



**INTEGRIS**  
TECHNOLOGY SERVICES

# Unconventional Well Perspectives

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# Agenda



- **Unconventional wells in the U.S.**
- **History of unconventional wells in the U.S.**
- **Types of unconventional completions**
- **Oil Price Volatility and the economics of unconventional wells**
- **Where is the Industry Now?**
- **What are Shale operators investigating to improve profitability?**
- **Q & A**

# Terminology



In this presentation, the following terms and equivalencies are used:

- **Fracturing = stimulation**
- **Stage = zone**
- **Unconventional Well = shale well**
- **Shale Operators = Shale Drillers**
- **Frac plugs = composite plugs or dissolvable plugs**
- **Lateral = horizontal section of an unconventional well**
- **Frac sleeves can be ball operated, hydraulic operated, or coiled tubing operated**
- **PCF = Positive Cash Flow**



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# History of Unconventional Wells in the U.S.

# What is an Unconventional Well?

The U.S. Energy Information Agency (eia.gov) says...

**“Unconventional oil and natural gas production:** An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production.”

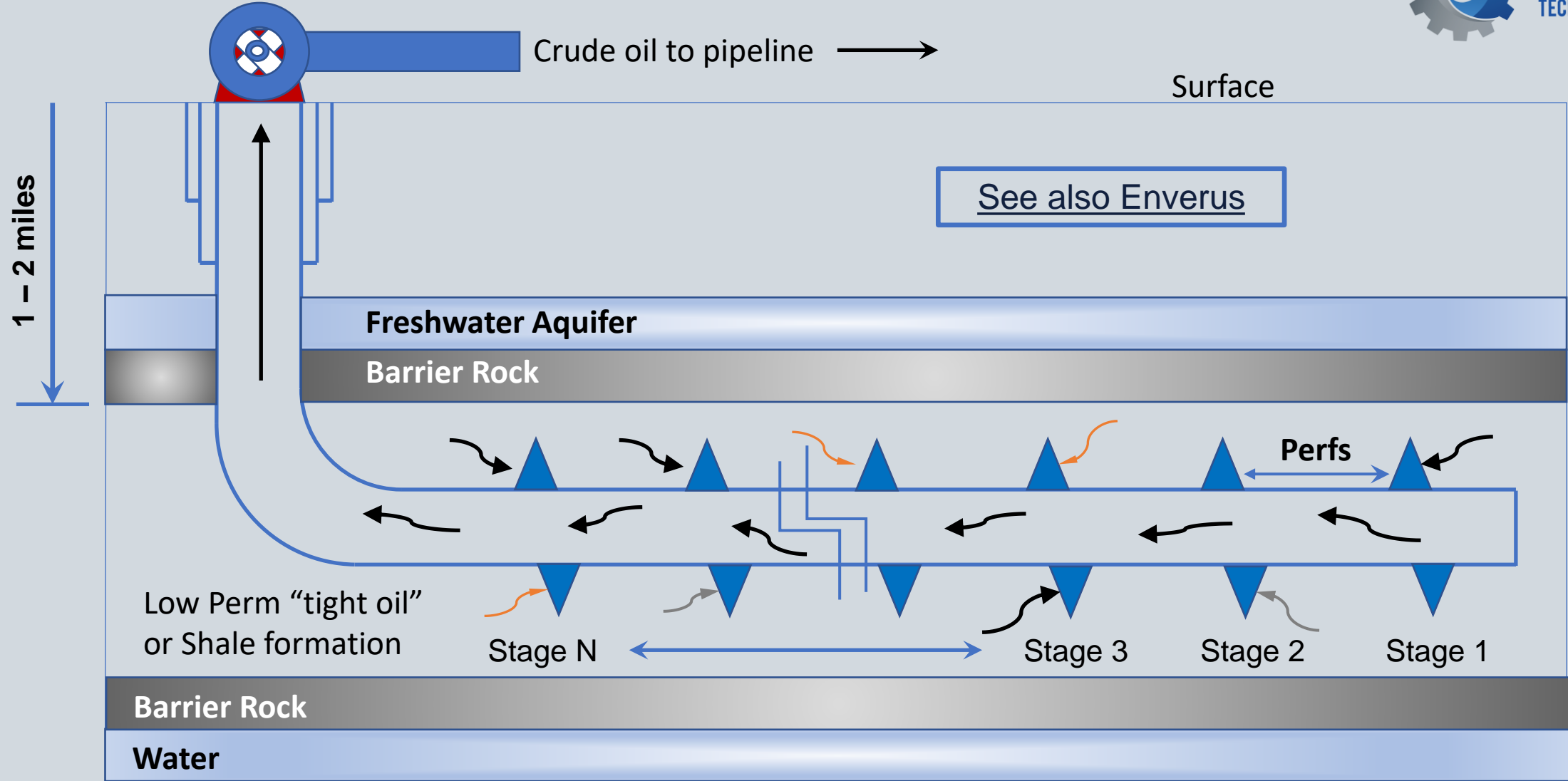
**“Conventional oil and natural gas production:** Crude oil and natural gas that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore.”




*In other words, fracturing is required for unconventional wells to produce oil or gas*

**Pressure  
Horsepower  
H<sub>2</sub>O**

# Unconventional Well Schematic



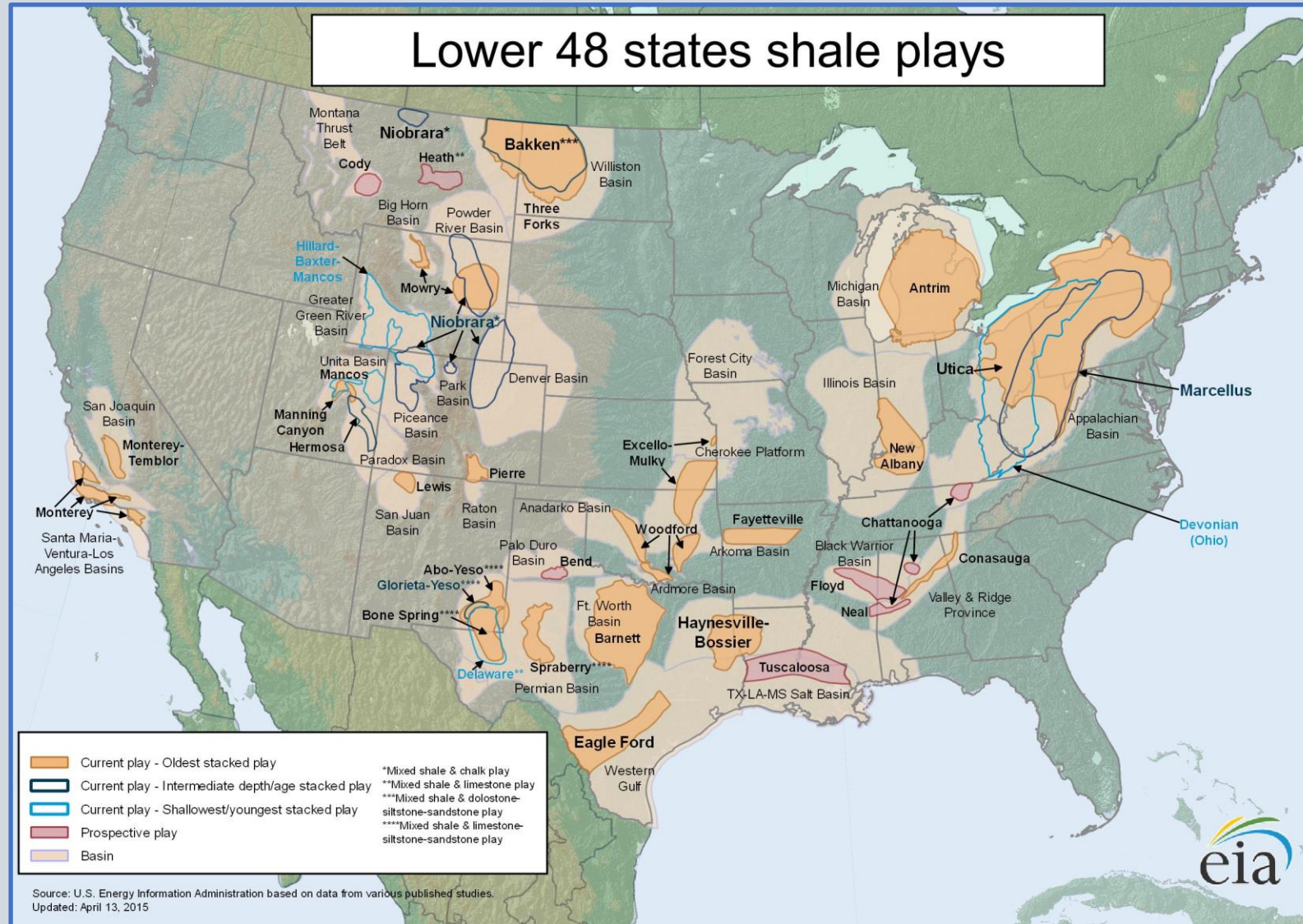
 = Perforation Cluster

# Where are Unconventional Wells in the U.S.?

The Bakken Field in North Dakota and Montana is the largest *producing* shale oil reserve.<sup>5</sup>

The field has layers of dense, oil-bearing rock about two miles underground. The field is roughly the size of West Virginia and, as of December 2012, produced 770,000 BOPD ...production doubled by 2014. Horizontal wells provide 95 percent of production.

