



Unconventional Oil and Gas

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Business Cycles & Innovation Cycles: Are They Related?

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Schlumberger is the actual provider of exploration, drilling and production services to the oil and gas industry.

The views expressed herein are those of the author and do not necessarily represent those of Schlumberger.



Dimmit County, Texas

Greene County, Pennsylvania



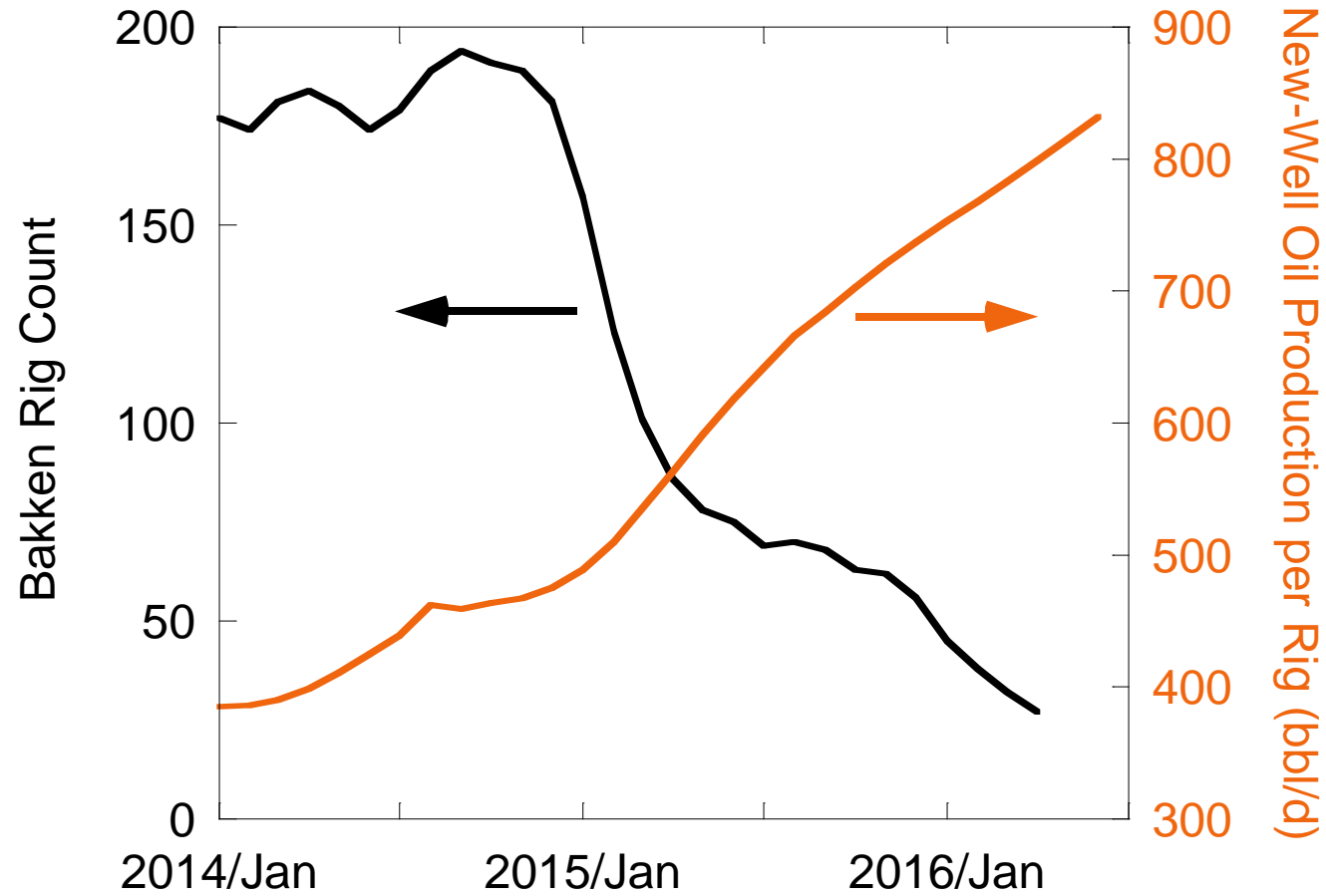
What Do We Mean by “Innovation”?

