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U.S. Shale Gas: Magical Thinking & The Denial of Uncertainty

Arthur E. Berman
Labyrinth Consulting Services, Inc.

Houston, Texas
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Shale Magical Thinking

All difficulties arise from what seems easy.
All great things arise from what is minute.
One who thinks that everything is easy
will encounter much difficulty.

Tao Te Ching

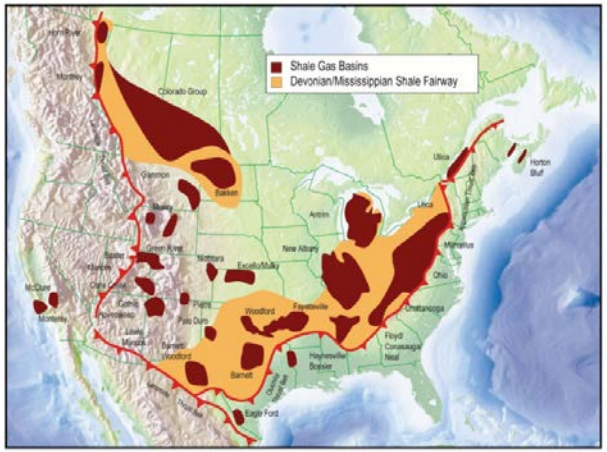
What most people believe:

- Less is more: we can produce more oil and gas from shale than was produced from better reservoirs over the past century.
- The United States has enough natural gas to last at least 100 years.
- A shale business model with no barriers to entry except capital, with an infinite supply of cheap gas, and somehow everyone makes a big profit.
- Shale plays can make a profit at less than $5/kcf gas price.
- Gas prices will be low forever because of abundance and low break-even price.
- If shale didn't make sense, big companies would not be involved.
- Big production volumes prove success.

Natural gas is not as abundant or as inexpensive as commonly believed

What few people realize:

- The United States does not have 100 years of natural gas.
- We have less than 22 years of possible reserves.
- Resources are not reserves, and reserves are not supply.
- Shale gas reserves are over-stated by at least 100%.
- The true break-even cost of shale gas is $7/mcf. The price must rise above this cost for companies to survive.
- Production is impressive but most wells are not profitable.
- All plays have contracted to core areas a fraction of the size of the play as originally advertised.
- The shift to liquid-rich shale plays will deflate the gas over-supply and cause prices to rise.
- Environmental problems will limit the development of the Marcellus Shale.



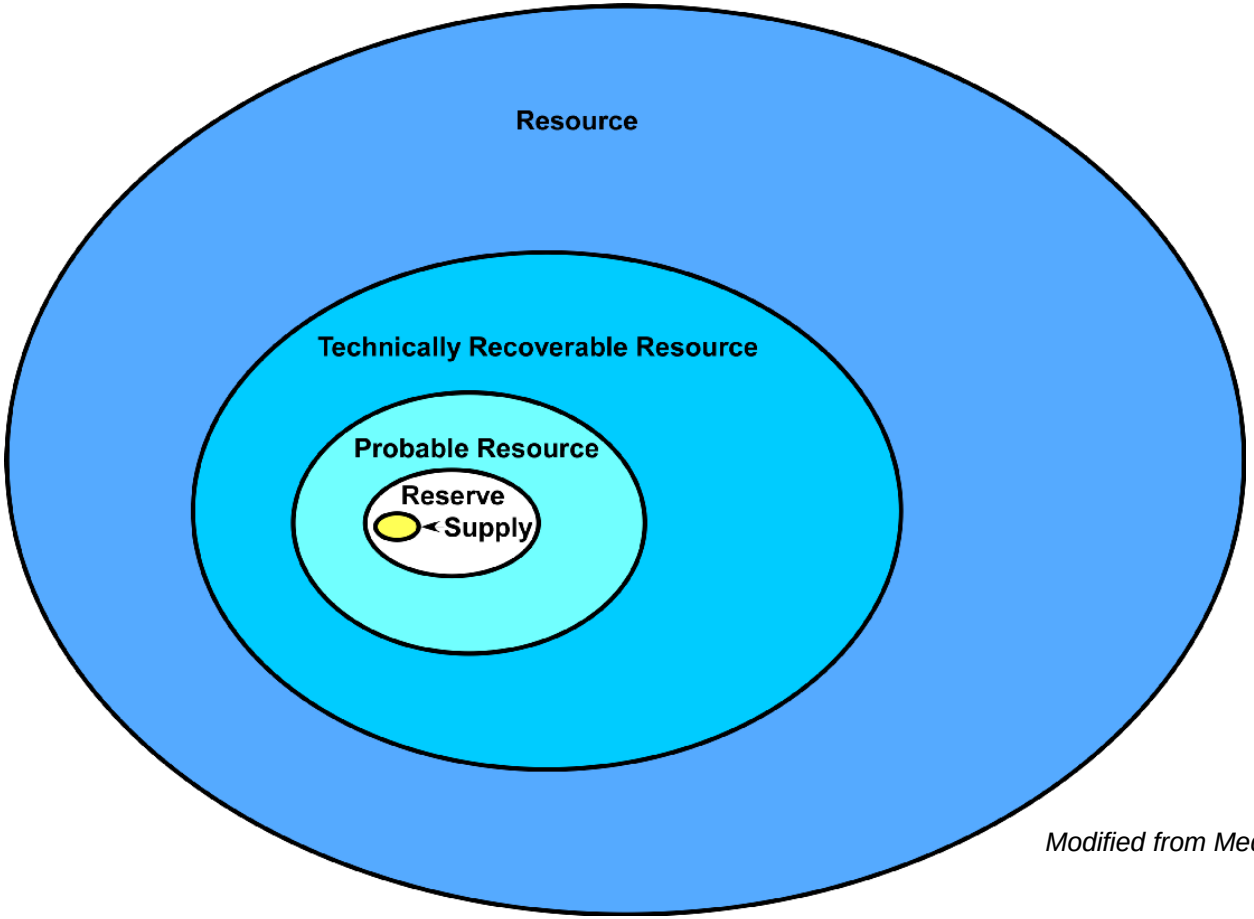
The United States has 22 Years of Natural Gas, not 100 Years

