

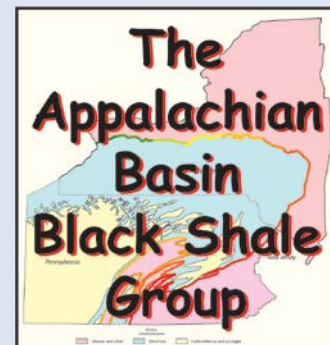


# The Confluence of Geopolitics and Science of Texas-Style Gas Production in Pennsylvania

## An Autobiography

Terry Engelder

Pennsylvania State University





Time since prediction

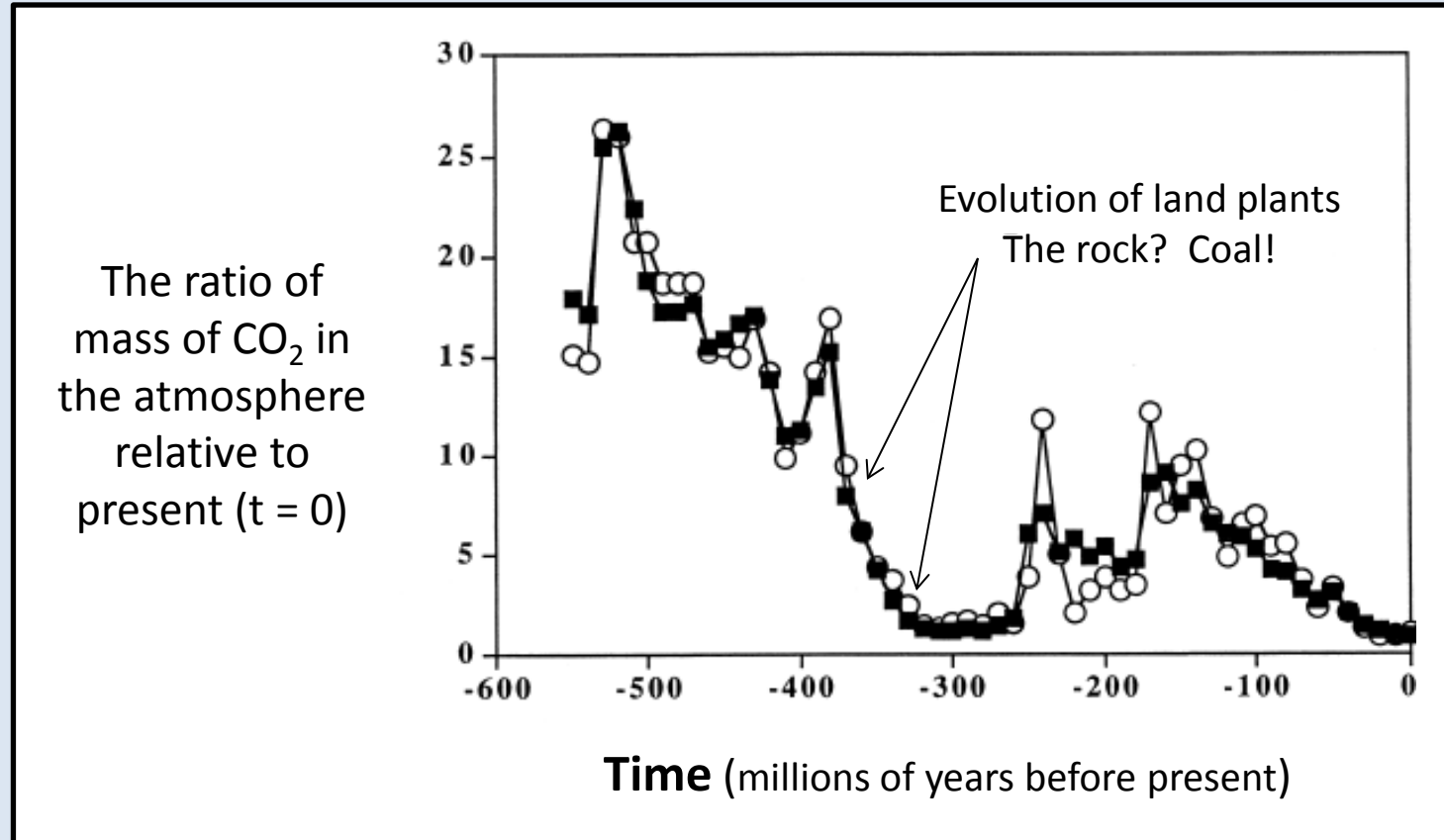
10/07-4/13  
67 months

Marcellus  
Talk #308

Cumulative  
Attendance  
22,470

1/08-3/13  
> 461 reporters





**Long-term cycle** affecting atmospheric CO<sub>2</sub> is exchange between the atmosphere and carbon stored in rocks.

**Short-term cycle** affecting atmospheric CO<sub>2</sub> involves the transfer of carbon between the oceans, atmosphere, biosphere, and soils.

Bob Berner:  
Yale





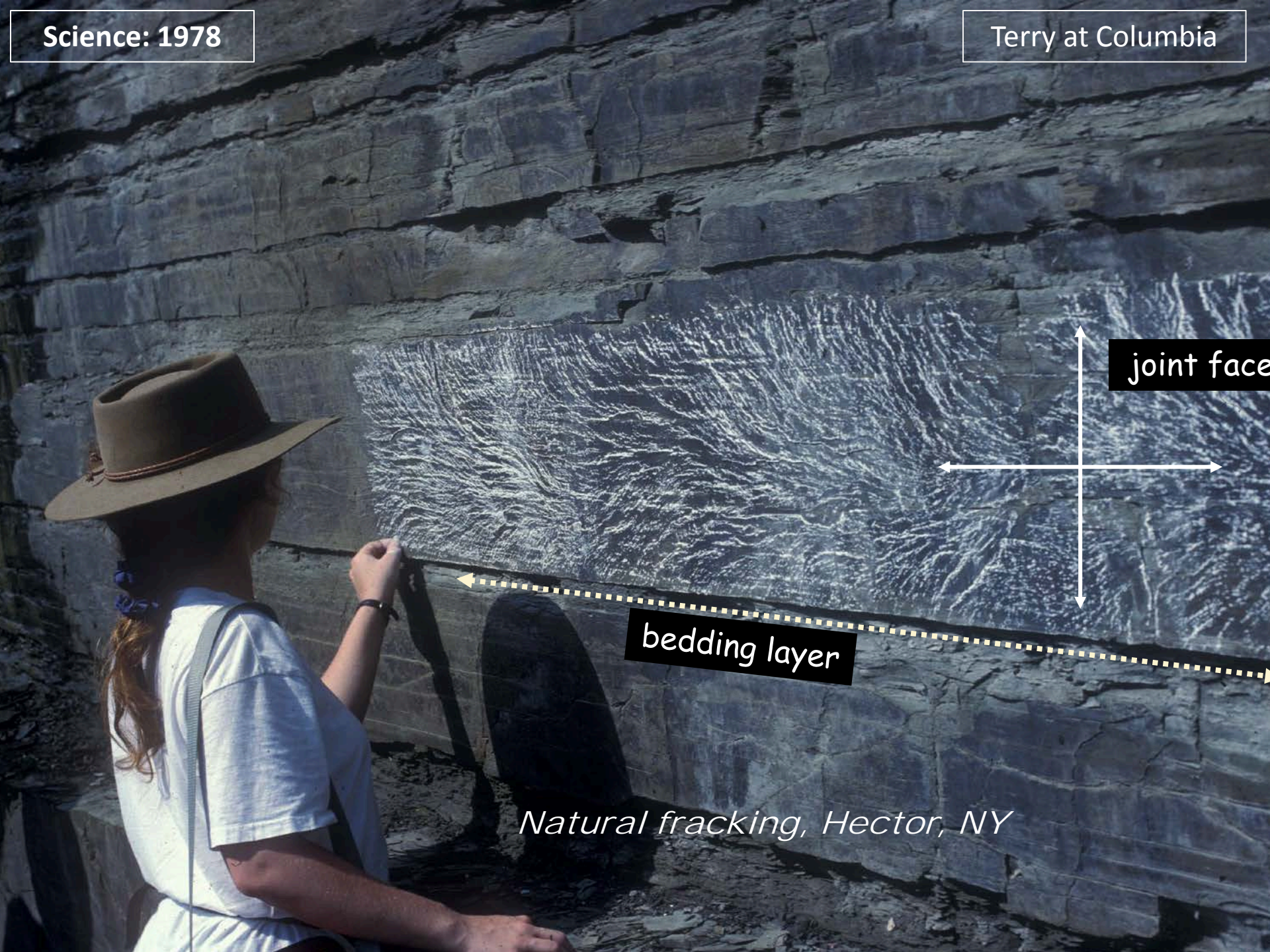
- Half the pipelines of our country have already curtailed shipments to the major industrial users. Four thousand plants are now closed. Four hundred thousand people have been laid off because of natural gas shortages. Shipments to homes have been curtailed by two major pipelines. And many other homeowners are now threatened with that same prospect, and the forecast for the rest of the winter is for continuing extreme cold.

## Public Law 95-620 95th Congress

- Power Plant and Industrial Fuel Use Act (FUA) of 1978. The law prohibited use of natural gas in new industrial boilers and new electric power plants.
- The law provides that no new base load electric power plant may be constructed or operated without the capability to use coal or nuclear.
- The goal is to preserve "scarce" (gas) supplies for residential customers.

