Natural Gas Supply: Not As Great or As Inexpensive As Commonly Believed*

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Search and Discovery Article #70097 (2011)
Posted June 26, 2011

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Abstract

It is widely believed that shale plays will provide an abundant and inexpensive supply of natural gas that can also be produced at a great profit to operators. While shale gas has added significantly to U.S. supply, the plays are marginally commercial at best, and the resources and reserves are considerably less than commonly believed. Shale plays will probably add 7-10 years of supply, but much of that will be non-commercial unless gas prices increase dramatically. The marginal cost of shale production for most operators is about $8/Mcf so prices must increase above that level to sustain these plays without corresponding increases in drilling, completion, land, and operating costs.

Current levels of drilling and over-supply of gas are likely to persist at least into mid-2011, which implies that prices will remain near current levels for a while. The present emphasis on liquid-rich plays does little to mitigate low gas prices because most of these plays produce considerable volumes of gas.

Because most operators are spending beyond cash flow and have high debt loads, some may run out of capital and experience financial distress if loan covenants are triggered. If this happens, the myth of abundant, cheap gas supply from shale will be exposed, and gas prices will increase. The U.S. has ample natural gas resources for at least the next 25 years, but it will probably cost more than is generally assumed today.

Reference

Medlock, K.B., III, 2010, Shale Gas and Emerging Market Dynamics: The Rice World Gas Trade Model: The Impact of the Shale Resource, Web accessed 19 June 2011, http://www.spegcs.org/attachments/studygroups/13/2010_10_Westside%20-%20Medlock%20Shale%20Gas%20Presentation.PDF

U.S. Shale Gas

*Natural gas supply: not as great or as inexpensive as commonly believed*

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April 12, 2011

Shale gas reserves are not as great or as inexpensive as are commonly believed

• Commercial outcomes from shale gas plays will be marginally commercial but have not been calibrated to other unconventional plays with more history.

• Shale gas is at the bottom of the resource pyramid: resource volumes are large, but costs are high and recovery efficiency is low.

•There are at most 20 years of natural gas supply in the United States. Claims of 100 years are not consistent with credible reserve estimates.

• Type curves produce over-stated reserve forecasts and must be replaced by more realistic methods.

• Low decline-rate hyperbolic models are not supported by empirical production history data.

• The manufacturing model has failed.

• All shale plays have contracted to core areas a fraction of the size of the play as originally advertised.

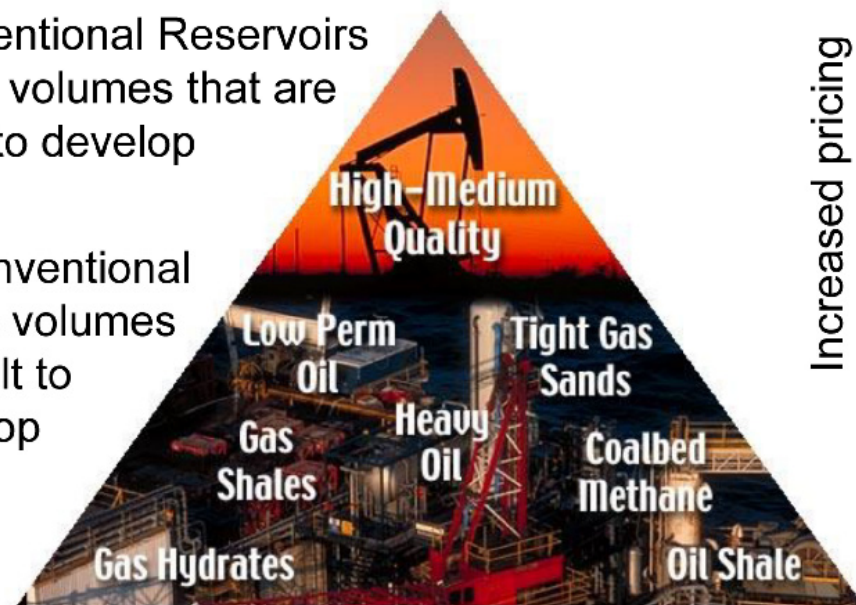• The trend suggests that natural gas prices will equilibrate.
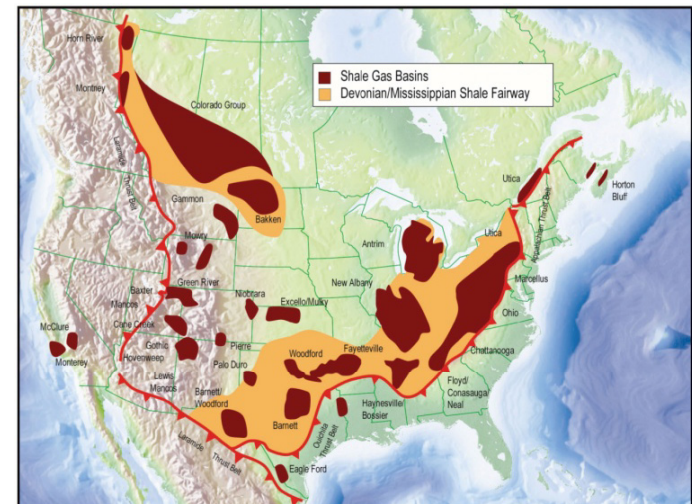
A view from the bottom of the resource pyramid

- Unconventional gas plays became important as better plays were exhausted.
- Economics are similar to tight-gas sandstone & coal-bed methane plays— marginal.
- Except that entry, drilling & completion costs are enormous.
- And the drilling treadmill never ends because of high decline rates.
- There is no technological revolution, just improvement through extensive & expensive trial-and-error.