-The Balance



...North Dakota extracts more oil than Alaska. It's closing in on the 2 million barrels a day produced by Texas. In 20 years, its number of wells could increase from the current 8,000 to at least 40,000. Part of the reason for expansion is that each well runs dry after about two years.

-The Balance



# Unconventional Well Records



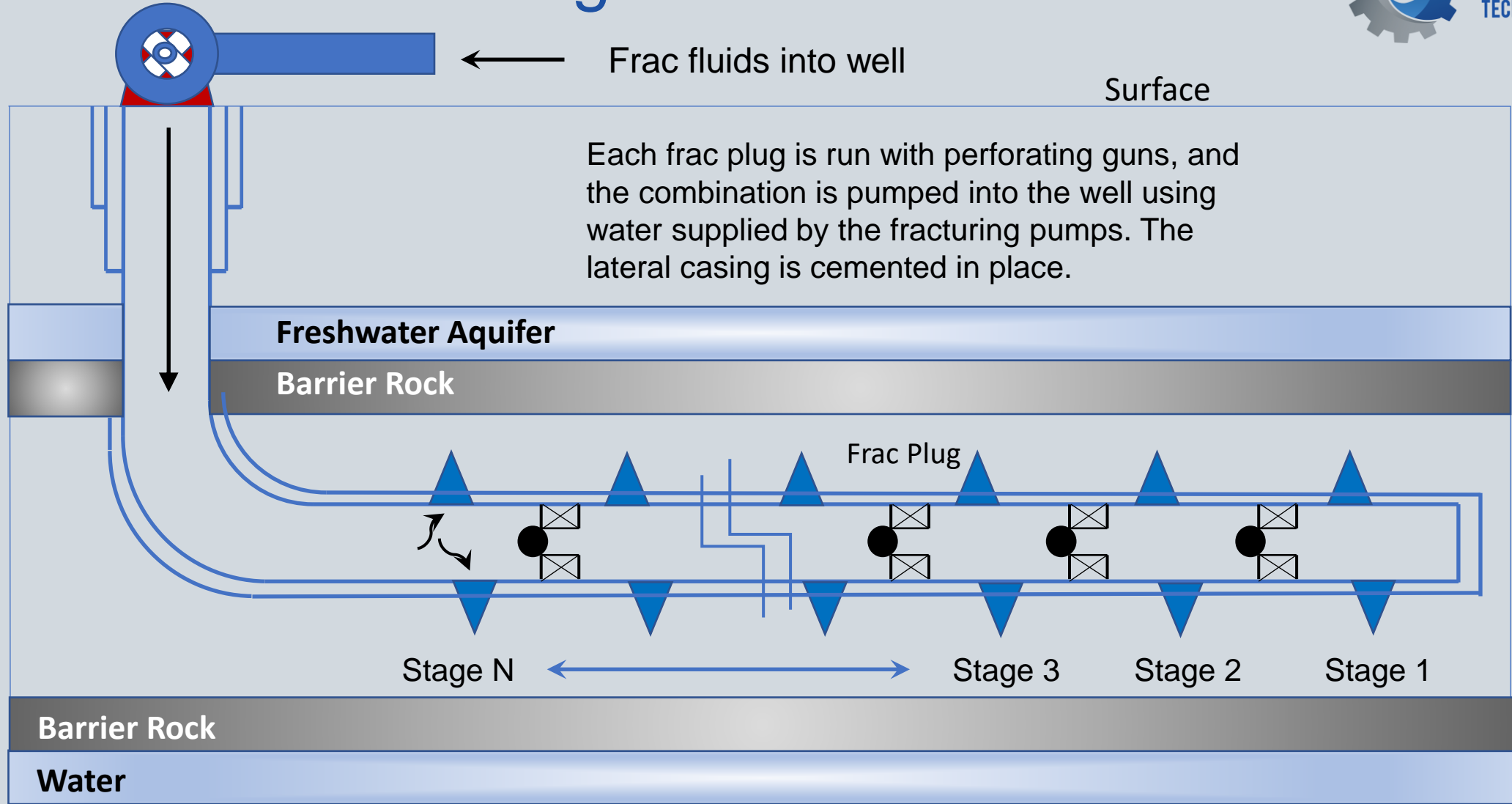
How deep and long can an unconventional well be?


In August 2016 **Eclipse Resources** drilled and completed the longest lateral well in the U.S. The “Purple Hayes” well is 7,000 ft. TVD and 18,500 ft. lateral length, or roughly 25,500 ft. TMD.

In July 2019, Houston-based **Surge Energy** reported that in the Permian Basin of West Texas, the lateral section of their 17,935 feet (3.4 mi.)(5.46 km) horizontal well is a record, and that frac plugs were drilled out to the same depth. 52 sections (zones) (2,200 lbs. sand per foot).