Science: 1978

Terry at Columbia



joint face

bedding layer

*Natural fracking, Hector, NY*

Science: 1978

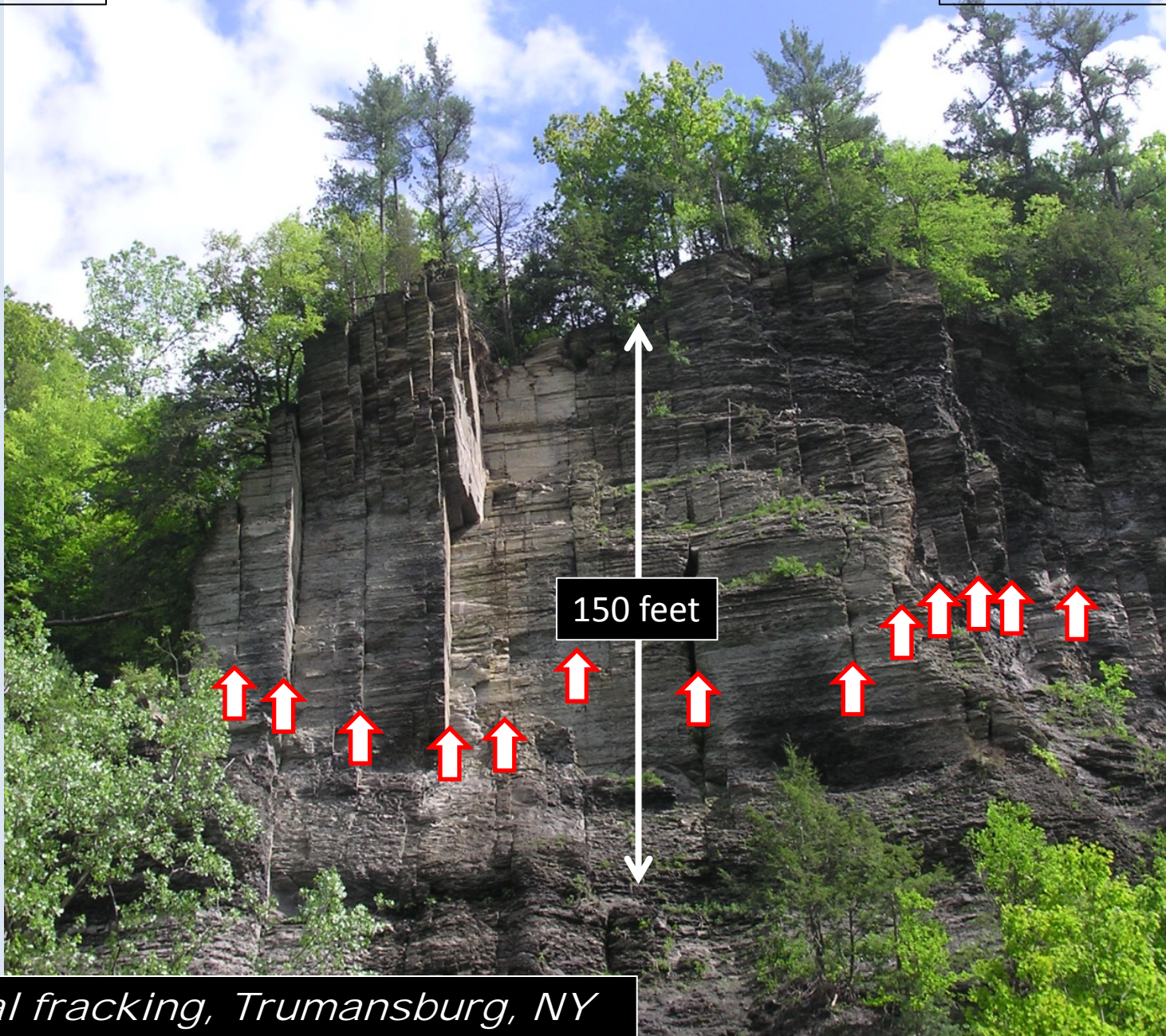
Terry at Columbia



*Natural fracturing, Watkins Glen, NY*

Science: 1978

Terry at Columbia

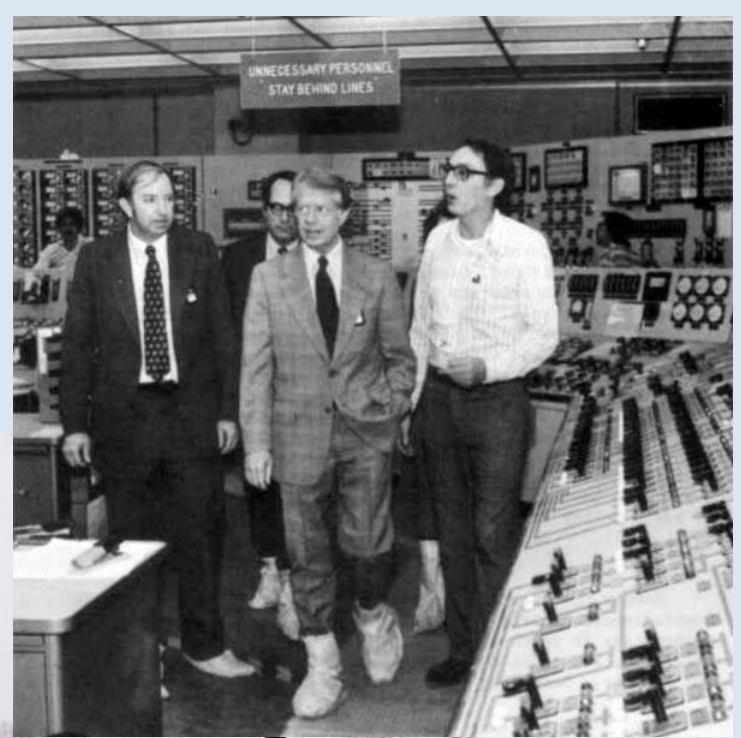


*Natural fracking, Trumansburg, NY*

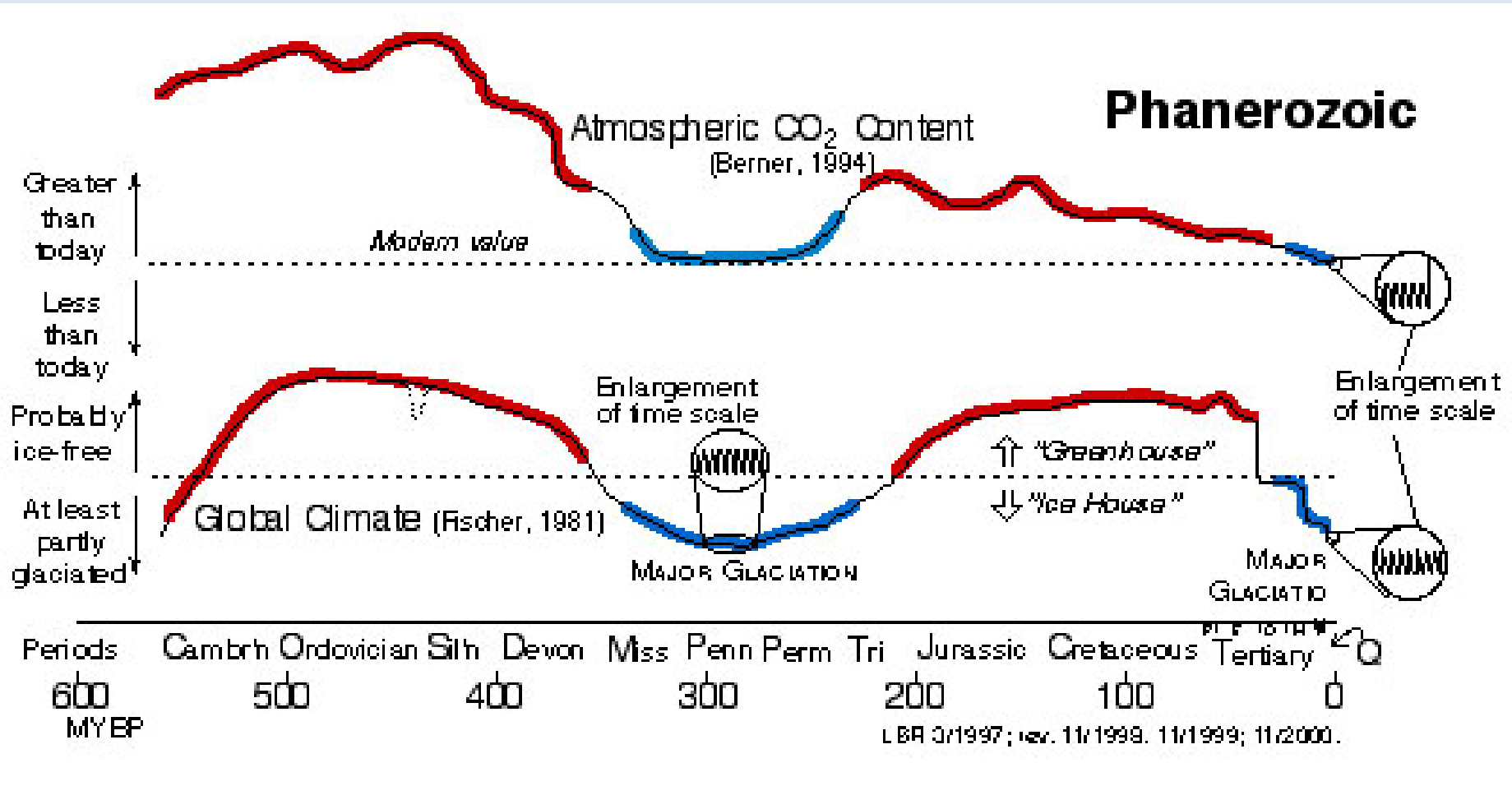


Politics: 1979

The **Three Mile Island accident** was a partial nuclear meltdown in Dauphin County, Pennsylvania, on March 28, 1979. It was the worst accident in U.S. commercial nuclear power plant history



President Carter visits  
Three Mile Island



James Hansen at NASA Goddard Institute for Space Studies of Columbia University concluded that CO<sub>2</sub> in the atmosphere would lead to warming sooner than previously predicted.

Science: 1986

Terry at Penn State



*Natural fracturing in Antrim Shale, Michigan Basin  
(America's First Targeted Gas Shale Play)*

Who had the best seat in the house?

## Age of U.S. Coal Plants

Years Built	# of Units	Total Capacity (MW)
2005-2009	21	6,785
2000-2004	13	1,382
1995-1999	24	4,372
1990-1994	67	8,638
1985-1989	102	23,734
1980-1984	117	56,105
1975-1979	125	55,879
1970-1974	137	66,466
1965-1969	158	41,656
1960-1964	157	25,310
1955-1959	209	28,883
1950-1954	213	17,518
1940-1949	93	2,583
1930-1939	20	132
1920-1929	10	69
Total	1,466	339,509

Natural gas consumption for electric generation rose from 2.6 trillion cubic feet (Tcf) in 1988 to 5.7 Tcf in 2002

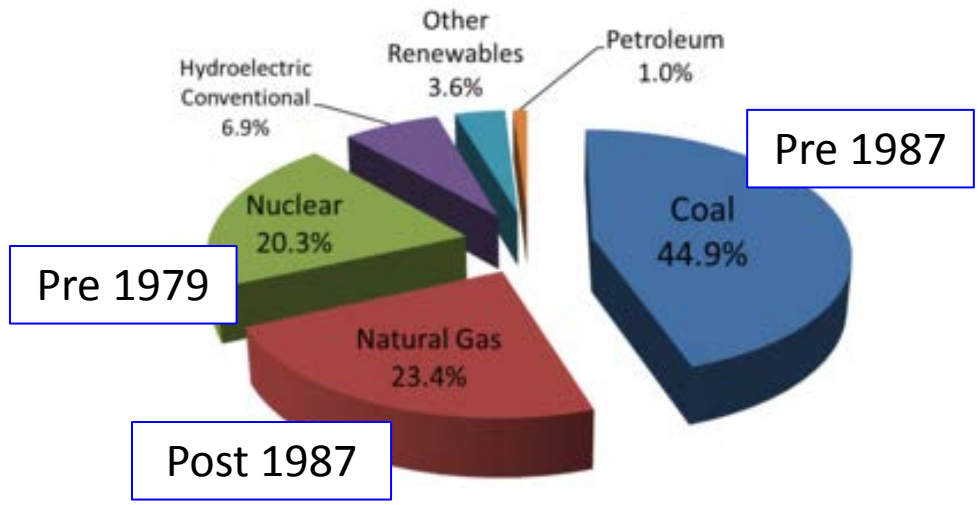


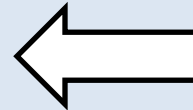
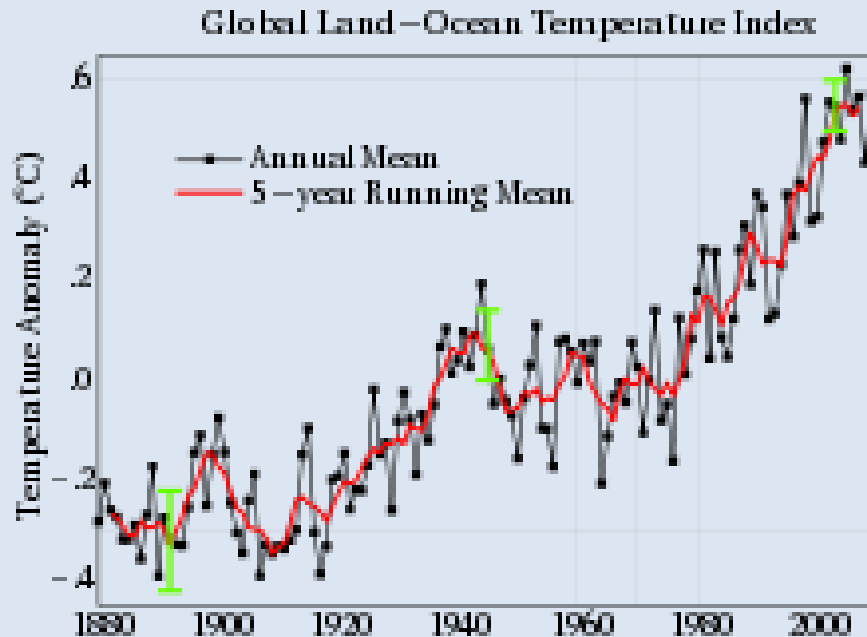
Fuel Use Act Repealed in 1987



Fuel Use Act (no gas for electrical generation)

2009 U.S. Electricity Generation by Source





There is the 0.4°C

In testimony before Congress, James Hansen argued that, if the temperature rises 0.4 °C above the 1950-1980 mean for a few years, it is the "smoking gun" pointing to human-caused global warming.

