SPE GCS Annual Drilling Symposium

# Technology Surprises and "Slam Dunks"

Steve Mueller
Southwestern Energy

14 April 2016
Houston, Texas

Society of Petroleum Engineers

# My Discovery
## Expect Surprises

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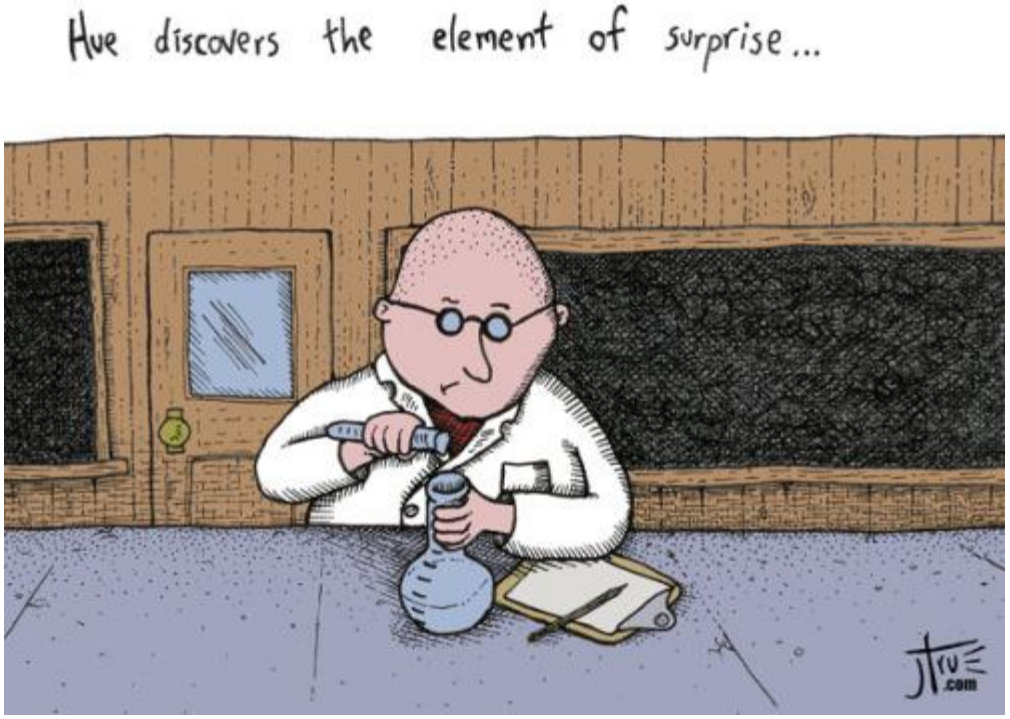

# “Slam Dunks” or “Dunked”

“My day? One amazing slam-dunk after another!”

# Big “Dunk” for Oil and Gas
## Monthly Data

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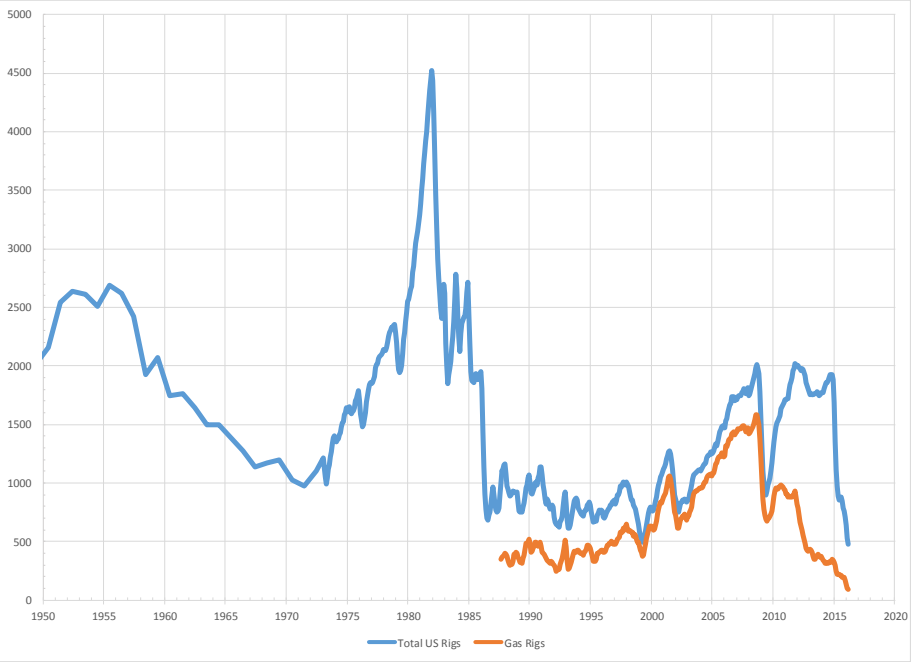
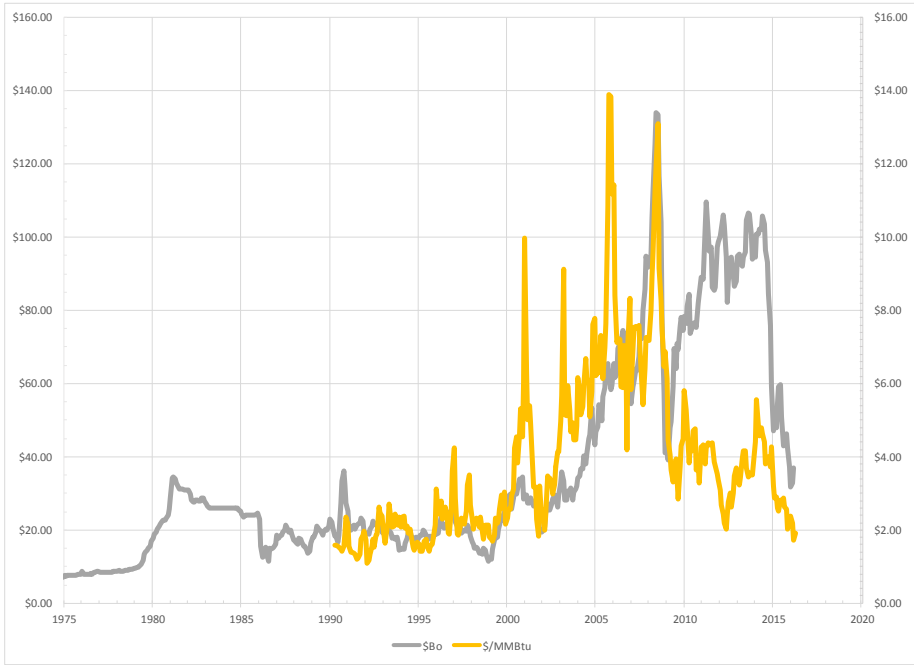
### Rig Count




### Oil & Gas Prices



# Surprises to “Slam Dunks”

“My day? One amazing slam-dunk after another!”