“US shale resilience a product of innovation, CEOs say”

– Oil & Gas Journal, March 2016

Amazing Increase in the Productivity of Drilling Rigs

One rig drilling for one month now adds 820 bbl/d



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EIA Drilling Productivity Report, May 2016

Costs Change During Stable Market Conditions

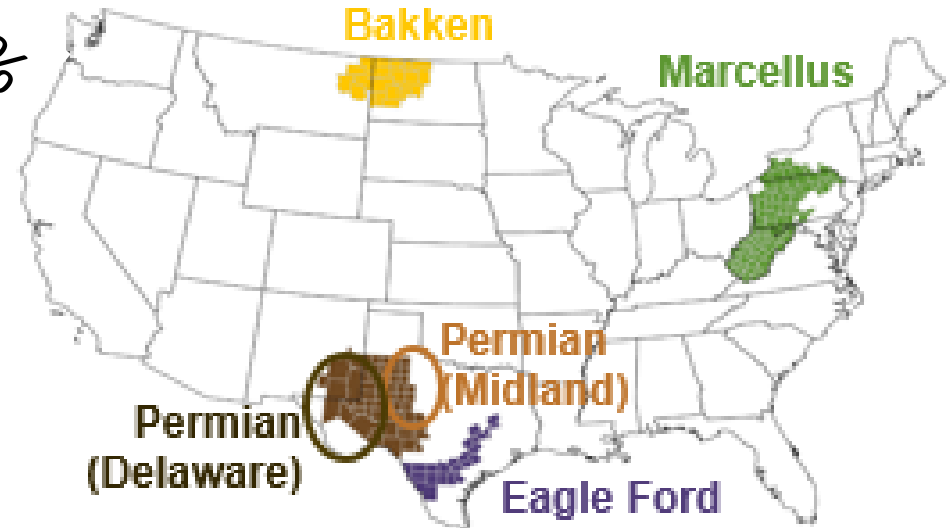
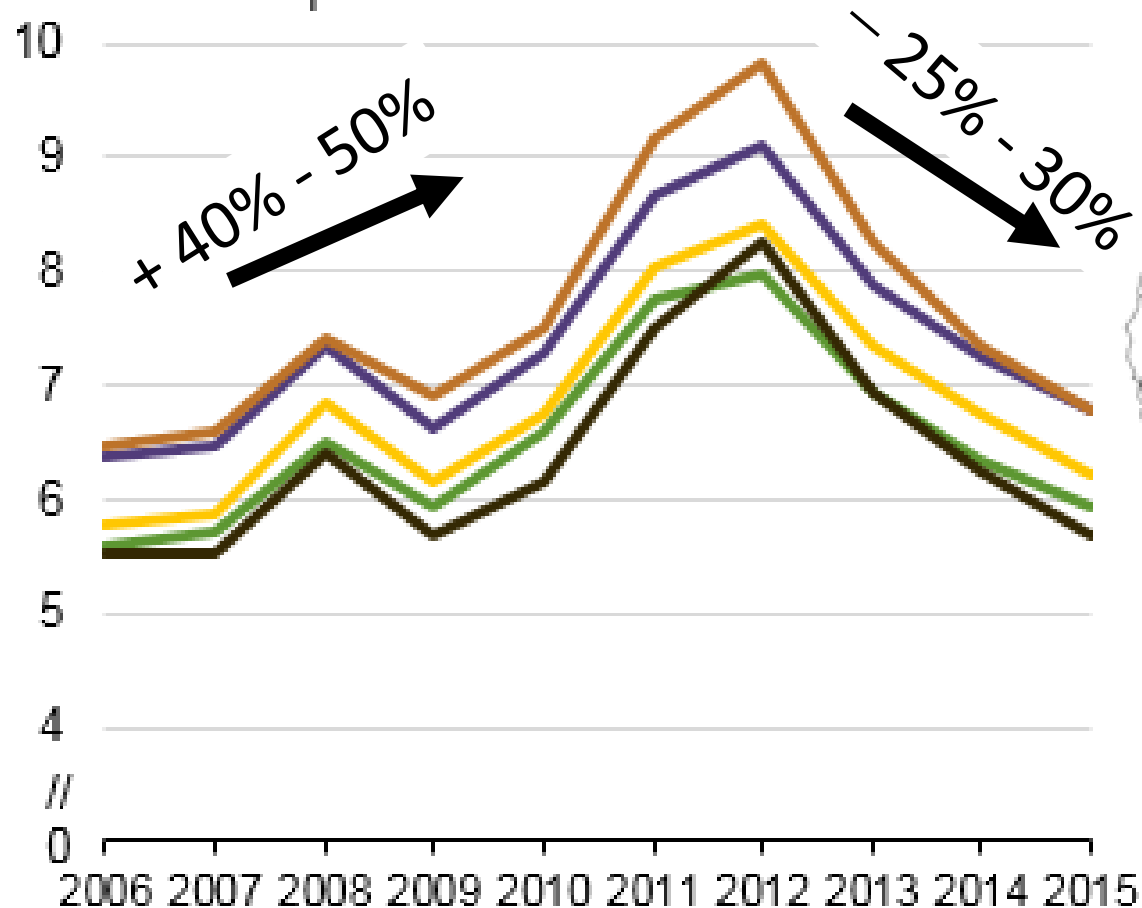
| Increase | Decrease |
|---|---|
| Play margin delineation | Derisked geology |
| Drilling/completion/ stimulation surprises | More efficient drilling/ completion/stimulation |
| Competition for leases | Consolidation of leases |
| Supply chain bottlenecks | Supply chain optimization |
| Infrastructure bottlenecks | Infrastructure buildout |
| Service cost increases <ul style="list-style-type: none"> ○ Equipment shortages ○ Personnel shortages | Service cost discounts <ul style="list-style-type: none"> ○ Amortization of CAPEX ○ Service efficiencies ○ Increased competition |