Conventional Reservoirs
Small volumes that are easy to develop

Unconventional
Large volumes difficult to develop

High–Medium Quality

Low Perm Oil

Tight Gas Sands

Gas Shales

Heavy Oil

Coalbed Methane

Gas Hydrates

Oil Shale

Increased pricing

Improved technology

From Holdich (2011)

No 100 years of natural gas because of shale plays

- Potential Gas Committee (PGC) June 2009 Report misinterpreted.
- Technically recoverable resources are not reserves.
- Probable shale gas component is 147 tcf.
- That's a lot of gas but it is not 100 years of supply.

Potential Gas Committee 2009 Report	
	TCF
U.S. Technically Recoverable Resources	1,836
Shale Gas Component	616
"Probable" (P_2) Technically Recoverable Resources	441
Shale Gas Component	147

"There is clearly sufficient North American gas supply to last for a bunch of years; 50 years at least. And there is clearly no need for us to import LNG (liquefied natural gas) for multiple years to come."
--Mark Papa, EOG CEO, November 2010

Assumes no demand growth and only 20 years if that is true.

Proved U.S. Reserves (tcf)	Probable PGC Resources (tcf)	Possible PGC Reserves (50%)	Years of Gas @ 23 tcf/year
238	441	221	20

Presenter's notes: PGC estimates are higher than Medlock's (2010), which we use for our evaluation because they are more consistent with our experience and view, and because they break out individual shale plays and include Canada. PGC is a credible mid-range estimate for the US, and less optimistic than industry-sponsored groups, like American Clean Skies Foundation (ACSF) & Navigant Consulting, The Canadian Society for Unconventional Gas (CSUG).
You asked about the evolution of the PGC's evaluations. Their methods have been quite consistent through their biennial report. The difference in 2009 was that they added shale as a legitimate resource for the first time. That increased the overall resource by 1/3.

Shale gas plays in the U.S. are commercial failures

Selected Company 5 Year Imputed Production Costs/Mcfe

■ Weighted Realized Price/Mcfe with Hedges   ■ 5 Year Calculated "Break-Even" Price
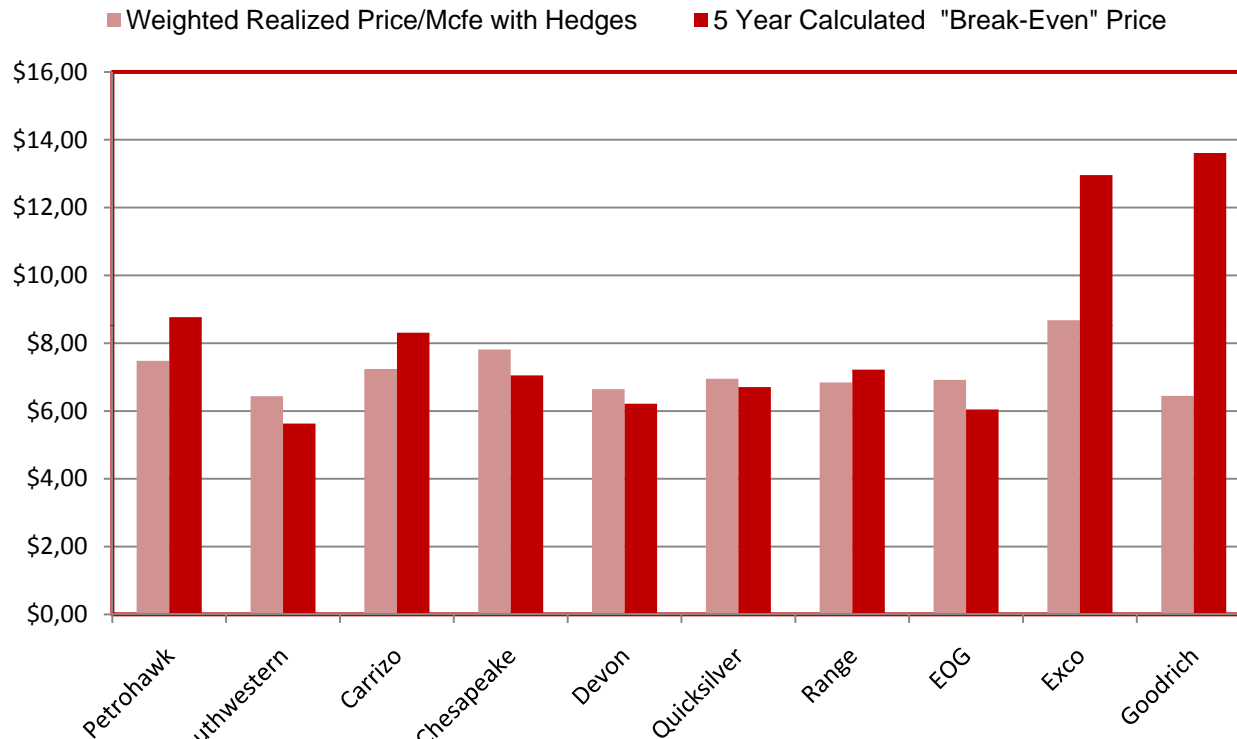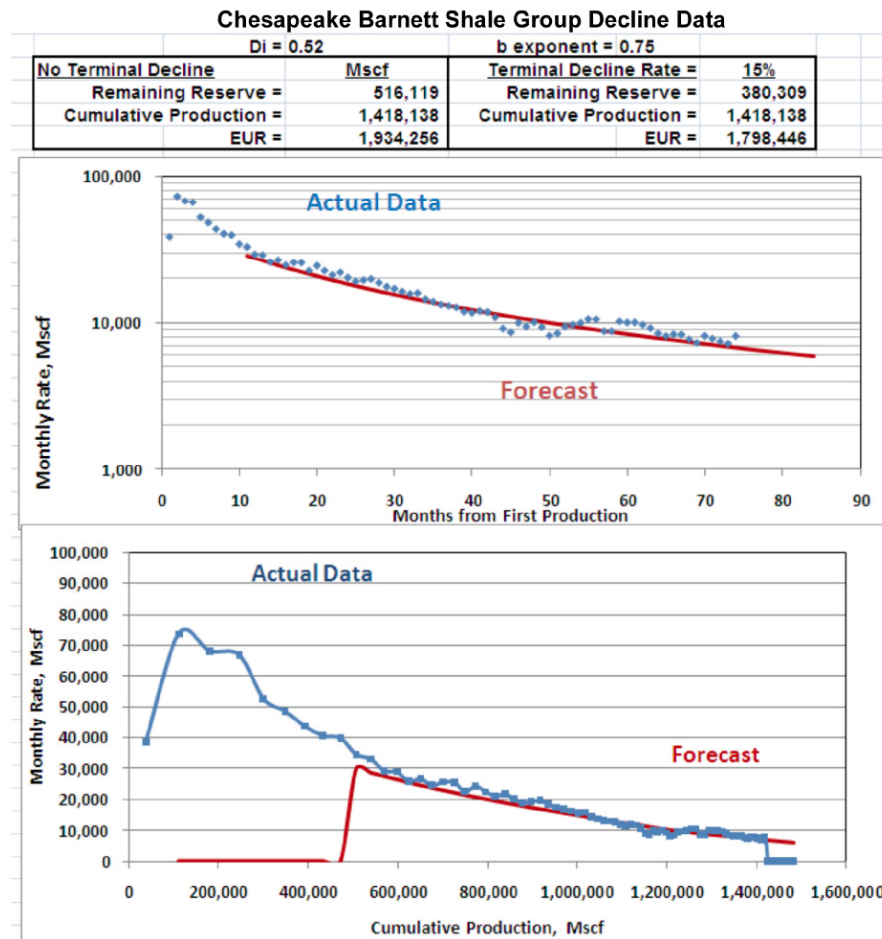