1. Maturing of Seismic into **THE** Exploration Strategy
2. Deep Water
3. Shale Revolution

# 1st Career Paradigm – Maturing of Seismic

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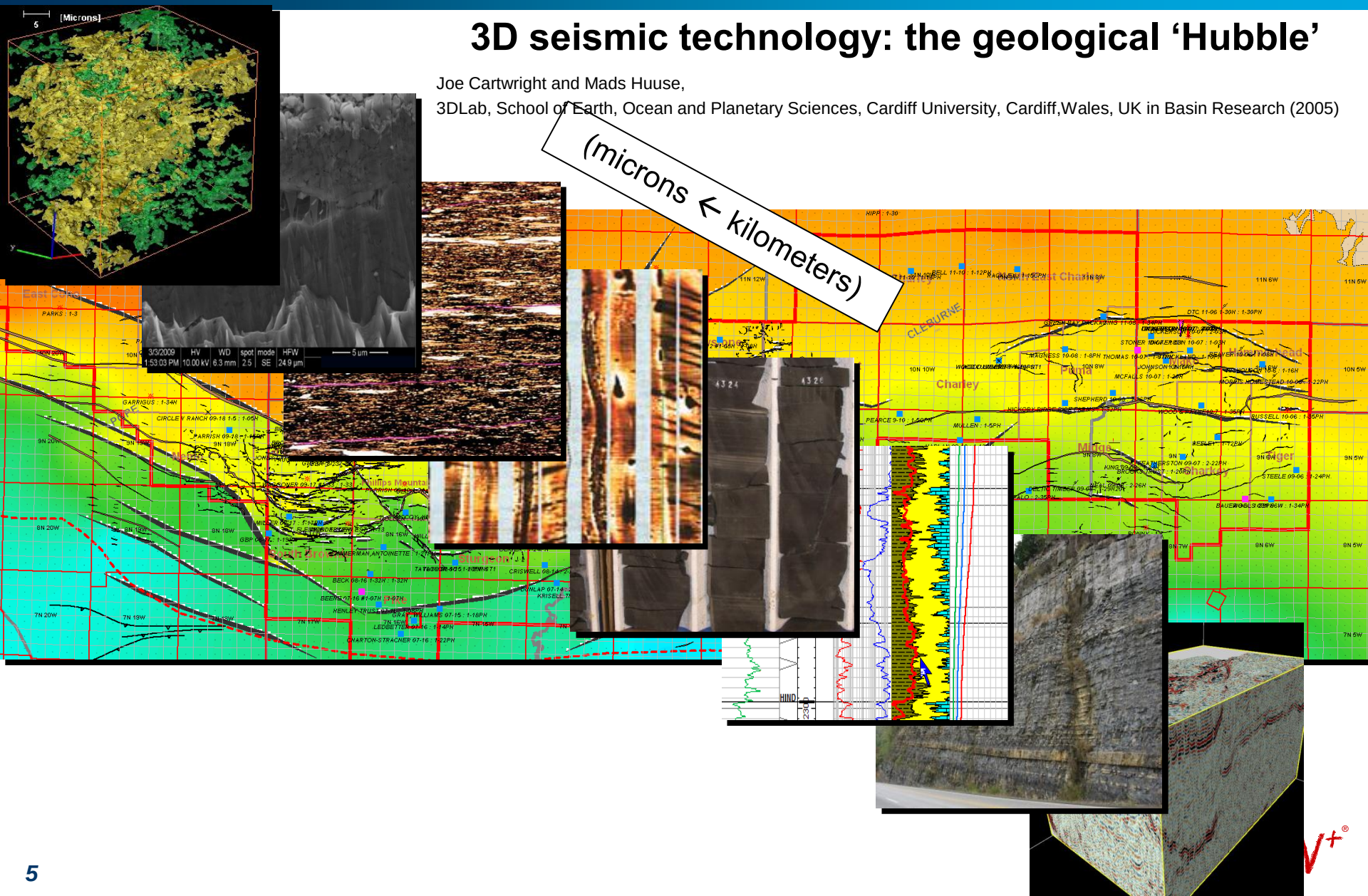
## 3D seismic technology: the geological ‘Hubble’

Joe Cartwright and Mads Huuse,
3DLab, School of Earth, Ocean and Planetary Sciences, Cardiff University, Cardiff,Wales, UK in Basin Research (2005)

(microns < kilometers)



# 2nd Career Paradigm – Deep Water

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"The deep offshore is believed to harbor some **7% of the world's oil and gas resources**. The deepwater domain could count significantly toward the replacement of oil and gas reserves: it contains an estimated 330 billion barrels of oil equivalent (Bboe) – **equivalent to six to seven years' worth of global consumption.** This amounts to nearly a quarter of the planet's as-yet undiscovered resources.