Potential Gas Committee Category	Tcf Gas
Probable resources (current fields)	537
Probable resources (coal-bed methane)	13
Total Probable	550
Optimistic reserve fraction (50%)	225
Years of supply when drilled & developed	10
Proved reserves	273
Years of supply when drilled & developed	12
Maximum years of supply when drilled & developed	22

Data from PGC

- The myth that the U.S. has 100 years of natural gas comes from confusing resources (possible) with reserves.
- Assumes flat consumption.

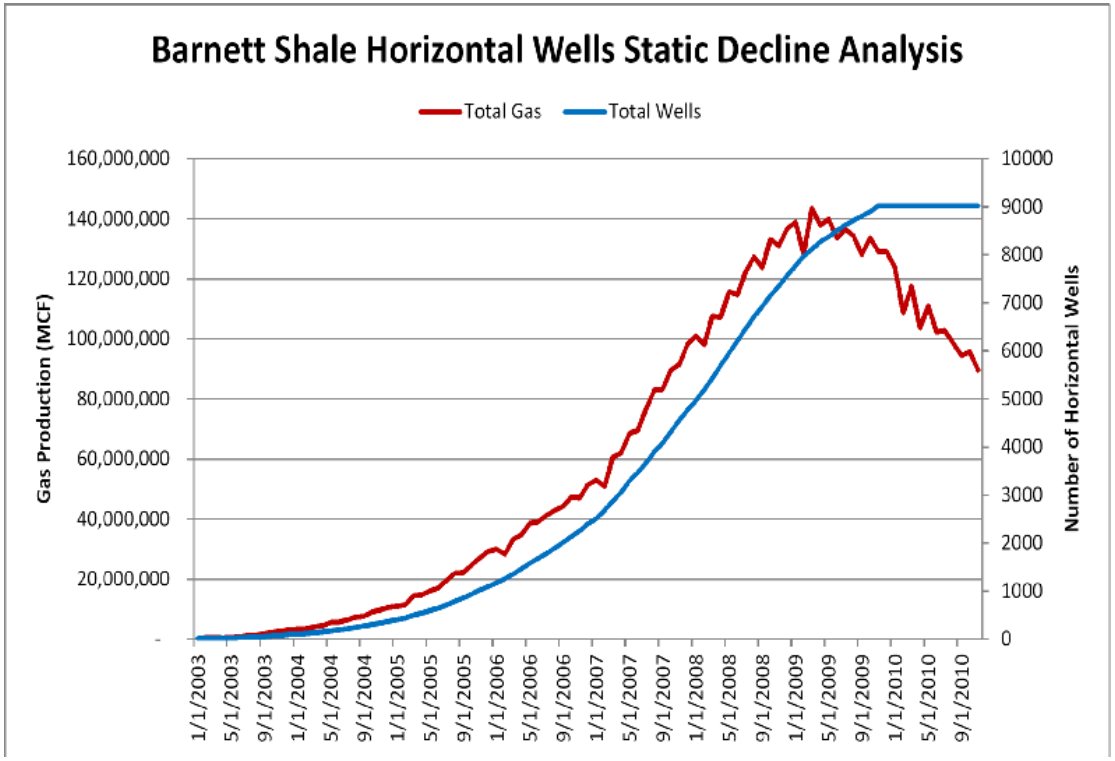
Resources ≠ Reserves ≠ Supply



Modified from Medlock (2010)

- Reserves are a very small sub-set of resources.
- Reserves take years of development drilling to become supply.
- Proved undeveloped reserves may never be developed.

Why Reserves are Over-stated—Decline Rates are Higher than Anticipated

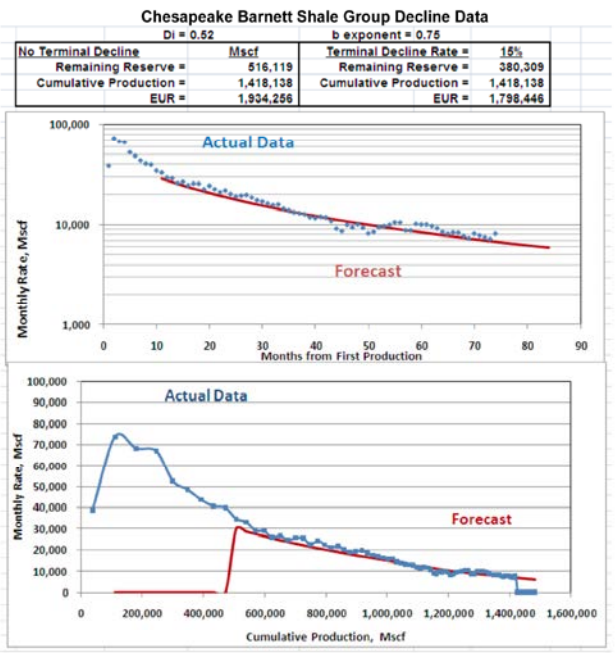


Data from HPDI

- Annual decline is 44 percent for the Barnett Shale.
- This means that to keep production flat, new wells must be continually drilled.

