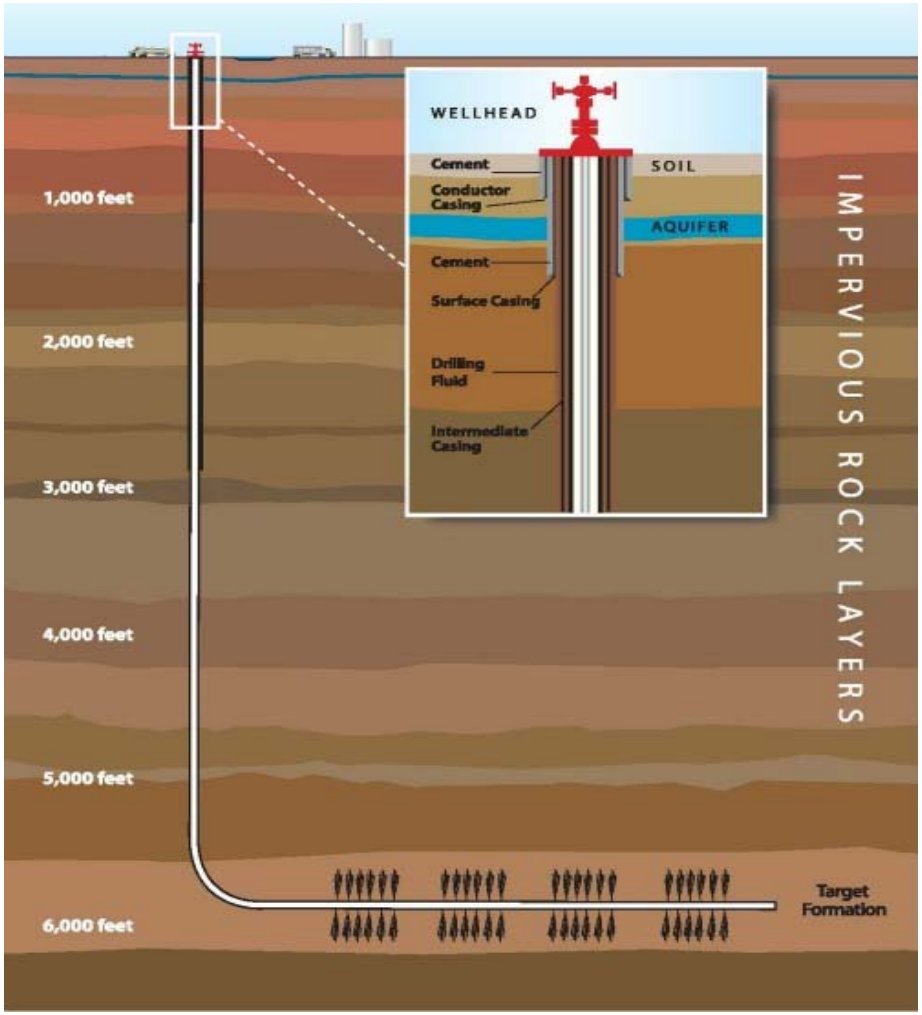
- Key elements - horizontal drilling & fracking
- Steering well through most productive zones
- MWD is important
- Maximum borehole contact with productive part of formation
- Fracking is key, many different techniques



Hydrofracking History & Why

- Conventional fracking begins 1947
- Modern “slick water hydraulic fracturing” starts 1997 Barnett Shale
- George Mitchell “invented” technique - 10 years & US$ 6 million in research
- Why frack? – shale low permeability, horizontal fractures seal naturally
- Injecting proppant keeps fractures open
- Enough pressure to split rock & transport proppant
- Coffee bean & hammer analogy for shale matrix

Fracking Notes & Negatives

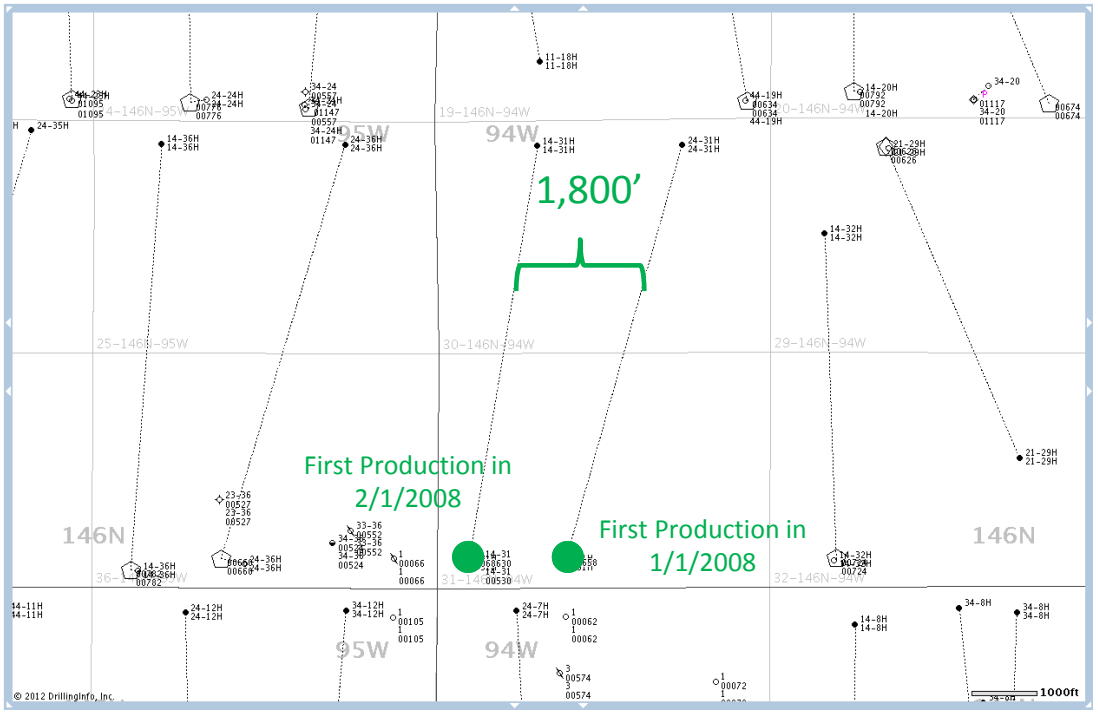


- Real time microseismic fracture mapping has become important
- Multistage is the rule & same zones can be fracked repeatedly
- Different kinds: Gasfrac, Simulfrac, Zipperfrac
- Expensive & controversial
- Hydrofracking uses 70 to 300 times more water – 1-8 MM gallons
- Safe if well below water table & well maintains casing & cement integrity
- Wastewater disposal problems

Best Practice – Simulfrac, Zipperfrac, and Sequential Frac

- Parallel wellbores
- Fracture stimulated at the same time (simulfrac), in alternating stages (zipperfrac), or sequentially
- Creates an interconnected network of fractures
- May improve well economics due to cost savings

