Top 10 Ways A Professor Know He is Getting Old...

#10: Current students do not recognize “wax on, wax off”

#9: They ask: “Who was that Paul McCartney guy on the Grammys?”

#8: Old people begin to call you “sir”

#7: You remember when cell phones were for talking

#6: Current students do no know what a land line is

#5: People refer to your publications as “classical”

#4: You have grandchildren of former students in class

#3: Someone has already thought up your best ideas (anticipatory plagiarism)

#2: You have to introduce yourself to more and more people at EOR conferences

#1: Unconventional hydrocarbon recovery does not include EOR

#0: You give retrospective talks
Perspectives on the Past and Future of the Oil and Gas Industry

Larry W. Lake

Department of Petroleum and Geosystems Engineering
The University of Texas at Austin

Presented at the
EORI EOR/IOR Conference
September 2012
Jackson Hole, WY
The Undergraduates...

UT-PGE Bachelor Graduates Total = 3764
Notable 1973

- I entered awl bidness
- Prudhoe Bay on stream
- Oil industry not immune from politics (Yom Kipur war)
- Gas lines at service stations
Notable 1973

• US using more foreign than domestic crude
• US no longer controlled price
• Downsizing (“reorganization”) begins
• M. King Hubbert was proved right
• For a while
• CO2 flooding tested in West Texas
• Start of a period of technical innovation
Perspective in Slogans…

• “We are running out of oil.” —Many sources, ca 1973
• “Energy independence is the moral equivalent of war.” —Jimmy Carter, US President, 1977

The Moral Equivalent Of War

By JIMMY CARTER, President of the United States

Delivered April 20, 1977 before a Joint Session of the United States Congress
Perspective in Slogans…

- “We are running out of oil.” —Many sources, ca 1973
- “Energy independence is the moral equivalent of war.” —Jimmy Carter, US President, 1977
- “The stone age didn’t end because we ran out of stones.” —Sheik Yamani, ca. 1985
- “The oil industry is a bunch of dinosaurs.” —Annette Bening in The American President, 1995

On Earth for about 160 million years
Perspective in Slogans…

• “We are running out of oil.” —Many sources, ca 1973
• “Energy independence is the moral equivalent of war.” —Jimmy Carter, US President, 1977
• “The stone age didn’t end because we ran out of stones.” —Sheik Yamani, ca. 1985
• “The oil industry is a bunch of dinosaurs.” —Annette Bening in *The American President*, 1995
• “I’ve just discovered how to solve the energy crises.” —Morgan Freeman in *Chain Reaction*, 1995
• “People are our only asset.” —Mobil, just before being bought by Exxon, and laying off many
• “The Oil Industry is Going Through Another Downturn. This one looks permanent” —Time magazine headline, ca. 1985
Perspective in Slogans…

• “The Party’s Over: Oil, war and fate of industrialized societies”-Heinberg, 2003

• “It’s not the technology that is important, it’s how you use it” —ca. 1992

  • Wireline readings
  • Logging while drilling
  • Computers
  • Top drives
  • Subsea equipment
  • Geophysical surveys
  • Drill bits
  • Reservoir modeling
  • Enhanced oil recovery
  • Drilling rigs

Top Ten Technologies in Last 75 years, Jacobs (2010)
Perspective in Slogans…

In Last 75 years, Jacobs (2010)

- Wireline readings
- Logging while drilling
- Computers
- Top drives
- Subsea equipment
- Geophysical surveys
- Drill bits
- Reservoir modeling
- Enhanced oil recovery
- Drilling rigs

Since 1973

- Logging while drilling
- FPSOs
- Gigacell numerical simulation
- Directional drilling
- Production geophysics
- ESPs
- Unbelievable large drilling rates
- Horizontal wells/fracturing
- Discovery of anthropogenic CO$_2$
- Large-scale CO$_2$ flooding
- High efficiency surfactants/polymers/designs
- Sequence stratigraphy
Forecasts...

- 1874 Only enough oil for 4 years, Penn State Geological Survey
- 1914 US Reserves exhausted by 1924, USGS
- 1939 World reserves to last 13 years, US Interior Department
- 1951 US reserves exhausted in 13 years, Interior Dept.
- 1960 proven reserves = 617 Bbl
- 1970 had pumped 767 Bbl
- Most forecasts say ca. 30 years
- 2012, Oil will be supplanted (not exhausted) in 2100, Haldorsen
Things I Think I Know…

• Industry is cyclical...
  – Slow expansions
  – Rapid contractions
  – Usually related to price
  – But then everything is cyclical

• One product industry
  – The most obvious value added of all
  – Huge diversity of skills, technologies

• Impossible to escape politics

• Energy demand keeps growing

• We are in the prosperity business
The Prosperity Business...
We fuel rising living standards. So refusing to explore is not an option. It would condemn humanity to a future of shortages, conflict and poverty - Dudley, 2012

Remember: All news is economic.