Early in development cycle

Late in development cycle

Process and Efficiency Improvements are “Every Day Innovations” that Continue Through Business Cycles

Average well drilling and completion costs indexed to 2014 well designs (2006-15)
million dollars per well

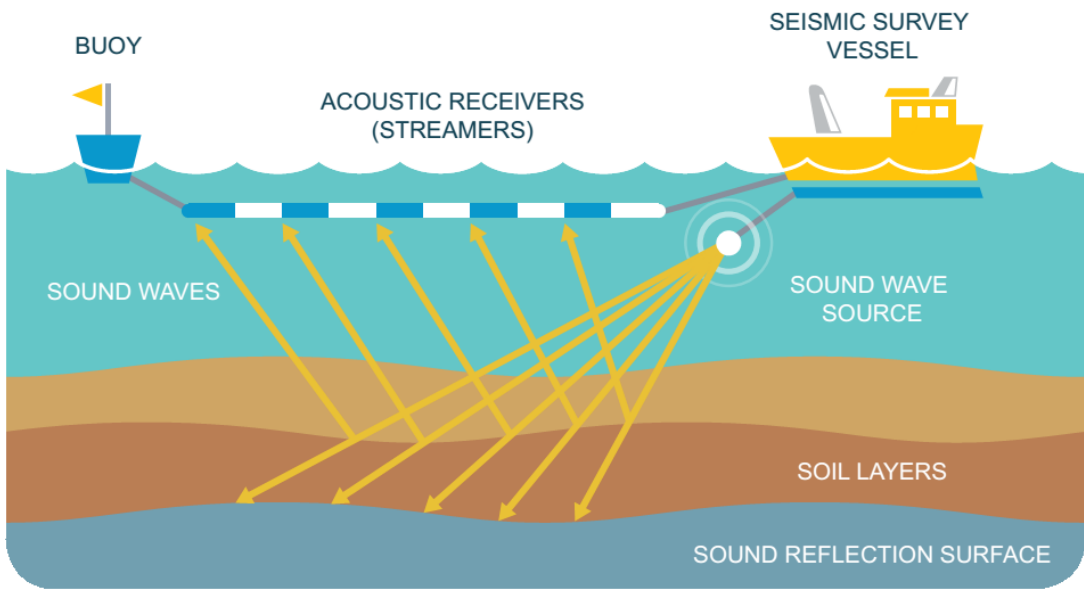


What Do We Mean by “Innovation”?