Simulfrac example of Marathon wells in Dunn County



Source: Drillinginfo, DI Analytics

US Unconventional Play Map

Source: Drillinginfo, DI Analytics

US Unconventional Future
Predicted Production Profile

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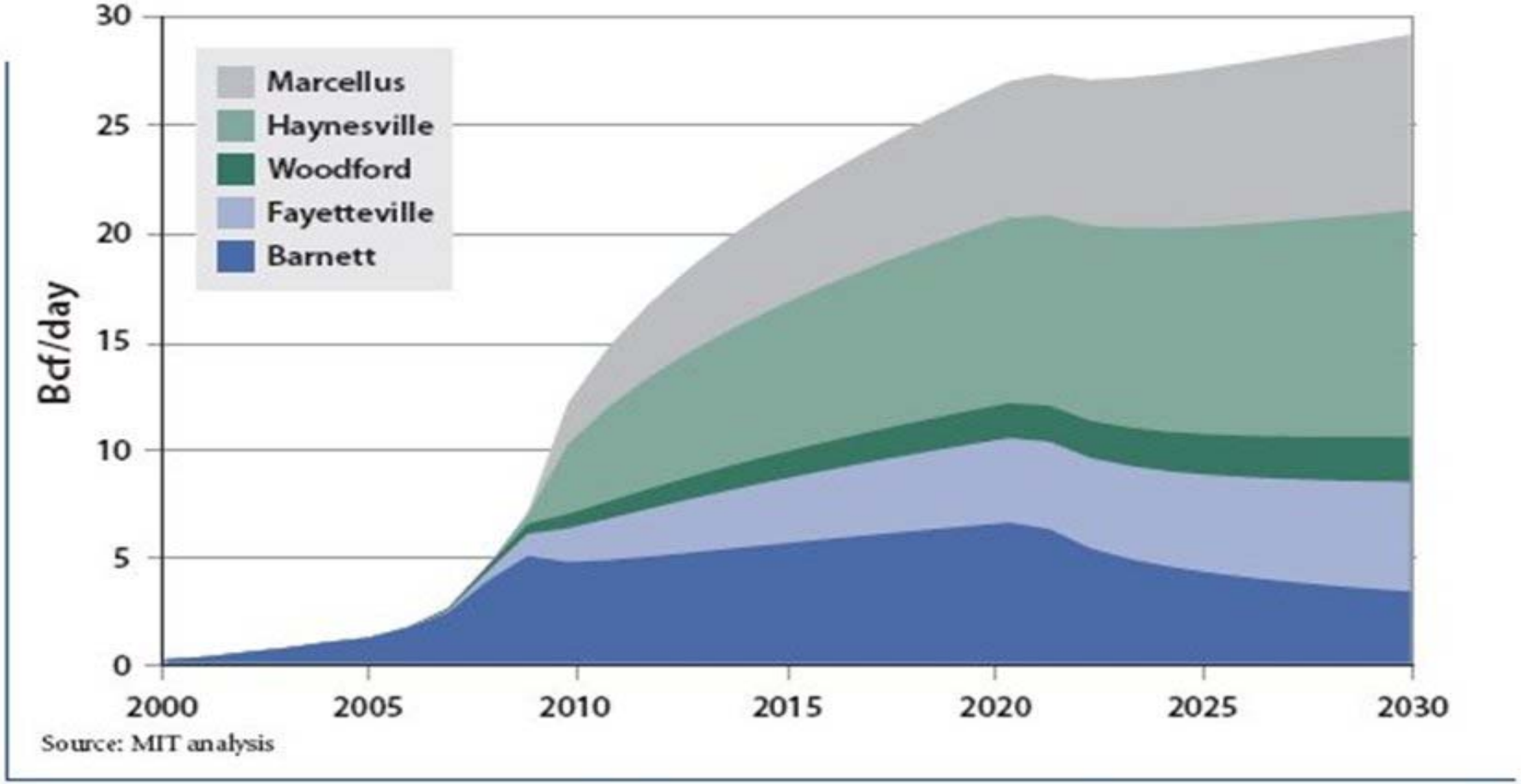
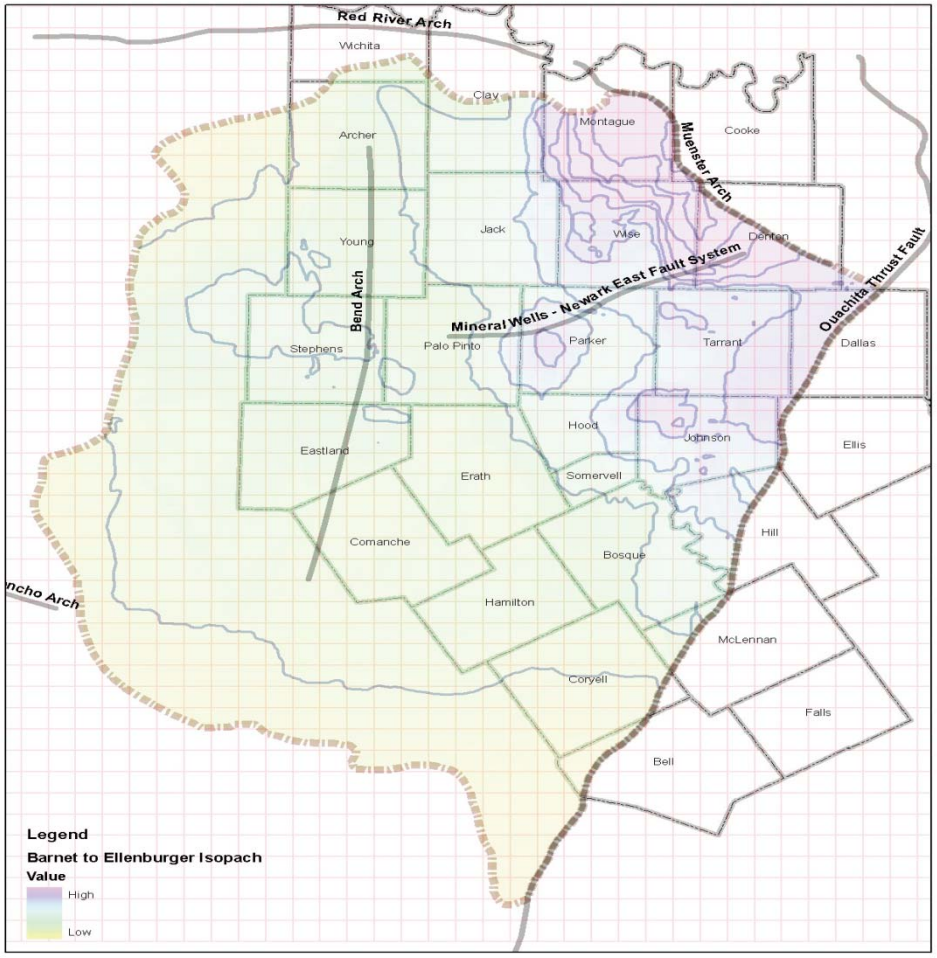
Figure 2.17 Potential Production Rate that Could Be Delivered by the Major U.S. Shale Plays up to 2030 — Given 2010 Drilling Rates and Mean Resource Estimates



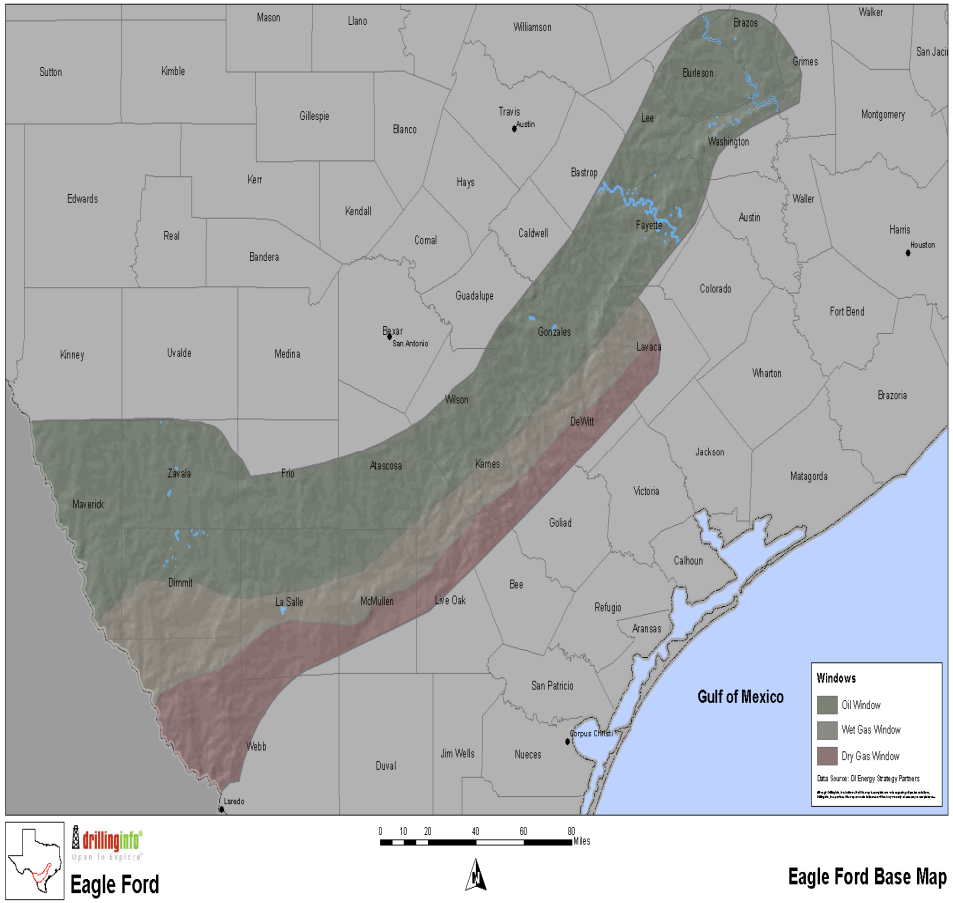
Unconventional Play Overview - Barnett Shale