Source: Company Reports

- Claims of profitability at less than $5.00 /mcfg are based largely on point-forward economics at odds with costs reported to the Securities and Exchange Commission in 10-K filings—all sunk costs written off.
- It is easy to make a profit if you have no costs.
- Interest expense and G&A (overhead), dry hole cost, P&A expense and others not considered.

Type curves produce over-stated reserve forecasts: Barnett Shale example

Group average has significant hyperbolic flattening matched by a hyperbolic b-exponent of at least 0.75.

Chesapeake Barnett Shale Group Decline Data

| Di = 0.52			b exponent = 0.75	
No Terminal Decline		Mscf	Terminal Decline Rate =	15%
Remaining Reserve =		516,119	Remaining Reserve =	380,309
Cumulative Production =		1,418,138	Cumulative Production =	1,418,138
EUR =		1,934,256	EUR =	1,798,446

Decline-curve analysis of individual wells result in lower average EUR

- Much lower b-exponents.

- Remaining reserves 44% lower than group decline.

- Survivorship bias and work-overs/refracs are the main cause.

Wellname	EUR, MMscf	Remaining Reserve, MMscf	Di	b exponent
KENNON, I.G. 1	459.6	22.8	0.50	0.25
MCANIER 1	2,677.7	561.2	0.25	0.25
CHILDRESS, B.F. 2	1,163.1	46.0	0.45	0.25
LAKEVIEW 1H	2,982.4	424.0	0.40	0.25
BUFFALO RIDGE 2H	1,666.5	137.0	0.38	0.10
CITY OF CLEBURNE 2H	1,128.2	99.7	0.38	0.10
FALVEL 2H	2,245.6	220.8	0.36	0.10
WHITE WING COACHMAN "B" 2	733.4	31.3	0.48	0.10
TUCKER 1H	171.3	0.0	0.50	0.10
CITY OF CLEBURNE 3H	1,007.4	81.3	0.35	0.10
WILLIAMS 3H	3,372.8	190.3	0.50	0.10
EAST GODLEY 2H	2,303.2	127.2	0.45	0.10
WEST, MAE "B" 2	1,160.2	282.2	0.15	0.10
MARTIN 1H	687.8	10.8	1.00	0.10
BOATRAMP 1H	1,146.8	101.3	0.35	0.10
SOUTHLAKE 1H	1,927.1	457.4	0.42	0.50
LAKEVIEW 2H	2,473.3	591.4	0.30	0.25
PENNINGTON 1H	1,695.1	109.3	0.55	0.25
MEADOWS 2H	1,485.1	262.4	0.30	0.25
LEE 2H	2,026.4	442.3	0.30	0.25
JENNY 1H	1,525.6	445.5	0.20	0.25
Average =	1,620.9	221.2	0.41	0.18
From Vintage 2004 Group Average	1,798.4	380.3	0.52	0.75
		42%		
	lower estimate of remaining reserve from individual well DCA			