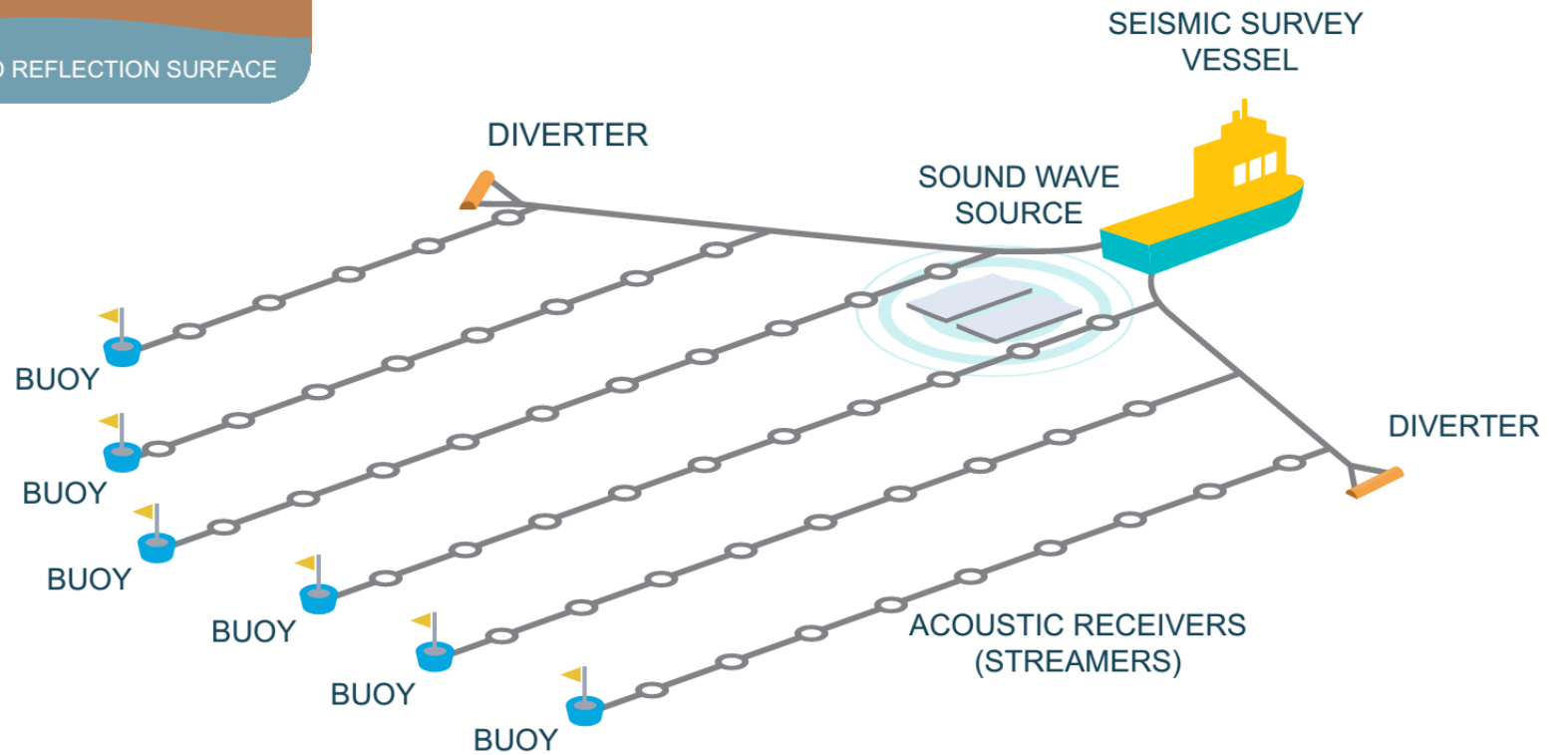
| | |
|--------------------|--|
| Super Fracks | <ul style="list-style-type: none">▪ Longer laterals▪ Tighter fracture initiation points▪ More water▪ More proppant |
| Asset High Grading | <ul style="list-style-type: none">▪ No more exploratory drilling▪ Completing DUCs▪ Only the best rigs and crews▪ Ultra sweet spotting |

How Do Industry-Changing Innovations Develop Through Business Cycles?