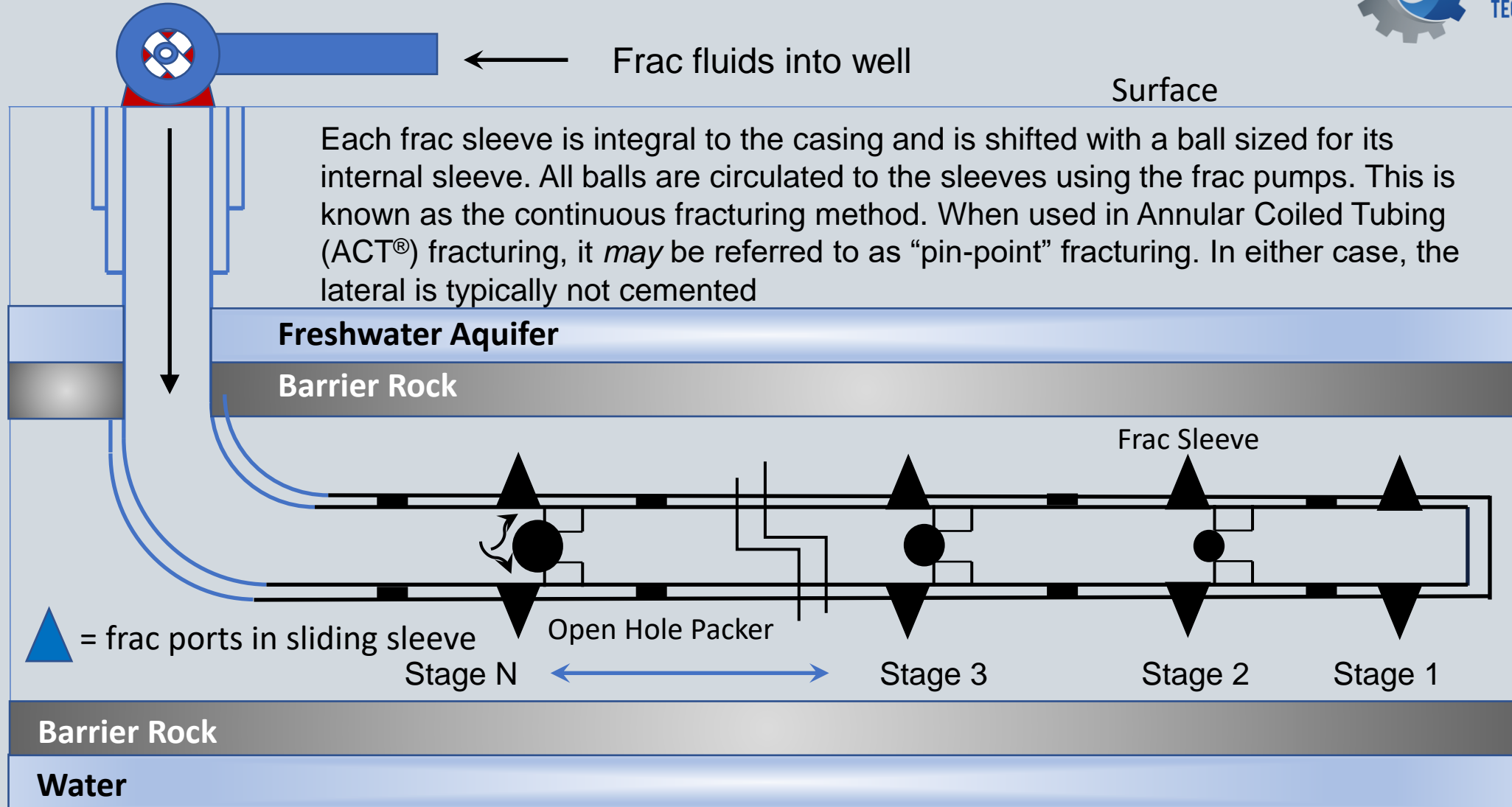
# Types of Unconventional Completions

# Unconventional – Plug-n-Perf

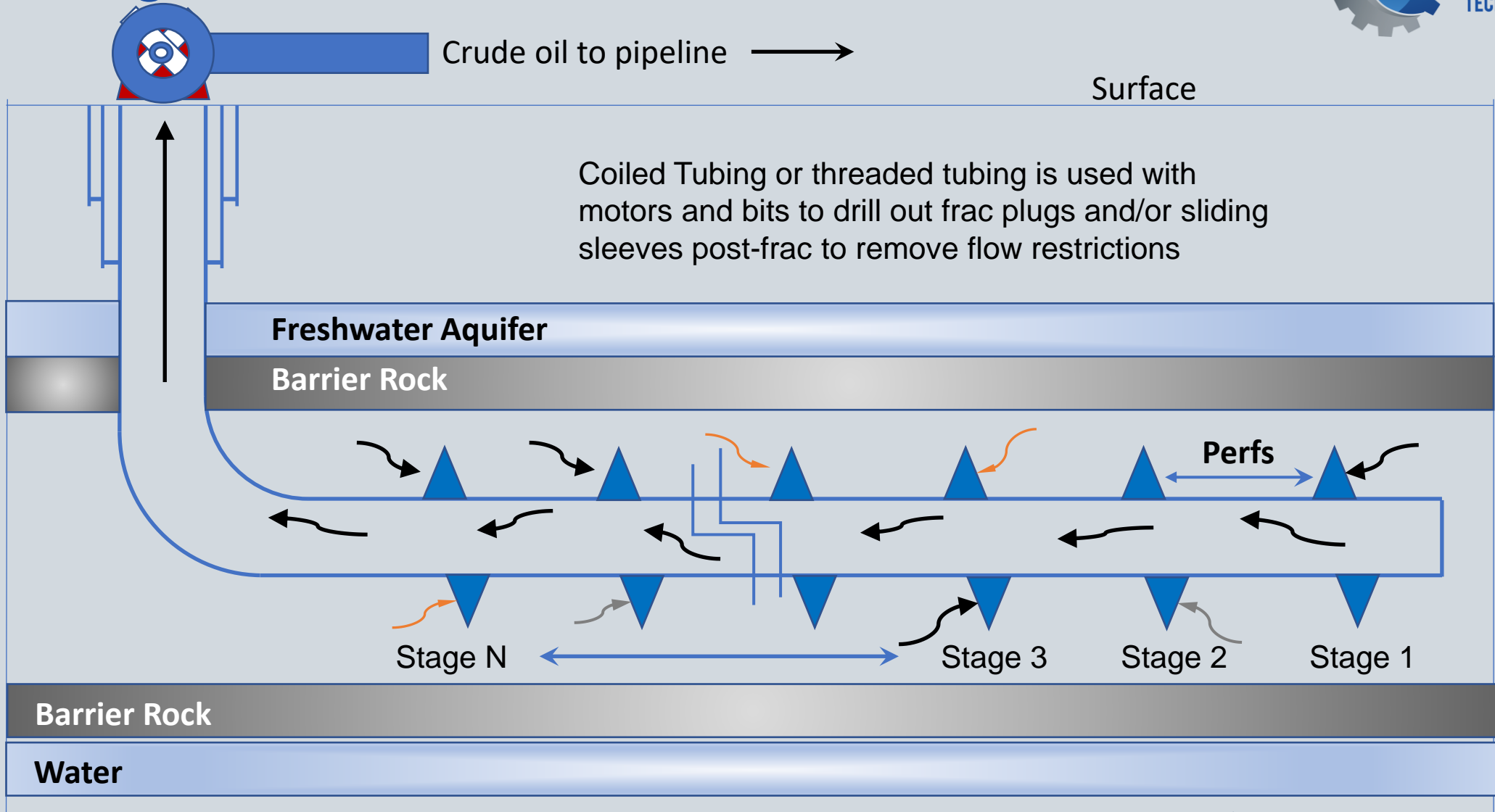



 = Perforation Cluster

# Unconventional – Frac Sleeves with Open Hole Packers



# Co-mingled Production, Post-drill out



 = Perforation Cluster

# Typical Unconventional Completion Tools



Visit these links to view commercially available frac plugs, dissolvable plugs, frac sleeves, and ACT Frac Sleeves.

[Composite Frac Plug](#)

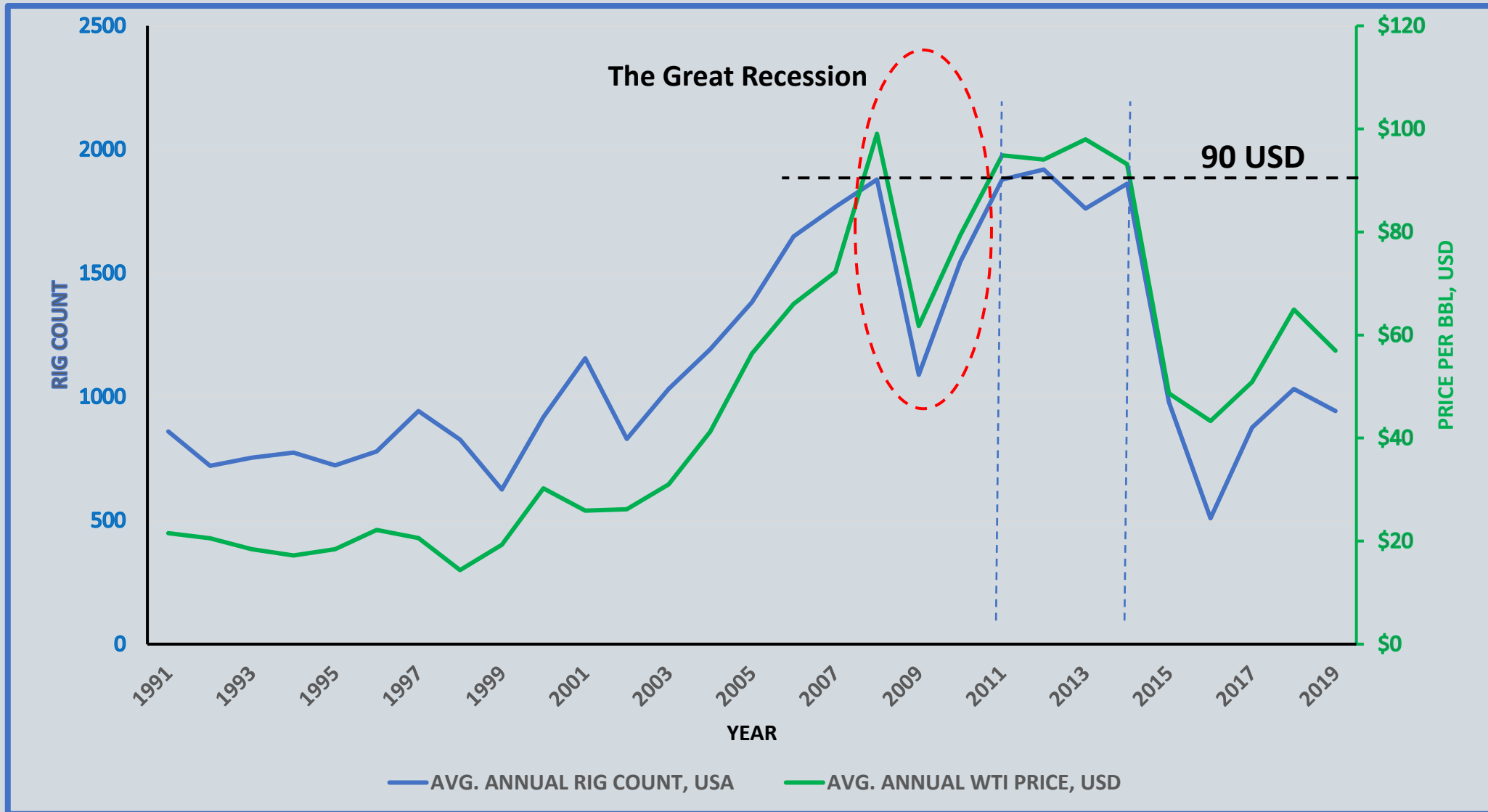
[Dissolvable Frac Plug](#) (Similar to the composite frac plug)

[Frac Sleeve](#)

[Annular Coiled Tubing \(ACT\) with Frac Sleeves](#) (Similar to the frac sleeve)

# Oil Price Volatility and the Economics of Unconventional Wells

# U.S Rig Count and Avg. Annual WTI Price





# The Boom...



From “The Balance”, 1 May 2020...