Type curves over-predict EUR

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



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%		

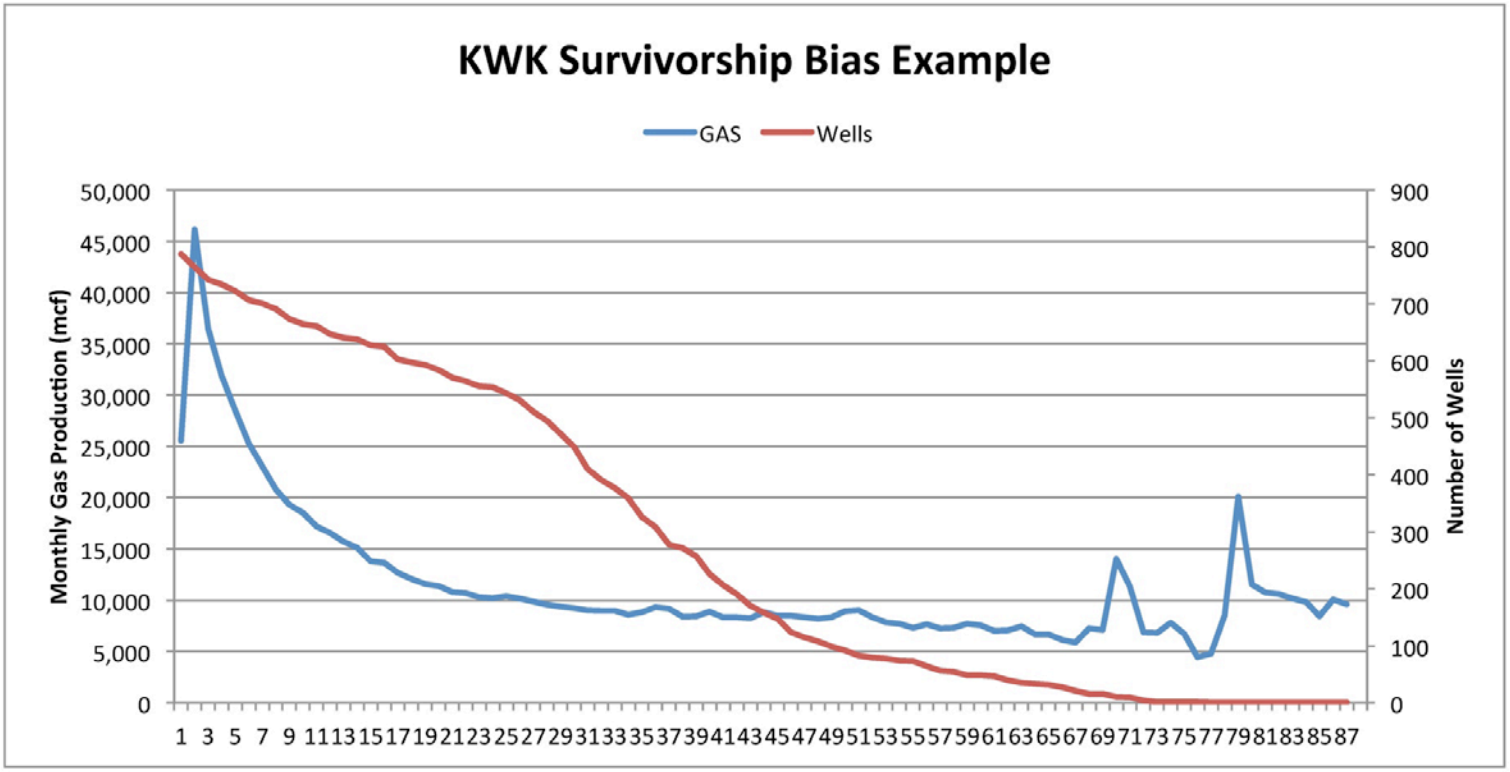
lower estimate of remaining reserve from individual well DCA

Data from HPDI

- Individual well decline-curve analysis shows group decline over-estimates remaining reserves by 42%.
- B-exponent over-estimated by 400%. Stong hyperbolic decline supported by data. This is due to survivorship bias—better wells survive longer & bias a progressively smaller group of wells—result is artificial hyperbolic flattening.
- Peer-reviewed SPE papers caution against b-exponents approaching 1.0—never model the transient flow.
- Standard is reasonable certainty, not a model or a preference.

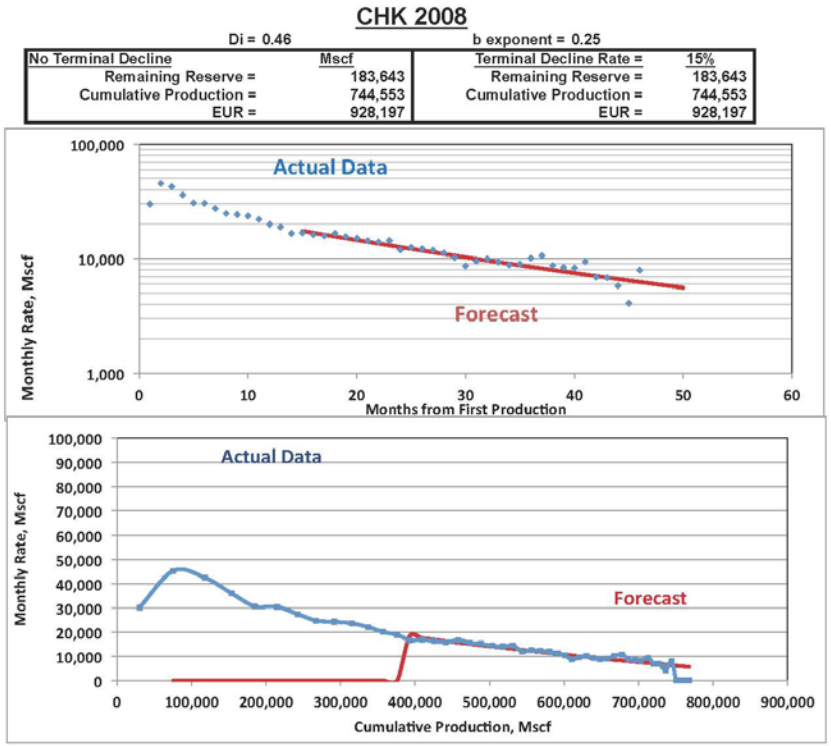
Type curves over-predict EUR: Survivorship Bias