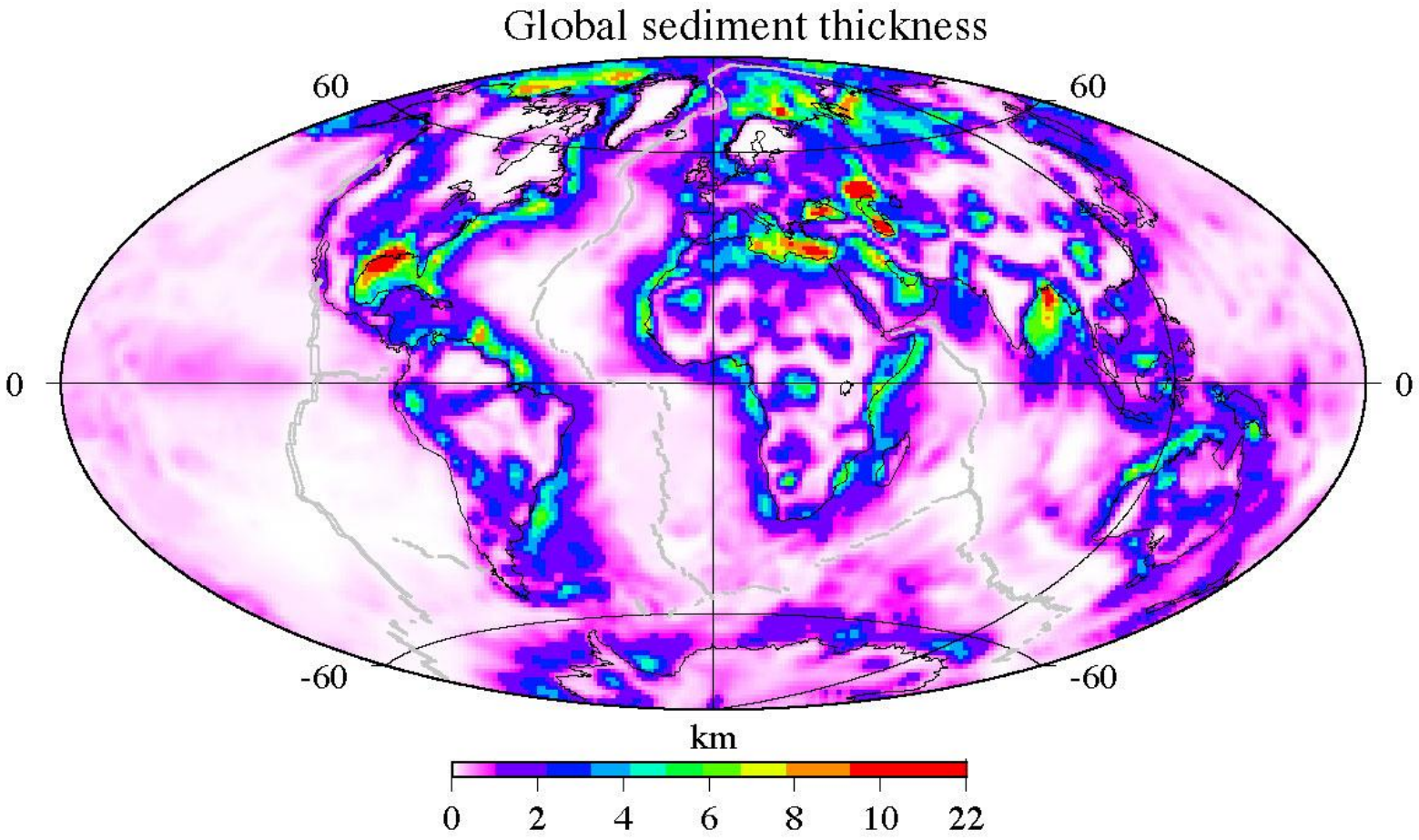
In 2010, deepwater oil and gas contributed a 6% share to cumulative global production of hydrocarbons. By 2020, that share is forecast to rise to 9% as deepwater production doubles to nearly 16 million boe/day. "

Total http://total.com/en/energies-expertise/oil-gas/exploration-production/strategic-sectors/deep-offshore/challenges/context-overview

# 3rd Career Paradigm – The BIGGEST

| World Oil and Gas Reserves<br>EIA 6/13/2013 | | | | |
|---|---|---|---|---|
| **United States** | | | | **Deep Water** |
| | **Crude oil (Bbo)** | **Wet Gas (Tcf)** | **Total (Bboe)** | |
| Added Total Resources due to Shale | 35% | 38% | | |
| Shale as a percent of total | **26%** | **27%** | | **7%** |
| R/P Proved (Years) | 6.81 | 13.25 | 10.15 | |
| R/P Total (Years) | 60.18 | 101.29 | 81.54 | |
| R/P added by Shale (Years) | **15.71** | **23.63** | **19.82** | **6-7** |
| **Total World** | | | | |
| | **Crude oil (Bbo)** | **Wet Gas (Tcf)** | **Total (Bboe)** | |
| Added Total Resources due to Shale | 11% | 47% | | |
| Shale as a percent of total | **10%** | **32%** | **22%** | **7%** |
| R/P Proved (Years) | 51.52 | 55.15 | 52.95 | |
| R/P Total (Years) | 105.32 | 184.53 | 136.48 | |
| R/P added by Shale (Years) | **10.82** | **58.07** | **29.41** | **6-7** |

# 3rd Career Paradigm – The BIGGEST




*Global sediment thickness based on the 1º x 1º compilation of Laske and Masters (1997). http://www.earth.ox.ac.uk/~tony/watts/basins.htm*

# Future Slam Dunks

## To a Slide-rule Widow

If you have an engineer for a husband, and he's so harassed by the logarithms and equations of a dull job that he's poor company for the family, maybe there's something you can do about it.

Wives of engineers at Boeing Airplane Company are happier. Why? Well, first of all, the men themselves like their work. They've found rewarding careers in a dynamic industry—as part of a company that's "writing the book" with such aviation advances as America's *first* jet transport-tanker, shown on the opposite page. But more, they've found a new way to live.

Boeing plants are located in young people's areas. They are in three different sections of the country, enabling you to choose the living and climate advantages that best suit your family. Each Boeing community offers an abundant variety of recreational opportunities for the whole family, and a pleasant, relaxed way of life. Good housing, schools and shopping centers appeal to young wives and mothers.

Boeing has attractive openings for *all* types of engineers and scientists.

Why not talk to your husband today? Persuade him at least to *find out* about the opportunities offered by Boeing. Good starting salaries, allowances for moving and for advanced study, regular merit reviews for promotion, a liberal retirement plan and real job stability are features both of you will appreciate. And the chance to do creative work with the leader in today's fast-moving aviation industry will inspire that man of yours.