“Two factors drove the [U.S. shale oil boom](#). First, [oil prices](#) averaged above \$90 a barrel for three years, from 2011 to 2014. That was enough to allow shale exploration and production to be profitable. Second, low-interest rates gave banks and [private equity](#) investors a strong incentive to lend to shale oil companies. The total amount of loans was almost \$250 billion in 2014.”

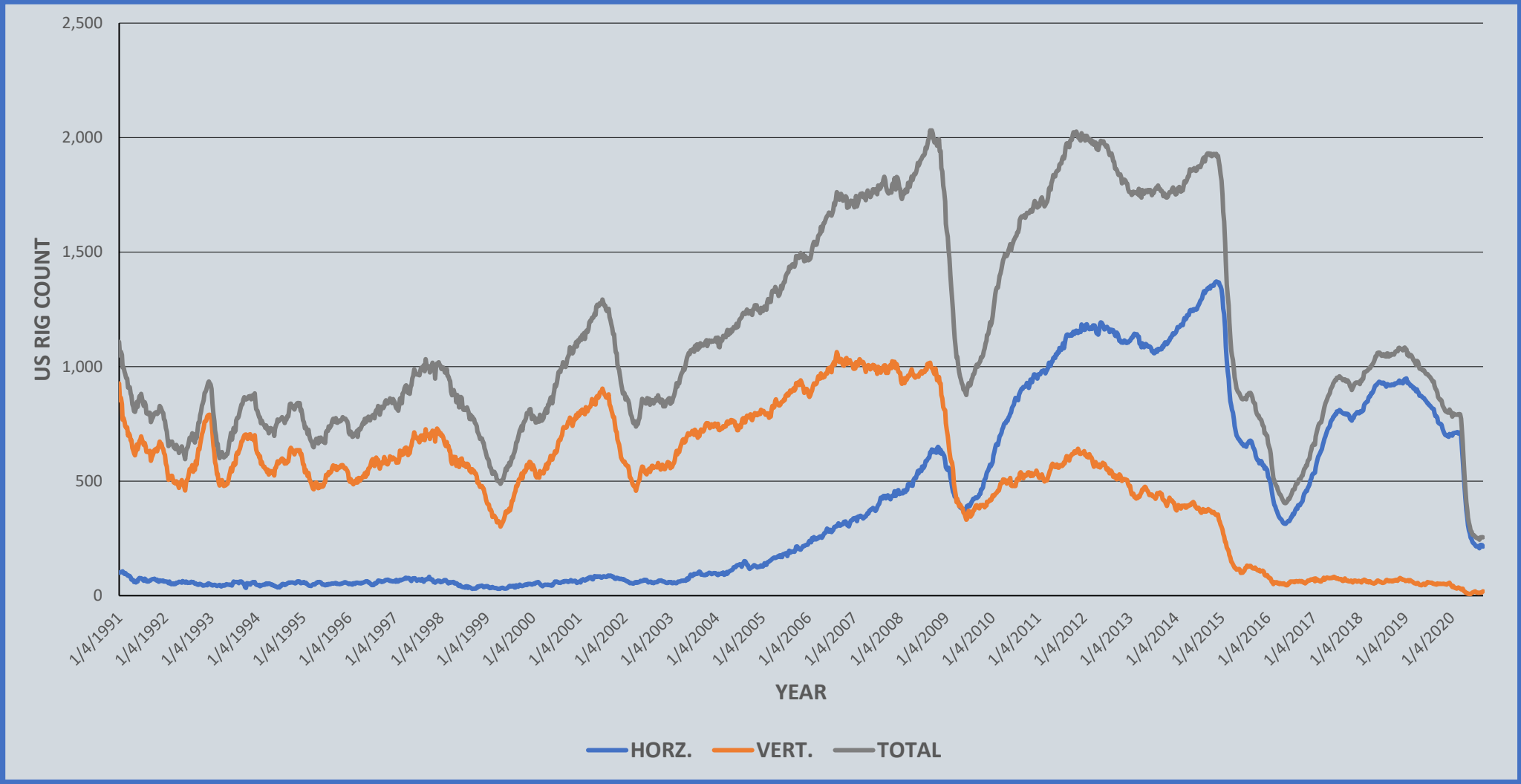
“Shale [oil producers kept drilling](#). They became better at cutting costs the more they drilled. .”The Balance”

Many competitors for completion products and services entered the market.

Well manufacturing enabled a supply chain approach to the management of inputs for unconventional wells.

Unconventional operators were able to negotiate volume discounts for commodity inputs such as drill bits, cementing, casing, tubing, perforating, frac plugs, frac sleeves, fracturing services, wireline services, coiled tubing services, etc.

# By 2016, Horizontal Wells Dominate U.S. Drilling



# Tech Milestones of Unconventional Well Progress



1999. Composite bridge plugs available. **Completion**

2000. MND perfects combined horizontal well drilling and fracturing. **Drilling & Stimulation**

2003. BJ Services Gorilla High horsepower frac units available (~2,800 HP each). **Stimulation**

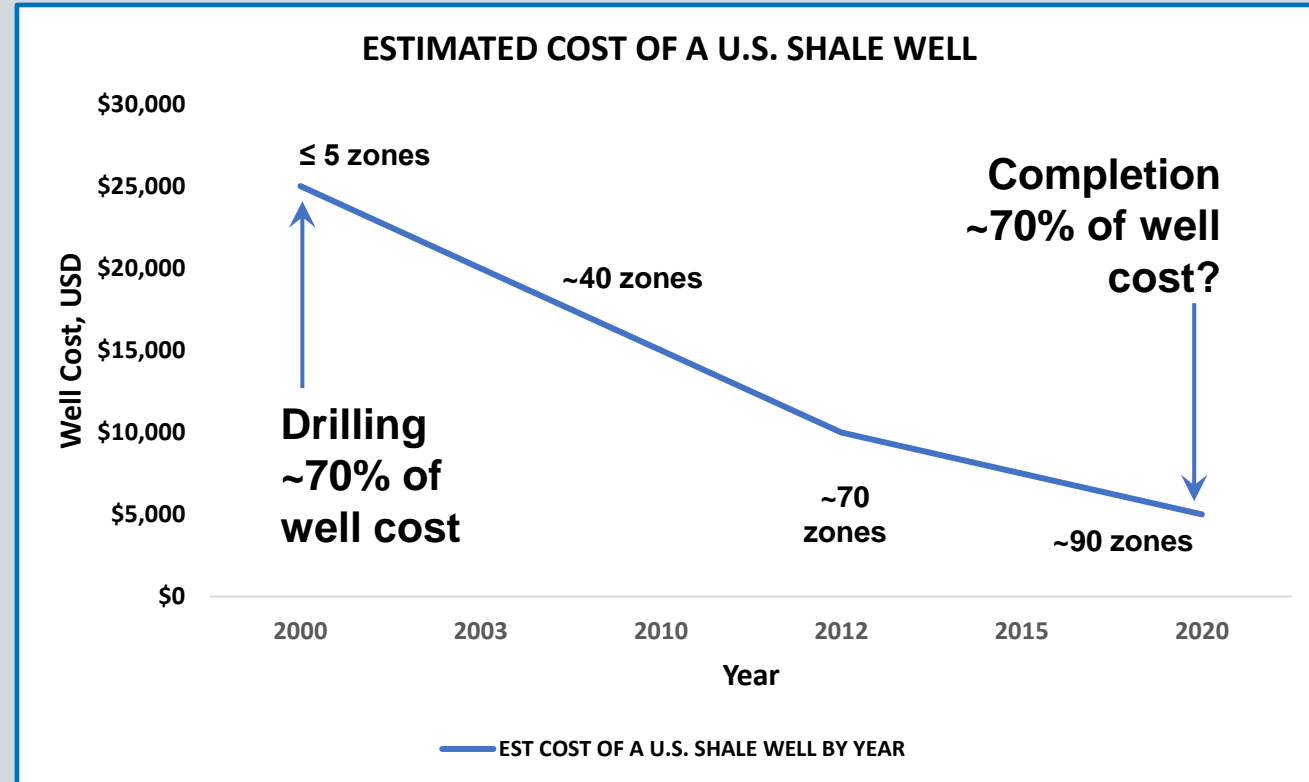
2007. Frac Sleeve availability. **Completion**