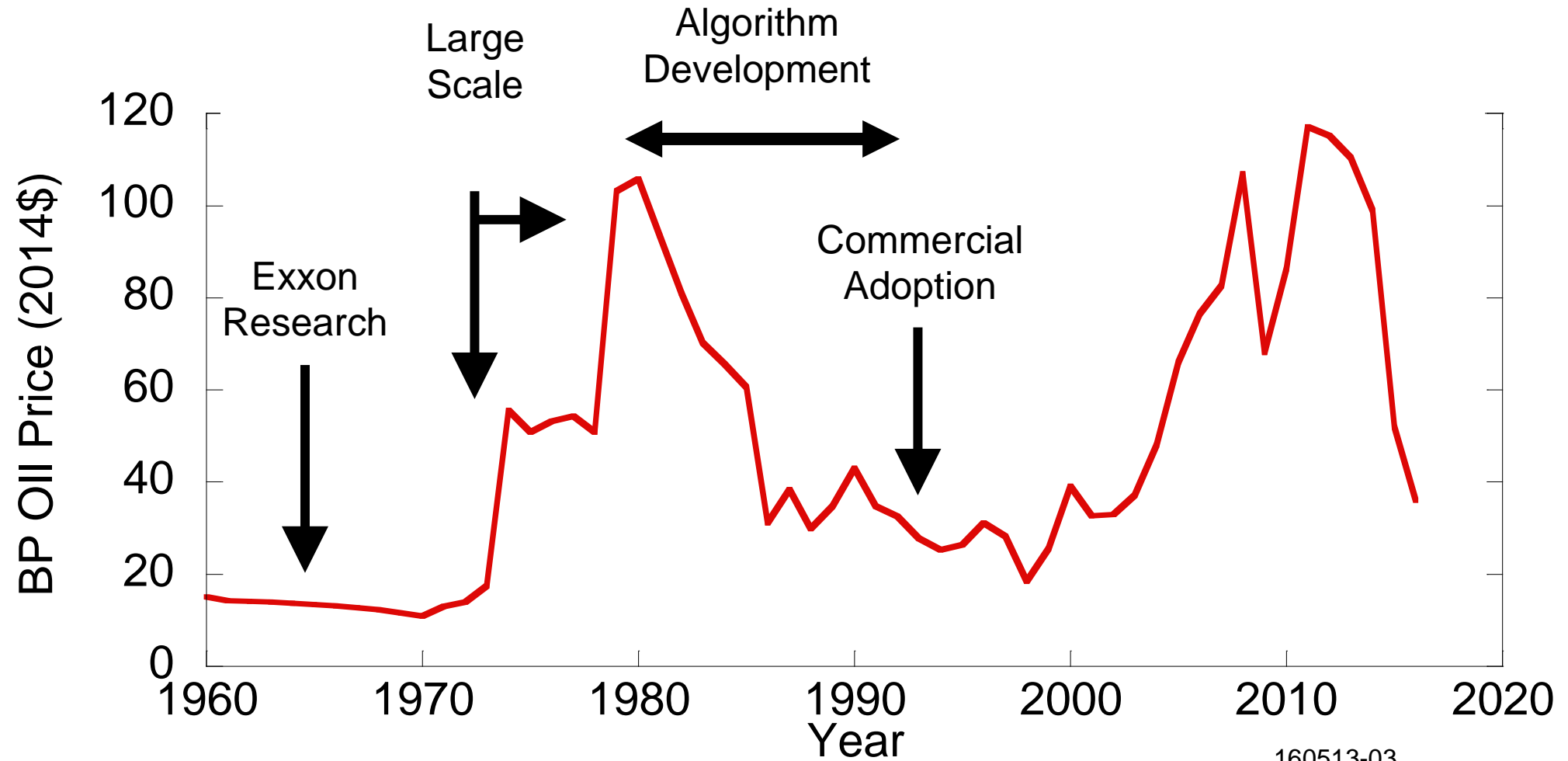
- 3-D Seismic
- Logging-While-Drilling & Geosteering
- Rotary Steerable Drilling
- Deepwater & Ultra Deepwater Technology
- Horizontal Drilling + Massive Hydraulic Fracturing