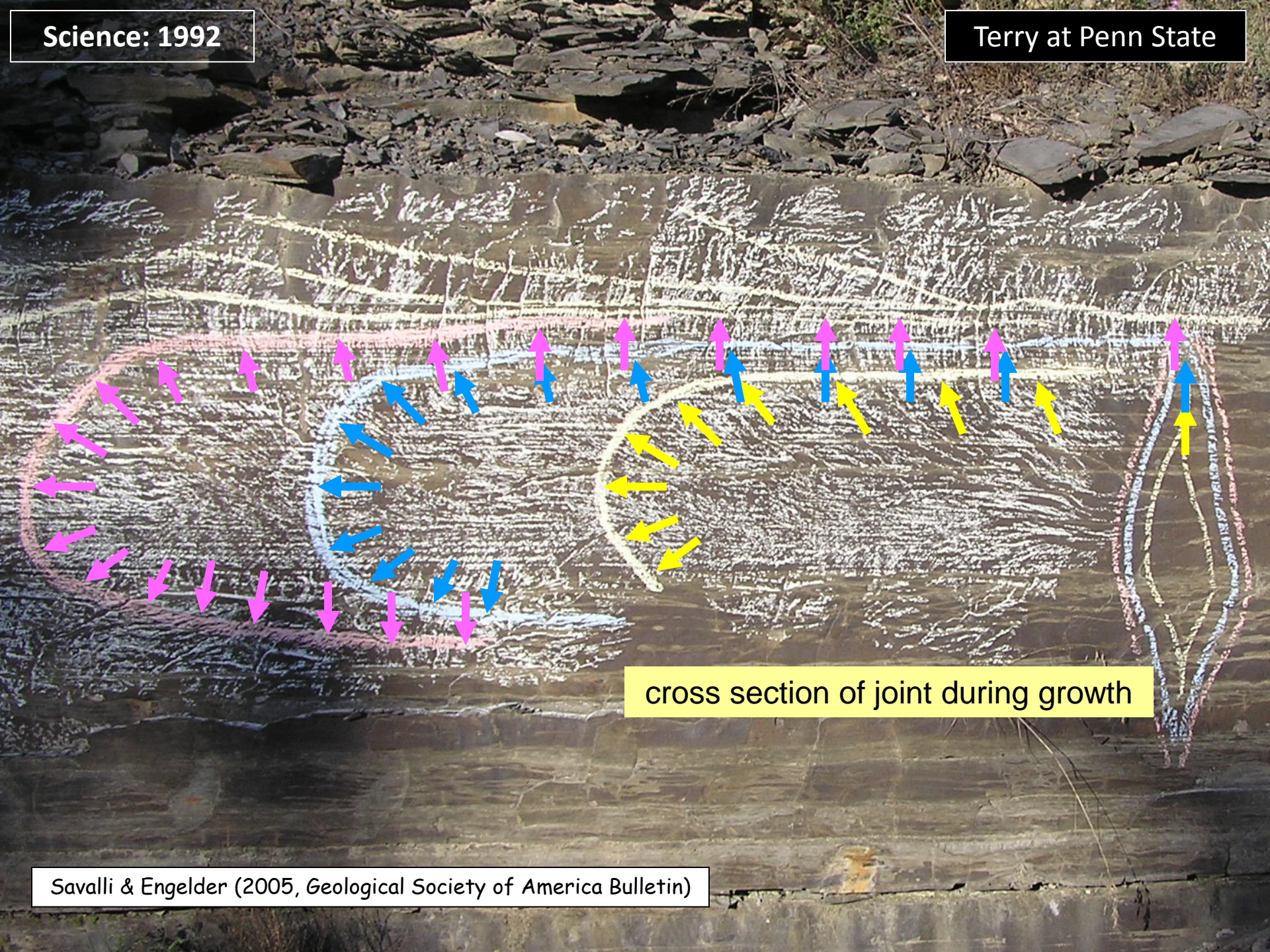


Science: 1992

Terry at Penn State



*Natural fracking, Burdett, NY*

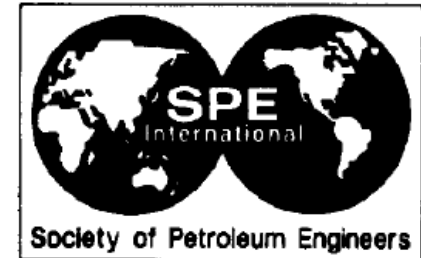


cross section of joint during growth

# Slickwater Frack



**SPE 38611**



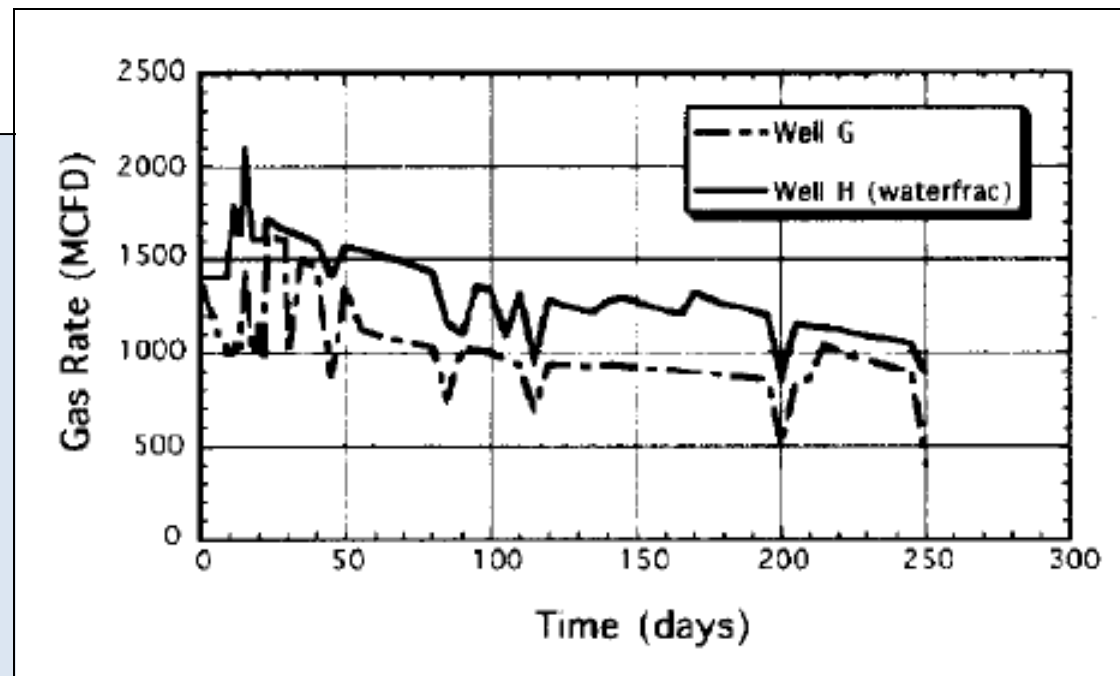
## Proppants? We Don't Need No Proppants

M.J. Mayerhofer<sup>1</sup>, SPE, M.F. Richardson<sup>1</sup>, SPE, R.N. Walker Jr.<sup>1</sup>, SPE, D.N. Meehan<sup>1</sup>, SPE, M.W. Oehler<sup>2</sup>, SPE and R.R. Browning Jr.<sup>3</sup>, SPE