OPERATOR	AVG WELL CUMULATIVE PRODUCTION	NORMALIZED AVG CUMULATIVE PRODUCTION	OVER-PREDICTION
CHESAPEAKE OPERATING, INC.	784,610	1,186,740	151%
DEVON ENERGY CORPORATION	629,422	1,243,758	198%
XTO ENERGY, INC.	677,192	1,376,106	203%
EOG RESOURCES, INC.	554,346	1,087,392	161%
QUICKSILVER RESOURCES, INC.	435,782	1,002,115	181%
ENCANA OIL & GAS(USA) INC.	682,009	1,217,549	180%



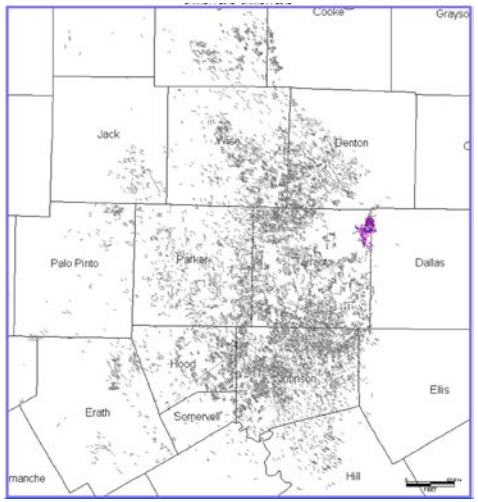
Data from HPDI

Barnett DFW Example

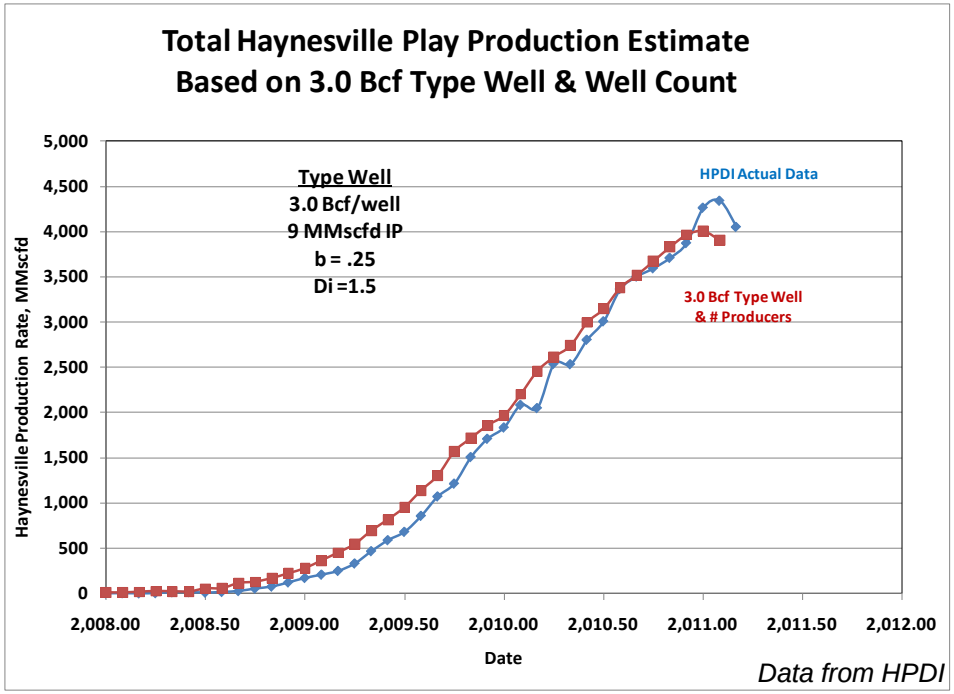


- CHK paid $20,000/acre. $750 million estimated project cost to develop 450 bcf.
- It now appears that only ¼ of those reserves will be produced with current wells.
- Average well EUR is 0.9 bcf.
- Break-even is 2.0 bcf.

Index	WELL VINTAGE	EUR	b exponent	NUMBER OF WELLS
1	CHK 2007	998,173	0.25	24
2	CHK 2008	928,197	0.25	57
3	CHK 2009	921,600	0.25	28
8	CHK COMPOSITE	949,323	0.25	109
	CHK WTD AVG	941,910		