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Co., Dept. S-02, Seattle 24, Wash.

F. B. WALLACE, Staff Engineer—Personnel
Boeing Airplane Co., Dept. S-02, Wichita, Kansas

A. J. BERRYMAN, Manager—Administration
Boeing Airplane Co., Dept. S-02, Melbourne, Florida

Mail this coupon to the address above from which you desire further information concerning the advantages of a career with Boeing.

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City_____ Zone____ State____
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BOEING
Aviation leadership since 1916

# Technology Timeline

| | 60's | 70's | 80's | 90's | 00's | 10's | 20's |
|---|---|---|---|---|---|---|---|
| **Computing** | •Slide Rule | •1977 Apple II | •1982 Lotus<br>•1982 Internet protocol | •1990 Windows 3.0<br>•1992 1st 3-D Printer | •2007 IPhone<br>•2007 Dropbox | •2011 Nest Thermostat<br>•2015 Apple Watch | **•Internet of Things (IoT)**<br>**•3-d printing**<br>**•Smaller** |
| **Space** | •1961 1st man in space<br>•1962 1st orbit<br>•1965 1st walk<br>•1969 Step on Moon | •1972 Last moon mission<br>•1975 Soyuz & Apollo dock | •1981 1st Space shuttle flight | •1998 1st module space station | •2004 private SpaceShipOne | •2011 Space shuttles retire | **•Private space flight routine** |

## Global Connected Devices
### Billions

| Year | Low | High |
|---|---|---|
| 2012 | | 9 |
| 2015 | 10 | 18 |
| 2016 | 14 | 23 |
| 2020 | 33 | 50 |
| 2025 | | +100 |

Estimated World Population 2016 = 7.4 Billion

# Backdrop for the Future

| | 60's | 70's | 80's | 90's | 00's | 10's | 20's |
|---|---|---|---|---|---|---|---|
| **World** | •1960 OPEC Founded<br>•1963 Kennedy assassinated<br>•1967 1st heart transplant | •1972 Nixon to China<br>•1973 Arab oil embargo<br>•1979 Iran revolution | •1986 OPEC floods market<br>•1989 Berlin Wall down | •1990 Iraq invades Kuwait<br>•1991 Soviet Union collapses | •2000 9/11 Terrorist attack<br>•2008 World Recession | •2014 ISIS takes Mosul | •**Middle East**<br>•**China** |
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| **Environmental** | •1963 Clean Air Act<br>•1969 Santa Barbara oil spill<br>•1969 National Environment Policy Act | •1970 EPA<br>•1970 Clean Air Act<br>•1974 Safe Drinking Water Act<br>•1978 Amoco Cadiz-France<br>•1979 Three Mile Island | •1987 UN defines Sustainability<br>•1989 Exxon Valdez | •1997 Kyoto Protocol<br>•1998 50 year moratorium on Antartica exploration | | •2010 Macondo<br>•2011 Fukushima<br>•2014 OK earthquakes<br>•2015 Aliso Canyon leak<br>•2015 Paris Climate | •**Local/Fed control**<br>• **Climate** |

# Aliso Canyon Updates
## It Is Not Just Storage Field Well


**Why Everyone Should Be Worried**

**About the California Gas Leak Disaster**

LOS ANGELES -- Call it a canary in a natural gas storage zone.

The enormous volume of natural gas spewing from a broken well here should serve as a wake-up call that more catastrophes are waiting to happen at similar facilities nationwide, conservationists warn.

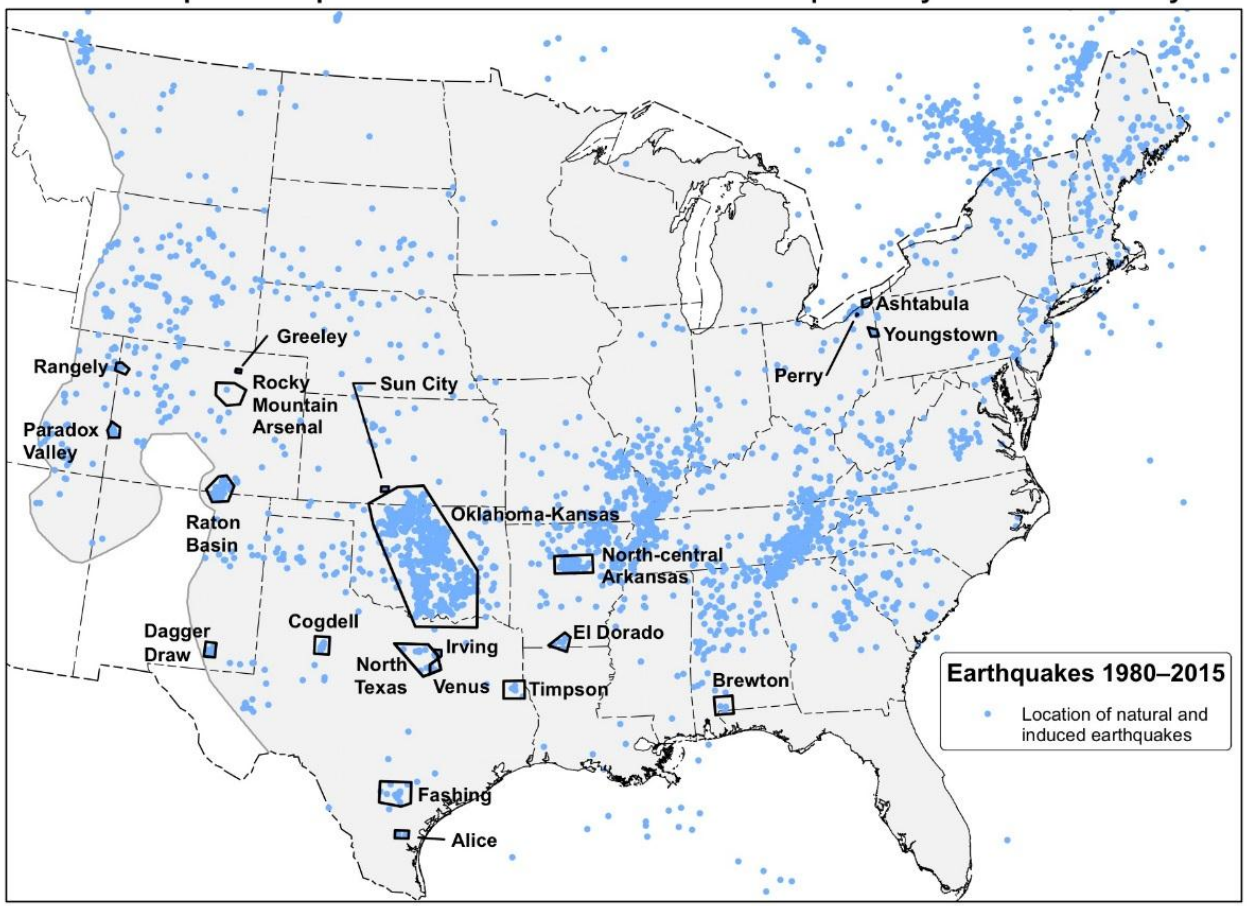
Aging infrastructure, industry negligence and scant state regulations are all factors … Huffington Post 1/21/16