2010. “Pad Drilling” (AKA Well Manufacturing) now standard. It places 6 or more wells in a 3.5 acre pad to manage the continuous supply of drilling and completion products and services. **Drilling**

2015. Dissolvable frac plugs available. They require no coiled tubing removal. **Completion**

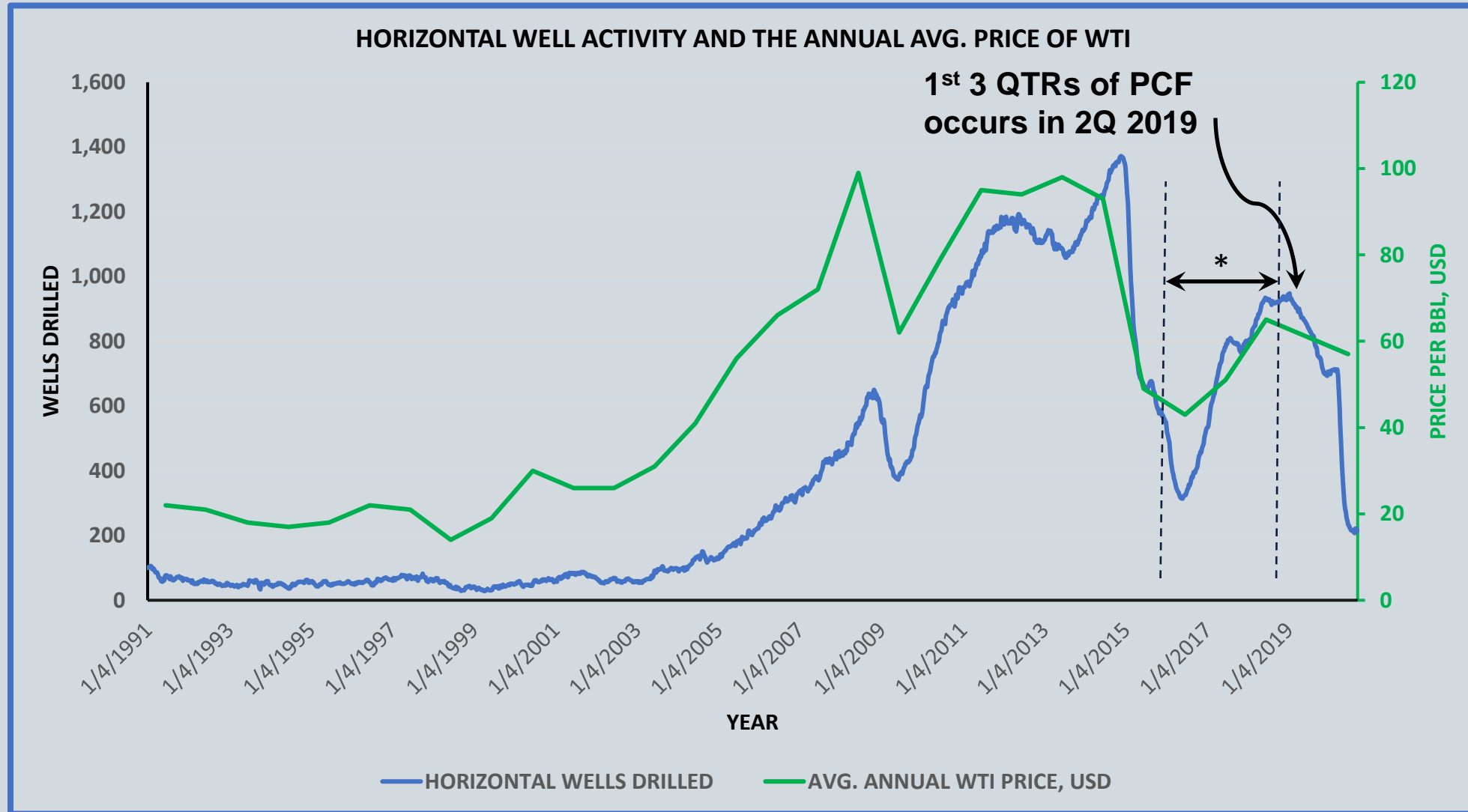
2020. One operator reports drilling 15,000 ft. with one bit in a shale formation. Same operator reports 10 days to drill and complete a well. **Bit technology.**

Other noteworthy technical advances have occurred in the last 15 years in coiled tubing motors, junk mills, fracturing fluids, MWD/LWD, drilling rigs, and wireline perforating.



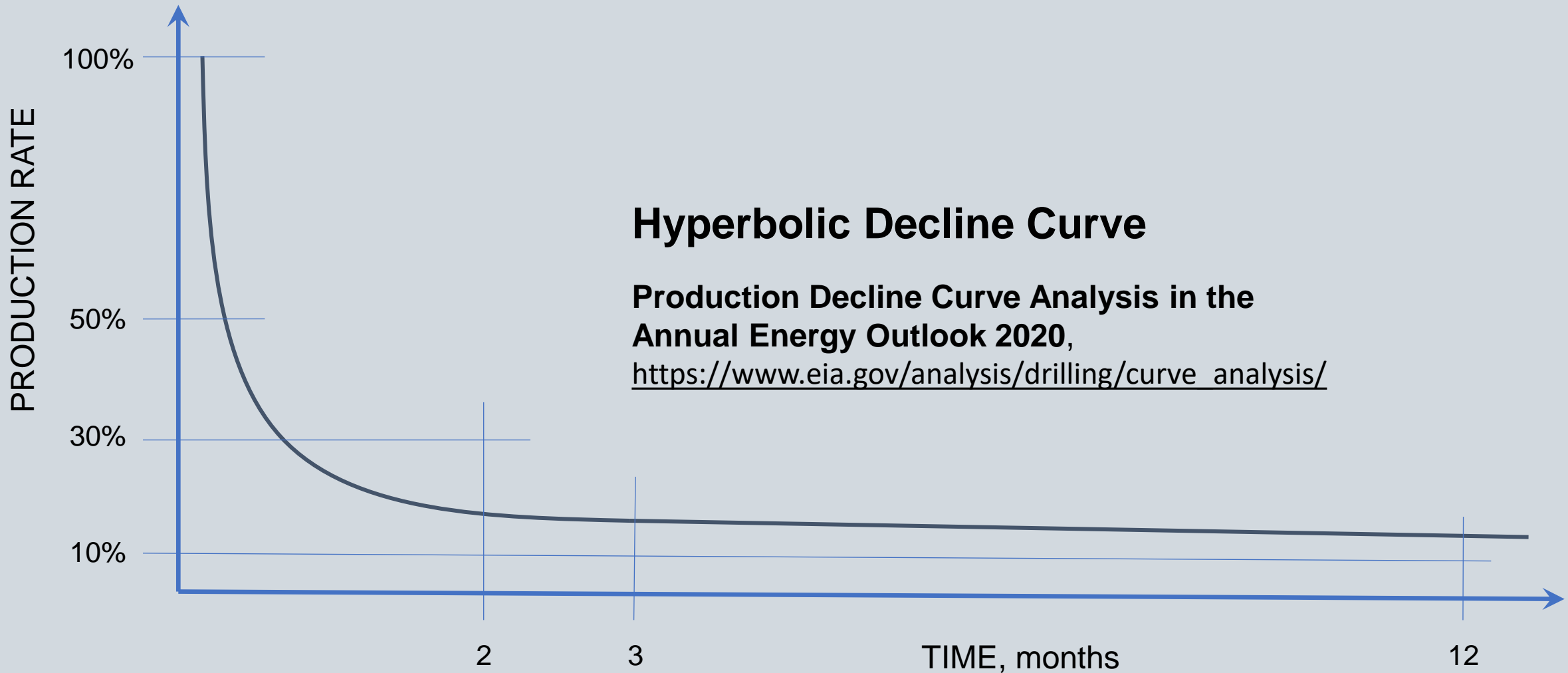
In the 1990s, Wytch farm wells in England took months to drill 15,000 ft