2-D vs. 3-D Seismic



3-D Seismic Waiting for Computing Power



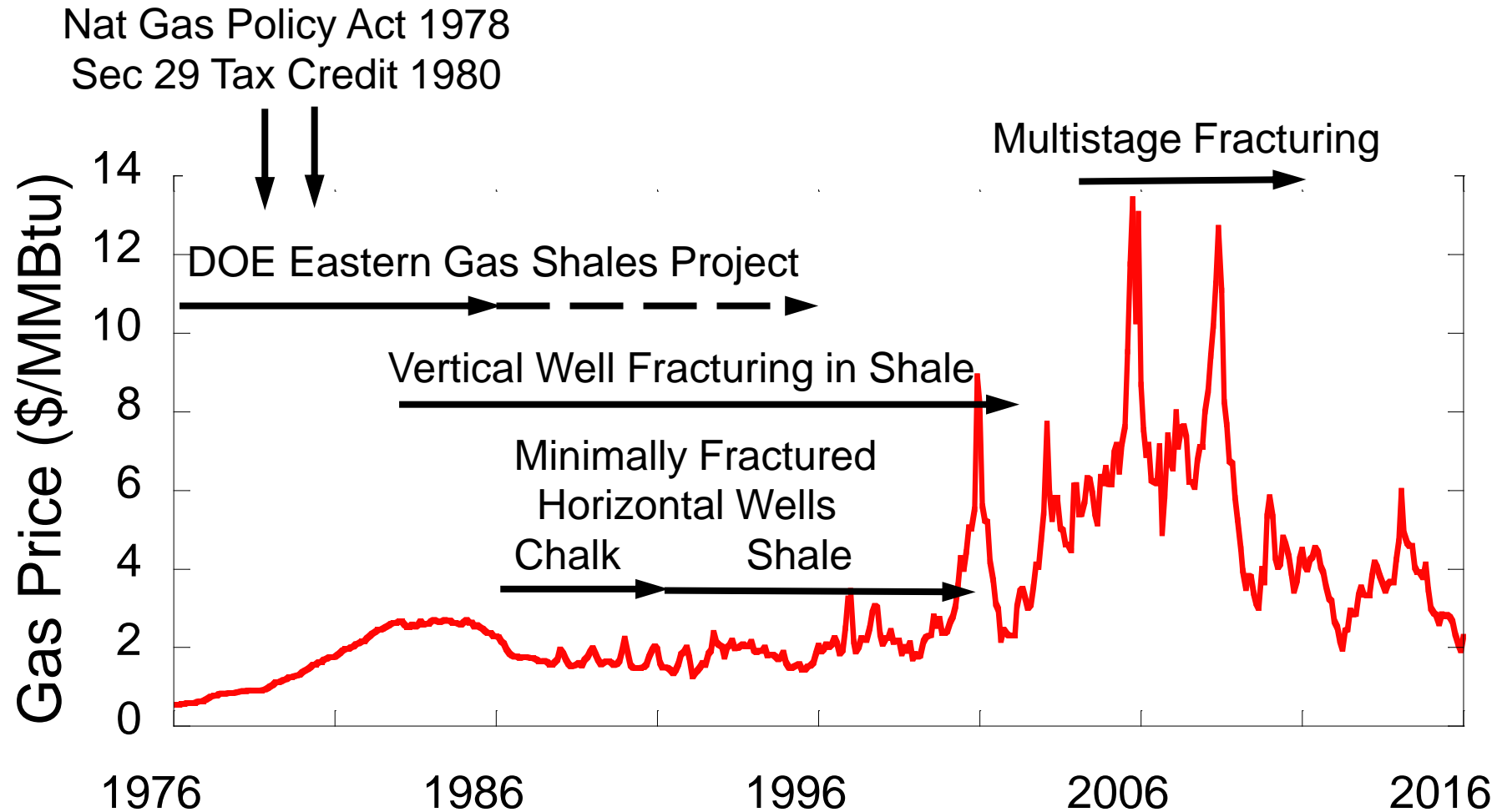
Gas Shale & Tight Oil



Greene County, Pennsylvania

Horizontal Wells and Hydraulic Fracturing Developed Separately

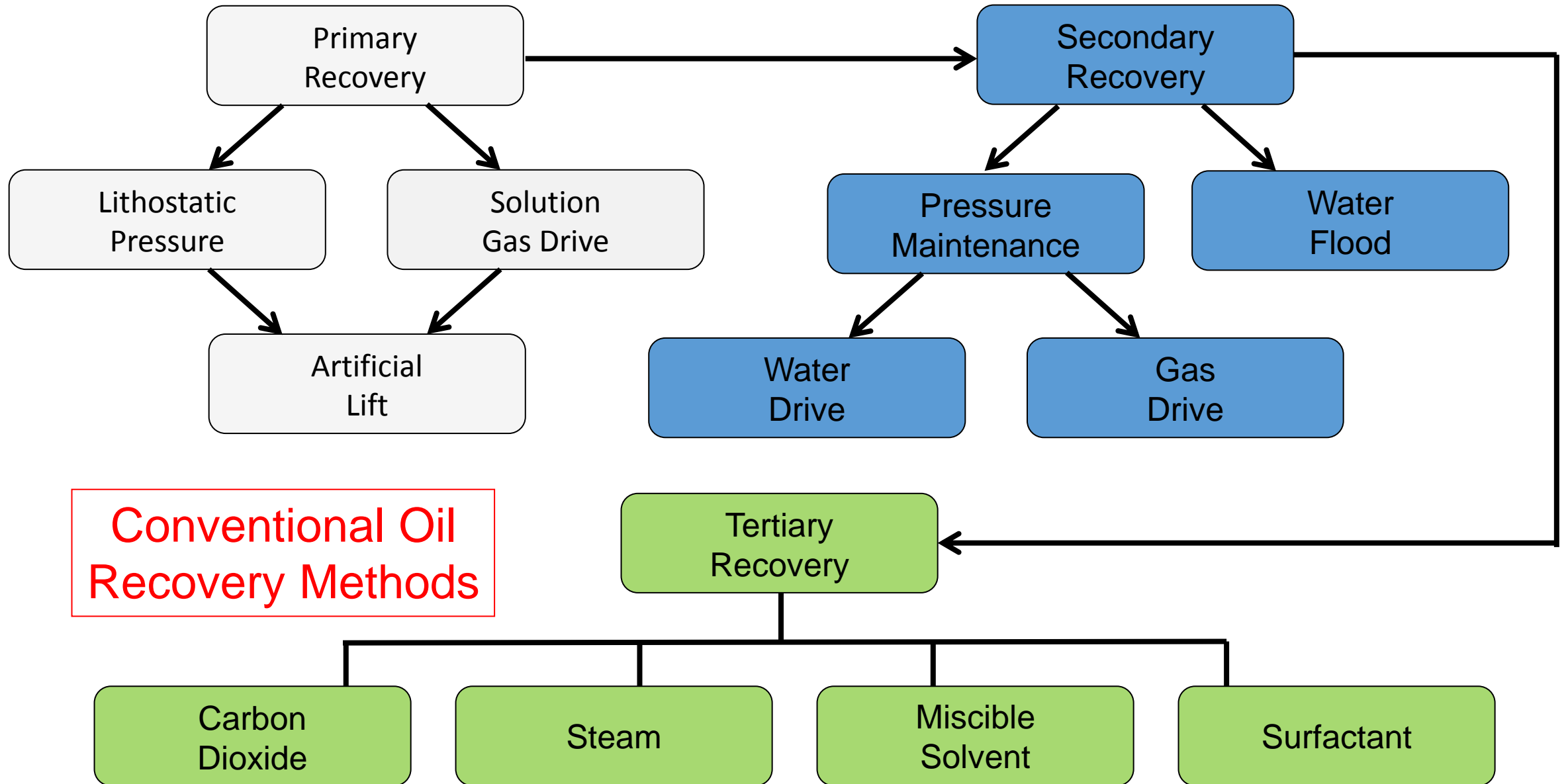
Multistage Fracturing Was the Key Enabler