Source: Drillinginfo, DI Analytics

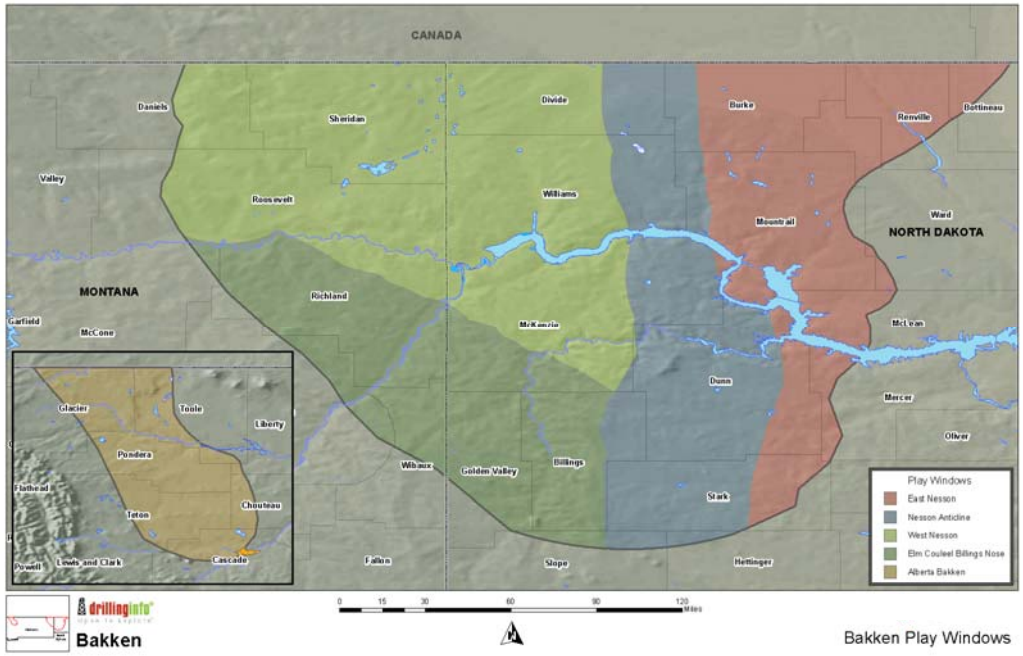
- Fort Worth Basin, Texas, first major unconventional play.
- Mississippian age, porosity .5 to 6%
- First horizontal wells 2001, standard by 2003
- EOG typical well – 300 Mboe
- 1,220m lateral, cost US$ 3.3 MM
- Year-end 2007 - 3.5 Bcfg/d from 7,000 wells
- Horizontal wells – Max IP 1.36 MMcfg/d, almost 2X verticals
- Prod decline – 60% yr 1, 30% yr 2, 15% yr 3

Unconventional Play Overview - Eagle Ford



- First production 2006 but main focus initially Austin Chalk
- First true Eagle Ford well by Petrohawk in Hawkville Field, Oct 2008.
- Upper Cretaceous, 30 to 100m thick, good for fracturing, up to 70% calcite
- Lower transgressive layers oil prone, upper regressive layers gas prone
- Activity has shifted from gas to liquids
- Simulfrac good practice for oil (20%) & gas (12%) higher.
- EURs - Dry gas 5.6 - 6.0 Bcf, Wet gas - 262 - 540 Mboe, Oil – 138 – 431 Mboe

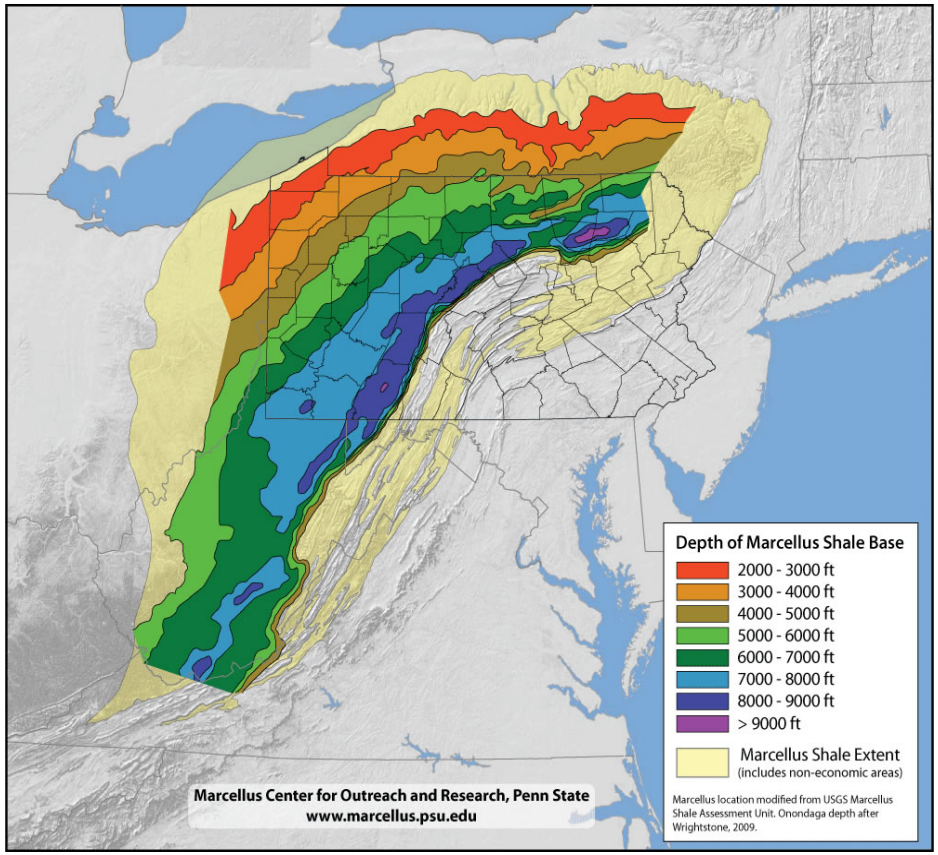
Unconventional Play Overview - Bakken



- Mississippian – Devonian, includes Upper, Middle, Lower Bakken & Sanish
- Middle Bakken most important, higher perm & porosity between high TOCs
- Middle Bakken overpressured, natural vertical fractures
- First produced in 1953, activity took off in 2004
- Peak leasing 2007-2009, activity still growing
- EUR since 2004 - 521 Mboe
- Current production -14 MMbo/month, 13 Bcfg/month
- Long laterals > 2,300m are best practice

