Technology Surprises and “Slam Dunks”

Steve Mueller
Southwestern Energy
Hue discovers the element of surprise...
“My day? One amazing slam-dunk after another!”
Big “Dunk” for Oil and Gas
Monthly Data

Rig Count

Oil & Gas Prices
Surprises to “Slam Dunks”

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

“My day? One amazing slam-dunk after another!”
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)
“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. “
### World Oil and Gas Reserves

**EIA 6/13/2013**

#### United States

<table>
<thead>
<tr>
<th></th>
<th>Crude oil (Bbo)</th>
<th>Wet Gas (Tcf)</th>
<th>Total (Bboe)</th>
<th>Deep Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Added Total Resources due to Shale</td>
<td>35%</td>
<td>38%</td>
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<tr>
<td>Shale as a percent of total</td>
<td><strong>26%</strong></td>
<td><strong>27%</strong></td>
<td><strong>7%</strong></td>
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<tr>
<td>R/P Proved (Years)</td>
<td>6.81</td>
<td>13.25</td>
<td>10.15</td>
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<tr>
<td>R/P Total (Years)</td>
<td>60.18</td>
<td>101.29</td>
<td>81.54</td>
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<tr>
<td>R/P added by Shale (Years)</td>
<td><strong>15.71</strong></td>
<td><strong>23.63</strong></td>
<td><strong>19.82</strong></td>
<td><strong>6-7</strong></td>
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</tbody>
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#### Total World

<table>
<thead>
<tr>
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<th>Crude oil (Bbo)</th>
<th>Wet Gas (Tcf)</th>
<th>Total (Bboe)</th>
<th>Deep Water</th>
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<tbody>
<tr>
<td>Added Total Resources due to Shale</td>
<td>11%</td>
<td>47%</td>
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<td>Shale as a percent of total</td>
<td><strong>10%</strong></td>
<td><strong>32%</strong></td>
<td><strong>22%</strong></td>
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<tr>
<td>R/P Proved (Years)</td>
<td>51.52</td>
<td>55.15</td>
<td>52.95</td>
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<tr>
<td>R/P Total (Years)</td>
<td>105.32</td>
<td>184.53</td>
<td>136.48</td>
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<tr>
<td>R/P added by Shale (Years)</td>
<td><strong>10.82</strong></td>
<td><strong>58.07</strong></td>
<td><strong>29.41</strong></td>
<td><strong>6-7</strong></td>
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</table>
Global sediment thickness based on the $1^\circ \times 1^\circ$ compilation of Laske and Masters (1997). http://www.earth.ox.ac.uk/~tony/watts/basins.htm
To a Slide-rule Widow

If you're an engineer or a husband, and she's as burdened by the intricacies and equations of a real job that she's your company for the benefit, maybe there's something you can do about it.

Women of engineers at Boeing Airplane Company are happier. Why? Well, first of all, the men themselves appreciate work. They've found something interesting to do in a dynamic industry, and a part of a company that's making the world go round. And that's something to be proud of.

Boeing plants are located in young people's area. They are so close to home that you can drive or ride a bicycle to the plant and back in one day. You get to choose the living and climate advantages that best suit your family. Each Boeing community offers an abundance of recreational opportunities for the whole family, and a pleasant, varied way of life. Good housing, schools and shopping centers are close to young wives and children.

If you're interested in a field that offers the challenges of a career with Boeing,
## Technology Timeline

<table>
<thead>
<tr>
<th>60’s</th>
<th>70’s</th>
<th>80’s</th>
<th>90’s</th>
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<th>10’s</th>
<th>20’s</th>
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<td>2025</td>
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<td>+100</td>
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</tbody>
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Estimated World Population 2016 = 7.4 Billion
### Backdrop for the Future

#### World
- **60's**
  - 1960 OPEC Founded
  - 1963 Kennedy assassinated
  - 1967 1st heart transplant
- **70's**
  - 1962 Nixon to China
  - 1973 Arab oil embargo
  - 1979 Iran revolution
- **80's**
  - 1986 OPEC floods market
  - 1989 Berlin Wall down
- **90's**
  - 1990 Iraq invades Kuwait
  - 1991 Soviet Union collapses
- **00's**
  - 2000 9/11 Terrorist attack
  - 2008 World Recession
- **10's**
  - 2014 ISIS takes Mosul
  - Middle East
  - China
- **20's**
  - Internet of Things (IoT)
  - 3-d printing
  - Smaller