Encana Barnett type curve example: mean over-predicts reserves

Encana Barnett Probabilistic EUR vs. Group Average Decline-Curve Analysis
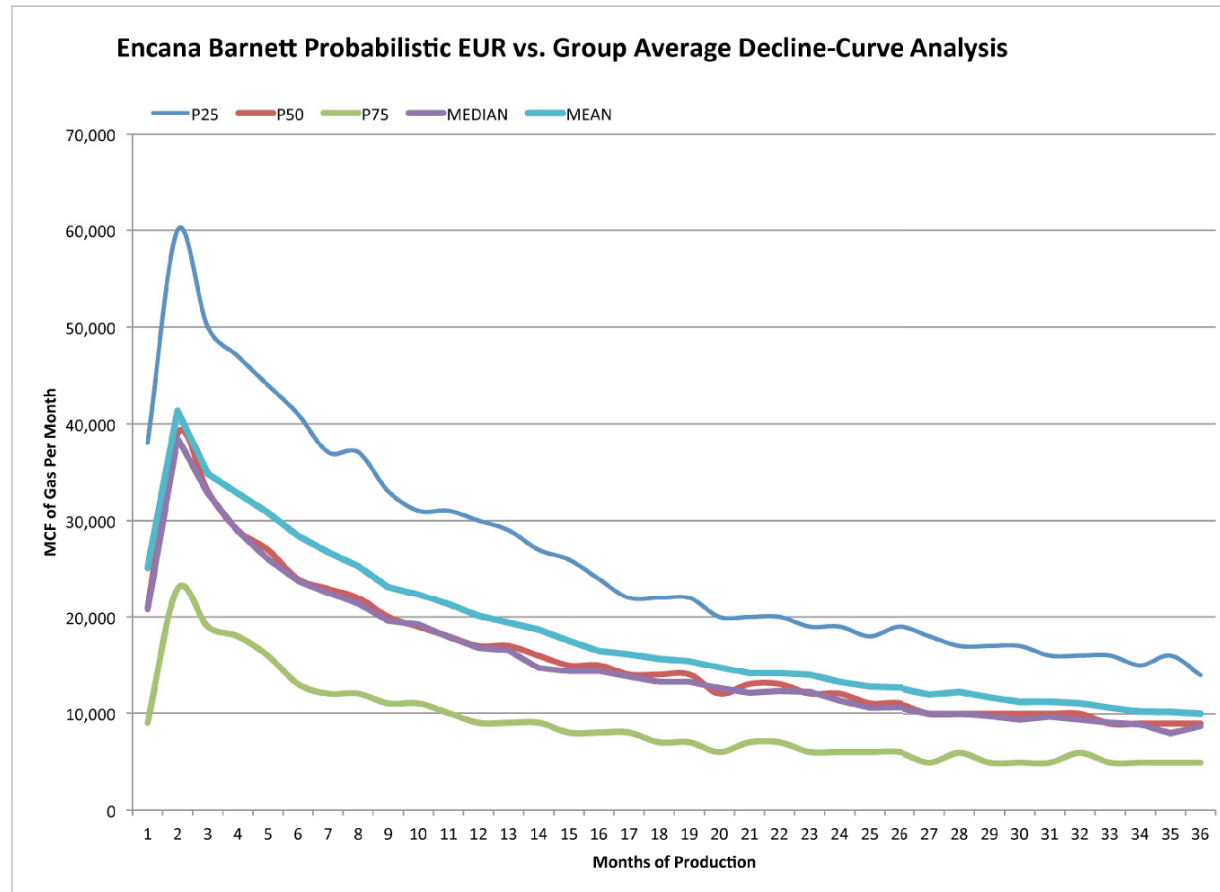
- Light blue is mean.
- Median (purple) better approximates P_{50} case (red)—15% less than mean.
- Huge probabilistic spread but operators usually claim one EUR value.