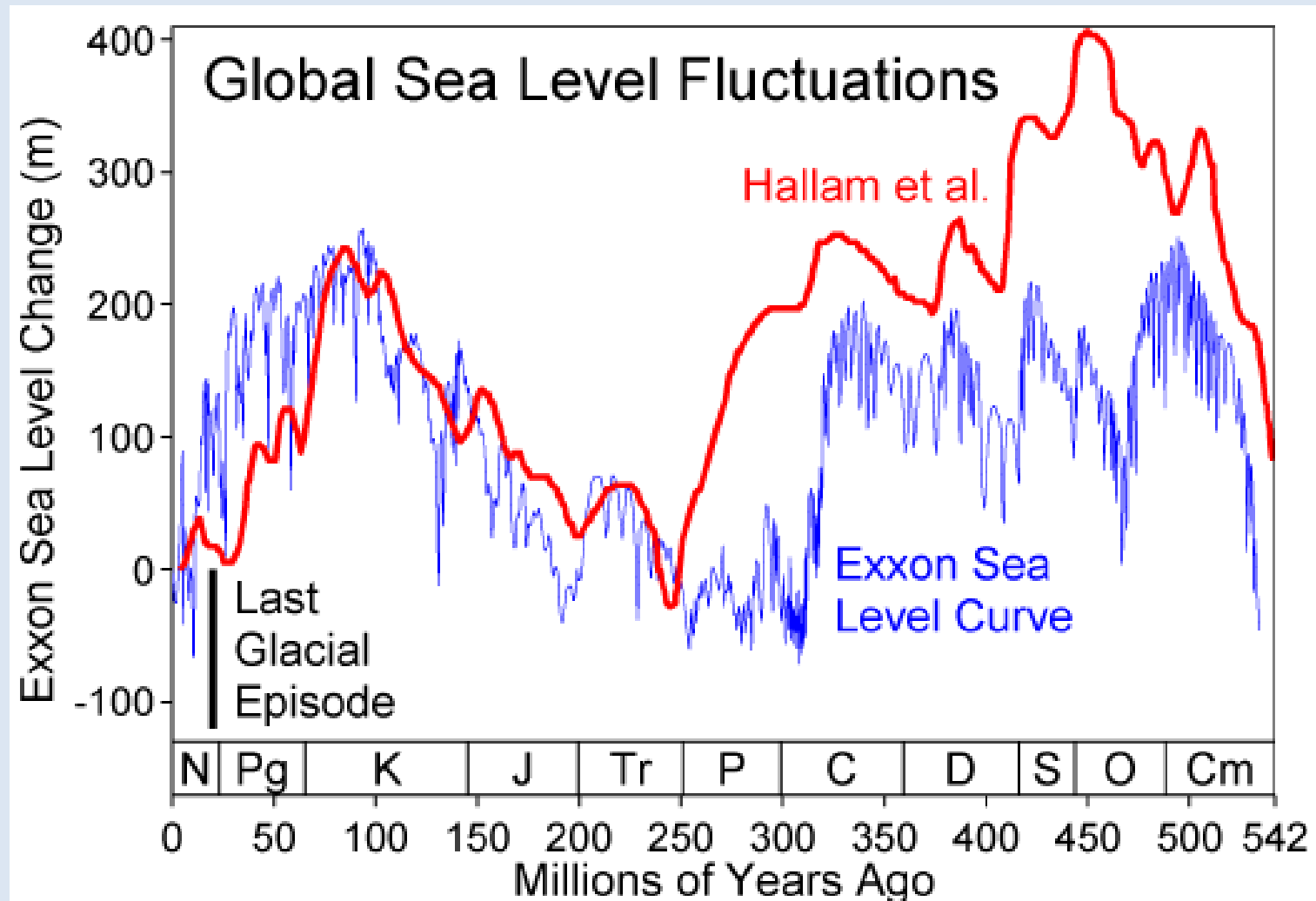
<sup>1</sup>Union Pacific Resources

<sup>2</sup>Halliburton Energy Services

<sup>3</sup>BJ Services



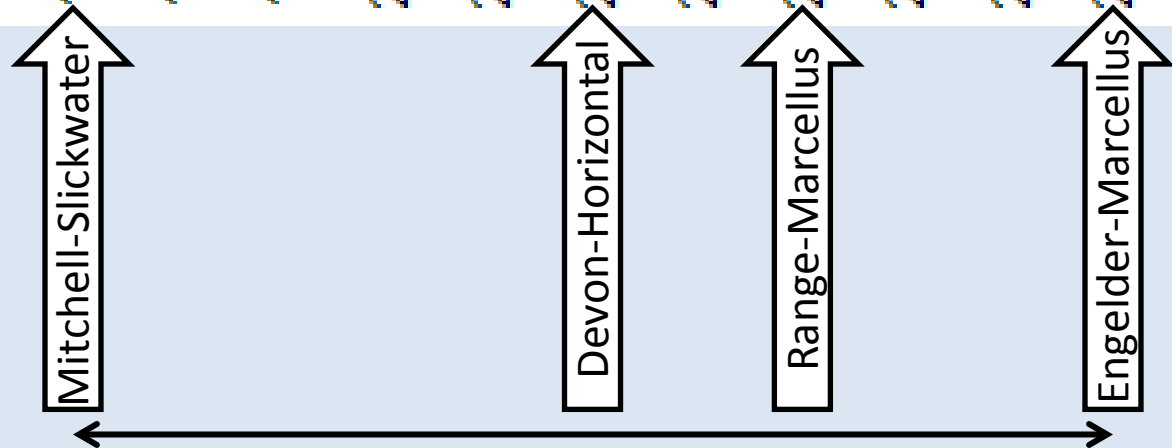
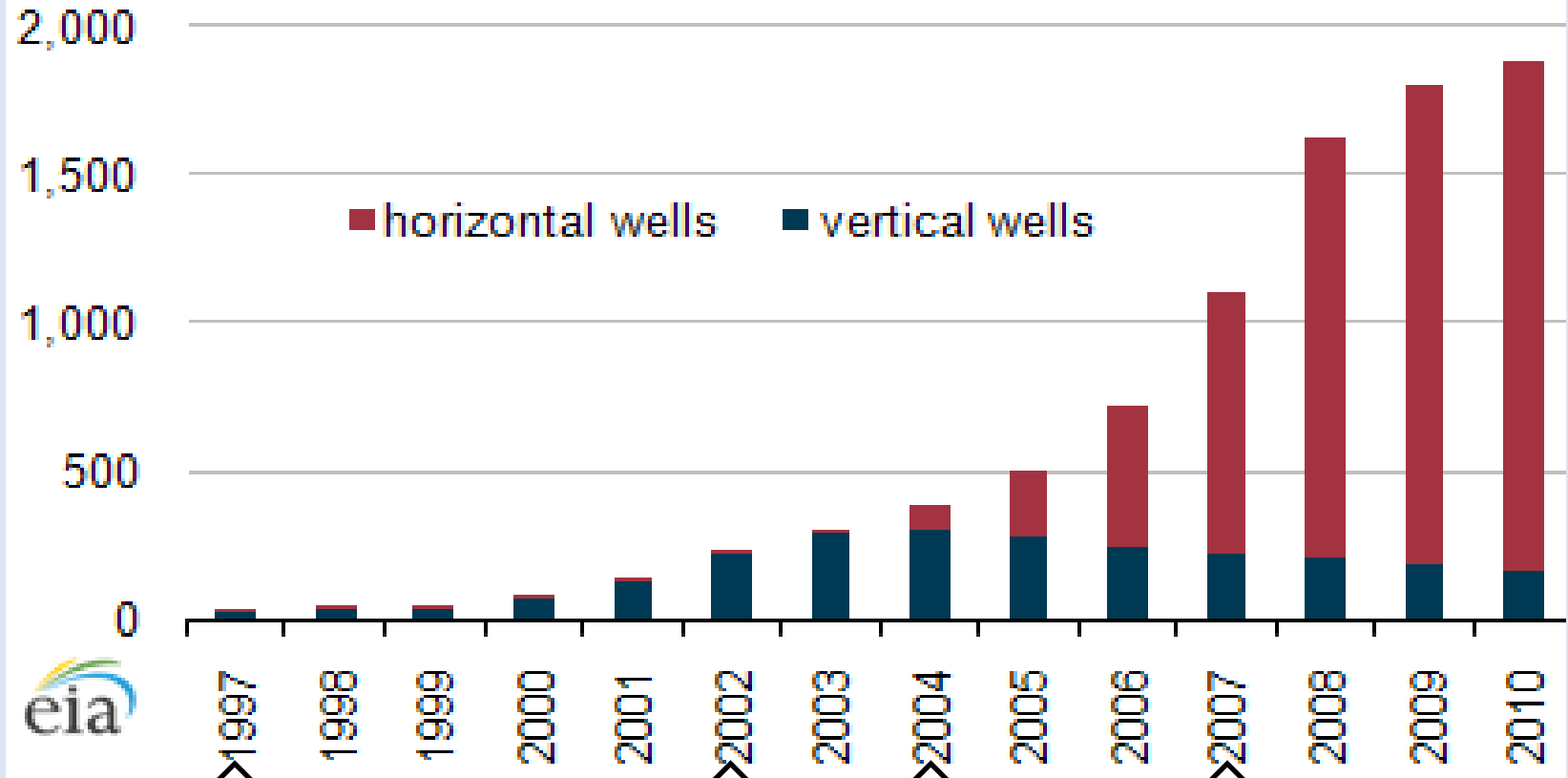




In one of the most bizarre corporate behaviors Exxon CEO, **Lee Raymond**, denies man's link to climate change while Exxon's climate change model serves as a tool for making the company, perhaps, billions of dollars.

# Annual Barnett shale natural gas production by well type

billion cubic feet (Bcf)



The Raymond to Jefferies Period

# Jefferies

OUR FIRM

INVESTMENT BANKING

EQUITIES

FIXED INCOME

COMMODITIES

RESEARCH &amp; STRATEGY

ASSET MANAGEMENT

WEALTH MANAGEMENT

## Principal Sector Focus:

- Oil & Gas Exploration and Production
- Midstream Oil & Gas
- Oil Field Services
- Energy Refining Marketing and Distribution
- Unconventional Resource Plays

2007: Jefferies calls Engelder

## Notable Facts:

- One of the largest energy investment banking teams in the world
- 72 professionals worldwide located in Houston, London and Hong Kong covering 180 companies
- Completed 92 bookrun financings and advisory transactions since the beginning of 2011 with valuation in excess of \$107 billion
- #1 ranked in number and value of U.S. shale sell-side M&A over last 5 years<sup>5</sup>
- Jefferies has advised on 7 of the top 10 U.S. shale transactions over the last 5 years
- Achieved highest price paid in most North American shale basins, including the Marcellus, Haynesville, Fayetteville, Montney, Utica and Eagle Ford
- 2011 M&A Deal of the Year awarded by *The Deal* magazine: Jefferies acted as sole financial advisor to Samson Investment Company in the \$7.2 billion sale to an investor group led by KKR

- **Jefferies has advised on 7 of the top 10 U.S. shale transactions over the last 5 years**

Who had the best seat in the house?

Science: 2007

Terry at Penn State



rad exam  
concern teachers  
advances plan for series of exit tests

Massive gas field detected

Russians pull back at key posts  
Georgians withdraw completely and retreat to Tbilisi, Kremlin says

Terry at Penn State

**Tapping the Marcellus**  
Dallers access mile-deep gas deposits in what may be called new 'gold rush'

**Business Atlas Energy Resources, LLC**

**Business**

INSIDE

**Natural gas boom trends energy equation**  
U.S. leads if

**Marcellus Shale — A COUNTRY GOLD MINE?**  
Engelder to speak Monday

**Weather**

**Index**

**THE FACTS ON MARCELLUS**

free access to radio tower

convoy is

**The Penn State Press Release: January 17, 2008**

Wellsville native discusses geology and natural gas during a Wellsville Citizens

90 Wellsville, NY 14895  
BASIL 585-593-4150

1. Shale gas - estimated recoverable resource worldwide = 24,000 Tcf  
33% located in America

2. US is biggest and most developed gas market in the world

3. SH sustains long-term growth ambition by focusing on Marcellus  
the most prolific resource play in NA

4. Gas markets moving from regional to global  
SH largest supplier of gas to Europe after Russian Gazprom

5. US is significant growth platform based on technical strengths  
In horizontal drilling for shale gas, American operators have a technology the rest of the world wants

StatoilHydro



\$1 billion in cash + \$2 billion for production:  
33% interest in Chesapeake's 1.8 million acres

black shale isopach map

(> 20 API units in excess of the gray shale value)

Who had the best seat in the house?

# Use early production data for determining reserve potential

- Statistical Analysis

- Objective – Resource security is strongly dependent on establishing confidence in facts
- Initial Production, Pro Forma Decline Curve, Geological Evaluation

» Expected EUR = 489 Tcf (August 2009)

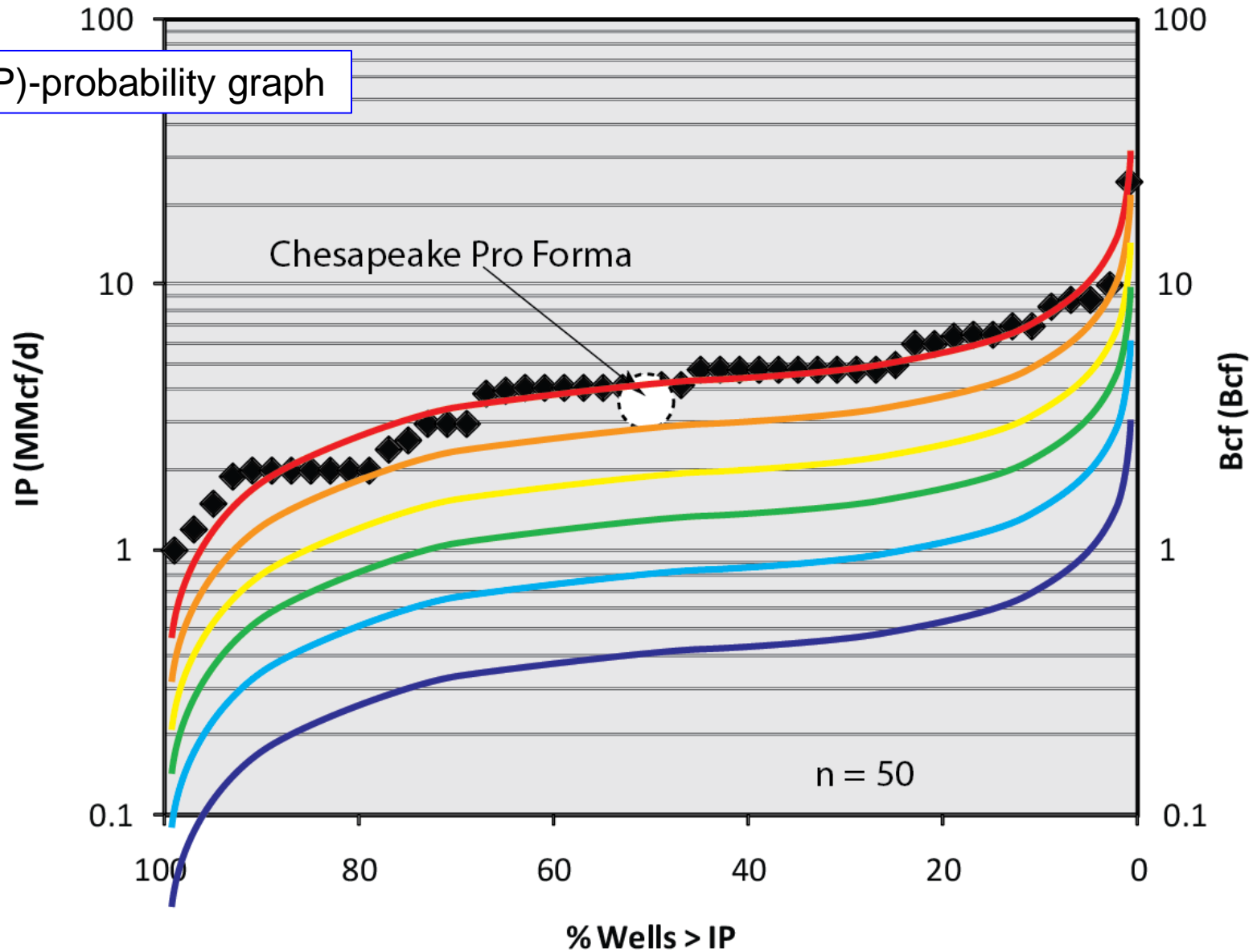
# Marcellus

By Terry Engelder, Ph.D., Professor of Geosciences, The Pennsylvania State University