Source: Drillinginfo, DI Analytics

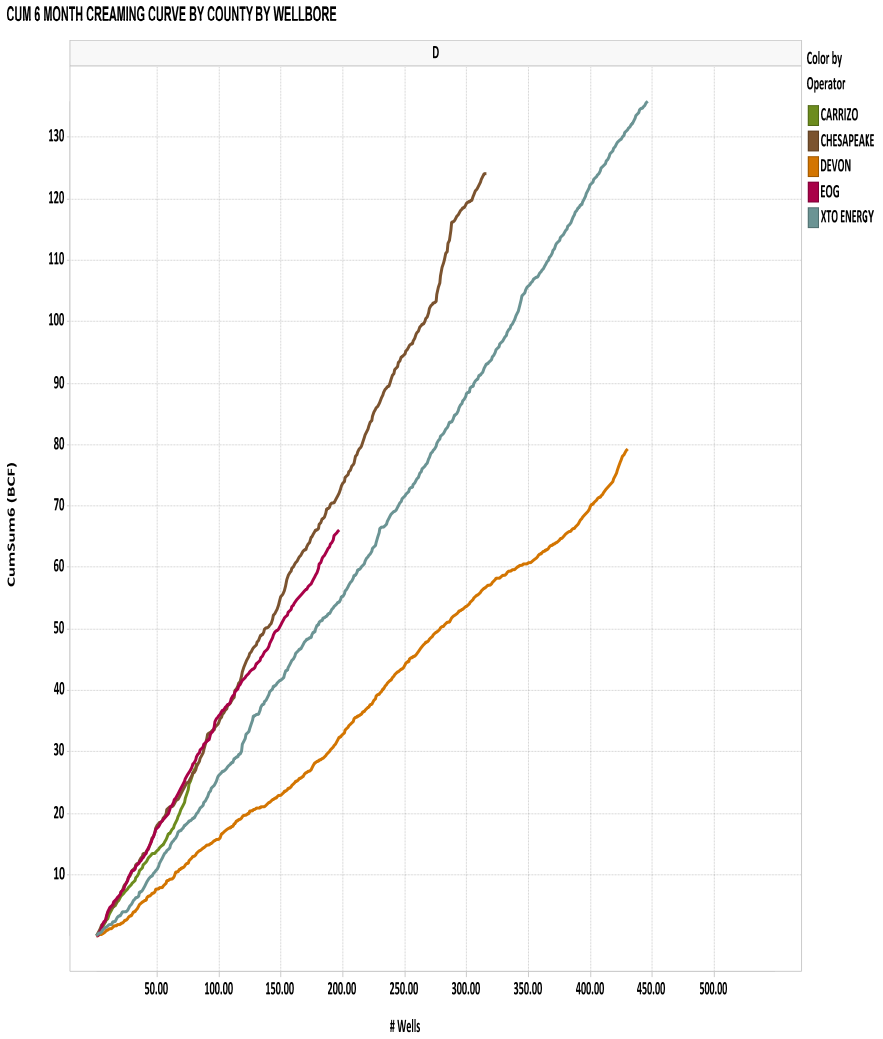
Unconventional Play Overview - Marcellus



- Middle Devonian low-density black shale, play also includes Huron
- Thickness, thermal maturity, Rome trough, underlying frac barrier
- Reserves – Proved 5.4 Tcfg to potential 34 Tcfg
- 132 Marcellus spuds through mid-May 2012
- Average EUR = 7.3 Bcfe
- Average lateral around 1,600m.
- Average wells cost US$ 6.1 million
- Top wells can produce over 8 MMcfg/d

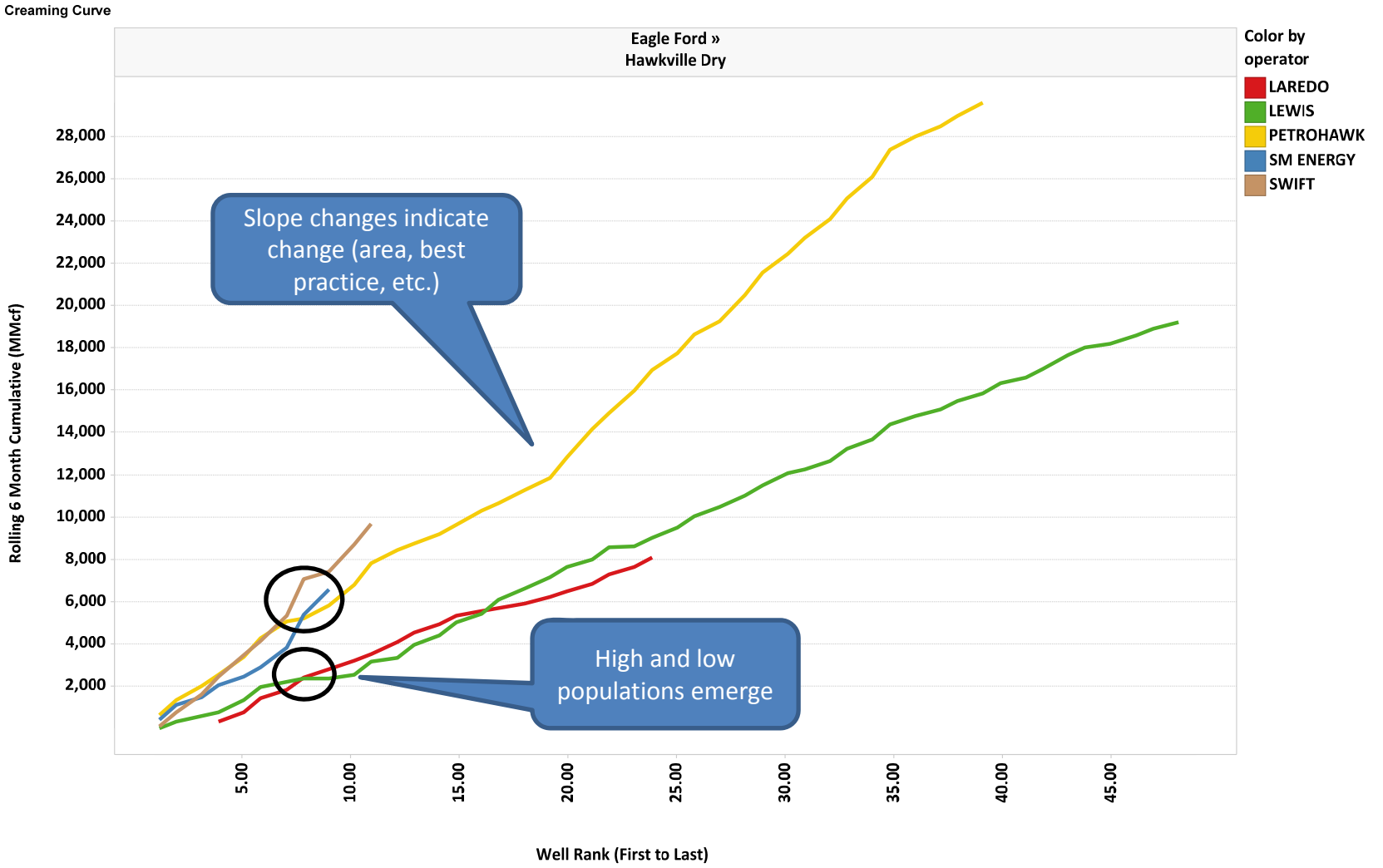
Data is Critical in US Unconventional E&P

- All rocks in the resource play are **NOT** created equal.
- All operators are **NOT** equal.
- All stimulation techniques are **NOT** equally applicable