Low decline-rate hyperbolic models are not supported by long-lived empirical production-history data: Barnett Shale Devon Energy examples
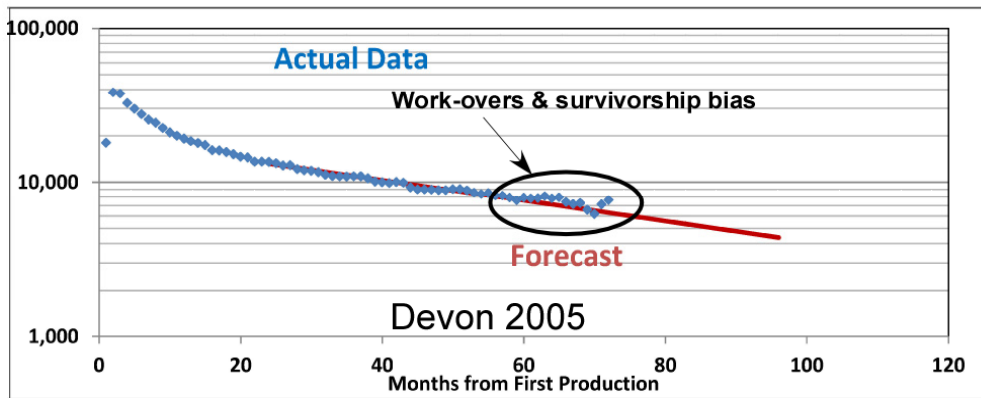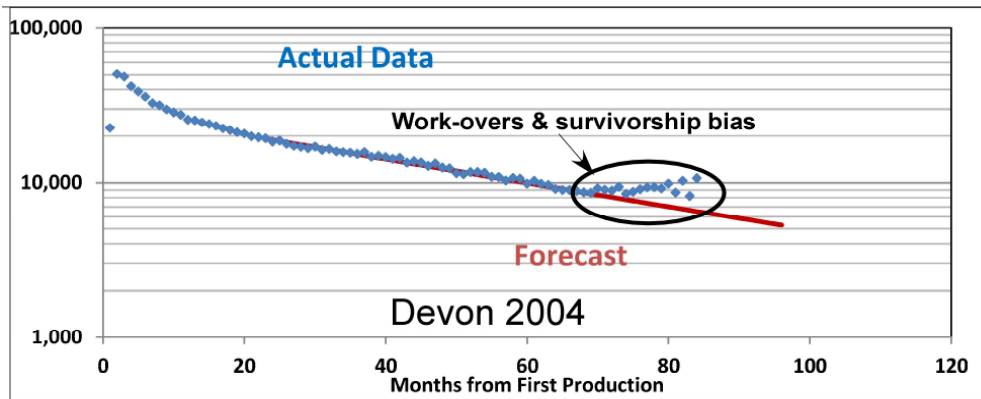
Index	WELL VINTAGE	EUR	NUMBER OF WELLS
1	DVN 2004	1,555,508	91
2	DVN 2005	1,172,450	160
3	DVN 2006	1,034,726	289
4	DVN 2007	1,139,035	459
5	DVN 2008	1,358,715	573
6	DVN 2009	1,156,912	287
7	DVN 2010	1,074,705	431
	DVN WTD AVG	1,189,856	2290

- Devon claims their average well EUR will be 2.2 bcf
- Reserves are approximately 50% of operator claims

The manufacturing model has failed
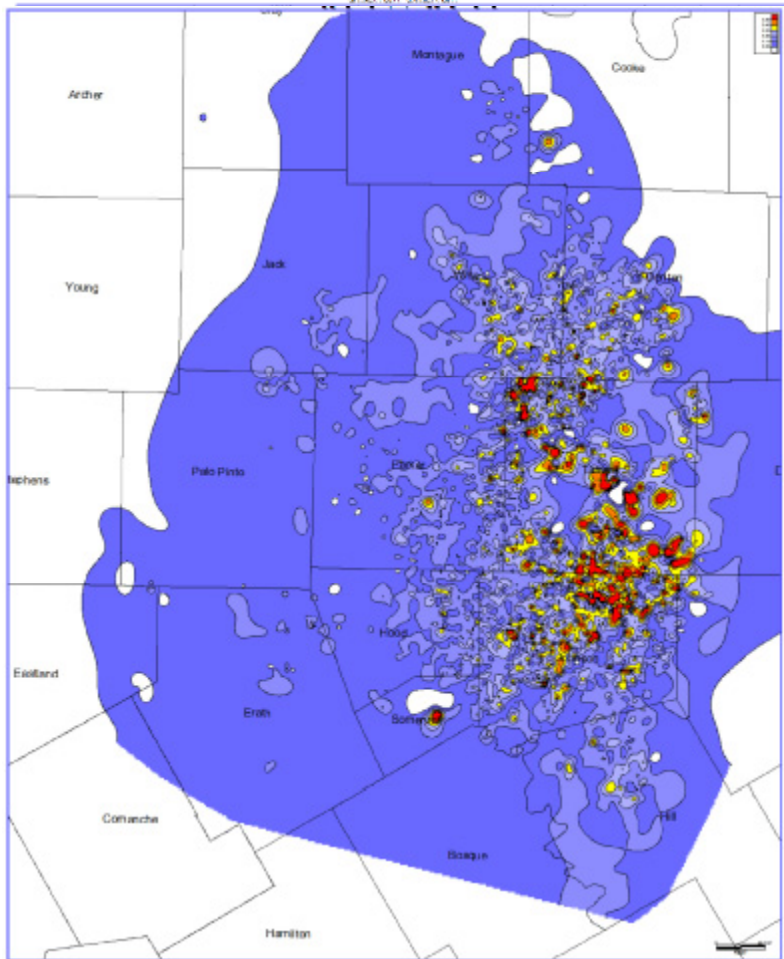
OPERATOR NAME	TOTAL GAS (BCF)	NUMBER OF WELLS
DEVON ENERGY CORPORATION	1.47	2,373
CHESAPEAKE OPERATING, INC.	1.23	2,178
XTO ENERGY, INC.	1.12	1,657
EOG RESOURCES, INC.	0.85	1,593
QUICKSILVER RESOURCES, INC.	0.38	887
ENCANA OIL & GAS(USA) INC.	0.29	424
RANGE PRODUCTION COMPANY	0.20	335
ENERVEST OPERATING, LLC	0.13	187
WILLIAMS PRODUCTION	0.12	214
CARRIZO OIL & GAS, INC.	0.12	223
TOTAL	5.92	10,071

- 8.6 million acres (13,500 sq mi).
- 14,500 wells producing wells.
- 72% of production from Devon, Chesapeake, XTO and EOG.
- 92 % of production from ten operators.
- The core areas (red and yellow) are the only part of the play with the potential to be commercial.