# 2008:

**Report card on the breakout year for gas production in the Appalachian Basin**

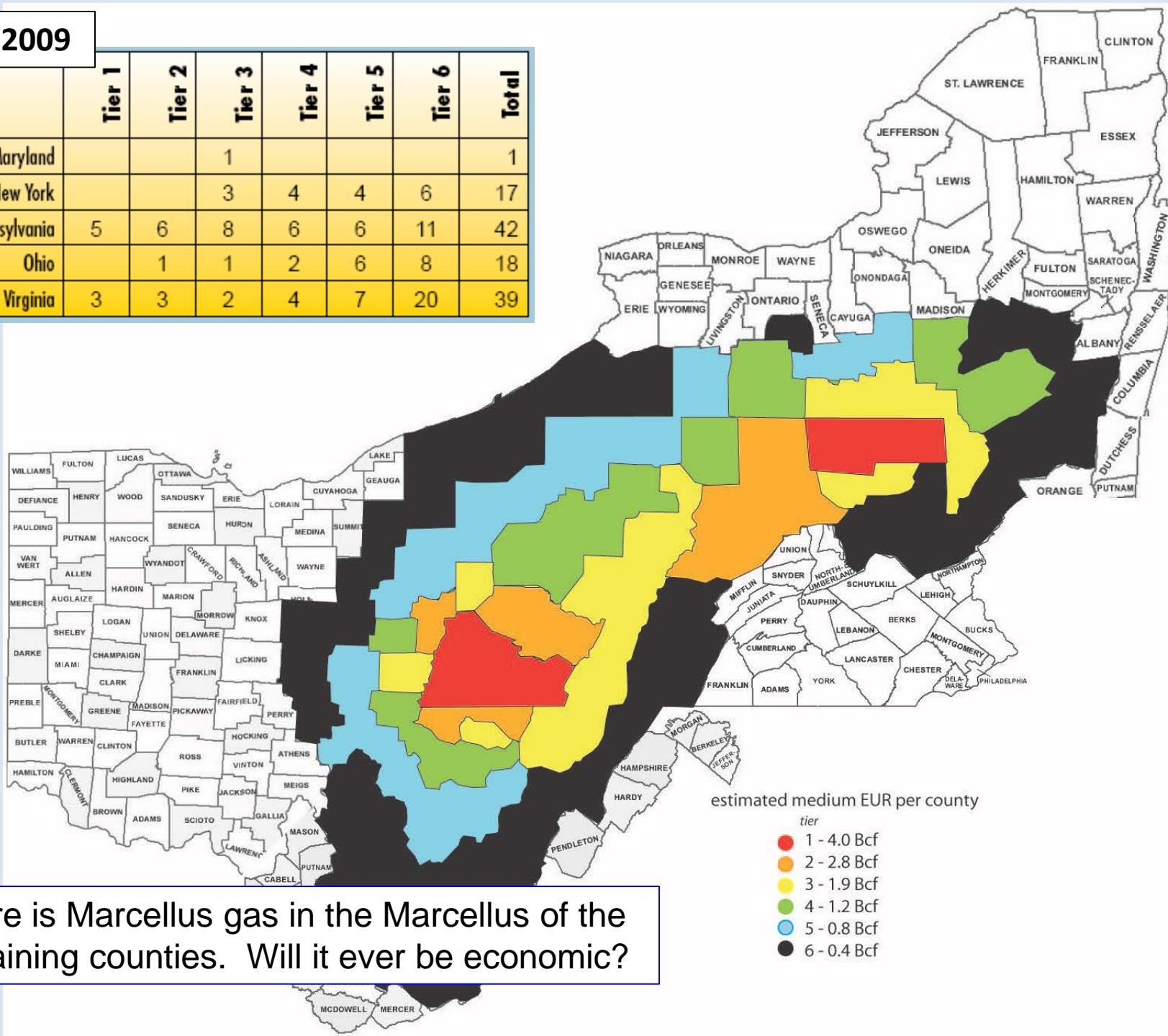
log (IP)-probability graph



*Pennsylvania does not require the reporting of production data!*

# Science: 2009

	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5	Tier 6	Total
Maryland			1				1
New York			3	4	4	6	17
Pennsylvania	5	6	8	6	6	11	42
Ohio		1	1	2	6	8	18
West Virginia	3	3	2	4	7	20	39



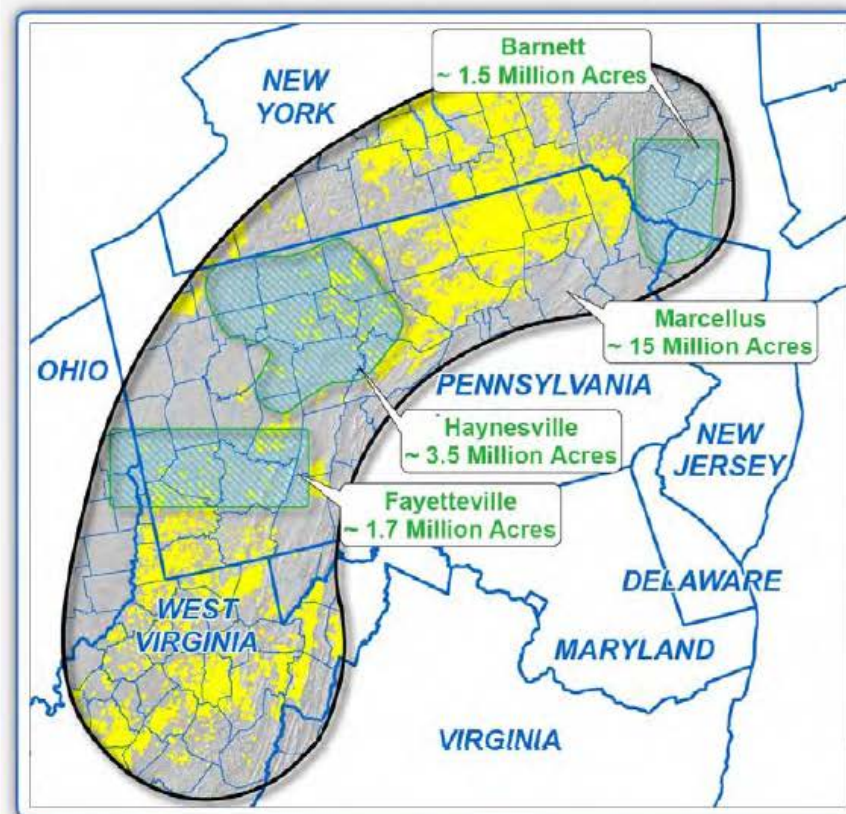
There is Marcellus gas in the Marcellus of the remaining counties. Will it ever be economic?





# Marcellus Shale Potential – How Does it Compare?

- Marcellus fairway is larger than other three Big 4 shale plays combined
- Marcellus has favorable depths, thickness, pressures and rock characteristics across large portion of basin
- Published estimates of ~489 tcf of potentially recoverable reserves from the Marcellus<sup>(1)</sup>
  - Haynesville - 250 tcf<sup>(2)</sup>
  - Barnett - 44 tcf<sup>(2)</sup>
  - Fayetteville - 42 tcf<sup>(2)</sup>



Market Cap. = \$15.74 B



1) Dr. Terry Engelder - Penn State University  
 2) Modern Shale Gas Development in the U.S. A Primer - April 2009

## NATURAL GAS

# Analyst fears shale bubble

**DENVER** — An analyst warns that the promise of enough natural gas to last the nation more than 100 years based on discoveries of vast shale formations could be the next speculative bubble to burst.

Geological consultant Arthur Berman says his analysis shows that gas shale fields in Texas and elsewhere aren't as profitable and likely don't contain as much retrievable natural gas as the industry and others portray.

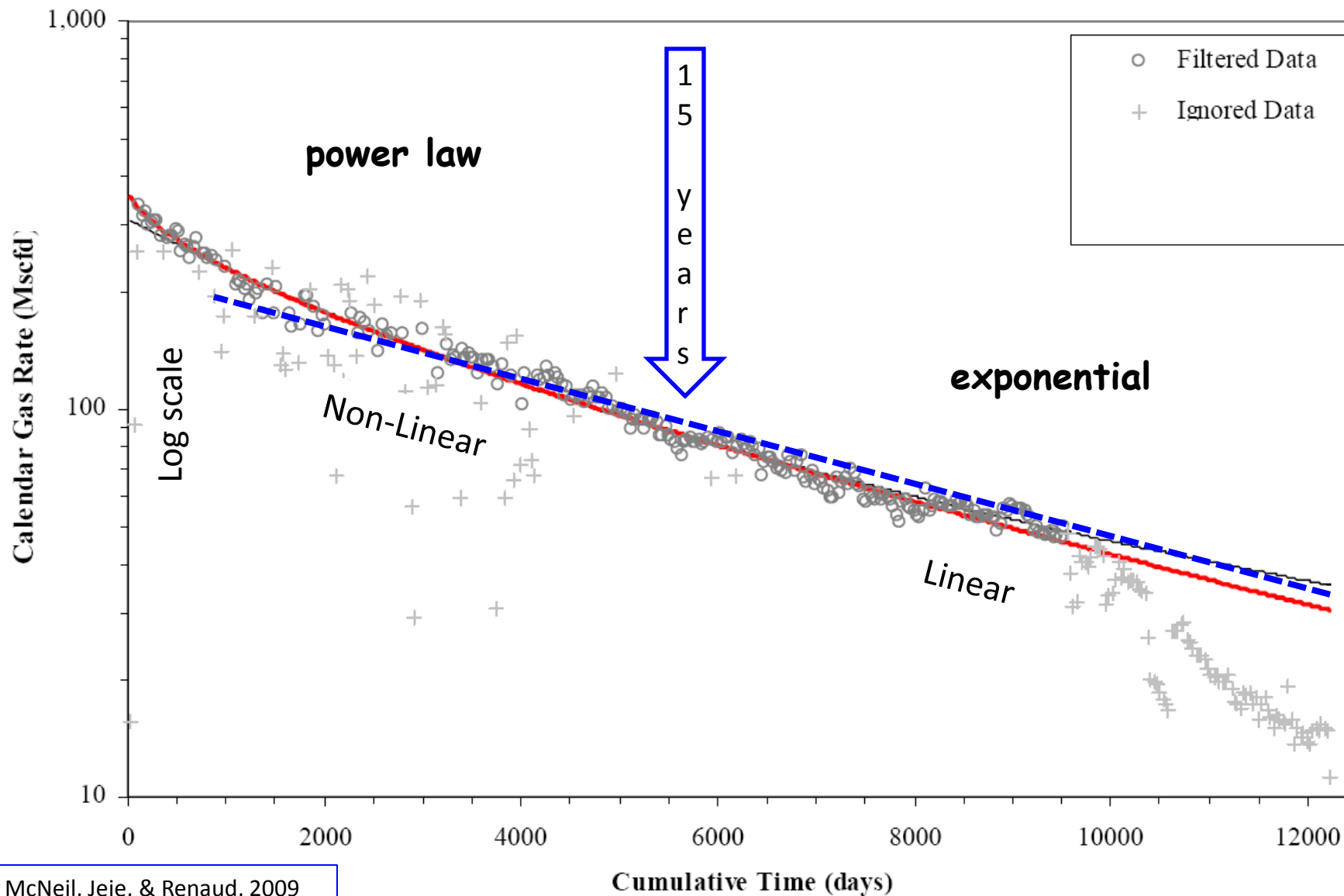
He spoke Monday at a conference in Denver exploring the notion that the world's oil and natural gas supplies are diminishing rapidly.