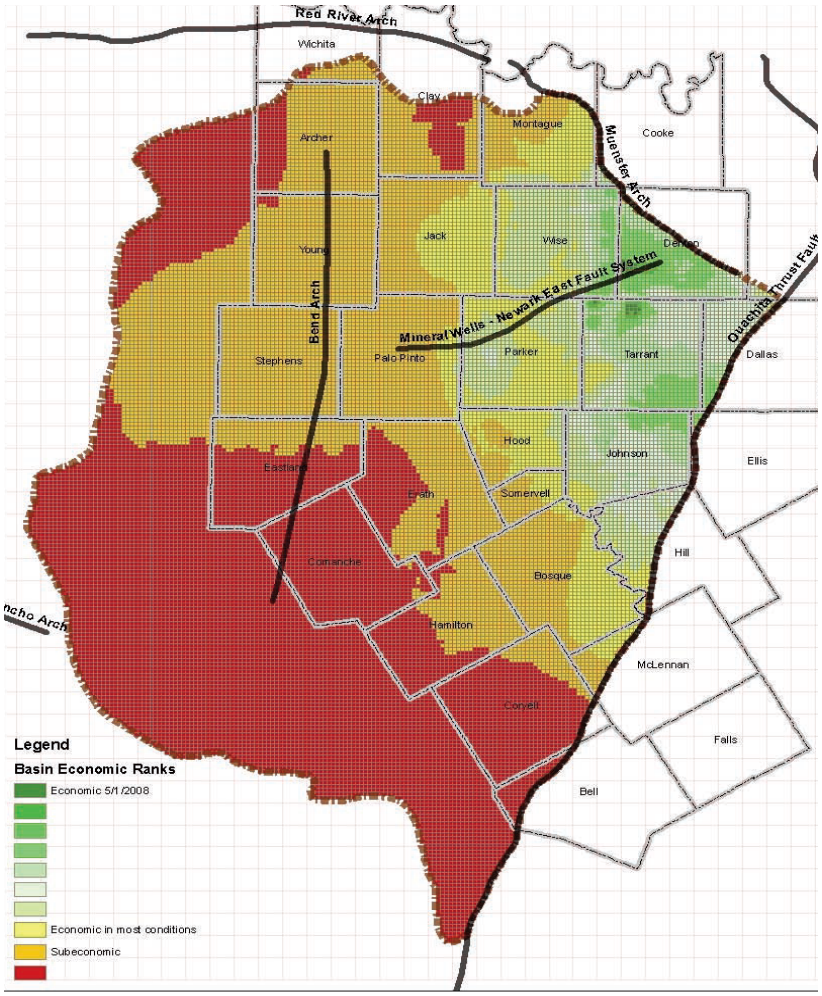
Source: Drillinginfo, DI Analytics

Creaming Curve Example – Eagle Ford



Source: Drillinginfo, DI Analytics

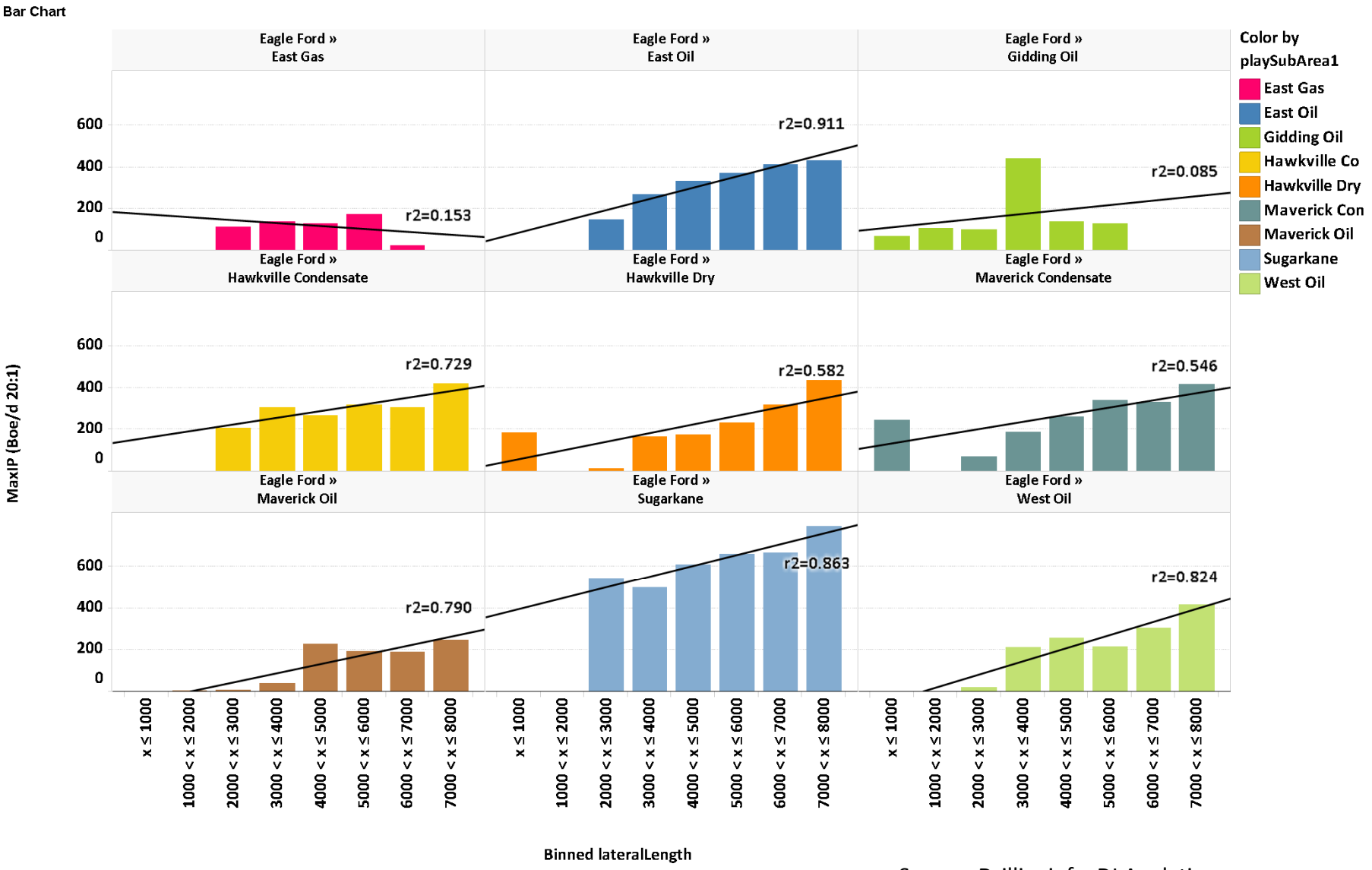
Data Example – Productive Acreage Grading Barnett Shale



GPA	Acres in Play	%	Cumulative %	Nominal Max Gas/Section	Nominal Min Gas/Section	Nominal Gas In Place	Cumulative NGIP
A	14,080	0.08%	0.08%	83	74.7	1,826	1,826
B	27,520	0.16%	0.25%	74.7	66.4	3,212	5,038
C	91,520	0.55%	0.79%	66.4	58.1	9,495	14,533
D	303,360	1.81%	2.60%	58.1	49.8	27,539	42,073
D_hl	5,760	0.03%	2.63%	58.1	49.8	523	42,596
D_ml	46,080	0.27%	2.91%	58.1	49.8	4,183	46,779
E	418,560	2.49%	5.40%	49.8	41.5	32,569	79,348
E_hl	46,080	0.27%	5.68%	49.8	41.5	3,586	82,934
E_ml	39,040	0.23%	5.91%	49.8	41.5	3,038	85,971
F	632,320	3.77%	9.68%	41.5	33.2	41,002	126,973
F_hl	16,640	0.10%	9.78%	41.5	33.2	1,079	128,052
F_ml	14,720	0.09%	9.86%	41.5	33.2	955	129,007
G	660,480	3.94%	13.80%	33.2	24.9	34,262	163,269
G_hl	126,080	0.75%	14.55%	33.2	24.9	6,540	169,810
G_ml	134,400	0.80%	15.35%	33.2	24.9	6,972	176,782
H	1,054,080	6.28%	21.63%	24.9	16.6	41,010	217,792
H_hl	225,280	1.34%	22.97%	24.9	16.6	8,765	226,557
H_ml	301,440	1.80%	24.77%	24.9	16.6	11,728	238,285
I	1,189,760	7.09%	31.86%	16.6	8.3	30,859	269,144
I_hl	1,227,520	7.31%	39.17%	16.6	8.3	31,839	300,983
I_ml	3,008,640	17.93%	57.10%	16.6	8.3	78,037	379,020
J	97,280	0.58%	57.68%	8.3	0	1,262	380,281
J_hl	6,204,800	36.97%	94.65%	8.3	0	80,469	460,750
J_ml	898,560	5.35%	100.00%	8.3	0	11,653	472,403
Basin Total	16784000	1					