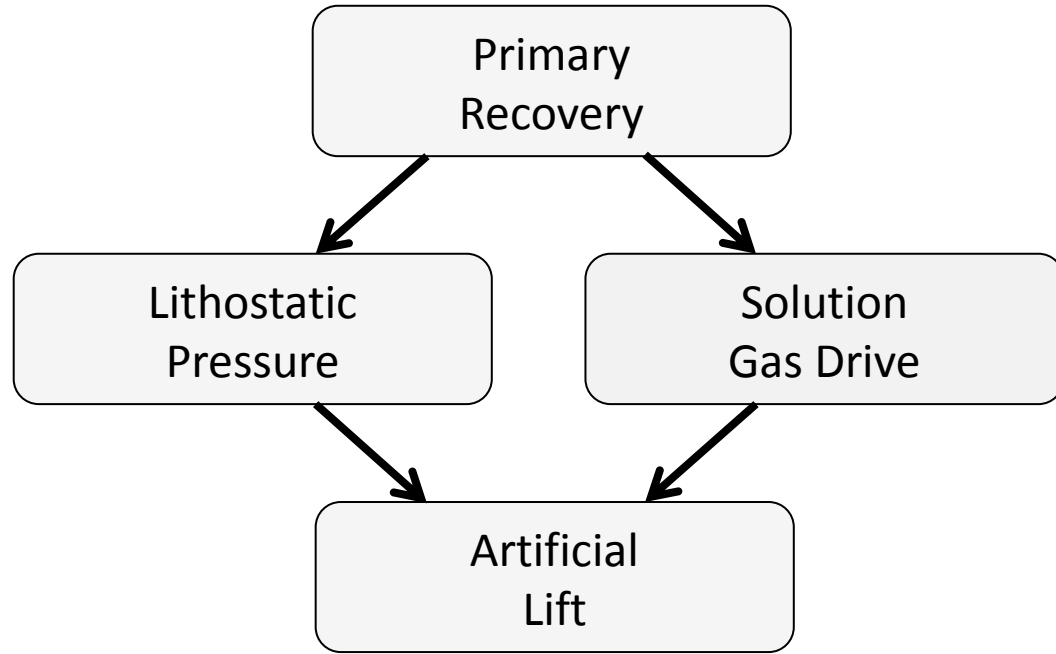
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EIA Wellhead Gas Price 1976-1996; Henry Hub Gas Price 1997-2016