**California Utility Faces Criminal Charges**

**Over Ongoing Gas Leak**

... In addition to the criminal charges, SoCalGas faces a number of civil lawsuits. … SoCalGas has also been sued by the city and county of Los Angeles; owners of businesses in Porter Ranch; residents of Porter Ranch; and the South Coast Air Quality Management District.
NPR February 3, 2016·11:12 AM ET

# Another Type of Surprise




USGS map displaying 21 areas where scientists have observed rapid changes in seismicity that have been associated with wastewater injection. The map also shows earthquakes—both natural and induced—recorded from 1980 to 2015 in the central and eastern U.S. with a magnitude greater than or equal to 2.5.

# Oil & Gas Industry Timeline

| | 60's | 70's | 80's | 90's | 00's | 10's | 20's |
|---|---|---|---|---|---|---|---|
| **World** | •1960 OPEC Founded<br>•1963 Kennedy assassinated<br>•1967 1st heart transplant | •1972 Nixon to China<br>•1973 Arab oil embargo<br>•1979 Iran revolution | •1986 OPEC floods market<br>•1989 Berlin Wall down | •1990 Iraq invades Kuwait<br>•1991 Soviet Union collapses | •2000 9/11 Terrorist attack<br>•2008 World Recession | •2014 ISIS takes Mosul | •**Middle East**<br>•**China** |
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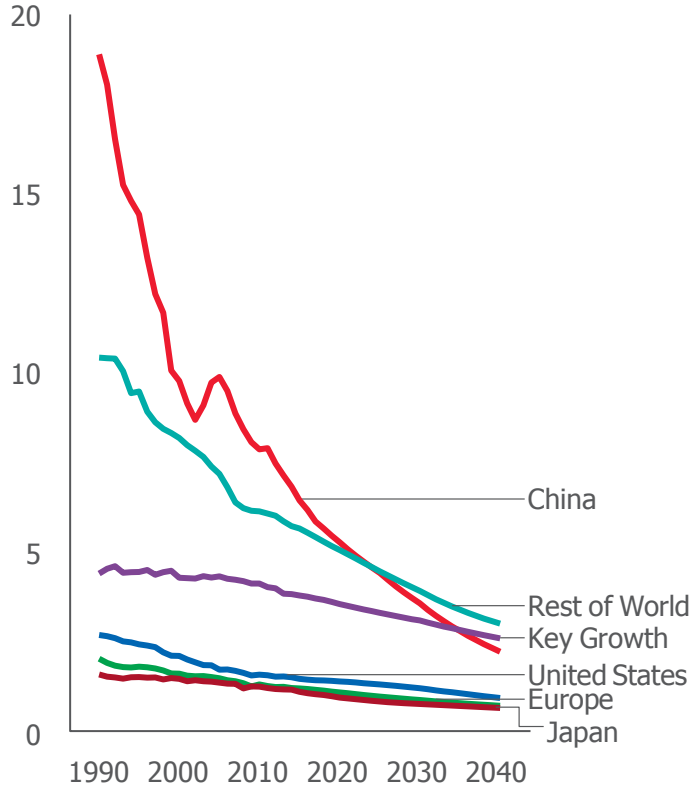
| **E&P** | •1960 CDP stacking<br>1961 Subsea completion<br>1st Coil tubing unit<br>1964 Invert emulsions | •1970 Bright Spots in GOM<br>•1970 Seismic vibrators<br>•1972 PDC<br>•1972 Pulse mud<br>•1978 ROV's | •1980 3-d seismic<br>•1981 Oil price decontrolled<br>•1983 Area-wide OCS sale<br>•1983 Subsalt GOM<br>•1984Tension-leg<br>•1984 Steerable drill | •1990 NYMEX<br>•1993 Synthetic drilling fluid<br>•1993 AC top drive<br>•1995 Chalk Horizontals<br>•1997 Closed loop<br>•1998 Level-6 multi-lateral | •2003 Barnett 1st horizontal<br>•2008 Oil Price $147.27/Bo | •2010 Shale efficiency<br>•2011 7.13 mi horizontal lateral | •**US**<br>**-Northeast**<br>**-Optimize & Expand Shale**<br>•**World**<br>**-Shales** |