Berman targets Engelder

Terry Engelder

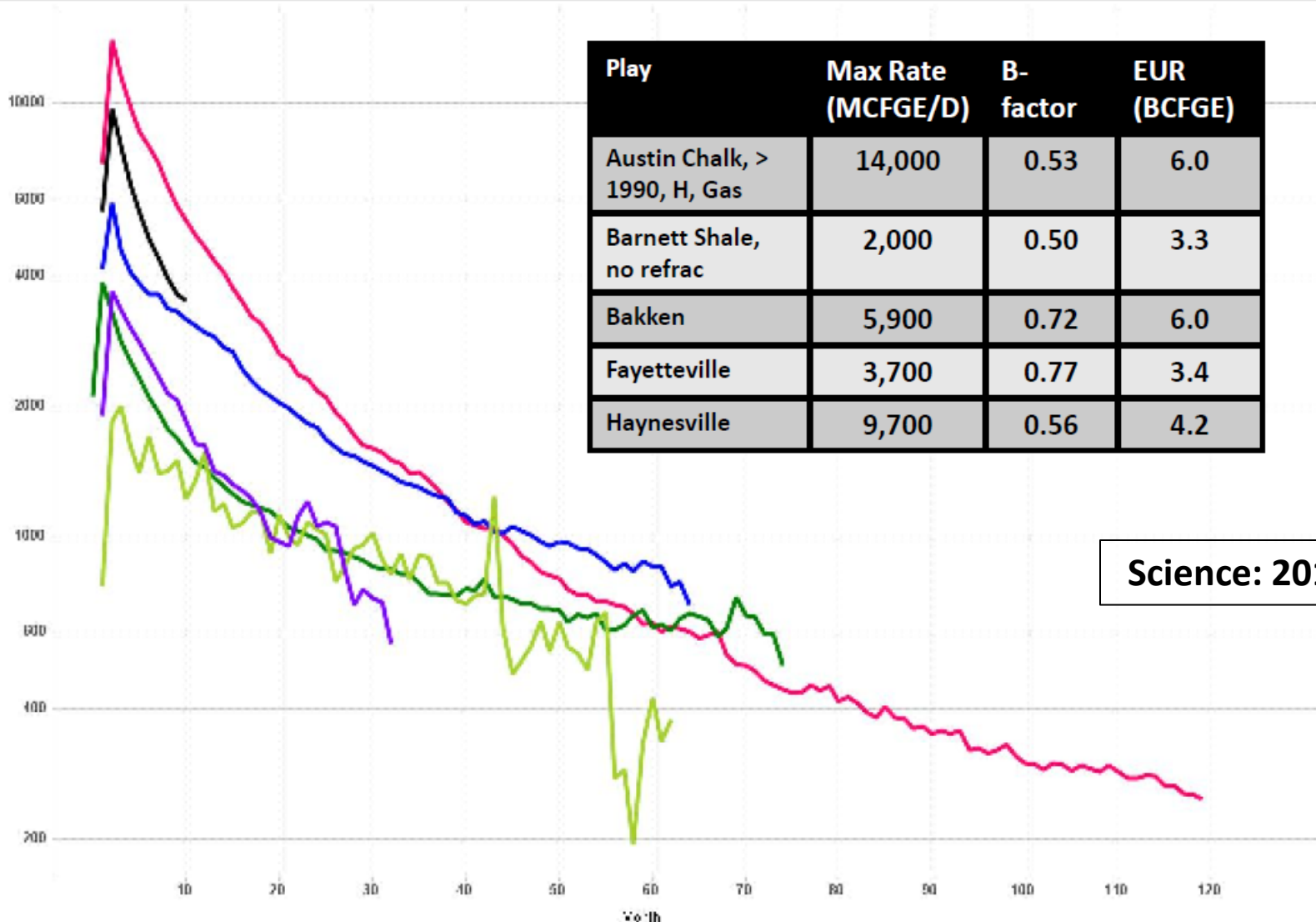
Houston Chronicle  
October 13, 2009

# Upper Cretaceous Milk River/Medicine Hat Formation, Alberta Canada



# Average Type Curves for Top Tier Wells by Play

TYPE CURVES TOP 10% OF WELLS IN PLAY



Color by Play

- AustinChalk90H
- Bakken
- BarnettGas
- BarnettNoRefrac
- Fayetteville
- Haynesville

Science: 2010



# “Fracking is immoral”



Ithaca, NY

“Doubt is not a pleasant condition, but certainty is absurd”

*Voltaire* French author, humanist, rationalist, & satirist (1694 - 1778)







### Disruption at Natural Gas Lecture

February 27, 2010



The term, fracking, becomes famous when Harvard students shout CHK CEO McClendon off the stage with "Frack you! Frack you!"





News and weather to start your day.  
Mornings 5am - 7am



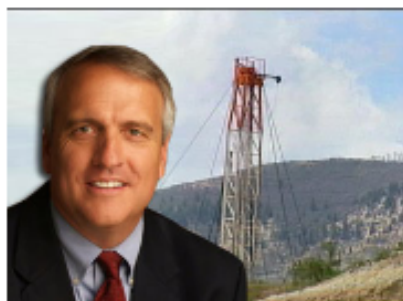
[✉ Email](#) [🖨 Print](#)

[A](#) [A](#) [A](#) Text Size

## Gov. Ritter signs historic clean-air clean-jobs act

*Posted: Apr 19, 2010 1:33 PM EDT*

*Updated: Apr 19, 2010 1:33 PM EDT*



**Grand Junction Colo. (KJCT)** -- Monday morning Gov. Bill Ritter signed into law the historic Colorado Clean Air-Clean Jobs Act, providing a new roadmap to a sustainable energy, economic and environmental future

"By shifting our oldest and least efficient coal plants to cleaner, Colorado-produced natural gas, we send a strong message to the rest of the country that we absolutely can cut air pollution and protect public health while also creating jobs and protecting ratepayers," Ritter said.

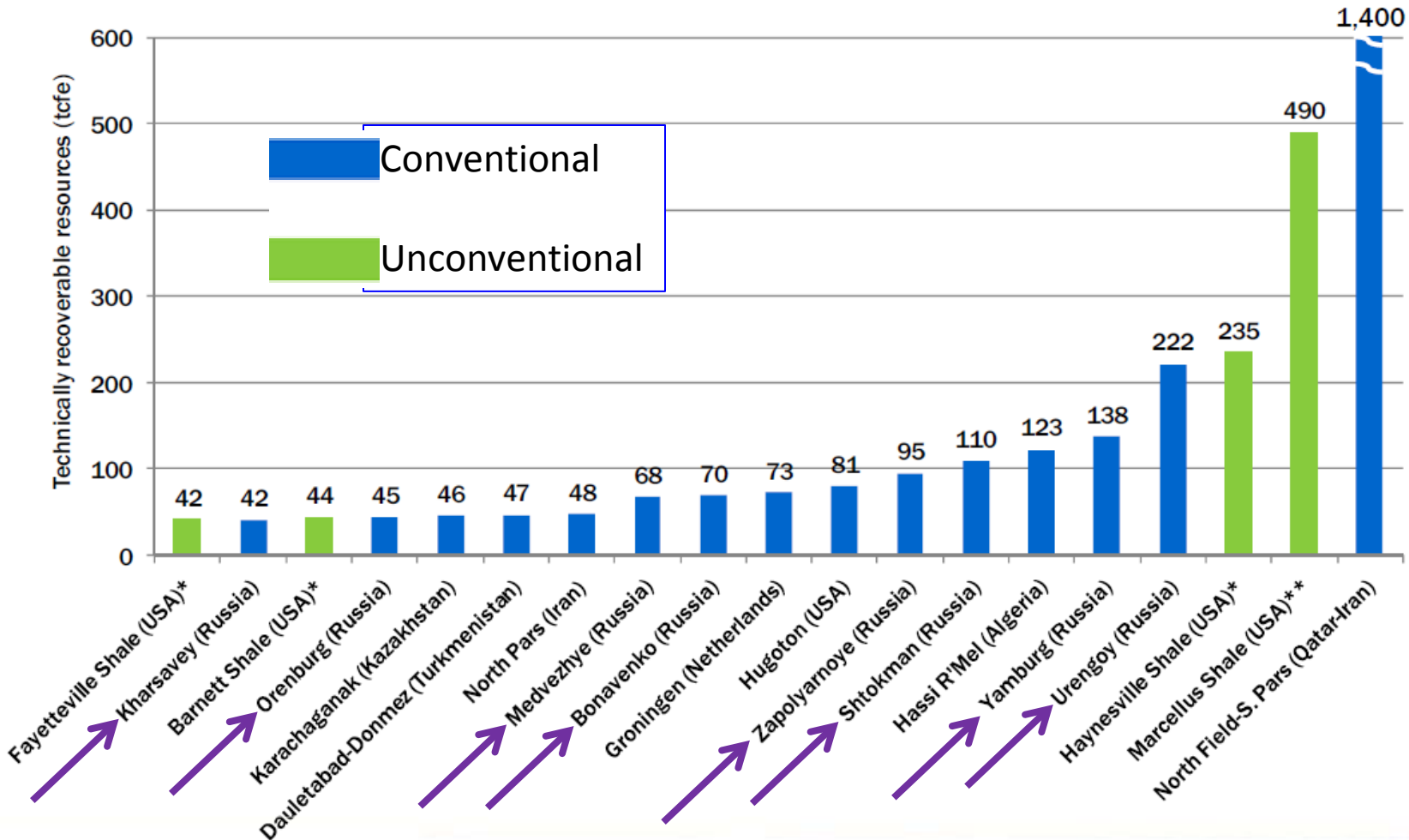
The Colorado Clean Air-Clean Jobs Act requires Xcel to cut nitrous oxide emissions by up to 80 percent from several Front Range coal plants by the end of 2017, most likely sooner.

Xcel will work with the Colorado Department of Public Health and Environment to submit a plan to the Public Utilities Commission by Aug. 15, detailing how it will retire or retrofit 900 megawatts of coal-fired capacity.

Xcel will give primary consideration to replacing or repowering those plants with natural gas, renewables, greater efficiencies and other cleaner energy sources.

"More drilling, less federal intrusion in Colorado – that's the reason so many Republicans supported this bipartisan compromise," Senate Minority Leader Penry said. "It was a pleasure to work with Gov. Ritter on this important public policy victory."

# U.S. Natural Gas Shale Plays are World-Class Resources



\*U.S. Department of Energy (April 2009): Modern Shale Gas Development in the United States: A Primer, p. 17

\*\*Dr. Terry Engelder, Penn State University



# Libya's Civil War

A GRAVE SCANDAL AT ARLINGTON

People Power for Palestine  
BY JOE KLEIN

BATTER UP!  
YOUR GUIDE TO THE 2011 BASEBALL SEASON

The last great work of David Foster Wallace  
BY L...

Terry Engelder

*Terry Engelder  
Ad. M. Ph.D. '73  
Penn State  
Pale '72*

Clayton Williams

*Clayton Williams '54*

Tom Corbett

*Tom Corbett  
Lebanon Valley  
'71*

George Mitchell

*George Mitchell  
1961 Class of '40*

# ENVIRONMENT SPECIAL THIS ROCK COULD POWER THE WORLD

Tom Ridge

*Tom  
Ridge  
Harvard  
'67*

Daniel Yergin

*Daniel Yergin  
State Dept.  
Carter Admin. 1974*

*Robert Mueller  
Duke  
'81*

Aubrey McClendon

WHY SHALE CAN SOLVE THE ENERGY CRISIS  
BY BRYAN WALSH

A century's worth is buried in our backyards ...