# Horizontal Well Activity and WTI Price

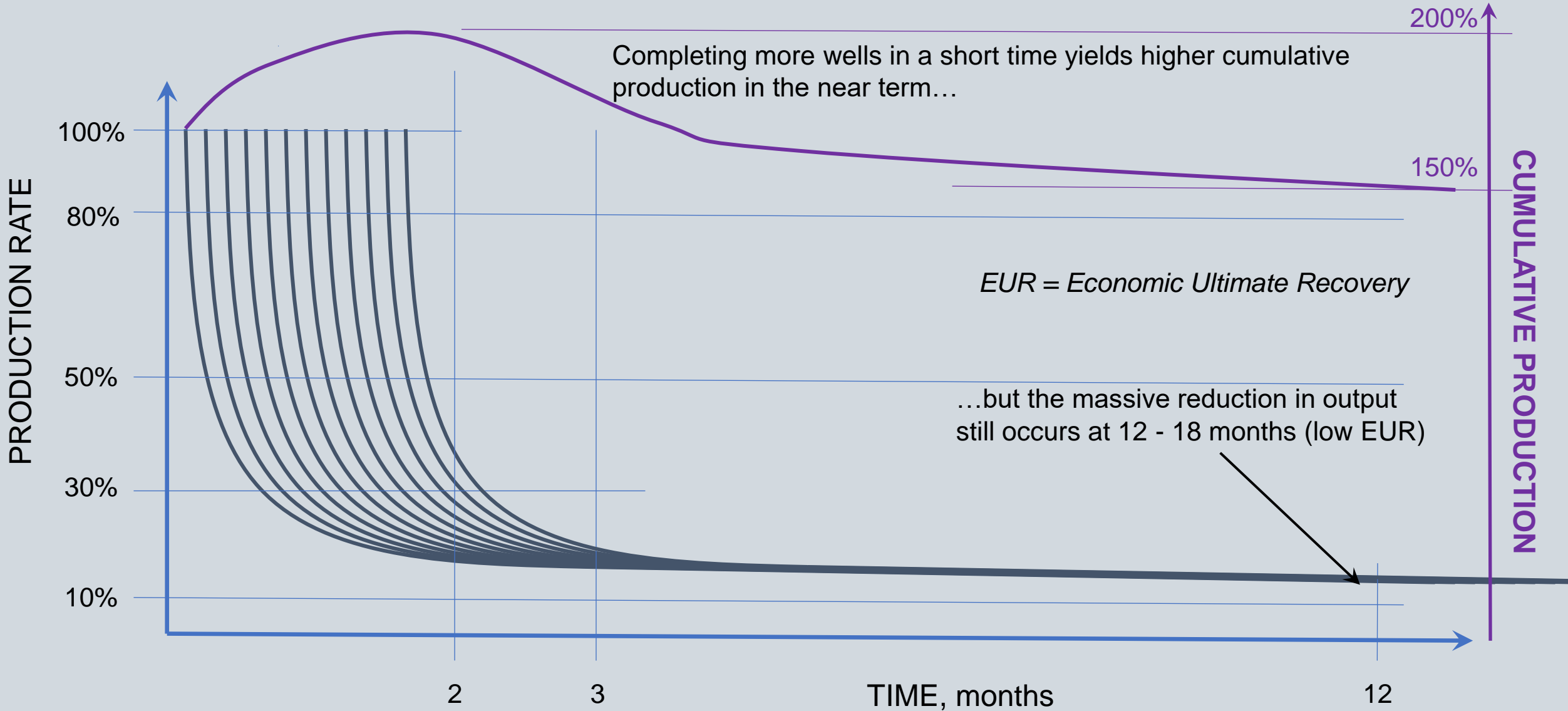


\* Shale operators cut costs

# General Unconventional Production Profile



# Production Profile, Multiple Wells...





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# Where is the Industry Now?

# Recent Headlines ☹️



Only 10% Of U.S. Shale Drillers Have A Positive Cash Flow, 29 May 2019,  
<https://oilprice.com/Energy/Crude-Oil/Only-10-Of-US-Shale-Drillers-Has-A-Positive-Cash-Flow.html>

For the year 2019, these drillers were cash-flow-positive  
Pioneer Natural Resources (Permian acreage)  
Concho Resources (Permian acreage)  
EOG Resources (acreage in the Permian, DJ, Eagleford, and other domestic basins)

Shale industry will be rocked by \$300 billion in losses and a wave of bankruptcies, Deloitte says – 22 June 2020 - <https://www.cnbc.com/2020/06/22/shale-industry-will-be-rocked-by-300-billion-in-losses-and-a-wave-of-bankruptcies-deloitte-says.html>

EOG Resources (EOG) Foresees No Recovery in US Oil Production,  
<https://finance.yahoo.com/news/eog-resources-eog-foresees-no-141902338.html>



# Shale Operator Bankruptcies - 2020



Whiting Petroleum – 1<sup>st</sup> to file for bankruptcy - 1 April 2020

Chesapeake Energy – June 2020

Denbury Resources – July 2020

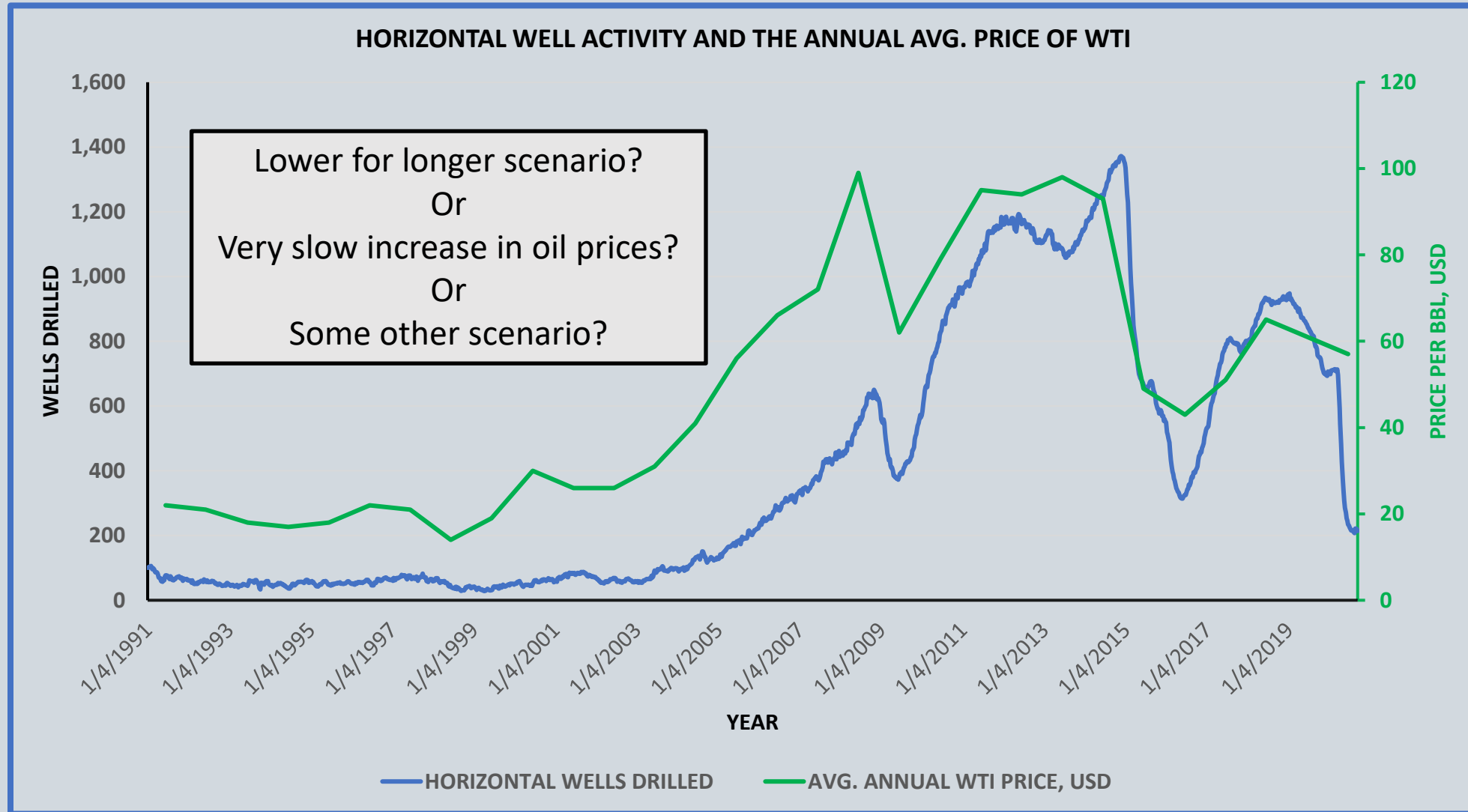
Chapparral Energy - August 2020

Remora Petroleum – August 2020

30% of shale operators are technically insolvent with oil prices at \$35 and 20% have “stressed financials.” (Delloite, June 2020)

**The sweet spot for WTI prices must be significantly higher than \$35.  
Is it \$50, \$55, or higher?**

# Horizontal Well Activity and the Future



# What are Shale Operators Investigating to Improve Profitability?

# Today's Reality...



“U.S. shale producers will have to tap brakes in 2020 after years of rapid growth”....