# Different Aspect to Efficiency

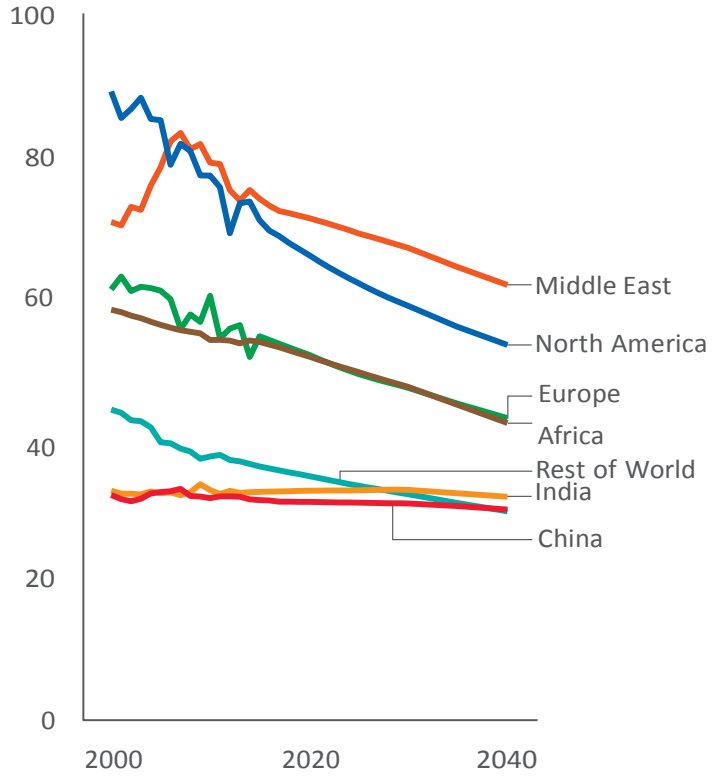
## Industrial energy intensity

Thousand BTUs per dollar of GDP (2010$)



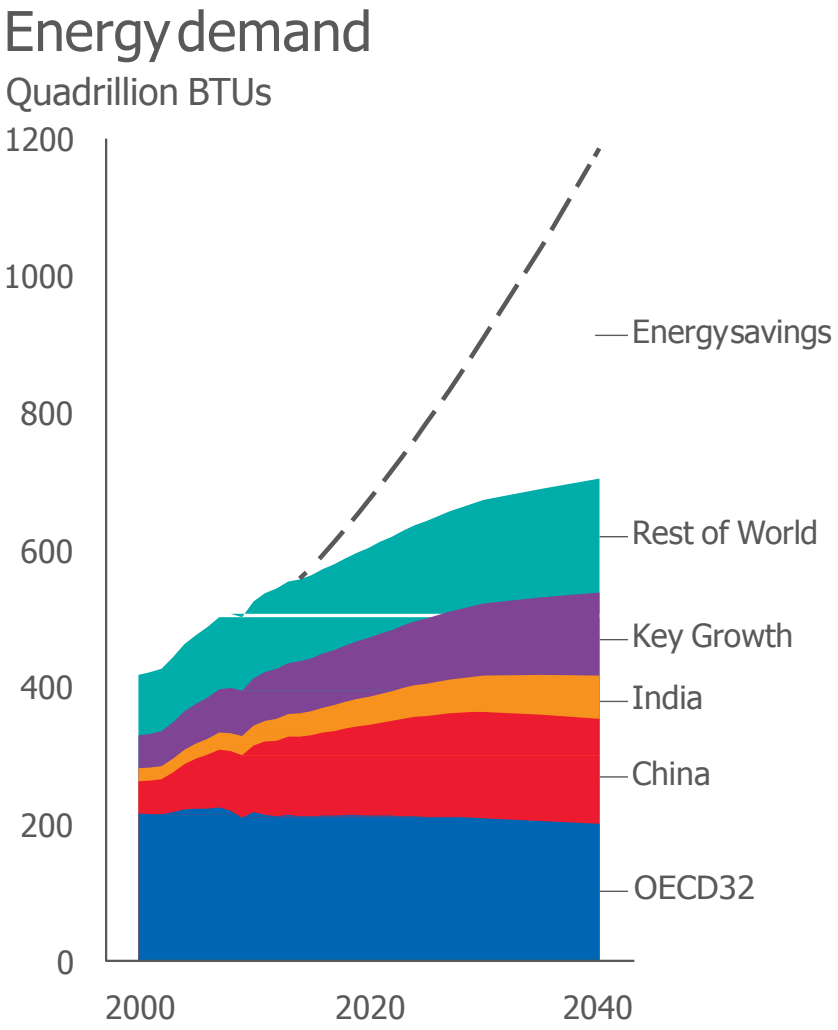

## Energy use per household

Million BTUs per household




From: Exxon 2016 The Outlook for Energy

# Efficiency Surprise




From: Exxon 2016 The Outlook for Energy

# Surprise Differences Made by the Industry

- **"America is now the world's top producer of natural gas,** and it's helped to push down the cost of keeping our students warm and local governments running," said Isakower.

  API Press Release WASHINGTON, June 5, 2014

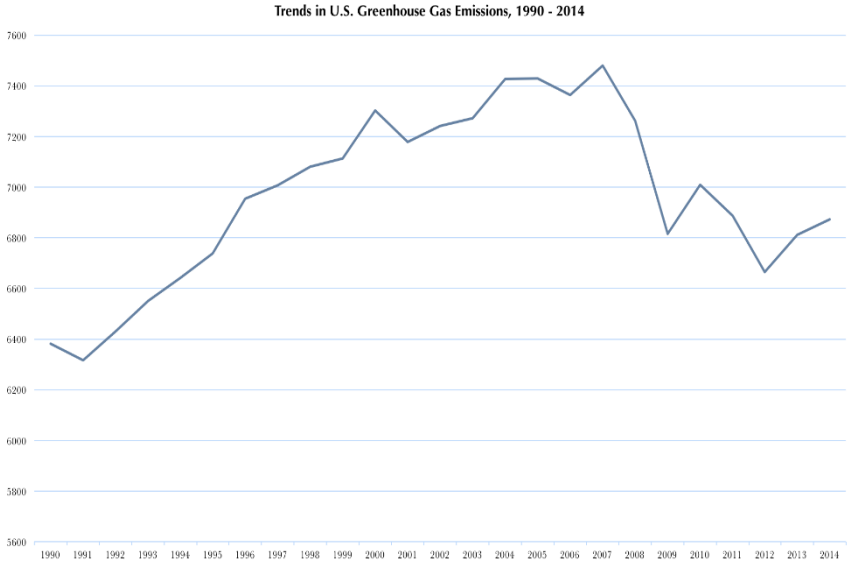
- U.S. public **elementary and secondary school districts saved approximately 9.3 percent on electricity and 21.3 percent on natural gas during the 2012-2013** fiscal year, all thanks to rising domestic oil and natural gas production. Altogether, that equals a total savings of **$1.2 billion**. During … At the same period, **state and local taxpayers saved another $720 million on other government spending.**