Source: Drillinginfo, DI Analytics

Lateral Length Impact on Productivity



Source: Drillinginfo, DI Analytics

Natural Gas
2010 Proved Reserves

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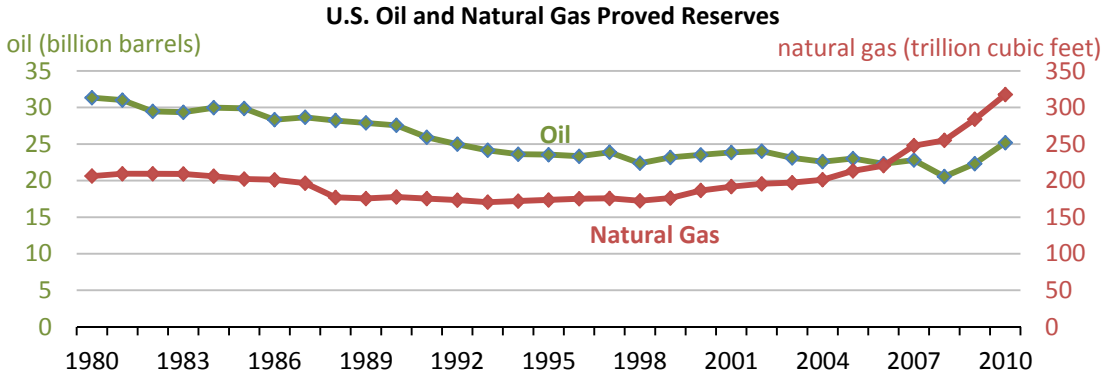
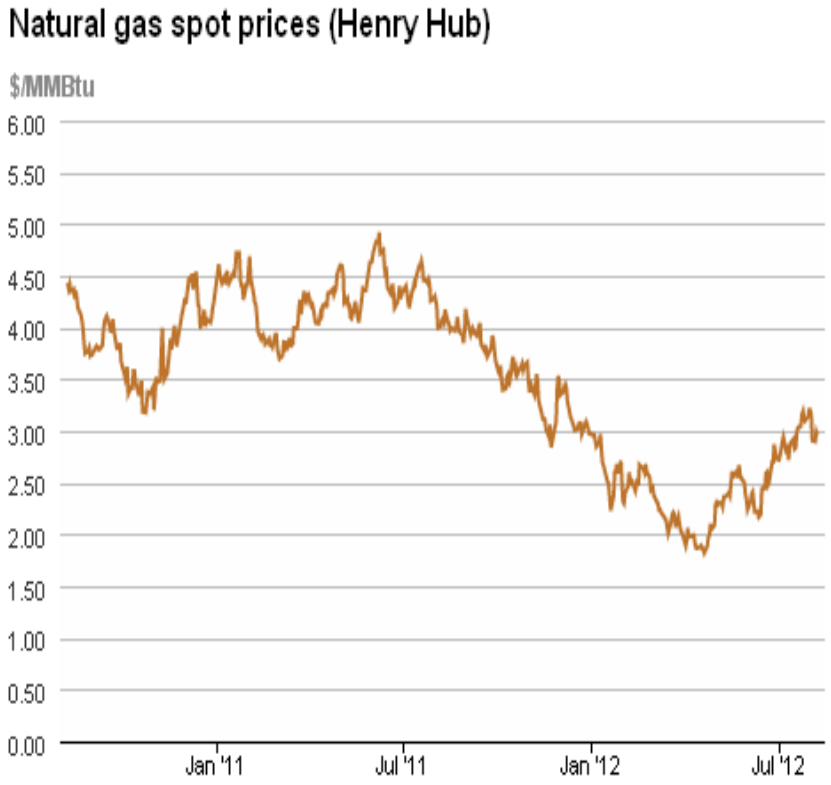
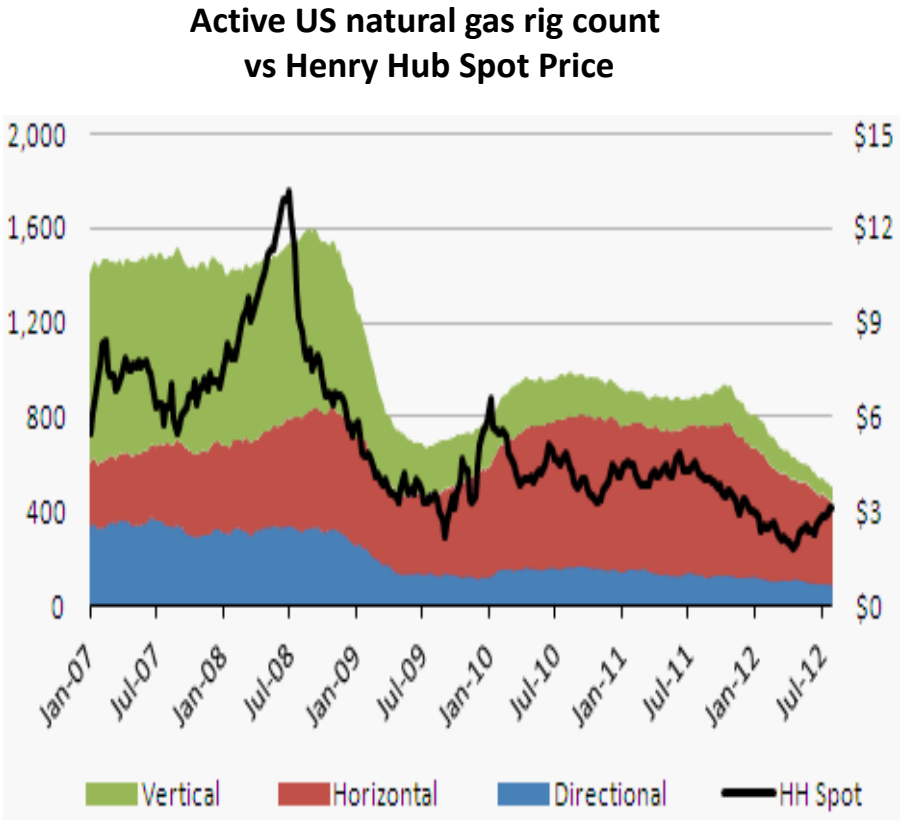
- Crude oil/condensate - 25.2 Bbo
- Wet gas – 317.6 Tcfg
- Produced – 2 Bbo, 23.2 Tcfg
- Net additions oil/cond – 2.9 Bbo or 12.8%
- Net additions wet gas – 33.8 Tcfg or 11.9%
- Record setting year - breaking 2009 records



Source: U.S. Energy Information Administration

Natural Gas Pricing Trends Rig Count





Source: Natural Gas Intelligence

Shale Gas Profitability? Contrarian View

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- Controversy over long-run profitability of shale gas production
- Depends on - total E&P costs in well lifecycle
- EUR of wells & length of time for production
- Sales price of gas over well lifecycle
- B factor – production decline modeling - is it accurate?
- Very few shale gas wells have finished entire lifecycle
- Are EURs overstated? –based on long production at low rates
- Some economic modeling shows prices over $10 MMbtu needed for marginal profitability
- Most contrarian modeling doesn't include liquids

Commercial Impact
Shale Gas Changes

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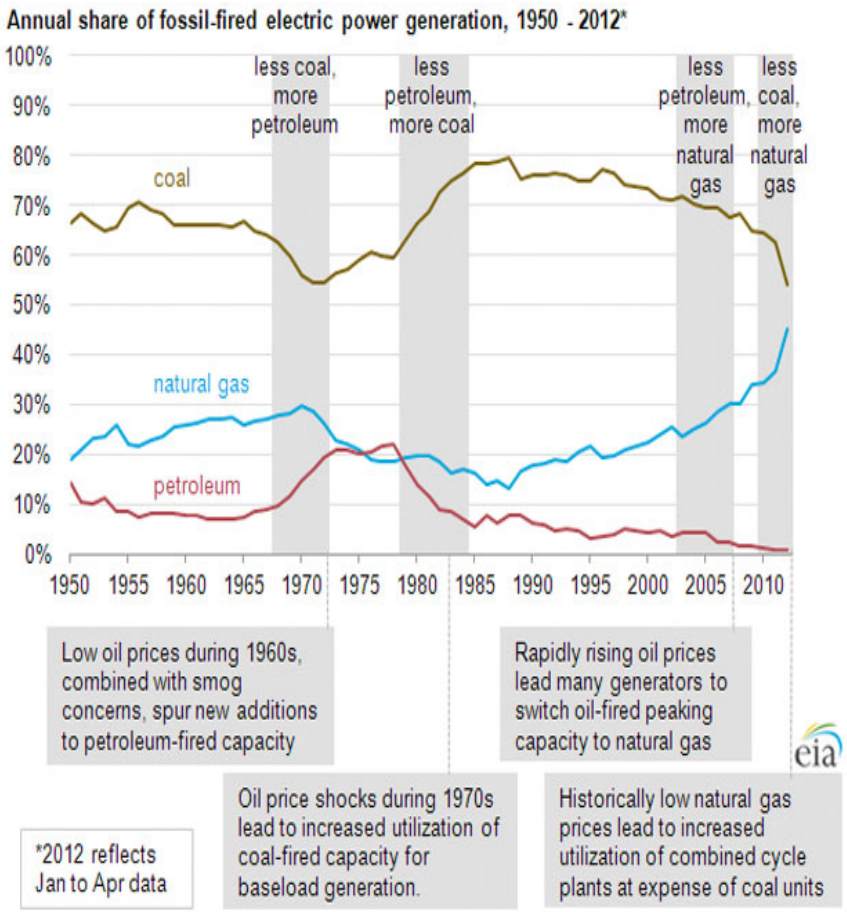
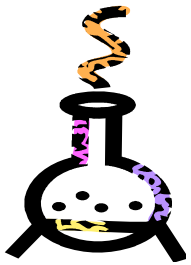
- Power generation – shift from coal to natural gas
- Reducing pollution & greenhouse gas emissions
- More expensive renewables on back burner
- Natural gas export permits – 3 Tcf already approved – refined products export first time since 1949
- Dramatic change to LNG market in North America
- Low natural gas & electric prices help consumers
- Technology revolution in E&P – horizontal drilling & fracking
- Petrochemical plants - new investment in US, based on gas
- Naptha feedstock replacement by NGL's ethane & propane