Total Haynesville play production estimate

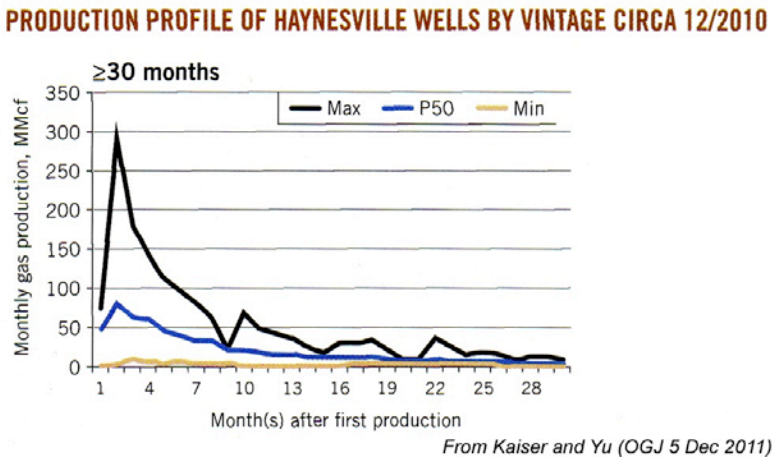


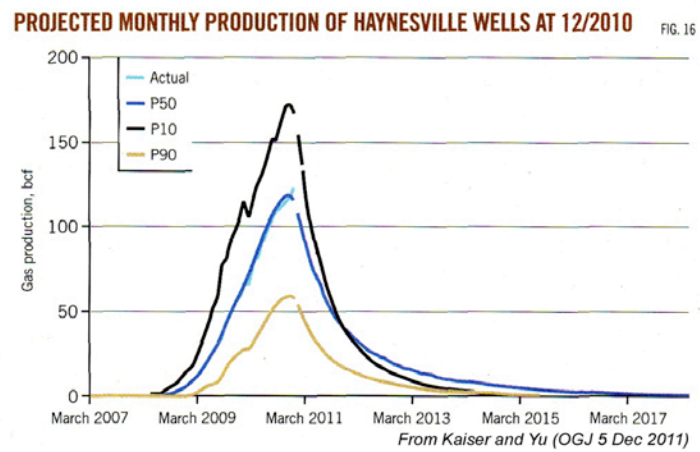
Overall Average EUR - Calculated Break-Even Gas Price for 8% Discount Rate								
	Barnett		Fayetteville		Haynesville		Marcellus	
	Full-Cycle	Point-Forward	Full-Cycle	Point-Forward	Full-Cycle	Point-Forward	Full-Cycle	Point-Forward
Break-Even Gas Price, $/mmBtu	**$8.75**	**$5.63**	**$8.31**	**$5.06**	**$8.68**	**$6.80**	**$7.84**	**$5.61**
EUR/Wel (Bcf/Well)	1.34	1.34	1.19	1.19	3.00	3.00	2.00	2.00
Well Cost ($mm)	$3.50	$3.50	$2.80	$2.80	$9.50	$9.50	$5.50	$5.50
Royalty	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%
Land* ($/acre)	$5,000	$0	$5,000	$0	$5,000	$0	$5,000	$0
Expense (LOE, G&T., G&A ($/net mcf)	$1.50	$0.75	$1.50	$0.75	$1.50	$0.75	$1.50	$0.75
Severance Tax	7.50%	7.50%	$0.11/mcf	$0.11/mcf	7.50%	7.50%	0%	0%
F&D ($/net mcf)	$4.92	$3.37	$4.78	$3.04	$4.87	$4.17	$4.99	$3.56
Total Cost ($/net mcf)	$6.41	$4.12	$6.42	$3.93	$6.37	$4.92	$6.03	$4.31

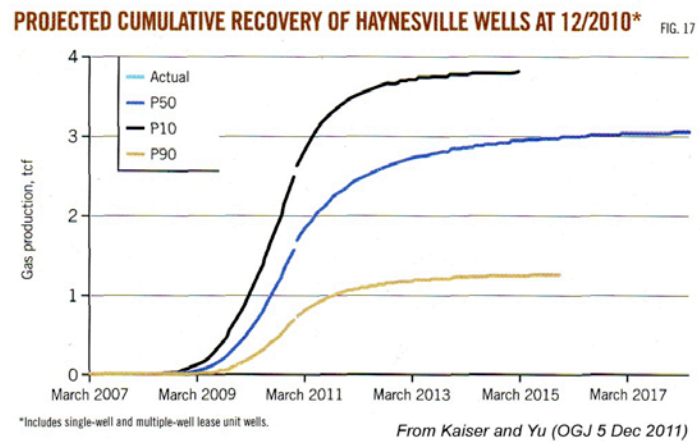
** Land cost assumes 169-acre spacing and 50% of leased land developed*

The play will not be profitable until gas prices are more than $7/mcf.