“Vastly slower U.S. oil growth this year and the prospect of a plateau for the world’s top oil producer have signaled a new and unfamiliar era of self-restraint for the go-go shale industry..”

“Spending cuts and production declines common to shale wells mean U.S. output growth is expected to brake from 2019’s pace that pushed domestic production past 13 million barrels per day (bpd)

“Analysts currently expect U.S. crude oil to average around \$58 per barrel in 2020, which would represent a modest pullback from current levels.”

“U.S. producers are "still going to need another year or two to get free cash flow yields up to levels that are competitive," said Rob Thummel, portfolio manager at Tortoise Capital, which owns shares in shale producers' Concho Resources Inc [CXO.N](#), Diamondback Energy Inc [FANG.O](#) and Pioneer Natural Resources Co. [PXD.N](#).”

***But, all of these comments were before COVID 19 (2 January 2020),  
so the challenge is greater now.***

# Opportunities for Improvement...

The basic profitability equation is

$$\text{\$ Profit (P)} = \text{Revenue (R)} - \text{Expenses (E)}$$

*To increase profitability, increase revenue, reduce expenses, or both*

Revenue Opportunities in a low price environment

Expense reduction opportunities

Increase EUR – extend well life (**↑ Volume**)

~~More concessions from service companies & contractors?~~

Higher production during 1<sup>st</sup> year (**↑ Volume**)

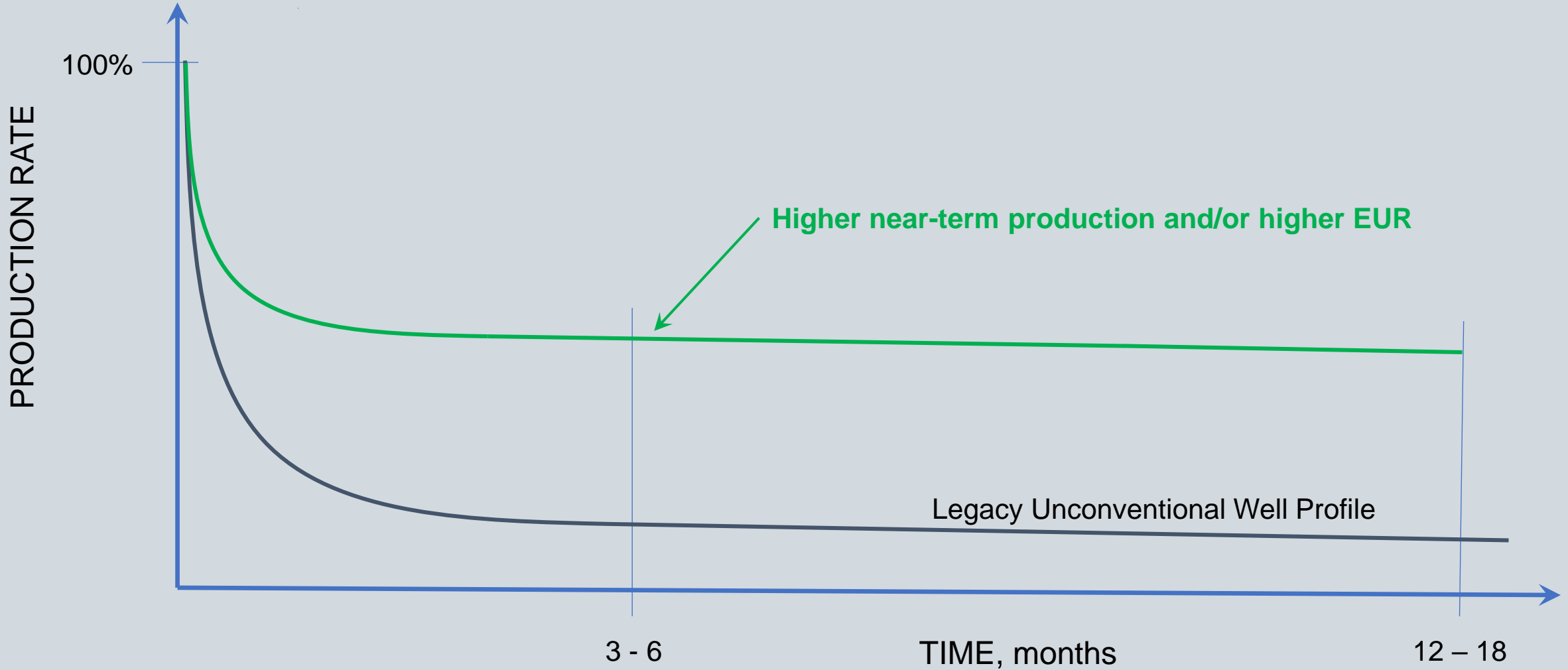
~~Fewer services (i.e. dissolvable plugs – no coiled tubing)~~

Optimize completion designs for lower oil prices

Efficiency - reduce inputs – services, horsepower, tools

Two possibilities for optimizing completion cost and performance:  
Fiber Optics  
Machine Learning

# The Goal – An Improved Production Profile...



# Achieving Higher Production /Longer Well Life

**SPE-194331-MS.** Continuous Use of Fiber Optics-Enabled Coiled Tubing Used to Accelerate the Optimization of Completions Aimed at Improved Recovery and Reduced Cost of Development. (Oasis Petroleum and Halliburton)

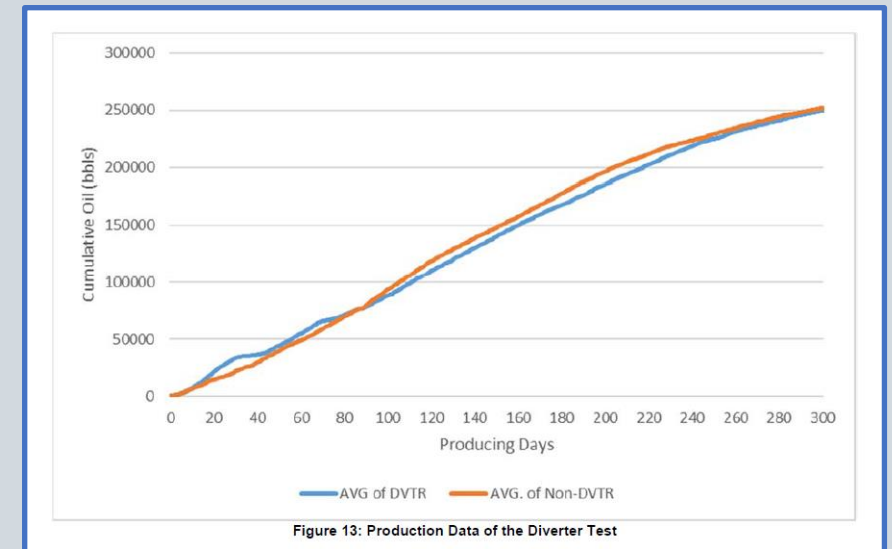
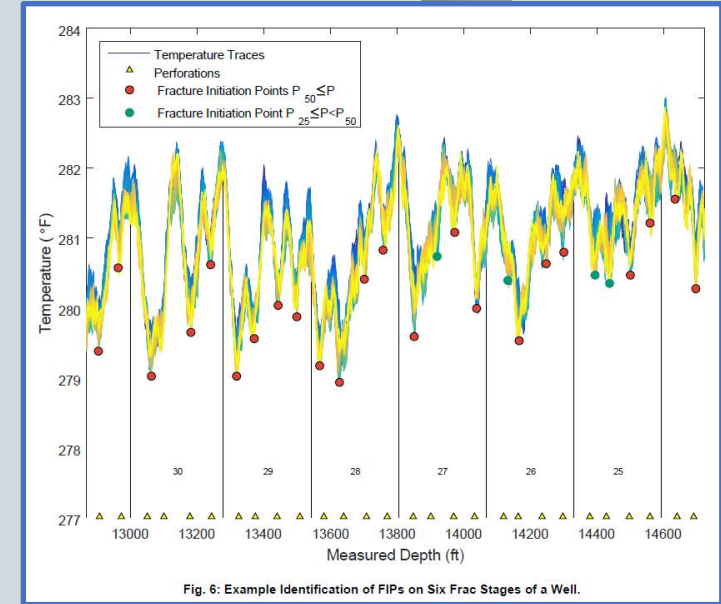
## Objectives:

- Improve completions designs leading to an increased return on asset development
- Reduce “reaction time” to make improvements to completions designs in a timely manner.