All economic news is bad
Things I Think I Know…

• Conservation
  – Rarely reduces consumption

• Renewables
  – Not competitors for transportation fuel
  – Will be some environmental backlash
  – Watch for solar powered semi

• Natural gas
  – You can be too successful
  – May offset some electrical power
Things I Think I Know…

- “Someone has a lot of ’splainin’ to do.” — Ricardo, ca 1950
  - Oil on the North Slope
  - Success of horizontal wells
  - Oil below 15,000 ft in GOM
  - Gas from shale (everywhere)
  - Oil from shale !!
- “Paradigm shifts.” — T. Kuhn
Things I Think I Know…

• We are slow adopters of technology
Things I Think I Know…

- Hiring…
  - Driven entirely by perception of profitability
  - More opportunity for on campus hires
  - Many bright, energetic students

- We are not running out of hydrocarbon
  - Try finding OOIP on websites
  - We are becoming short of easily mobile HC
  - Shift to rate-based reserves
If We Must Forecast (1960s)...

U.S. Production, Hubbert vs. Actual
If We Must (2005)...

USGS Est. of Ultimate Rec

<table>
<thead>
<tr>
<th>Probability</th>
<th>UR B-Bbls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (95%)</td>
<td>2,248</td>
</tr>
<tr>
<td>Mean (Expected Value)</td>
<td>3,003</td>
</tr>
<tr>
<td>High (5%)</td>
<td>3,896</td>
</tr>
</tbody>
</table>

2% Growth
Decline
R/P = 10

Campbell-Laherrere World Oil Production Estimates, 1930-2050
EIA-DOE Estimates, 1900-2125
If We Must (2010)…

Undulating Plateau vs. Peak Oil
Estimates of Ultimate Global Oil Recovery…
Things I Think I Know…

“Forecasts are the mirrors of our ignorance, not the embodiment of our understanding.” —Smil, 2006

• It’s a great business
  – Intellectual challenges of all types
  – Great people
  – We are helping society

• But it really is dying
Perspectives on One Dying Business…

9 BCE

1500s

2010
And Another…

The Drake discovery, Aug. 27, 1859
Depth of 69’, Titusville, Pa.
1850’s

Rotary Rig from late 1950’s
note standard derrick – built on site

Semi-Submersible Type
Floating vessel with well head placed on the ocean floor.

It’s all a matter of time scale(s)
Enhanced Oil Recovery Technologies

The increase of ultimate recovery through injection of steam, chemicals or gas to more effectively displace the oil bringing RFs to the 50-70% range.

‘Deploy’ & Repeat

Steam (SF, CSS)
Miscible Gas
Thermal GOGD
SAGD
Polymer Flooding
Low Salinity Waterflood

‘Develop’ & ‘Demonstrate’ Optimisation

Alkaline Surfactant Polymer
High Pressure Steam Injection
Contaminated/Acid Gas
Solvents
In-Situ Combustion / HPAI
In-Situ Upgrading (heating)

‘Discover’

R&D

Hybrid Processes

Microbial

\( \text{N}_2/\text{CO}_2 \text{ Foam} \)

In Situ Upgrading (catalytic)

Integrated Solutions
- Mature Field Mgmt
- Surface+Subsurface
- Onshore/Offshore
- Smart Surveillance
- Wells & Resv Mgmt
- Operations
There are Plenty of Resources

But they may cost more to produce, and may be CO2 intensive

Adjusted to include CO2 mitigation costs, ie, make CO2 neutral w.r.t. conventional

$/bbl

Already produced OPEC ME

Other conv

Heavy oil, bitumen

Ultra Deep

Arctic

DW

EOR

Oil shales

Available Oil Trillion Barrels

Source: IEA

2009

$80

160

120

80

40

20

0

0

1

2

3

4

5

6

Arctic

Ultra Deep

EOR

Oil shales

Heavy oil, bitumen

DW

Other conv

OPEC

ME

Already produced

Source: IEA

Adjusted to include CO2 mitigation costs, make CO2 neutral w.r.t. conventional