... but drilling for it threatens our land

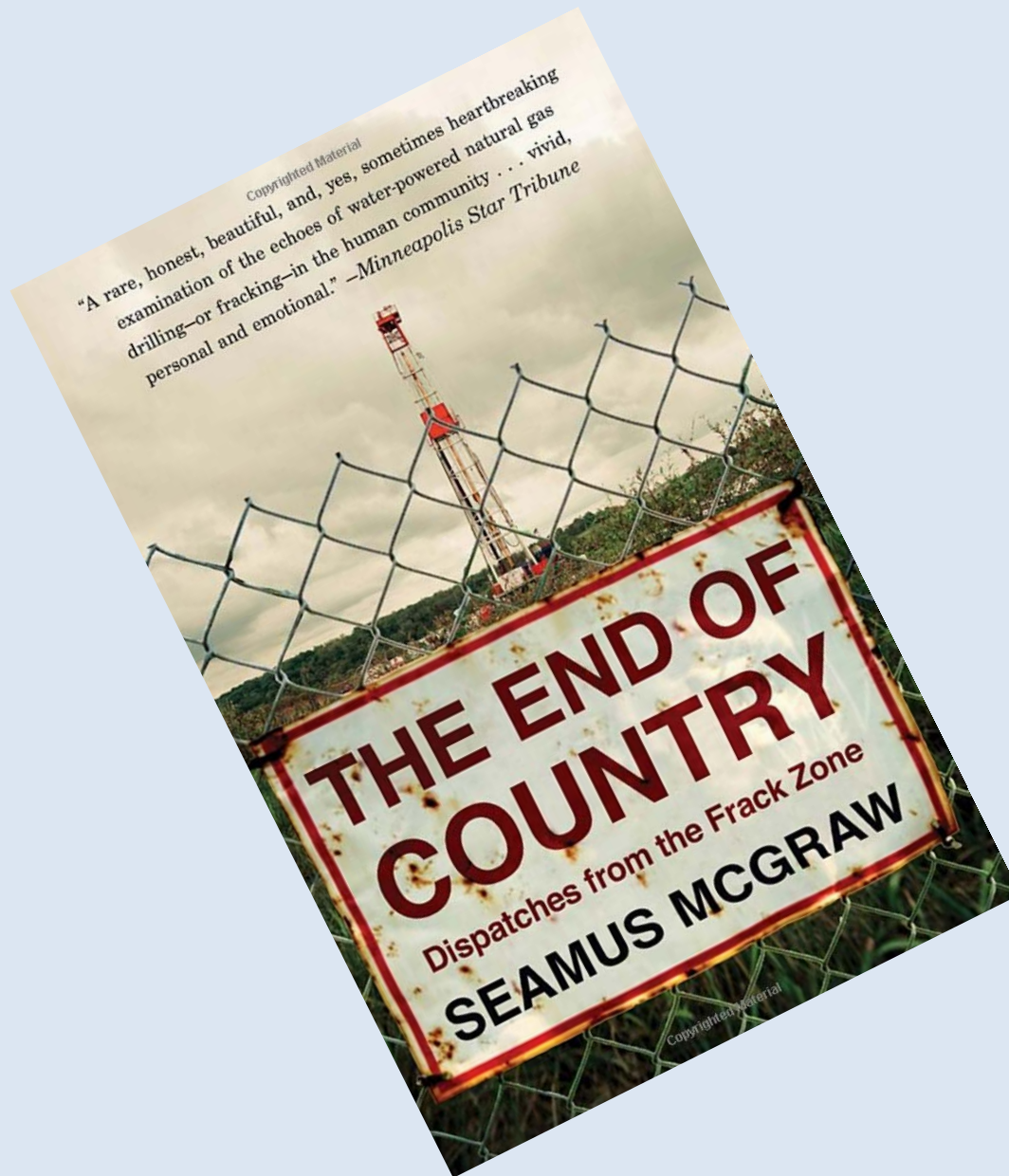
Gary Lash

*Gary Lash  
Lebanon Valley  
'80*

*T. Boone Pickens  
OKLA. STATE '51*

T. Boone Pickens

\$4.99US \$5.99CAN 1.50



# THIS AMERICAN LIFE FROM WBEZ



## 440: Game Changer

JUL 8, 2011

A professor in Pennsylvania makes a calculation, to discover that his state is sitting atop a massive reserve of natural gas—enough to revolutionize how America gets its energy. But another professor in Pennsylvania does a different calculation and reaches a troubling conclusion: that getting natural gas out of the ground poses a risk to public health. Two men, two calculations, and two very different consequences. [\(Transcript\)](#)

⏪ \_\_\_\_\_ 00:00 / 00:00

DOWNLOAD ⏴ TRANSCRIPT 📄 FAVORITE ⭐ HEARD IT 🎧 TWEET 🐦 LIKE 👍 SHARE 🔄 LAUNCH PLAYER

### PROLOGUE

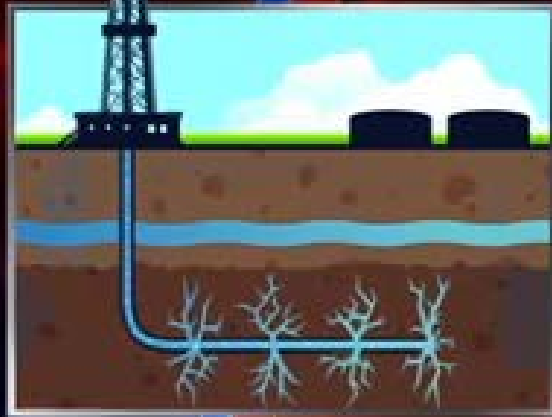


Host Ira Glass tells the stories of two professors, each making a calculation that no one had made before. One gets acclaim. One ends up out of a job. The first, Terry Engelder, a geologist at Penn State, was estimating the amount of natural gas that's recoverable from the Marcellus shale, a giant rock formation that's under Pennsylvania and several other Eastern states. The second, Conrad "Dan" Volz, at [the University of Pittsburgh](#), estimated how much toxic crap—chemicals and pollution from gas exploration—might be getting into water supplies. (6 1/2 minutes) [education](#) • [environment](#) • [jobs/employment](#) • [politics](#) • [science](#)

[Ira Glass](#)

# The Colbert Report

Politics: 2011



## Talisman Terry the Friendly Frackosaurus

Monday July 11, 2011

<http://www.colbertnation.com/the-colbert-report-videos/391552/july-11-2011/anti-frack-attack>

### Anti-frack Attacks

To promote fracking, Talisman Energy releases Talisman Terry the Frackosaurus, the funnest energy extraction-based character since Mountaintop Mining Manny.

# The Colbert Report

Politics: 2011



## Talisman Terry the Friendly Frackosaurus

Monday July 11, 2011

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### Anti-frack Attacks

To promote fracking, Talisman Energy releases Talisman Terry the Frackosaurus, the funnest energy extraction-based character since Mountaintop Mining Manny.

# There is moral ambiguity on both sides!



Tony Ingraffea with Yoko Ono and son.



A drilling operation in Bradford County, Pennsylvania: one of the many places where shale rocks are fractured to release oil and gas.



Terry Engelder, profesor geologie Pensylvánské University (USA).

## Should fracking stop?

Extracting gas from shale increases the availability of this resource, but the health and environmental risks may be too high.

### POINT

### Yes, it's too high risk

*Natural gas extracted from shale comes at too great a cost to the environment, say Robert W. Howarth and Anthony Ingraffea.*

### COUNTERPOINT

### No, it's too valuable

*Fracking is crucial to global economic stability; the economic benefits outweigh the environmental risks, says Terry Engelder.*



Cornell  
(NY)

Penn State  
(PA)





## 100 TOP GLOBAL THINKERS 2011

Politics: 2011



11

Barack Obama



12

Dick Cheney



12

Condoleezza Rice



13

Bill and Melinda Gates



17

Mark Zuckerberg



20

Hillary and Bill Clinton



21

Nicolas Sarkozy



27

Angela Merkel



36

George P. Mitchell



36

Terry Engelder



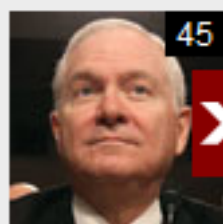
36

Gary Lash



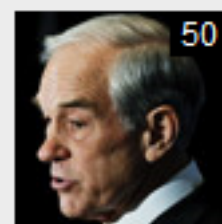
39

David Cameron



45

Robert Gates



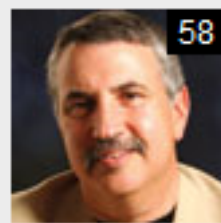
50

Ron Paul



51

John McCain



58

Thomas Friedman



*In honor of  
The Right Honorable  
David Cameron, M.P. #39  
Prime Minister of the United Kingdom  
of Great Britain and Northern Ireland  
The Vice President.  
and  
The Secretary of State #20  
request the pleasure of your company  
at a luncheon  
on Wednesday, March 14, 2012*

#20  
invites  
#36  
to a  
luncheon  
to honor  
#39

Who had the best seat  
in the house?



# raging chicken press

if you're not angry, you're not paying attention

<http://www.ragingchickenpress.org/2012/02/15/the-unholy-alliance-of-big-energy-big-university-big-state-my-exchange-with-terry-engelder/>

## The Unholy Alliance of Big Energy, Big University, Big State: My Exchange with Terry Engelder

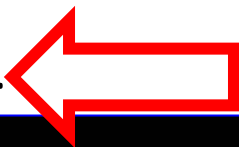
By Wendy Lee

February 15, 2012

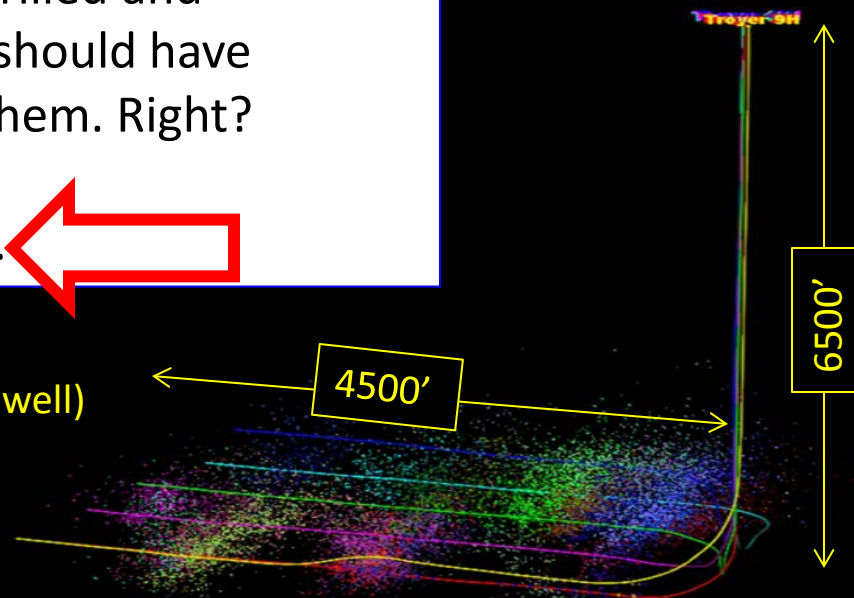
Philosopher: Bloomsburg U., PA

**[Engelder]:** Every horizontal well drilled and stimulated by high pressure water should have triggered earthquakes and lots of them. Right?