Natural Gas in Power Matrix



- April 2012 – Natural gas power catches coal both at 32%
- Other factors important besides price
- Gas generation capacity increase 96% from 2000 -2012
- Since 1990 – expanding pipelines, combined cycle technology improves
- Gas-fired plants cheaper to startup & shutdown
- CO2 emissions down 4% 2008-2010, SO2 & NO2 down 32% & 31%
- CO2 emissions 2006-2011 down 450 MM tons, more than any country



Industrial & Petrochemical

- Dow Chemical Freeport Tx – US$ 4 billion to expand - low ethane price
- 12 other Texas plants advance new petrochem projects
- ExxonMobil, ChevronPhillips, Occidental also plan petrochemical expansion
- Biggest expansion since 1980s, dramatic turnaround from 4 years ago
- Shell – major new ethane cracker Beaver Co. Pa
- Methanol, Ethane, Propane, Olefins, (plastics), Ammonia (fertilizer) also important
- Revival of US steel – new factories Baton Rouge US$ 3.4 billion, Ohio
- US will not lose competitive advantage until Henry Hub gas price is over US$ 17 MMbtu

Future Shale Gas Economic Impact

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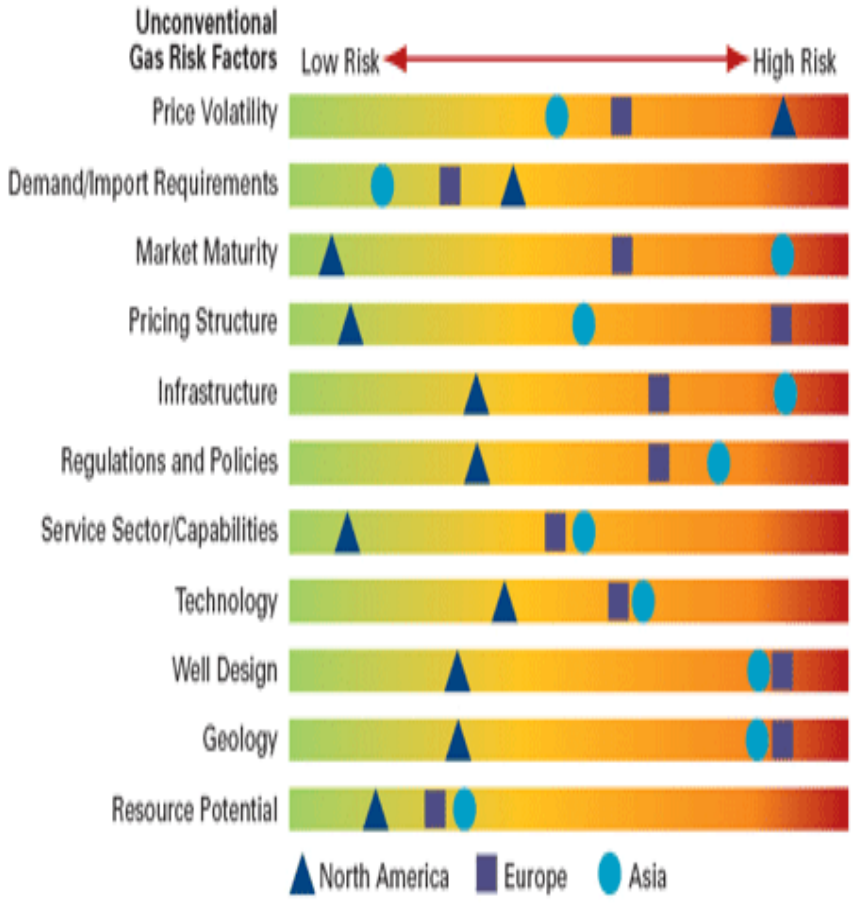
- 2015 - US to add 1.5 million jobs
- Contribute US$ 197 billion to GDP
- Govt revenue - US$ 49 billion
- 2035 – 2.4 million jobs & US$ 332 billion GDP
- US$ 3.2 trillion to be invested from 2010
- Govt revenue 2010 – 2035 – US$ 1.5 trillion
- Contrarian views – no price for reserves
- Is it possible to sustain cheap & plentiful gas?
- Is it cleaner? Leaking methane during frack argument

Future Shale Gas
Other Effects

- Slow the transition to renewable energy
- No gas export cartel – (Russia, Iran, Qatar)
- Improvement of trade deficit
- Increase in electric cars and/or CNG vehicles
- Prediction – by 2020 US exporting 2-4 Bcfg/d LNG, to begin 2015
- Cleaner air – enable retirement of more coal plants
- Easier to meet future greenhouse gas reduction targets
- Gradual evolution to one worldwide LNG market

Shale Gas Around the World
What is Different?

- Less mature, lower drilling density, less subsurface data
- Less ability to use existing infrastructure
- Lack of mature service industry
- Inadequate regulatory framework developed
- Geologic risk
- Environmental/political considerations
- Land access



