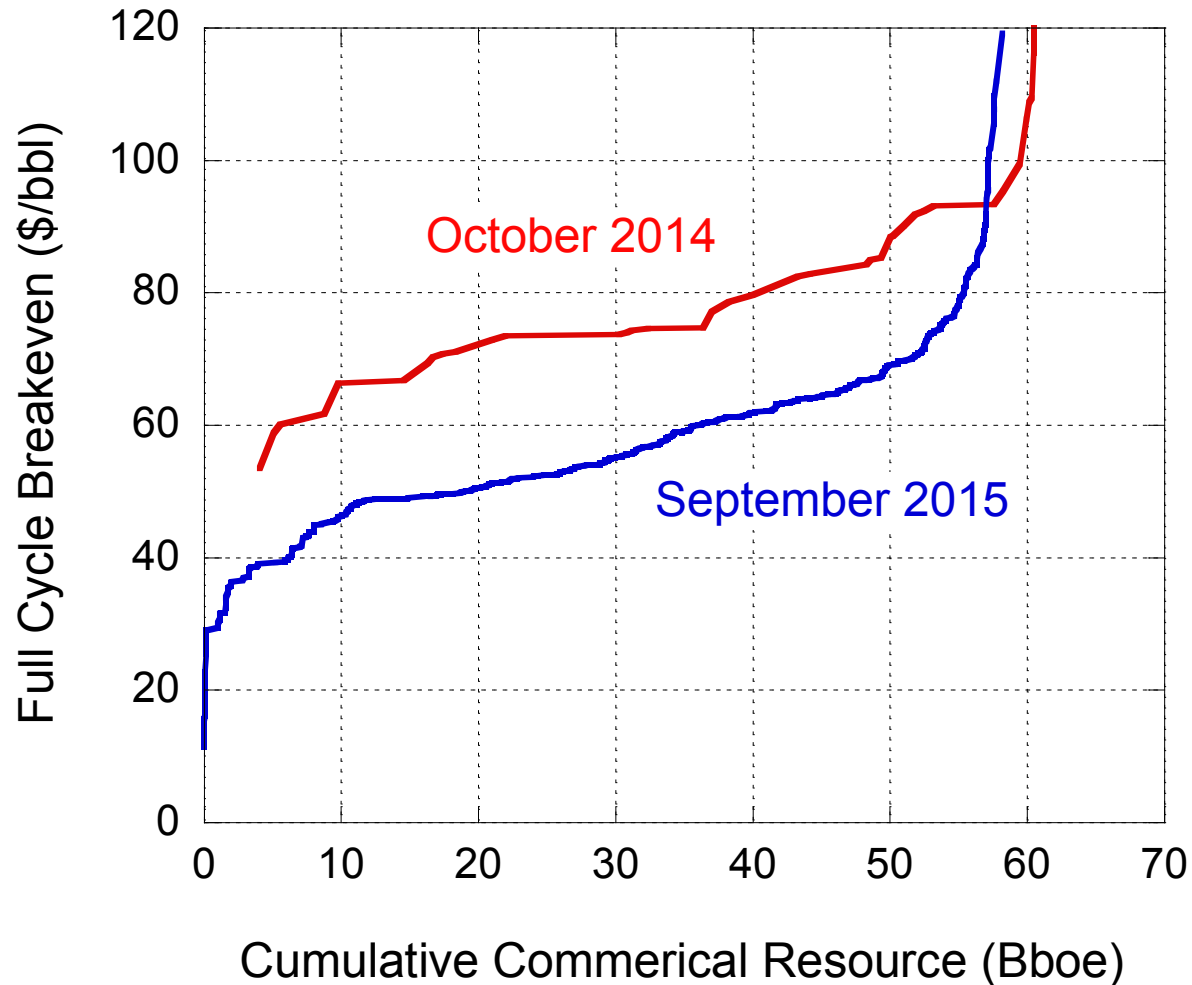


Center for Energy Economics
20th Annual Meeting
December 9-10, 2015

Technology White Space
&