**[Lee]:** This claim is patently absurd.



Marcellus, PA  
Microearthquakes (approx 5600 per well)  
Schlumberger (Stimview)





# raging chicken press

if you're not angry, you're not paying attention

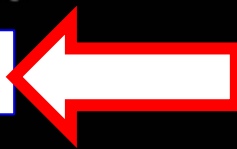
<http://www.ragingchickenpress.org/2012/02/15/the-unholy-alliance-of-big-energy-big-university-big-state-my-exchange-with-terry-engelder/>

## The Unholy Alliance of Big Energy, Big University, Big State: My Exchange with Terry Engelder

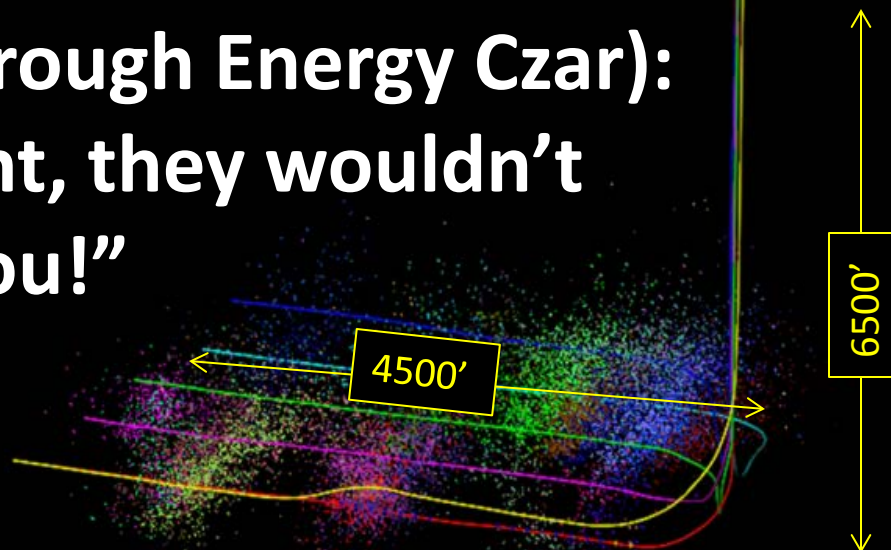
By Wendy Lee

February 15, 2012

[Lee]: This claim is patently absurd.



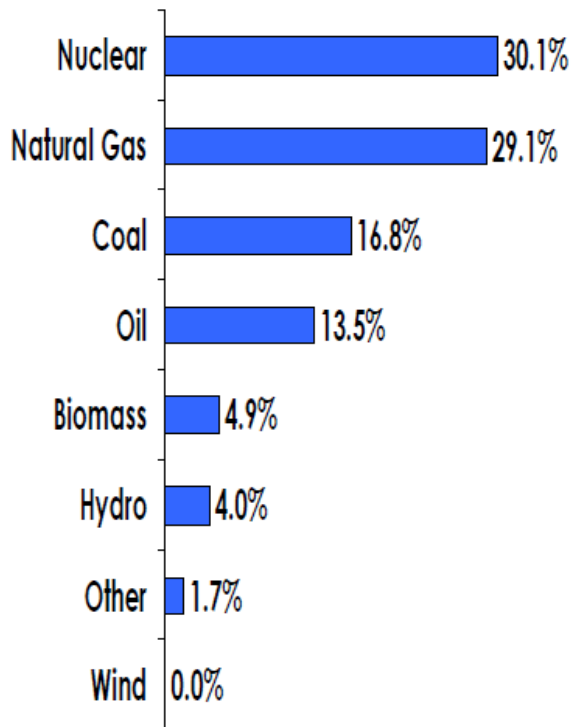
**Governor of PA (through Energy Czar):  
"If you weren't right, they wouldn't  
bother attacking you!"**



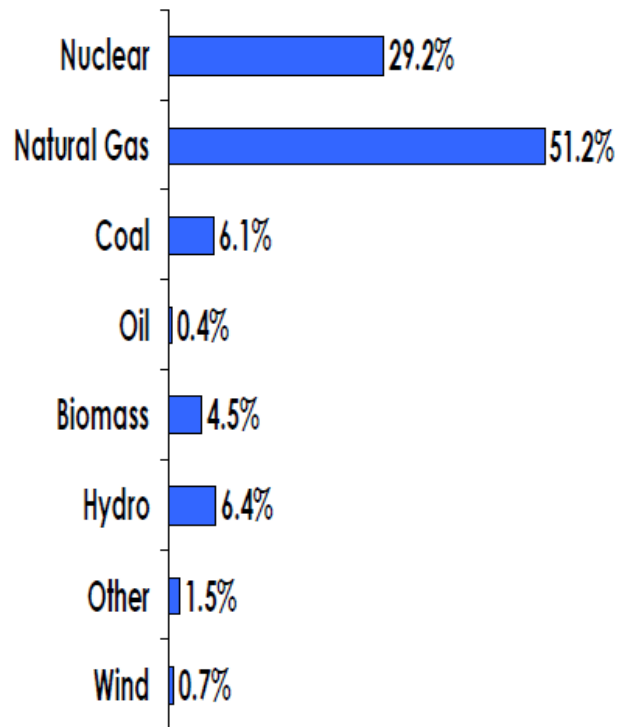
# Natural Gas Power Market Share 50% and Growing

## New England Electricity Generation

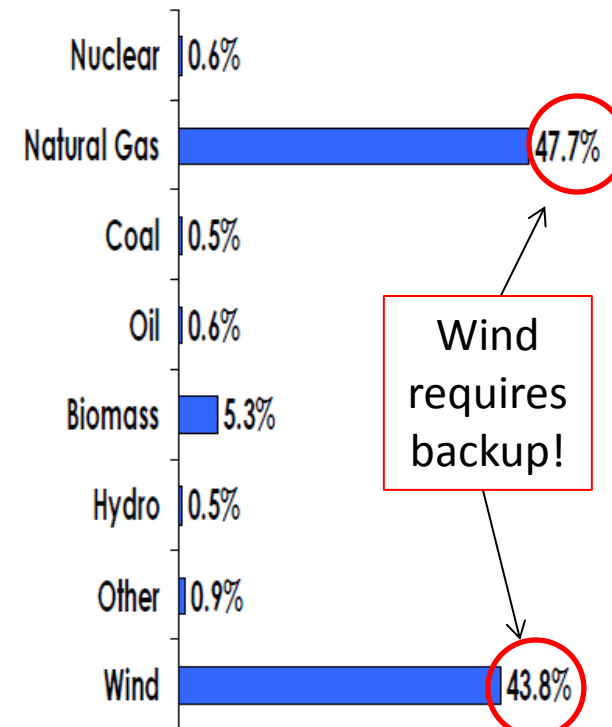
### 2001 Generation (MWH)



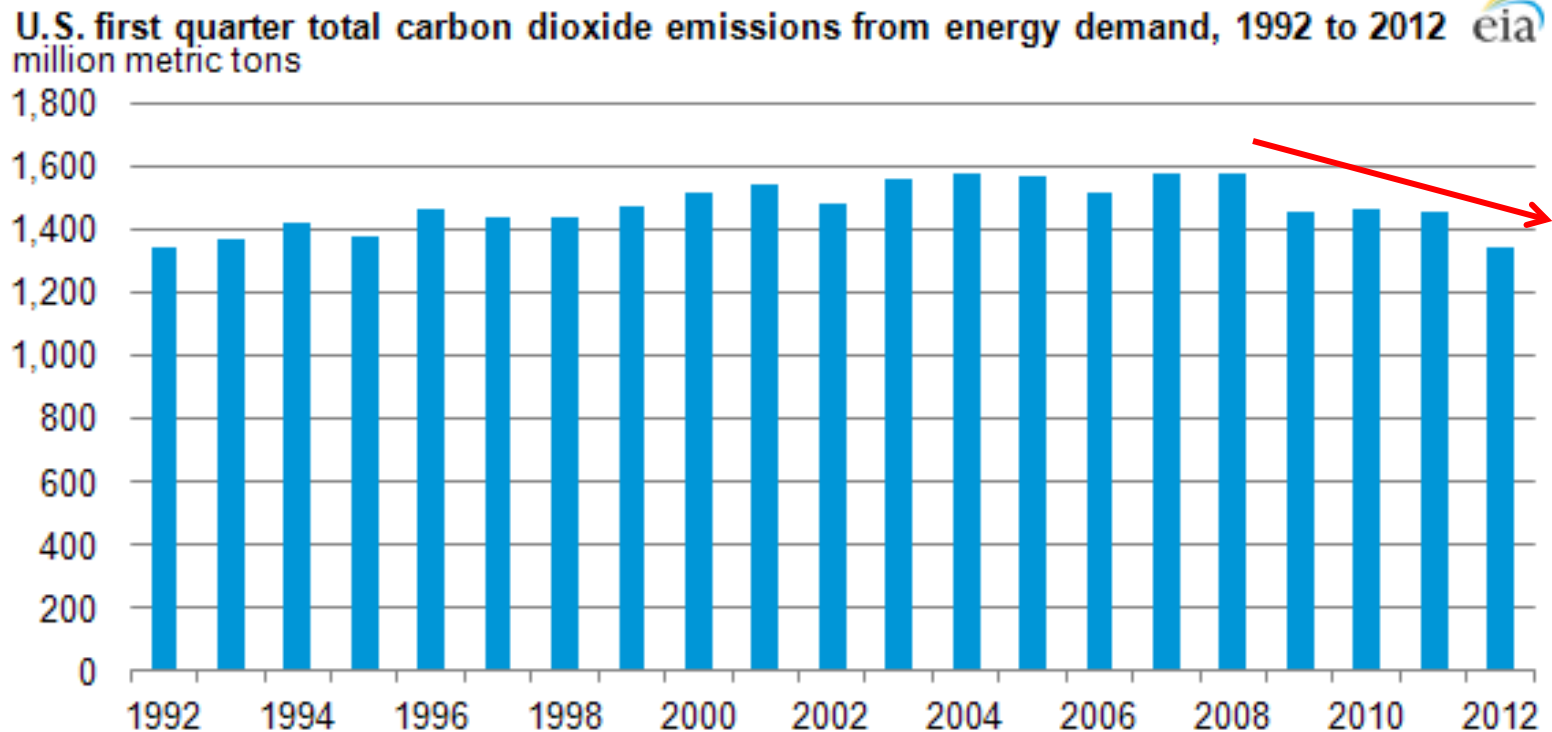
### 2011 Generation (MWH)



### Proposed Capacity (MW)



## U.S. energy-related CO<sub>2</sub> emissions in early 2012 lowest since 1992



Source: U.S. Energy Information Administration, [Monthly Energy Review](#).

Note: Reflects total carbon dioxide emissions in [metric tons](#) by quarter.

- A mild winter that reduced household heating demand and therefore energy use
- A decline in coal-fired electricity generation, due largely to historically low natural gas prices
- Reduced gasoline demand

### Yoko Ono Takes Fight Against Gas Drilling to Albany

By DANNY HAKIM  
Published: January 11, 2013



Dimock  
Water

“Fracking kills, and it doesn’t just kill us,” Ms. Ono said. “It kills the land, nature and, eventually, the whole world.”







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## Old King Coal Loses Ground To Natural Gas In New York

Submitted by [Elizabeth Mooney](#) on Thu, 2013-04-11 08:00.

As recently as 2007, the year before the national economy tanked, coal produced 15 percent of the electricity generated in New York. Since then, coal plants that figure has plummeted by a bit more than 3 percentage points, the **Albany Times Union** reported.

Although hydraulic fracturing for [natural gas](#) in New York has been delayed by a four-year study over environmental and health issues, the state is benefiting from shale gas drilling in Pennsylvania, Texas and other states that has driven

[natural gas prices](#) to historic lows. In New York, natural gas surpassed nuclear power as the single-largest sources of the state's electricity in 2009, and has been widening its lead every year since then, as coal slipped away.



**Most coal-fired power plants in New York are located in the western part of the state, such as this one on Lake Erie.**

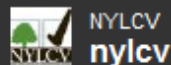
Natural gas has other advantages over coal: It produces fewer emissions of toxic chemicals and gases that contribute to climate change, key attributes as tougher federal environmental rules go into effect.

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**nylcv** We couldn't agree more, @StephenLevin33! G train needs more love!  
[bit.ly/16SfWqz](http://bit.ly/16SfWqz)  
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**nylcv** Welcome to new MTA Chairman & CEO Tom Prendergast. Look