Total Haynesville play production estimate



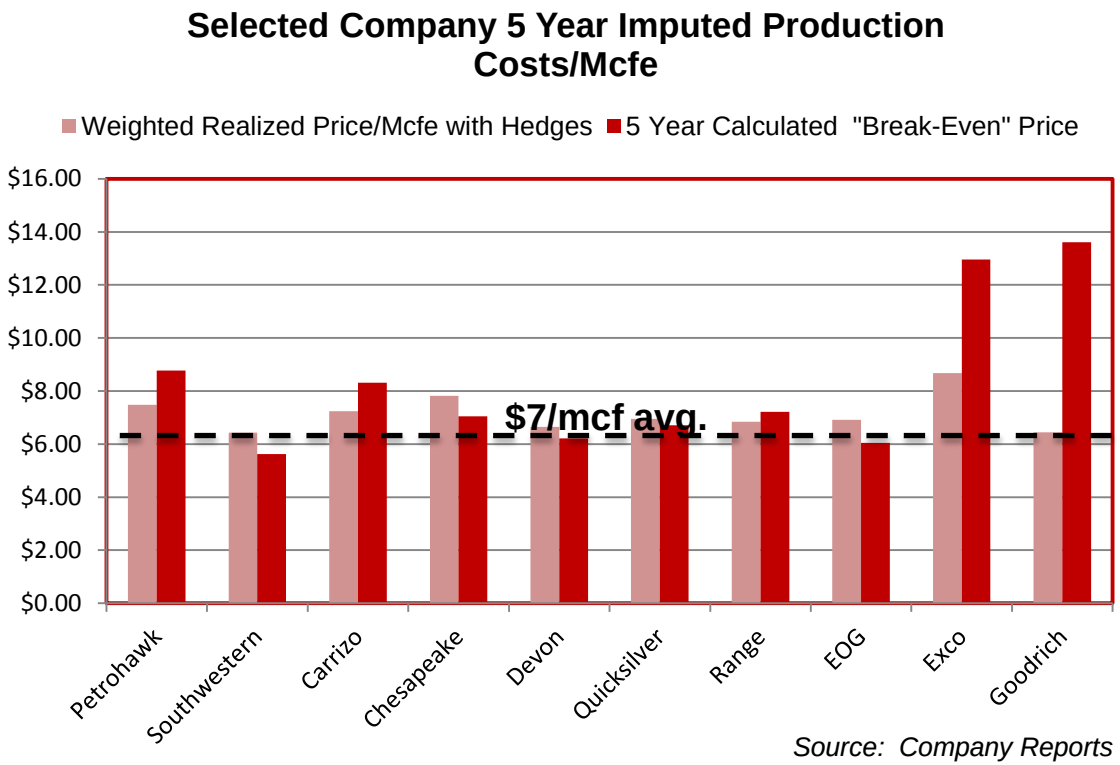




New LSU Haynesville Study (OGJ 5 Dec 2011)

- Production growth due to continual drilling of new wells and concentrating in the core area.
- 80% of EUR produced in first 2 years production.
- Individual well EUR P_{10} 4 bcf – P_{50} 3 bcf – P_{90} 1.2 bcf .
- Projected field EUR: 3 – 9 tcf (200-800 wells/3 years).
- This field was advertised as 250 tcf in 2006.

Cost is Understated: The True Break-Even Price is $7.00/mcf



- 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.
- Price must rise to meet the true break-even cost.
- Several executives have recently said that $6/mcf is a minimum threshold to justify more drilling.