From Schlumberger 2012

Shale Gas Around the World

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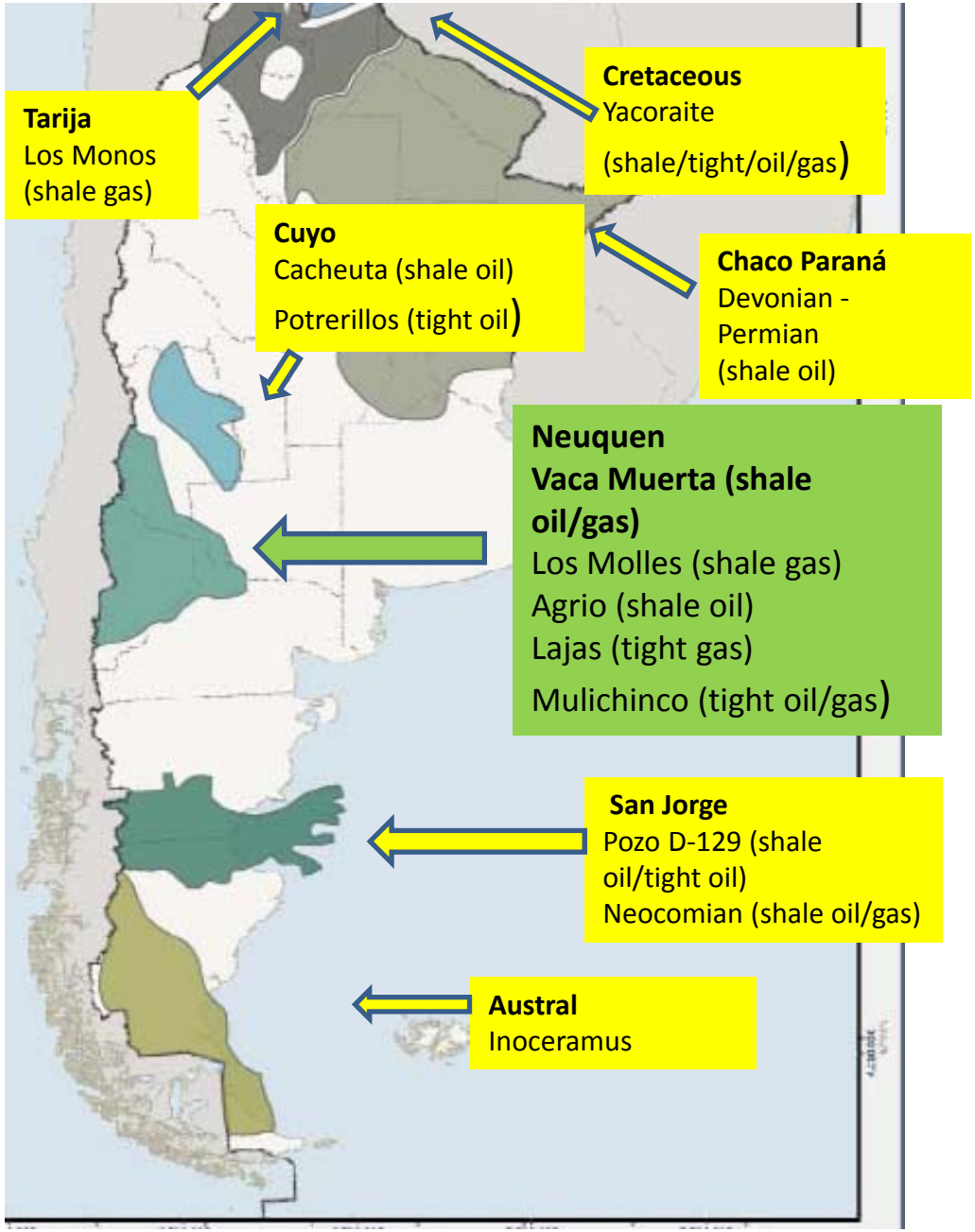
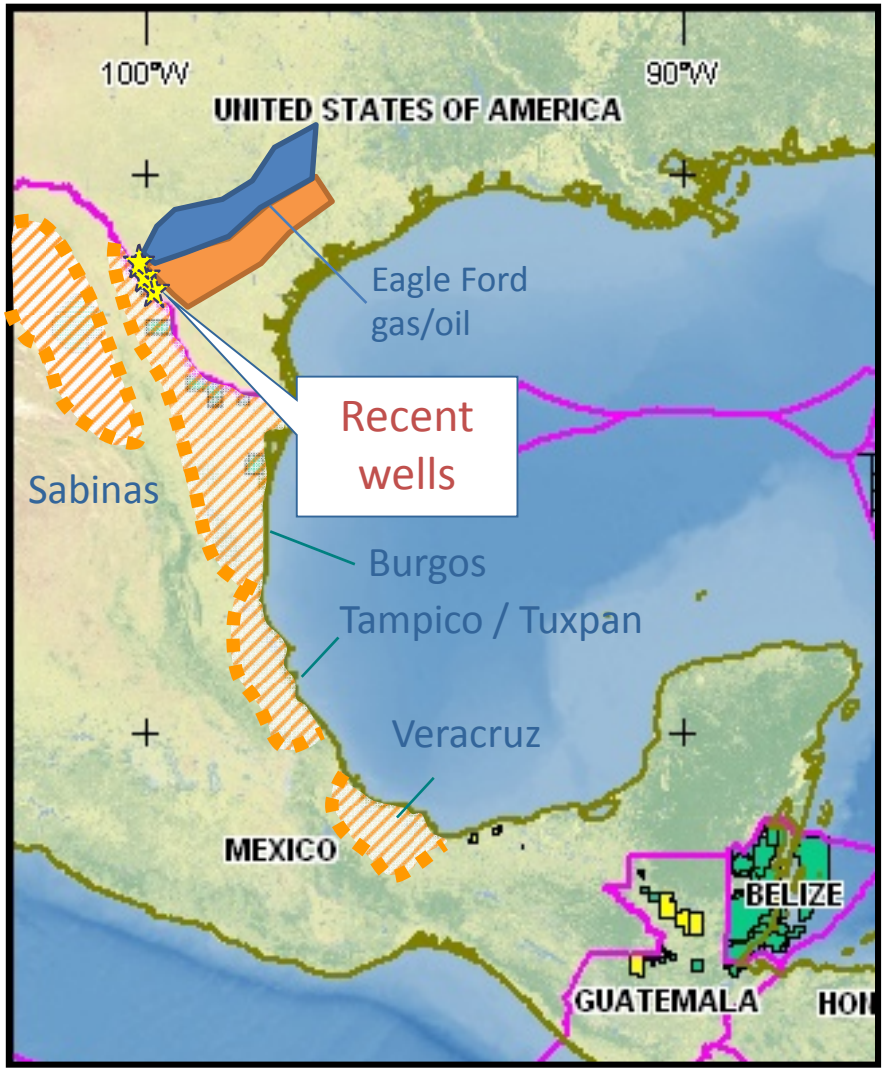
- Poland – reserve write after initial optimism, 30 wells drilled
- France & Bulgaria – banned groundwater pollution fears
- Austria, Hungary – exploration started
- UK – 200 Tcfg onshore but exploitation questionable
- Offshore North Sea – 1,000 Tcfg, very expensive, distant future
- Canada numerous shale plays but mostly in exploratory stage
- China – 1,275 Tcfg, world's largest reserves, likely to duplicate US
- India – 15th largest reserves but hungry for energy
- Indonesia – 574 Tcfg but no development yet
- Brazil – 226 Tcfg but more worried about pre-salt development

Argentina Unconventionals



- Argentina – 3rd place behind China & US shale gas – 774 Tcfg
- Neuquen Basin –Vaca Muerta shale leads way
- YPF top operator, 45 VM wells, 15 producing, no horizontals
- Liquids focus -200-600 bo/d IPs
- Loma la Lata Norte & Loma Campana most important fields
- 741 MMbo & over 1 Tcfg resources
- Notable operators, ExxonMobil, Pluspetrol, Total, EOG, Apache, Shell, Tecpetrol
- Apache drills first hz well in Los Molles, (Anticlinal Campamento)

Mexico - Unconventionals



- 4th place shale gas after China, US & Argentina – 681 Tcfg
- Plans big shale push in Tampico-Misantla Basin – oil rather than gas
- 5 shale integrated field laboratories in Sabinas Basin
- Five basins to be studied for shale potential
- 175 wells, 10,000 sq km 3D seismic, US$ 2.4 billion expl planned to 2016.
- First horizontal – Emergente well, Eagle Ford, US$ 20 million, 2.9 MMcfg/d IP

Colombia Shale Gas

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- 31 unconventional blocks in current bid round with incentives
- 40% royalty reduction, higher price for windfall profits tax
- Most important unconventional basins - Eastern Cordillera, Middle & Lower Magdalena, Catatumbo
- ANH P50 – uncon prospective resources, 2.22 Bbo, 265 Tcfg
- Ecopetrol goal by 2020 - produce 50,000 bo/d
- La Luna & Rosablanca formations most unconventional potential – Eagle Ford & Bakken analogues, respectively
- Shell, ExxonMobil, Vetra & Canacol in Middle Magdalena Basin, Nexen (Eastern Cordillera Basin).
- Pacific Rubiales in Lower Magdalena Basin & claims first successful hydraulic fracking

Abundante: Recursos de Shale Gas

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Energy Information Administration (EIA)

Región	Shale Gas (TMC)
Europa	18
Norte América	55
Asia	39
Australia	11
África	30
Sudamérica	35
Total Mundo	**188**

6,639 TPC

International Energy Agency (IEA)

Región	Shale Gas (TMC)
OECD Europa	16
OECD Norte América	55
Asia/ Pacifico	51
Medio Oriente	14
Africa	29
Latinoamérica	35
Total Mundo	**204**

7,204 TPC

Tanto la EIA como la IEA, estiman similares potenciales recursos de Shale Gas en diferentes regiones del mundo.

Thoughts and Conclusions

- Most dramatic impact on industry in 50 years.
- Victim of own success on pricing but will reach balance
- Depends on mature industry
- Critics have valid points but problems not insurmountable
- Technology driven play – data is crucial in learning curve
- Shale gas reserves make large traditional fields less strategic
- Other parts of world will follow the US but more slowly

Final Thought

- Viva Shale Gas Revolucion Americana
- Muchas Gracias Por Su Atencion