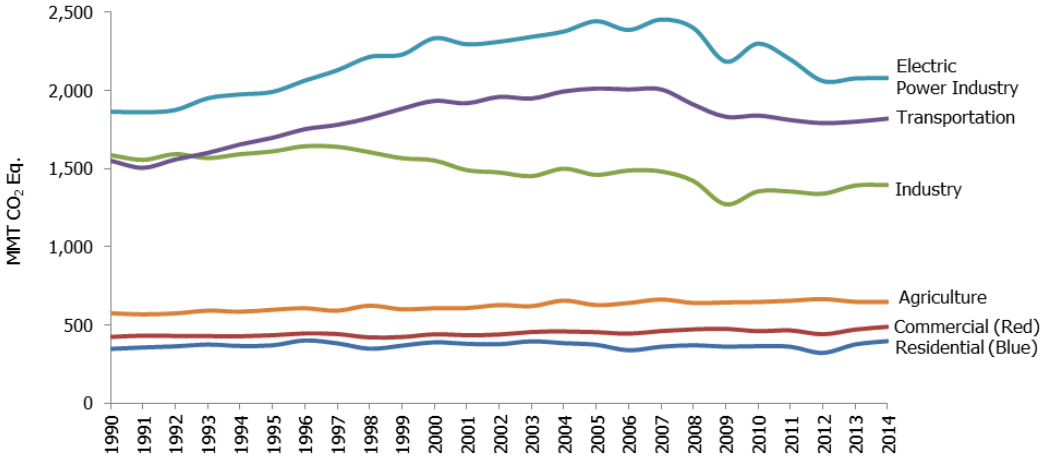
  June 5,2014 IHS Global Insight

- U.S. **gas imports plunge to 25-year low according to a recent note from the U.S. Energy Information Administration,** U.S. net imports of natural gas in 2013 fell 14% to 1,311 billion cubic feet, or Bcf, the **lowest level since 1989**. Meanwhile, U.S. natural gas production likely set a new record of 24,282 Bcf last year.

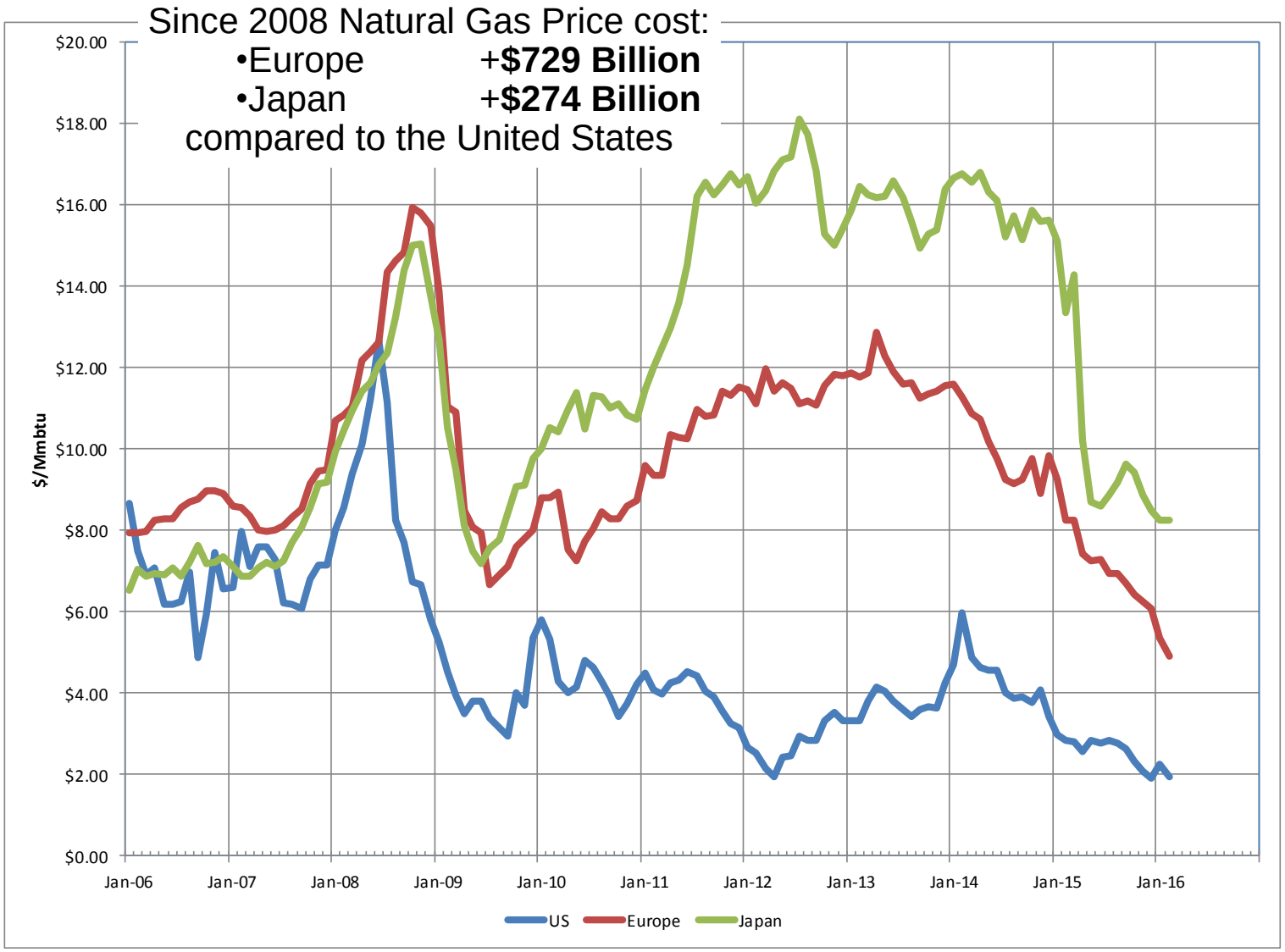
  Motley Fool By Arjun Sreekumar June 12, 2014