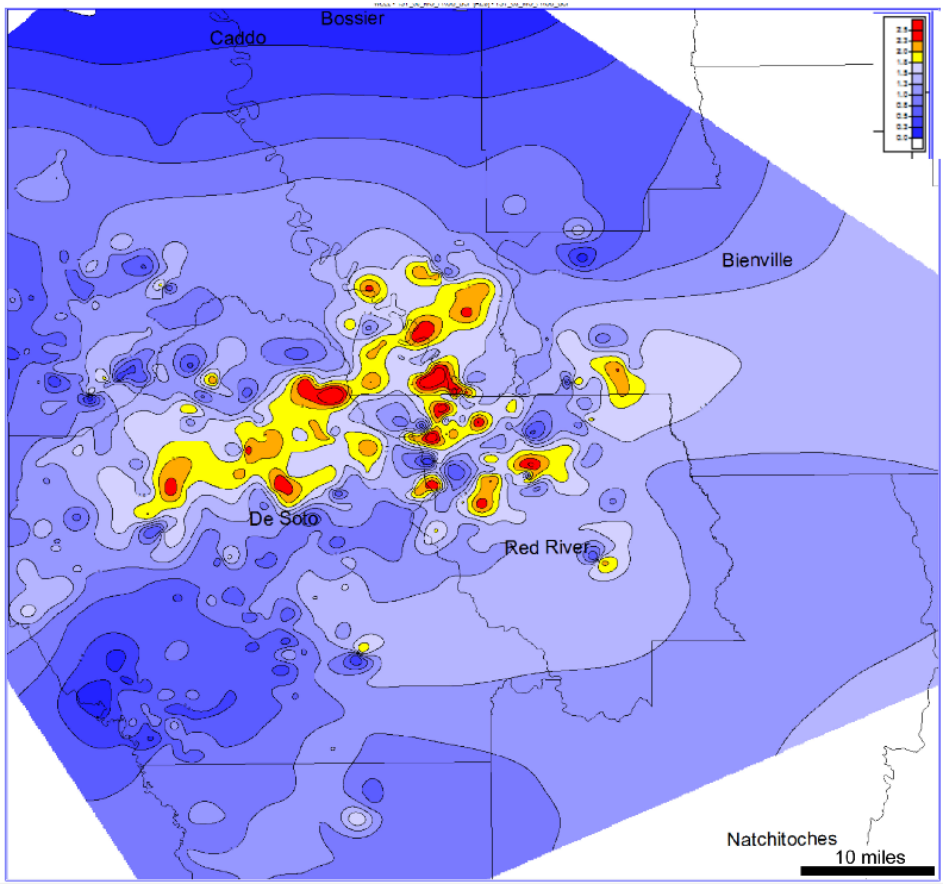
Capex-to-Cashflow Ratios

Ticker	Share Price as of 12/19/11	Mkt Cap ($B)	EV ($B)	1-Year Change in Price	Production 3Q11 (kboepd)	Gas as % of Production	Cash Margin ($/boe)	Debt to Total Cap	Capex to Cashflow
RRC	59.45	9.4	11.2	39%	89	76%	20.62	43%	860%
SM	68.08	4.5	5.1	23%	77	61%	27.91	28%	368%
KWK	6.35	1.2	3.2	-55%	71	82%	6.95	65%	321%
TLM	11.75	11.7	15.4	-44%	324	60%	36.97	28%	282%
CRZO	24.27	1	1.6	-21%	20	88%	18.81	56%	275%
XCO	9.48	2.1	3.8	-51%	90	98%	18.35	50%	207%
CHK	22.06	14.7	29.5	-5%	554	83%	25.18	42%	196%
GDP	12.17	0.5	1	-27%	19	89%	14.84	77%	190%
COG	72.05	7.8	8.9	97%	91	95%	20.49	37%	174%
WLL	43.93	5.3	6.5	-23%	71	17%	49.04	29%	173%
UPL	28.68	4.6	6.4	-39%	101	96%	27.57	52%	159%
CRK	14.78	0.7	1.5	-33%	48	96%	18.35	41%	158%
NFX	35.89	4.9	7.9	-49%	134	59%	33.06	44%	156%
ROSE	41.89	2.3	2.4	15%	26	49%	31.57	29%	143%
PXP	32.25	4.6	8.4	7%	105	52%	28.99	52%	135%
EOG	95.57	26.3	30.1	4%	427	62%	30.48	29%	133%
PXD	81.38	10.2	12.7	-4%	128	48%	30.39	33%	133%
XEC	59.8	5.3	5.6	-32%	99	56%	33.18	10%	133%
DVN	59.05	24.4	26.8	-19%	661	66%	22.72	30%	128%
SFY	28.23	1.2	1.7	-29%	28	53%	32.87	33%	122%
FST	12.26	1.4	3	-66%	54	73%	18.34	61%	121%
SWN	32.66	11.6	12.9	-9%	233	100%	18.26	26%	117%
CNQ	0.09	0	0	-39%	547	37%	40.37	30%	112%

Source: Corporate Reports, Capital IQ, and Bernstein Analysis

- Unsustainable capital expenditures will limit capability to deliver on supply.
- Service cost acceleration will compound this limitation.
- Further constraints on cost-of-capital will limit options.

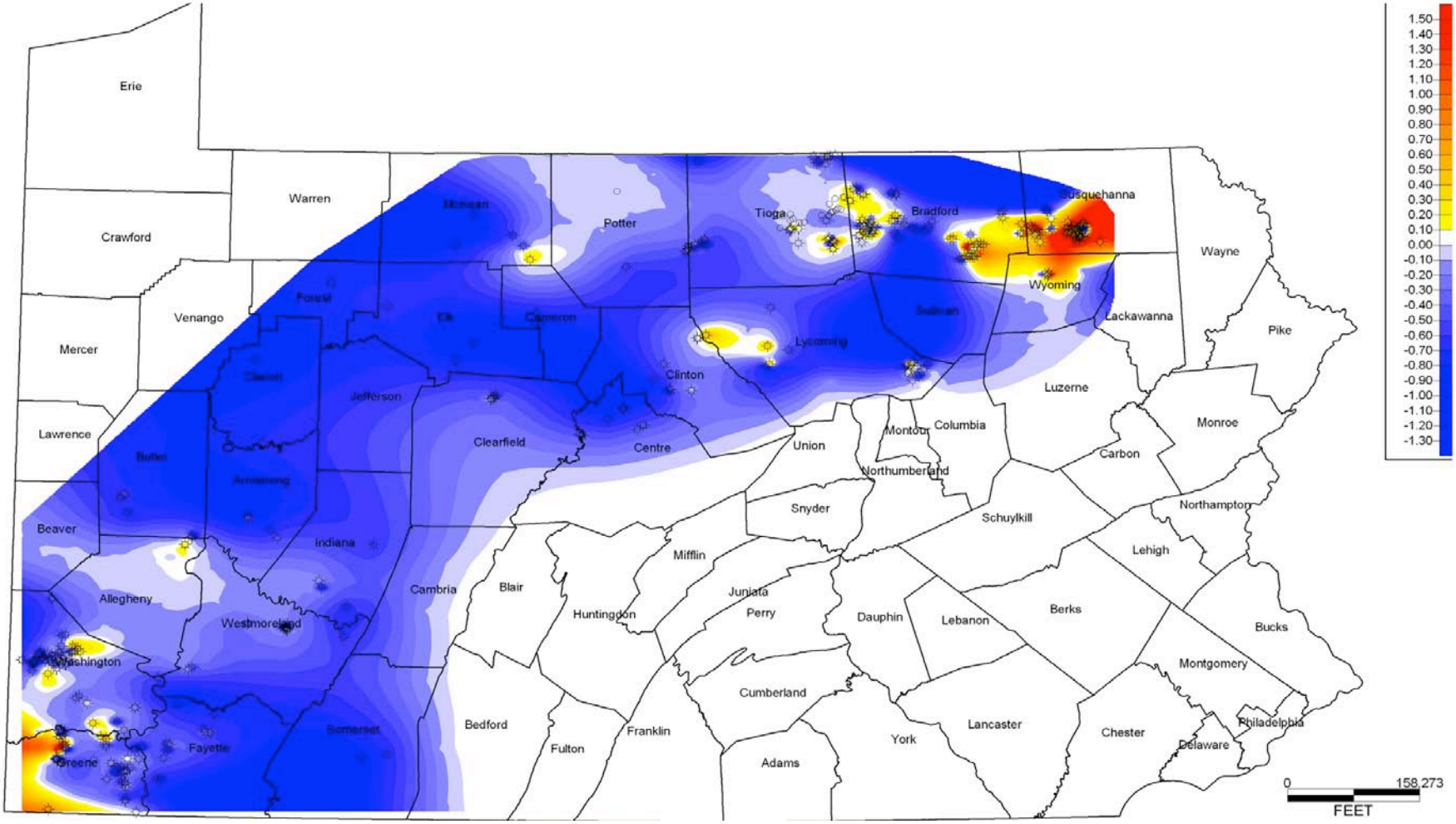
Shale plays have contracted to a fairway or core area: Haynesville Shale example



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.
- It will be approximtely 10-15% of what was promised in 2007.

Shale plays have contracted to a fairway or core area: Marcellus Shale example: blue areas under-performing.