The Effect of Oil Price Decline on Innovation

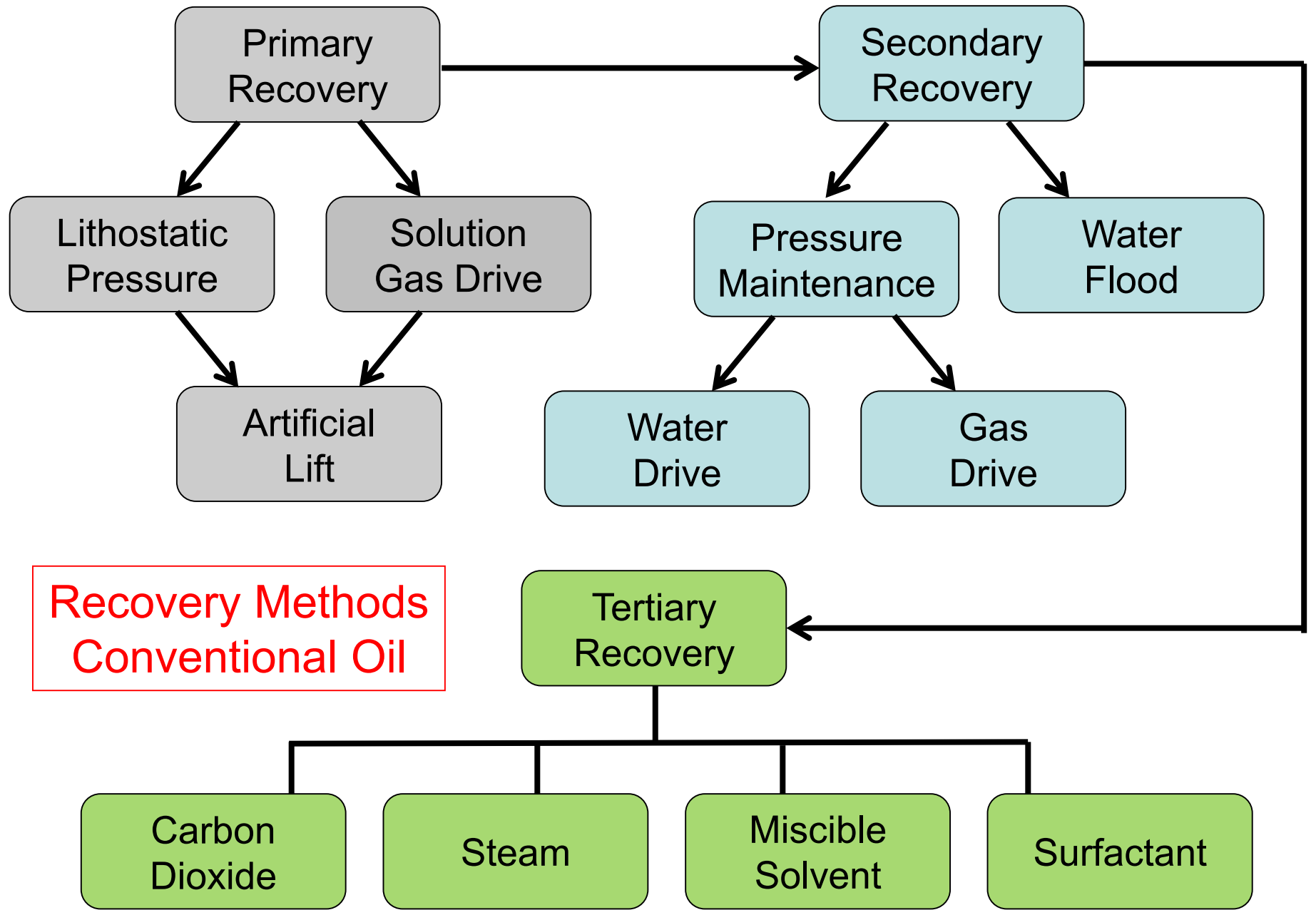
Robert Kleinberg
Schlumberger

Brilliant New Technology, Or Something Else?