# Surprise Environmental Differences in U.S.

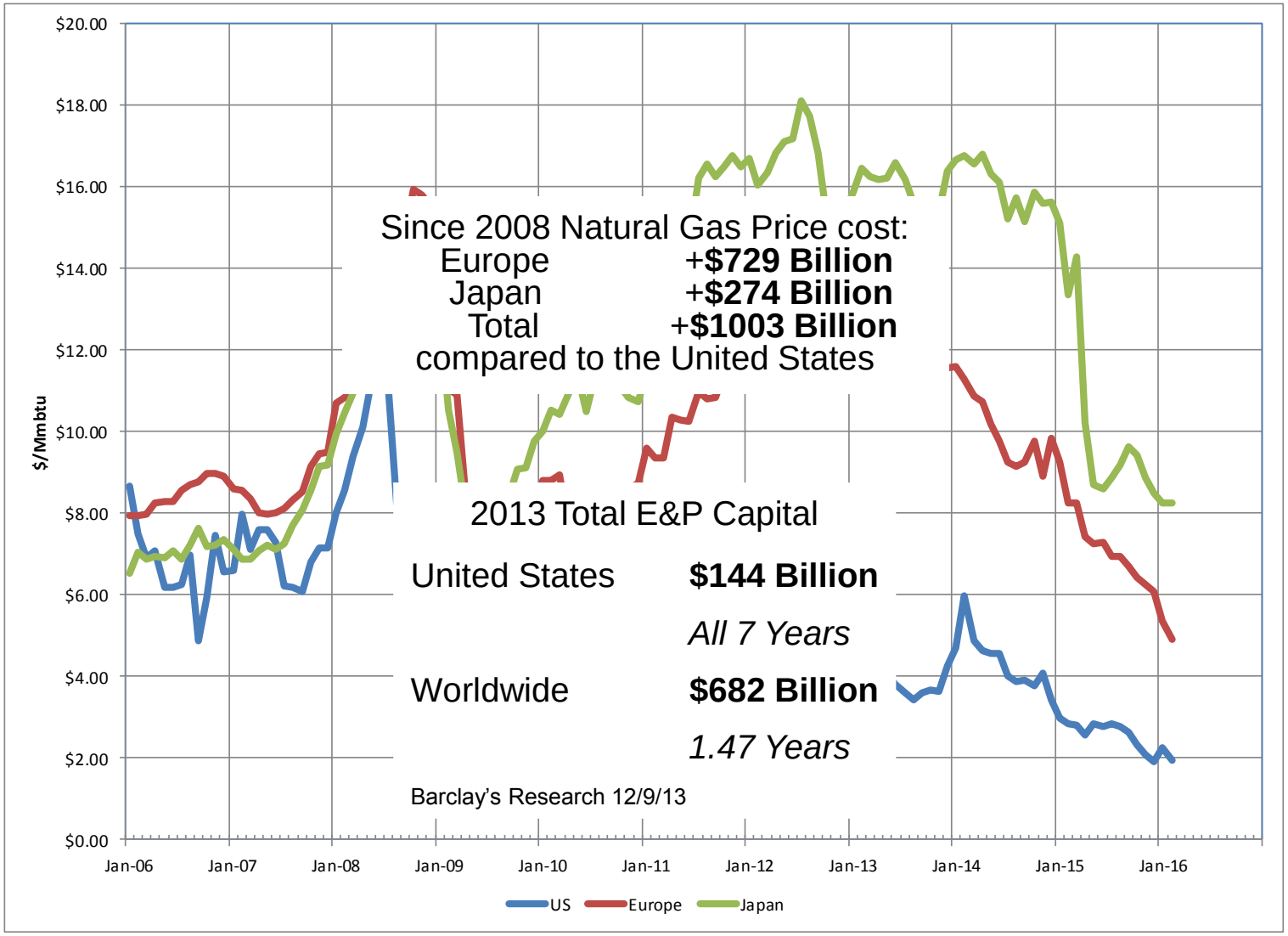


# Surprise Advantage to United States



# Surprise Economics for United States



# Surprise Future for the World

## Top Ten Problems Facing Humanity Over the Next 50 Years

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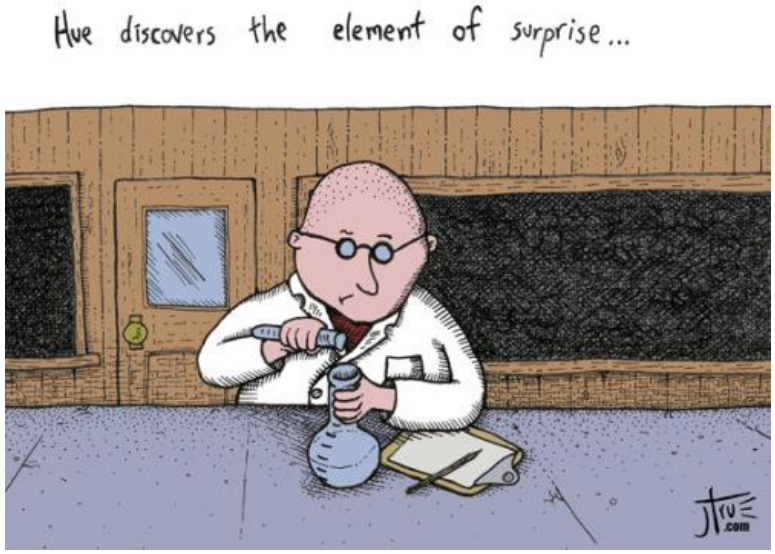
1. **Energy**
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population

From: Richard Smalley
Smalley Institute, Rice University, 2003

# Future Surprises and Slam Dunks

"My day? One amazing slam-dunk after another!"




- **Smaller, "thinking", interconnected**
- **Efficiency – unintended consequences**
- **Local and Federal control battles**
- **Industry environmental response**

# THANK YOU

# QUESTIONS & COMMENTS

*Technology Surprises and "Slam Dunks"*
S Mueller