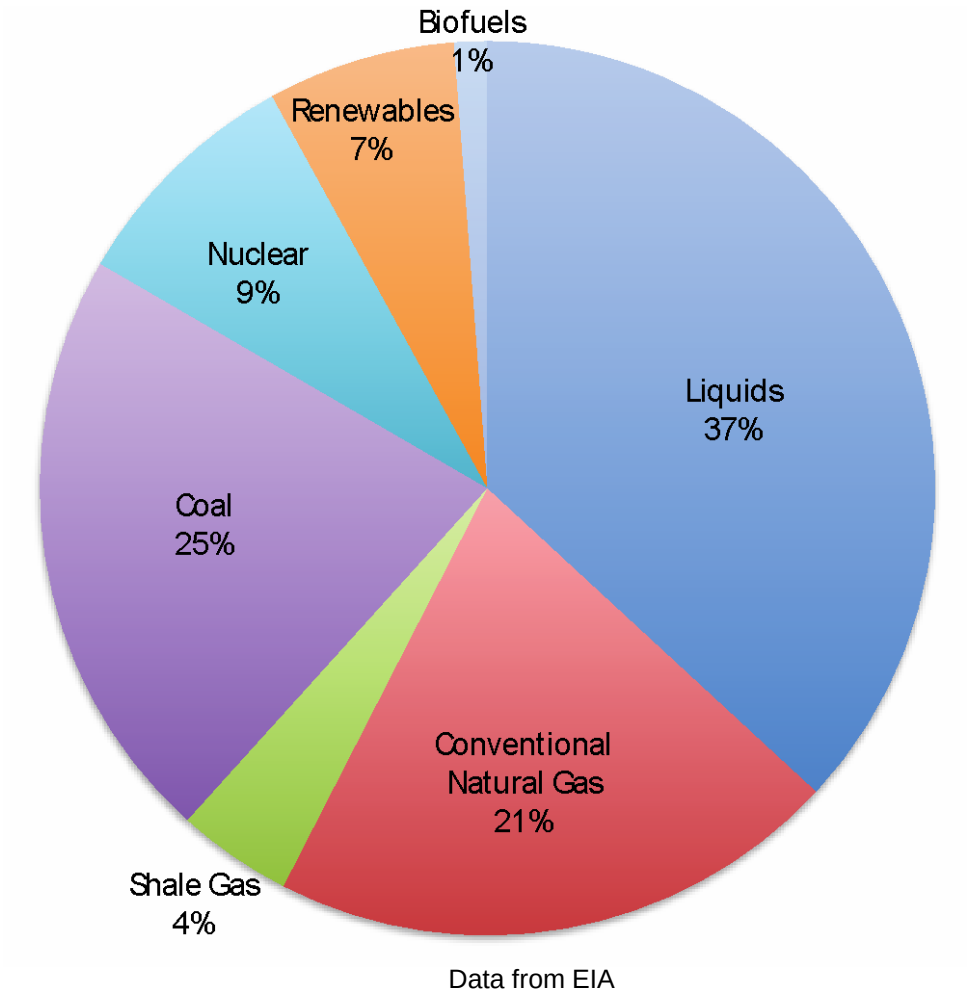


Comparison of Marcellus cumulative Production to a 4.2 bcf type curve. Data source: PA DEP.

Environmental Concerns

- Regardless of the merit of environmental concerns, perception is everything. Environmental issues will be an obstacle that adds cost and time to shale development.
- The oil & gas industry has always done a poor job of public relations.
- Much of the debate is fueled by other energy interests struggling for market share.
- Earthquakes don't help.

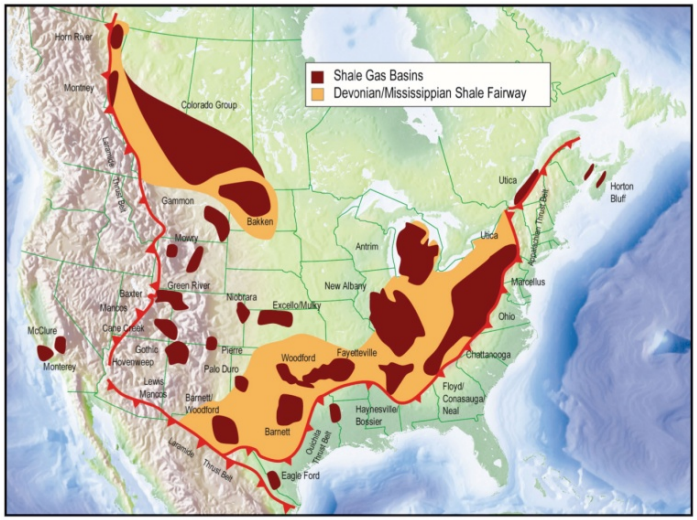
Can natural gas reduce dependence on foreign oil?



- Natural gas was 25% of U.S. primary energy mix in 2010.
- Shale gas was ~4% of total energy mix—is this really a **game-changer?**
- Will natural gas eliminate U.S. dependence on foreign oil (Pickens, etc.)?
- 3% of natural gas used for transportation.
- 72% of liquids used for transportation.
- Natural gas and crude oil are used differently & are not interchangeable without massive, long-term equipment changes.

U.S. Shale Gas Magical Thinking: What It Means

- A tremendous amount of capital has been bet on shale and much of this is in the form of debt.
- A new paradigm in land and completion costs has forever changed the domestic E&P business.
- There is very little shale production history so the outcome is uncertain.
- It is unclear that shale gas production will support even short-term expectations of abundance.
- Capital expenditures exceed cash flow for most companies.
- Full-cost and off-book accounting mask the weak performance of most shale-dominated companies.
- There is great uncertainty about reserves, and most are undeveloped.
- Yet, the prevailing view is that success is certain.
- There are considerable risks in magical thinking.



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