# The manufacturing model has failed
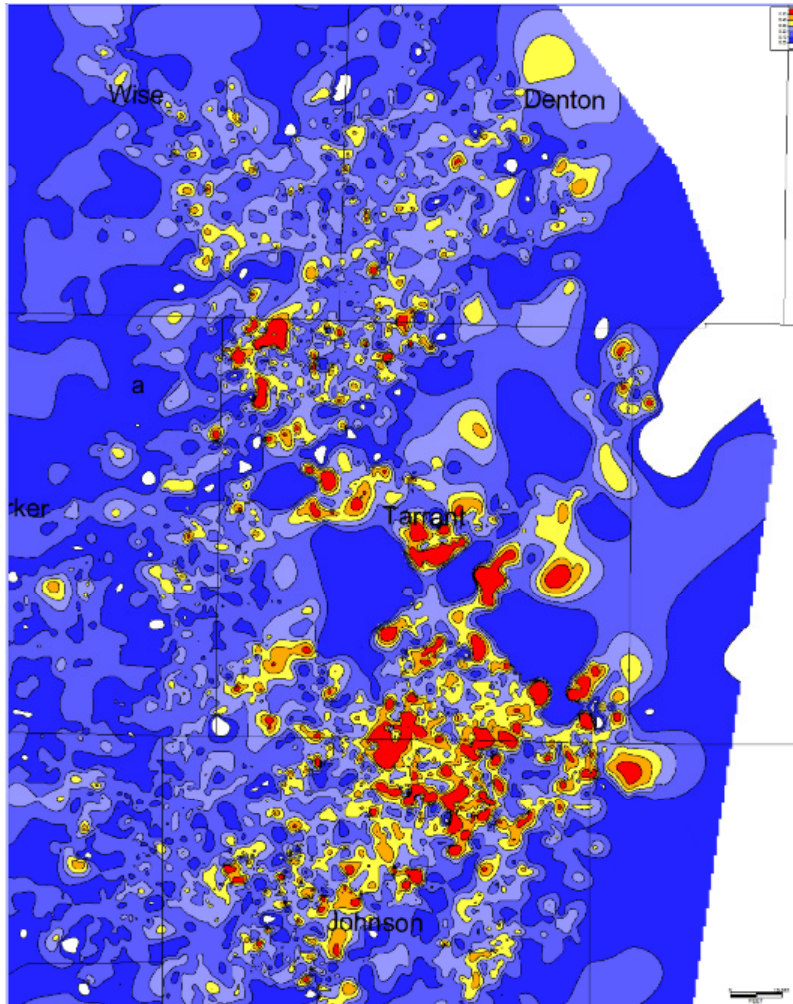
First 6-month cumulative production for Barnett Shale horizontal wells. Data source: HPDI

• All shale-gas plays have contracted to core areas.

• These core areas represent a fraction of the size of the plays as originally advertised.

"There was a time you all were told that any of the 17 counties in the Barnett Shale play would be just as good as any other county," McClendon said. "We found out there are about two or two and a half counties where you really want to be."

--Bloomberg News October 14, 2009

## Shale plays have contracted to a fairway or core area: Haynesville Shale example
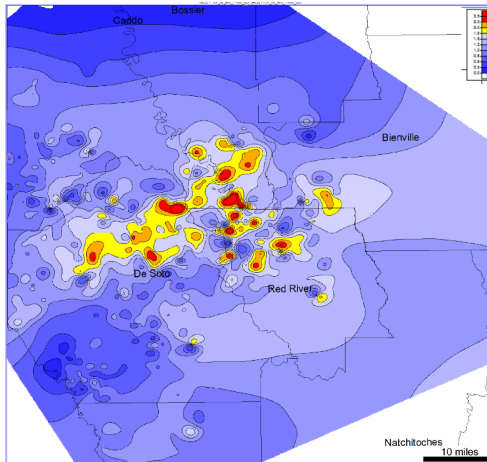
First 6-month cumulative production for Haynesville Shale horizontal wells (with contours). Data source: HPDI

• The emerging core area includes ~110,000 acres or about 5 Townships.

• This represents approximately 10% of the play area in Louisiana defined by limits of drilling (1.5 million acres or 65 Townships).

• A few years ago, this was promoted as the 4th largest gas field in the world, and the largest in North America.

• Core areas are structurally influenced.

Presenter's notes: All shale plays contract to a core area or areas that represent a fraction of the resource that was originally promoted.