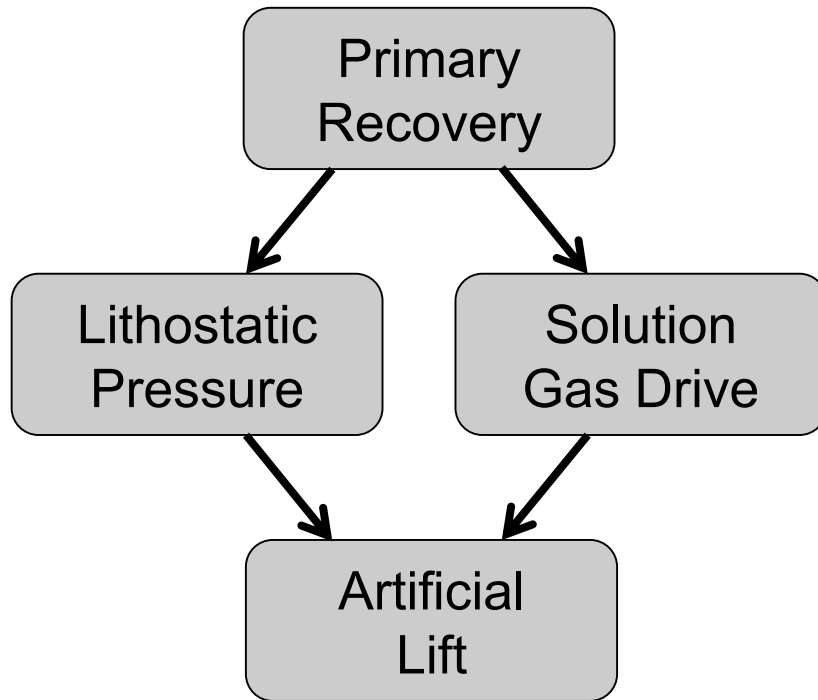
WoodMac 1410 North American Breakeven
WoodMac 1509 Lower 48 Breakeven

151125-01



**Recovery Methods
Conventional Oil**

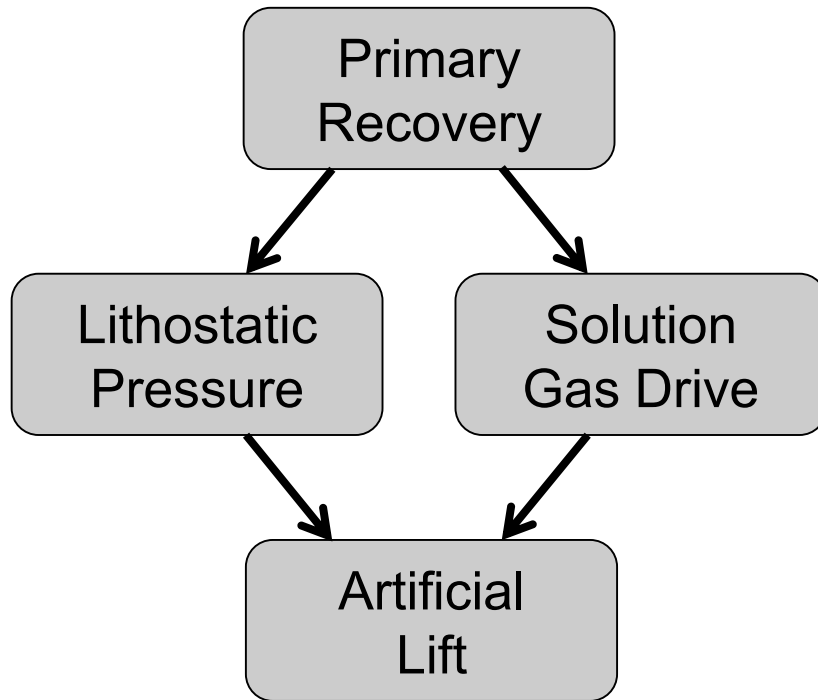
EIA Conference, July 2014



Recovery Methods
Tight Oil

Today

Same Techniques, Even More Brute Force



Recovery Methods Tight Oil

- No more derisking
 - ◇ Retreat to sweet spots
- Superfracks
 - ◇ Longer laterals
 - ◇ More water
 - ◇ More proppant
- Back to slickwater
 - ◇ Replacing technically superior gel fracks
 - ◇ Propane fracks have died
- Focus on OPEX breakeven

Does a Low Price Environment Encourage Innovation?

No

Familiar prospects developed in familiar ways

Operators: An end to “science experiments”

Service companies: Major cuts in resources, including R&D

Scaling back or withdrawal from university collaborations

Hiring freeze cuts off major source of new ideas

Case Study: Service Company A

Massive layoffs: ~ -25% yoy

Easy-to-replace personnel first, but Company A quickly reached bone

Clearing out of senior staff

No costly retirement incentives, but old-timers know the party is over (again) and is unlikely to resume soon.