The New Frontier: Tight Oil Recovery Factor

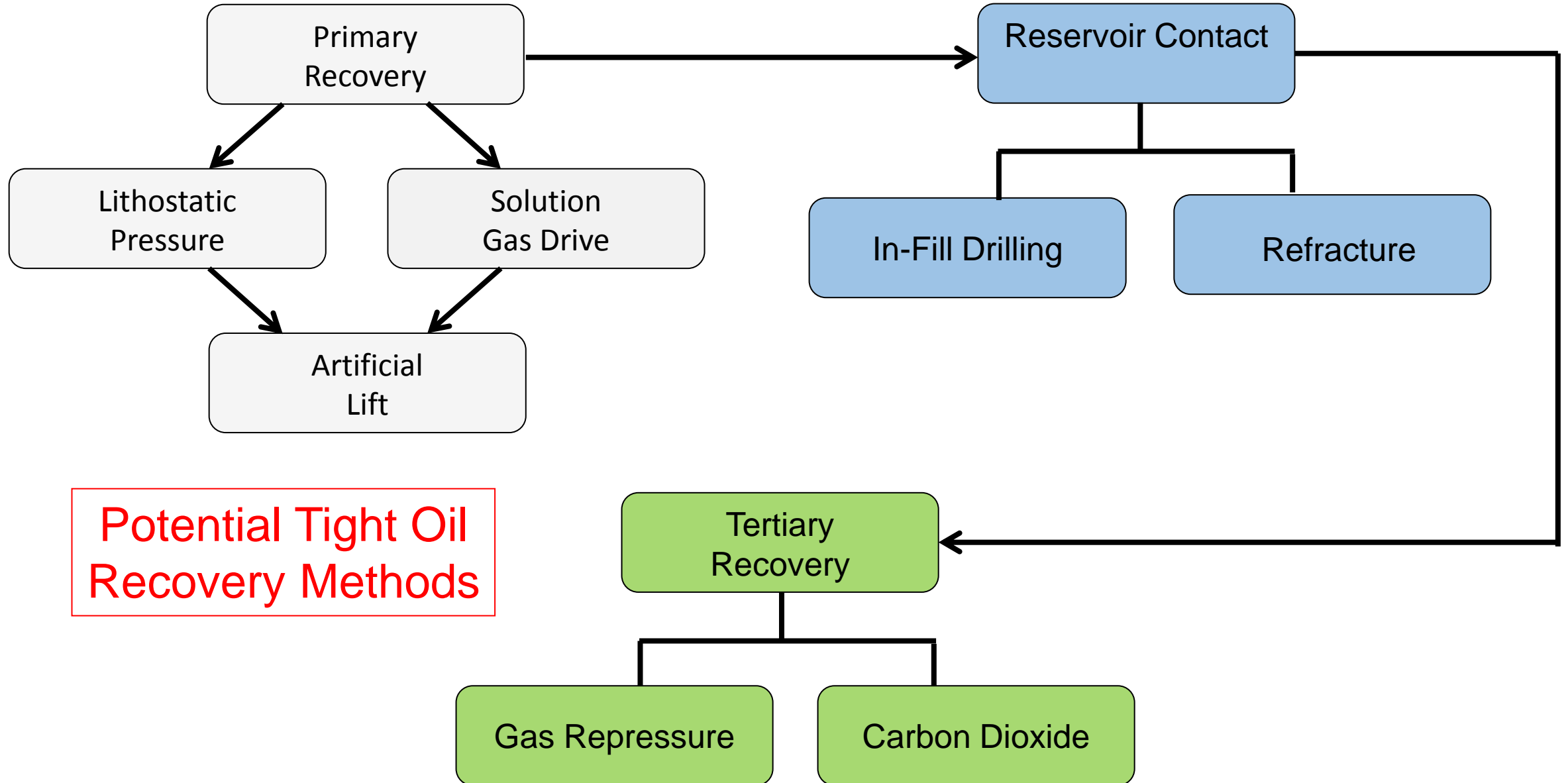


The New Frontier: Tight Oil Recovery Factor



**Tight Oil
Recovery Methods**

The New Frontier: Tight Oil Recovery Factor



Innovation & the Business Cycle

When Oil & Gas Prices are Rising & High

- Industry R&D grows
- Research prioritizes novel techniques
- New people enter the field, generating fresh ideas.
- Academic & government research driven by societal goals
 - 1970s Petroleum & Synthetic Fuels
 - 1980s Unconventional Gas
 - 2010s Renewables

Innovation & the Business Cycle

When Oil & Gas Prices are Falling & Low

- Industry R&D shrinks
 - Technology leaders of the next up-cycle shrink the least
- R&D prioritizes efficiency improvements
- Technology development outsourced
 - Downsizing of risk
 - IOCs → Service Cos → Start Ups
- Academic & government research winds downs
- People exit the field
 - Research is high-graded
 - Survivors carry on

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