Shale plays have contracted to a fairway or core area: Fayetteville Shale example at least partly related to structure
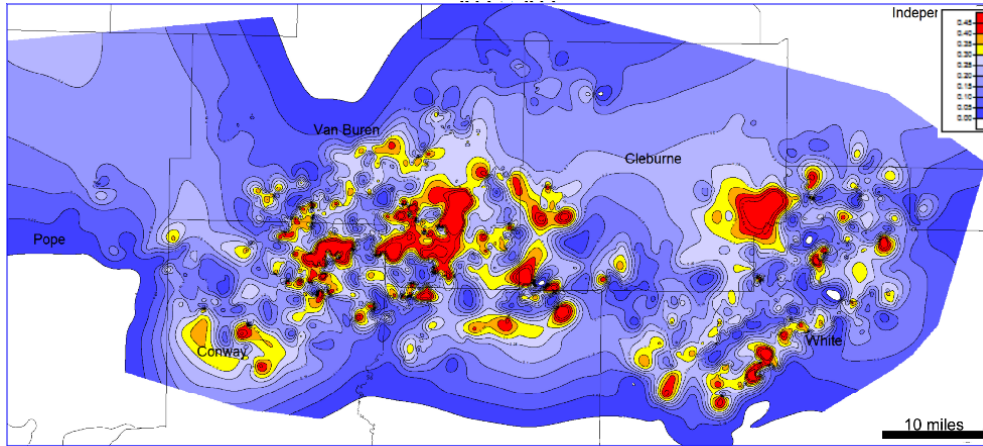

First 6-months cumulative production for the Fayetteville Shale horizontal wells. Data source: HPDI
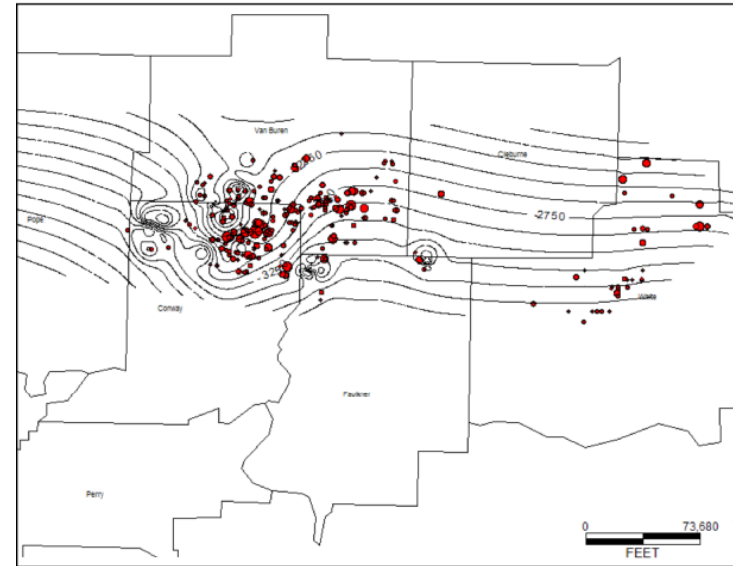
- Contraction to core areas not as extreme in the Fayetteville as other plays.
- Structure plays a strong role in the western core area.
- Associated natural fracturing is also an important factor.

The elephant in the room: decline rates

Barnett Shale Horizontal Wells Static Decline Analysis
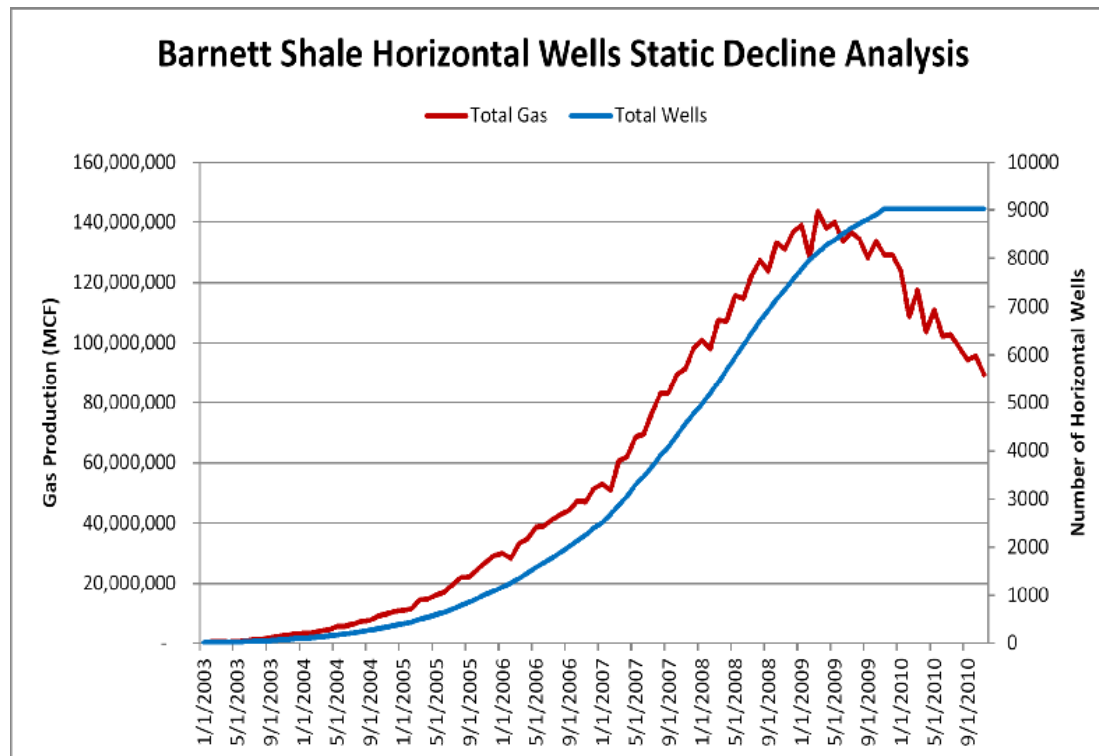
- Static analysis involves adding no new wells for the last 12 months of reported production.
- Resulting annual decline is 44 percent.
- This means that to keep production flat, new wells must be continually drilled.