#### Computing
- **60's**
  - Slide Rule
- **70's**
  - 1977 Apple II
- **80's**
  - 1982 Lotus
  - 1982 Internet protocol
- **90's**
  - 1990 Windows 3.0
  - 1992 1st 3-D Printer
- **00's**
  - 2007 IPhone
  - 2007 Dropbox
- **10's**
  - 2011 Nest Thermostat
  - 2015 Apple Watch
- **20's**
  - Environment

#### Environmental
- **60's**
  - 1963 Clean Air Act
  - 1969 Santa Barbara oil spill
  - 1969 National Environment Policy Act
- **70's**
  - 1970 EPA
  - 1970 Clean Air Act
  - 1974 Safe Drinking Water Act
  - 1978 Amoco Cadiz-France
  - 1979 Three Mile Island
- **80's**
  - 1987 UN defines Sustainability
  - 1989 Exxon Valdez
- **90's**
  - 1997 Kyoto Protocol
  - 1998 50 year moratorium on Antartica exploration
- **00's**
  - 2010 Macondo
  - 2011 Fukushima
- **10's**
  - 2014 OK earthquakes
  - 2015 Aliso Canyon leak
- **20's**
  - Local/Fed control
  - Climate
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 of Earthquakes since 1980 and Recent Areas Impacted by Induced Seismicity

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

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- **1960**: OPEC Founded
- **1963**: Kennedy assassinated
- **1967**: 1st heart transplant
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- **2015**: Paris Climate Local/Fed control

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- **2011**: Fukushima
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- **2015**: Paris Climate Local/Fed control

### E&P
- **1960**: CDP stacking
- **1961**: Subsea completion
- **1964**: Invert emulsions
- **1970**: Bright Spots in GOM
- **1970**: Seismic vibrators
- **1972**: PDC
- **1972**: Pulse mud
- **1978**: ROV’s
- **1980**: 3-d seismic
- **1981**: Oil price decontrolled
- **1982**: Area-wide OCS sale
- **1983**: Subsalt GOM
- **1984**: Tension-leg
- **1984**: Steerable drill
- **1990**: NYMEX
- **1993**: Synthetic drilling fluid
- **1993**: AC top drive
- **1995**: Chalk Horizontals
- **1997**: Closed loop
- **1998**: Level-6 multi-lateral
- **2003**: Barnett 1st horizontal
- **2008**: Oil Price $147.27/Bo
- **2010**: Shale efficiency
- **2011**: 7.13 mi horizontal lateral
- **2010**: Macondo
- **2011**: Fukushima
- **2014**: OK earthquakes
- **2015**: Aliso Canyon leak
- **2015**: Paris Climate Local/Fed control

### Local/Fed control
- **Climate**

### US
- **Northeast**
- **Optimize & Expand Shale**
- **World - Shales**
Different Aspect to Efficiency

**Industrial energy intensity**

Thousand BTUs per dollar of GDP (2010$)

- China
- Rest of World
- Key Growth
- United States
- Europe
- Japan

**Energy use per household**

Million BTUs per household

- Middle East
- North America
- Europe
- Africa
- Rest of World
- India
- China

From: Exxon 2016 The Outlook for Energy
Efficiency Surprise

Energy demand
Quadrillion BTUs

- Energy savings
- Rest of World
- Key Growth
- India
- China
- OECD32

From: Exxon 2016 The Outlook for Energy
• “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

- Electric Power Industry
- Transportation
- Industry
- Agriculture
- Commercial (Red)
- Residential (Blue)
Surprise Advantage to United States

Since 2008 Natural Gas Price cost:
- Europe: +$729 Billion
- Japan: +$274 Billion

compared to the United States
Surprise Economics for United States

Since 2008 Natural Gas Price cost:
- Europe: +$729 Billion
- Japan: +$274 Billion
- Total: +$1003 Billion

compared to the United States

2013 Total E&P Capital
- United States: $144 Billion (All 7 Years)
- Worldwide: $682 Billion (1.47 Years)

Barclay’s Research 12/9/13
Top Ten Problems Facing Humanity Over the Next 50 Years

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

• Smaller, “thinking”, interconnected
• Efficiency – unintended consequences
• Local and Federal control battles
• Industry environmental response

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

Hue discovers the element of surprise...
THANK YOU

QUESTIONS & COMMENTS

Technology Surprises and “Slam Dunks”
S Mueller