R&D budget reduced

No new hires

No CAPEX

No interns

No travel budget

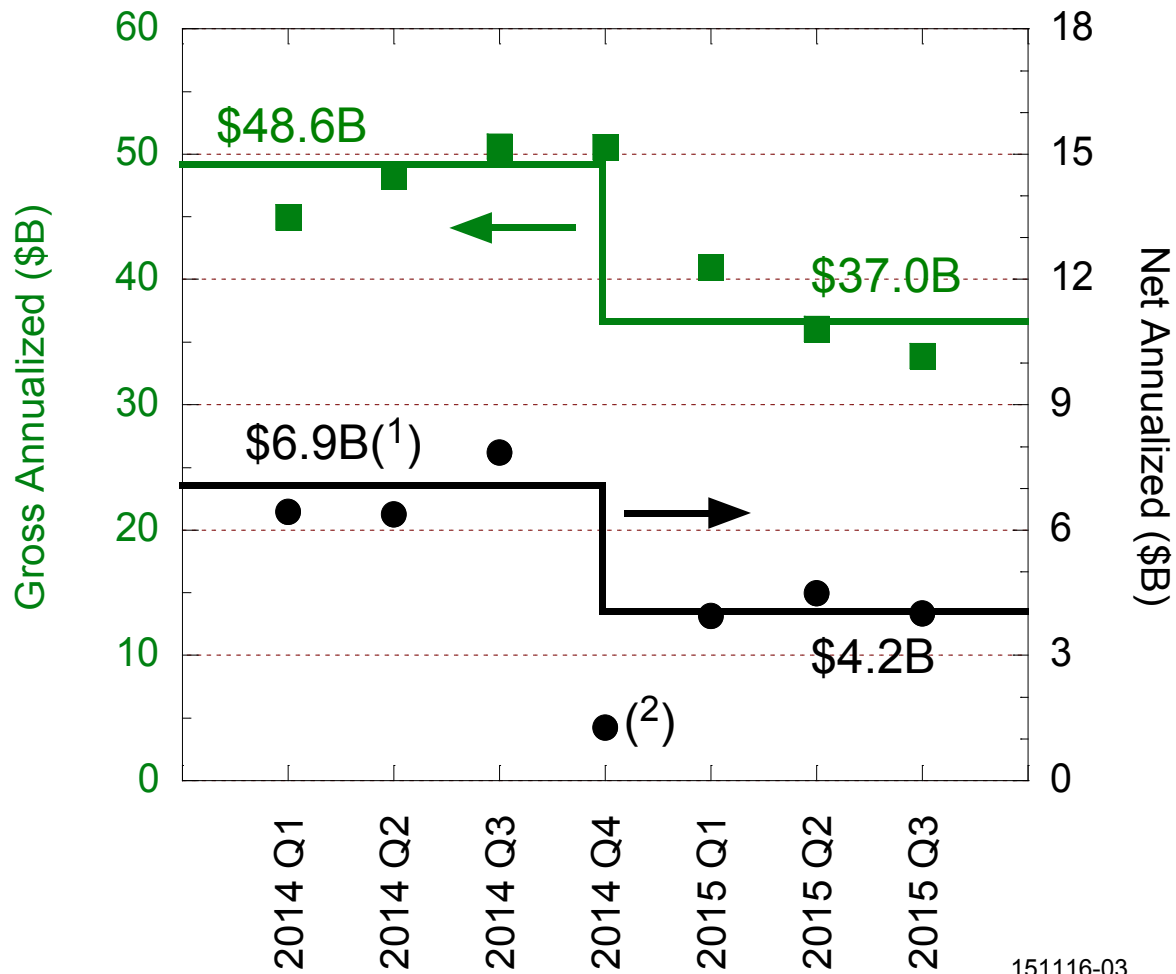
No pay increases

No Christmas Party



E. Scrooge, CEO
Company A

Schlumberger Gave Back 24% of Its Revenue 40% of Its Net Income



151116-03



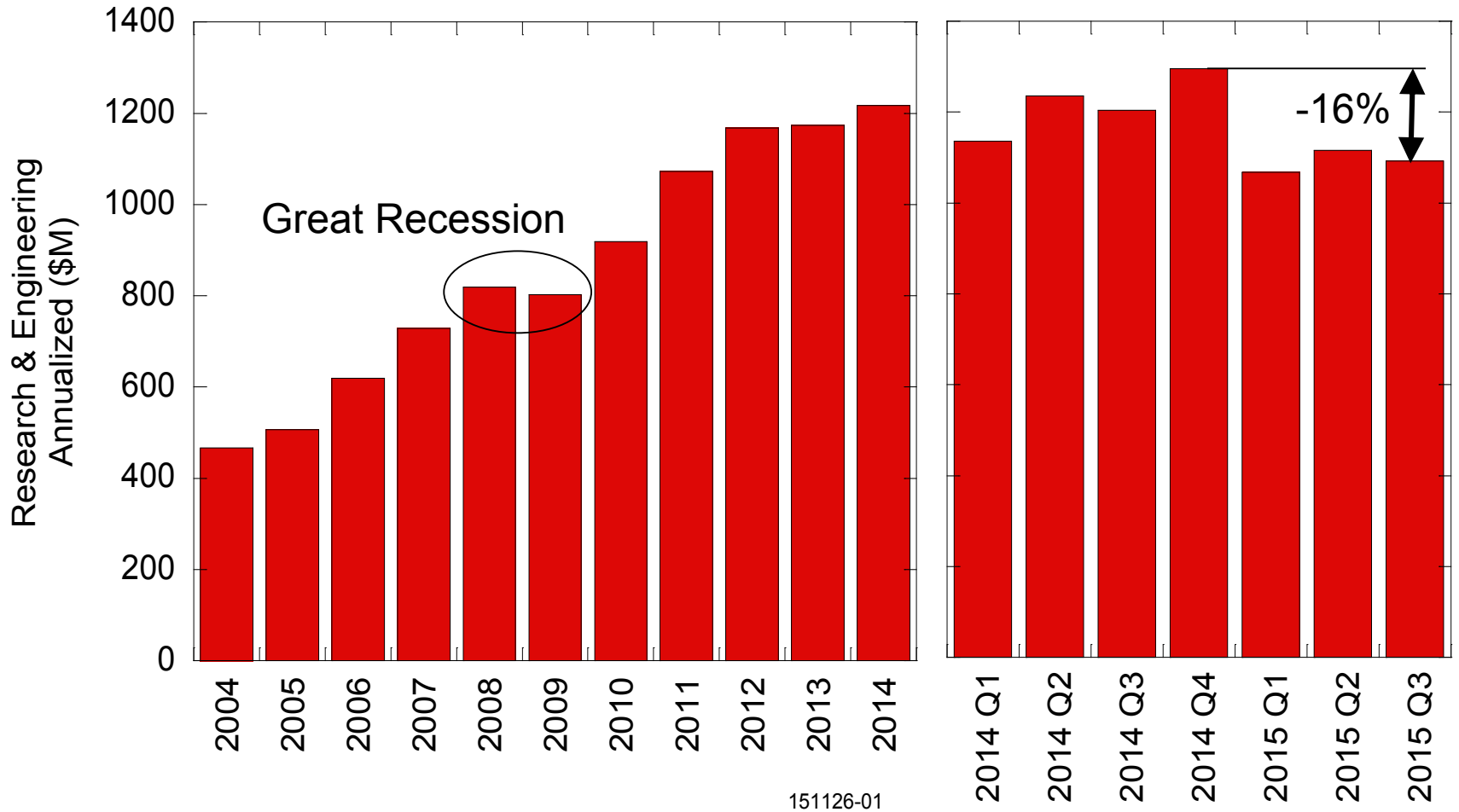
P. Kibsgaard, CEO
Schlumberger

- (1) Annual rate, excluding fourth quarter
- (2) Includes charge against earnings

Schlumberger Research & Engineering

2004-2014: Laissez les bon temps roulez

2015: Short Sharp Shock



151126-01

151116-02

Refrac

Realization that there are many ways to do it wrong

Remediation of heel but not toe

Screen outs

Incremental technology improvements

Service company marketing push

Fiscal incentives, some with Wall Street involvement

In-Fill Drilling

No longer controversial, now part of the business plan
Cross-well interference is usually temporary

Multi-well pads: 5 wells destined to increase to 30

Maintains roughly-even flows in gas gathering systems
As do DUCs (drilled uncompleted wells)

Especially attractive in stacked plays

Marcellus-Utica

Middle Bakken-Three Forks

Permian Basin: Wolfberry et al.

Tight Oil EOR?

Huff & Puff is the Most Promising Method

| | | |
|-----------------------------|---|------------------|
| System | Carbon Dioxide | Miscible Gas |
| Supported by | Government | Industry |
| Ancillary Problem Addressed | Climate Change | Flaring |
| Barriers | see below | Gas processing |
| Activity | Many academic papers; some lab tests | A few SPE papers |

Petroleum industry lives in a CO₂ constrained world

- Limited supply, in the absence of carbon capture regime
- Carbon capture is expensive
 - greater than the social cost of carbon
- Pipeline infrastructure limited

End