# U.S. Crude Oil vs. Natural Gas Investment Index
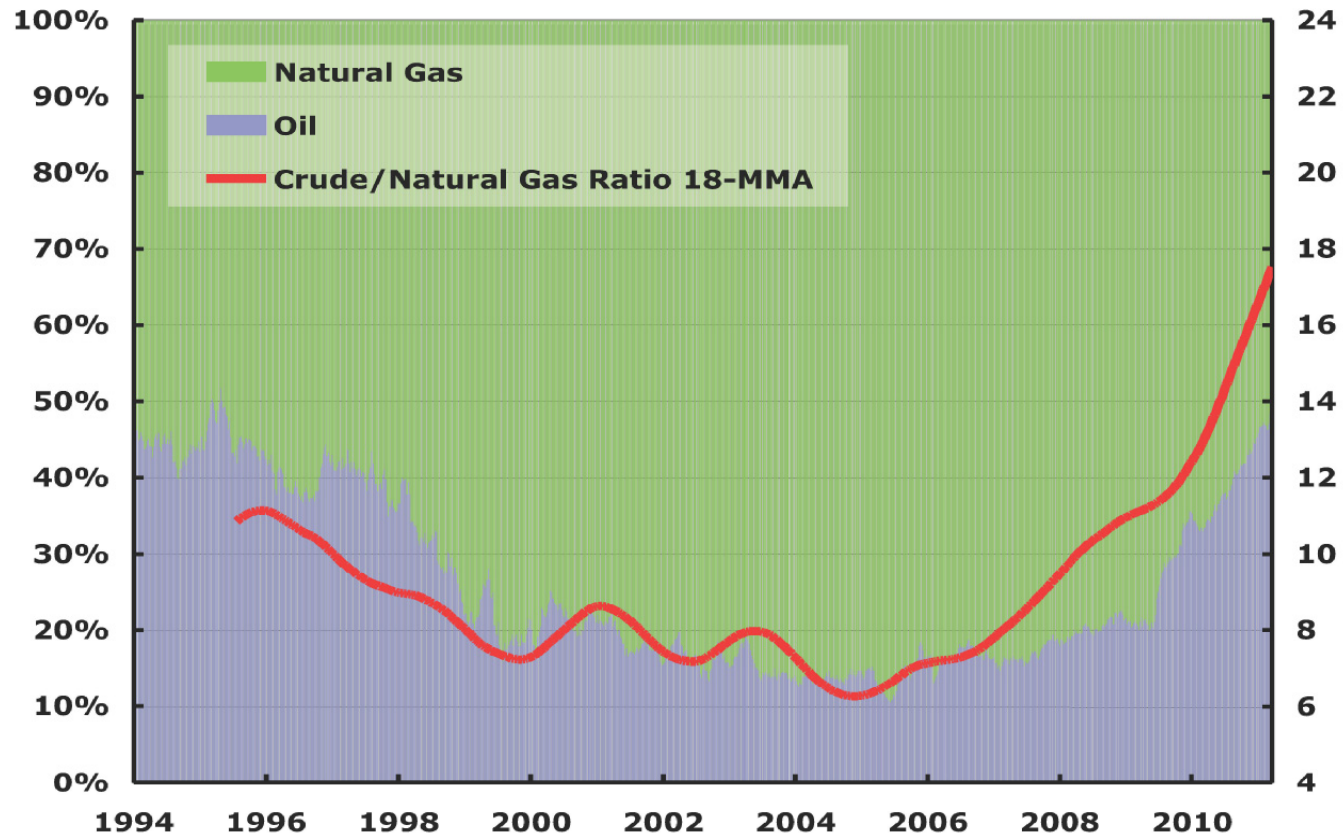
Source: J.M. Bodel, Aperio

- U.S. over-production is significant and commercially unjustifiable.
- The shift to more oil-rich plays will result in equilibration of gas production and price but will take a few years.

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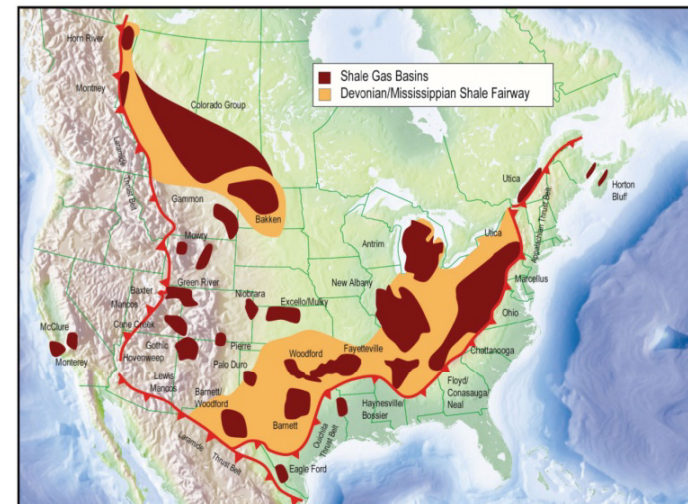
Acknowledgments

- Mike Bodell
- Allen Brooks
- Perry Fischer
- Robert Gray
- Jim Halloran
- IHS
- Lynn Pittinger
- Keith Shanley

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