Acoustic-based temperature observations were used to understand cluster efficiency and cluster spacing.

## Results:

- Reaction time for completions design changes evaluation changed from about six months to one month
- Up to 25% increase in production was achieved
- Up to 8% reduction in capital for well completions



# Reducing Completion Cost

**SPE 194314-MS.** Improved Completion Economics Through Real-time, Fiber Optic Stimulation Monitoring (SM Energy and Halliburton)

Objective:

- Reduce dollars per barrel spent by increasing stage lengths completed along the lateral

Acoustic-based flow profiles were used to make decisions on subsequent well designs. Changes involved adding clusters to each stage, sand staging, and rate adjustments, among other variables.

Results:

- Increased clusters per stage from eight to twelve.
- 15.9% overall completion savings achieved, attributable to reductions in stimulation, wireline, and coil costs.
- Reduced number of stages

	W&P	Stimulation	Days
Base Design	-	-	-
New Design	-18.0%	-15.6%	-10.3%

Table 1 Economic impact and savings from changes to completion design.

$$\uparrow \$ \text{ Profit (P)} = \text{Revenue (R)} - \downarrow \text{Expenses (E)}$$



# Optimize Completion for Different Scenarios

## Machine Learning (ML)

**SPE-195311-MS.** Prescriptive Analytics for Completion Optimization in Unconventional Resources (Diamondback Energy and Baker Hughes)

Objective:

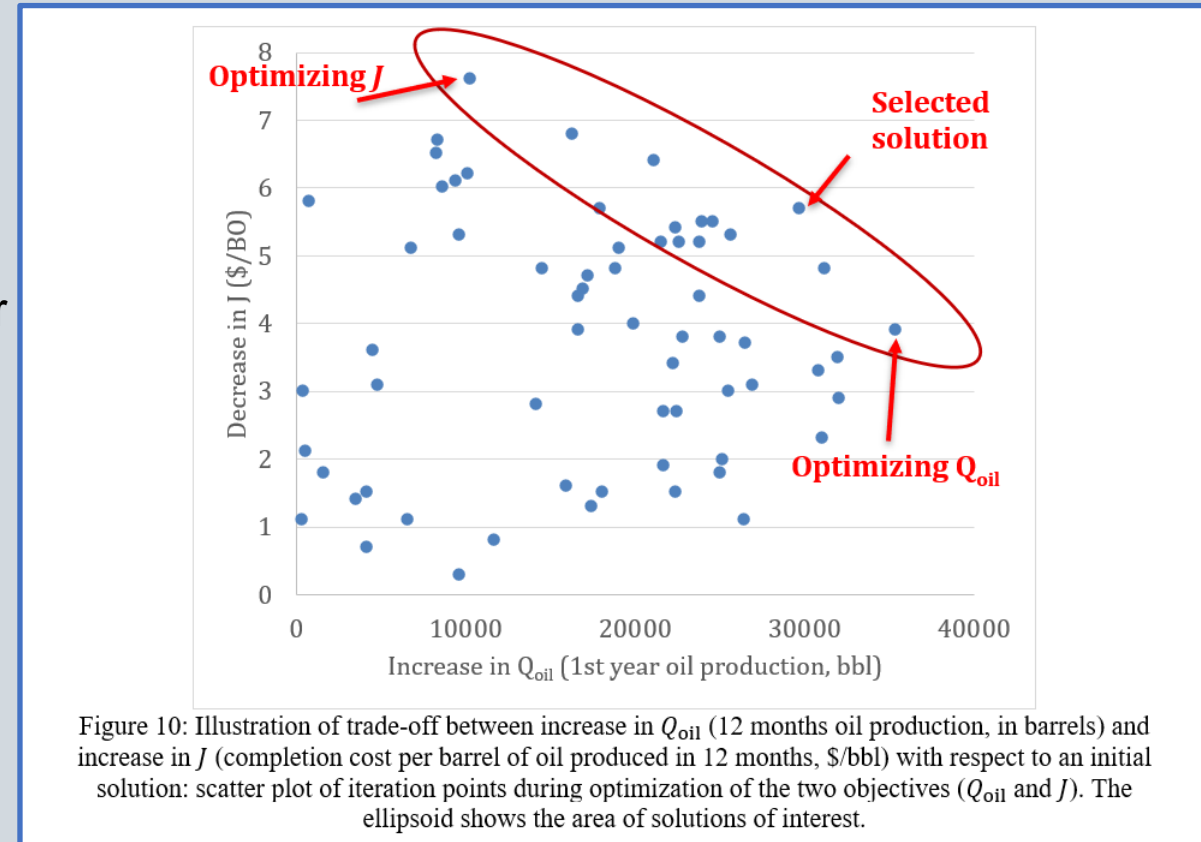
- Optimize \$/bbl spent on total oil produced in the 1<sup>st</sup> year

Used data from > 100 horizontal wells in Permian Basin.

Generated an accurate model to predict future production from a well based on the completion recipe.

Results:

- Can optimize for either 12-month cumulative oil production or completion cost per barrel of oil
- When algorithms applied to > 100 wells, 5-32% of savings in completion cost per well predicted while maintaining similar production (1<sup>st</sup> year)



# Three More Ideas to Save Completion Time



A little homework assignment  
for you 😊

**The Journal of Petroleum  
Technology May 2020**

# Recommended Reading



**The Prize**, Daniel Yergin, latest edition (2010?)

**Shale Experts** website, [https://www.shaleexperts.com/?utm\\_source=headerLogo](https://www.shaleexperts.com/?utm_source=headerLogo)

**Houston-based Surge Energy horizontal well is a record** (July 2019),  
<https://www.chron.com/business/energy/article/Drilling-Down-Surge-Energy-s-record-breaking-14106898.php>

**Drilling Cost**, <https://www.tidalpetroleum.com/processes/drilling-cost>

**Pad Drilling: Innovation in the Oil and Gas Industry**,  
<https://www.visualcapitalist.com/pad-drilling-innovation-in-the-oil-and-gas-industry-infographic/>

**Average annual West Texas Intermediate (WTI) crude oil price from 1976 to 2020**, Statista,  
<https://www.statista.com/statistics/266659/west-texas-intermediate-oil-prices/>

**Shale Drillers Are Staring Down Barrel at Worst Oil Bust Yet, 9 March 2020**,  
<https://www.bloomberg.com/news/articles/2020-03-09/shale-drillers-are-staring-down-the-barrel-of-worst-oil-bust-yet>

# Recommended Reading, cont'd



**US Shale Oil Boom and Bust - Behind the US Shale Oil Boom and Bust,**  
<https://www.thebalance.com/us-shale-oil-boom-and-bust-3305553>

**Analysis shows U.S. shale drillers still not profitable**, <https://ieefa.org/analysis-shows-u-s-shale-drillers-still-not-profitable/>

**U.S. shale producers to tap brakes in 2020 after years of rapid growth, 2 January 2020,**  
<https://www.reuters.com/article/us-usa-shale-outlook-idUSKBN1Z108U>

**The Distribution of U.S. Oil and Natural Gas Wells by Production Rate** December 2019,  
[https://www.eia.gov/petroleum/wells/pdf/full\\_report.pdf](https://www.eia.gov/petroleum/wells/pdf/full_report.pdf)

**SPE 197573**, “Asset Value Maximization Through a Novel Well-Completion System for 3D Time-Lapse Electromagnetic Tomography Supported by Machine Learning”

**Diamondback Energy, Inc. Announces Fourth Quarter and Full Year 2019 Financial and Operating Results; Doubles Dividend**, 18 February 2020, <https://www.diamondbackenergy.com/news-releases/news-release-details/diamondback-energy-inc-announces-fourth-quarter-and-full-year-0>

**Thank you for your attendance today**

**Questions?**

**You can also view this presentation on Linked In at <https://www.linkedin.com/in/doug-lehr-pe/>  
or in the Learning Center at [integris-llc.com](https://www.integris-llc.com)**