Tight Oil and The Willing Suspension of Disbelief

College of the Coast & Environment

Louisiana State University November 22, 2019

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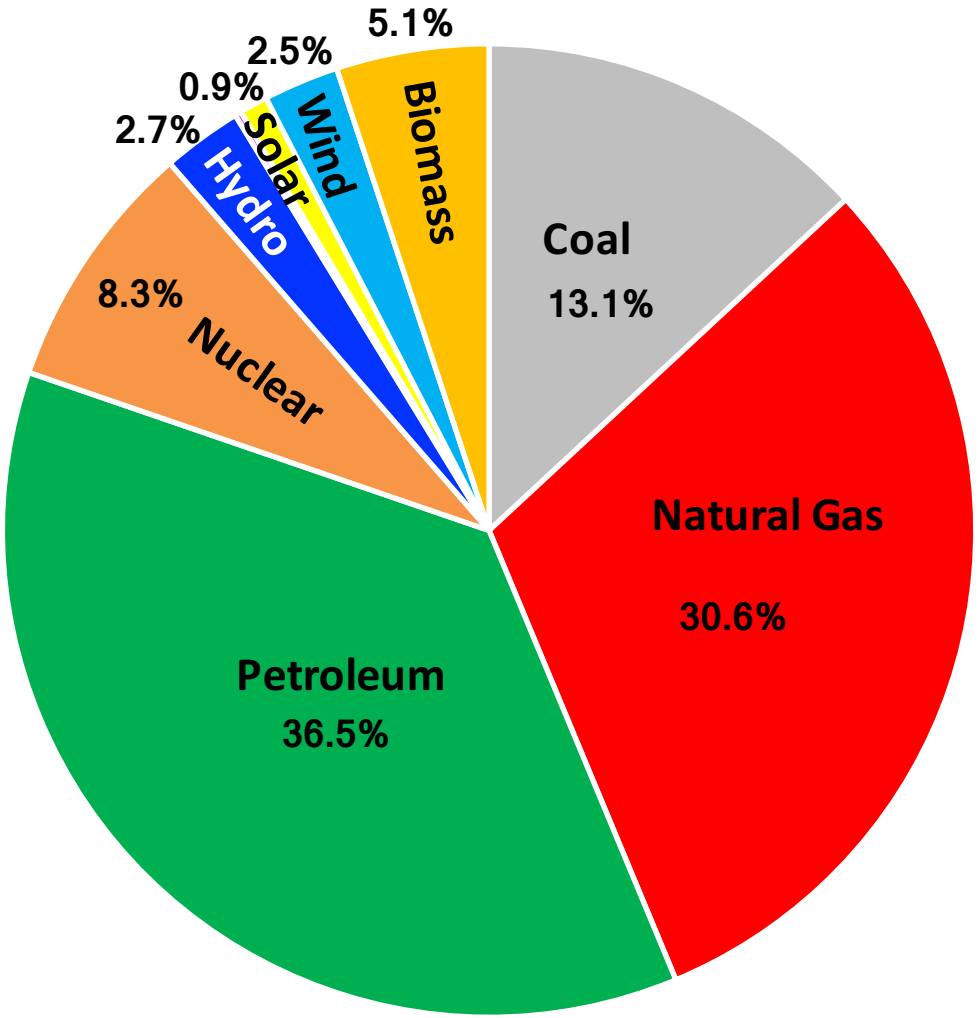
Labyrinth Consulting Services, Inc.

“Energy is and always will be the currency of life”
–Nate Hagens

- Any movement, activity or event in nature requires energy
- Human society runs on energy
  - Work requires energy—joules/calories.
  - Subsistence: energy intake = energy expenditure.
  - Surplus: energy intake > energy expenditure.
  - If I accumulate excess energy such as grain, I may choose to have you do some of my work in exchange for some of that energy.
- Money is a call on work
  - Today, most work is done by oil, natural gas and coal.
  - 1 barrel of oil contains about 4.5 years of human manual labor.

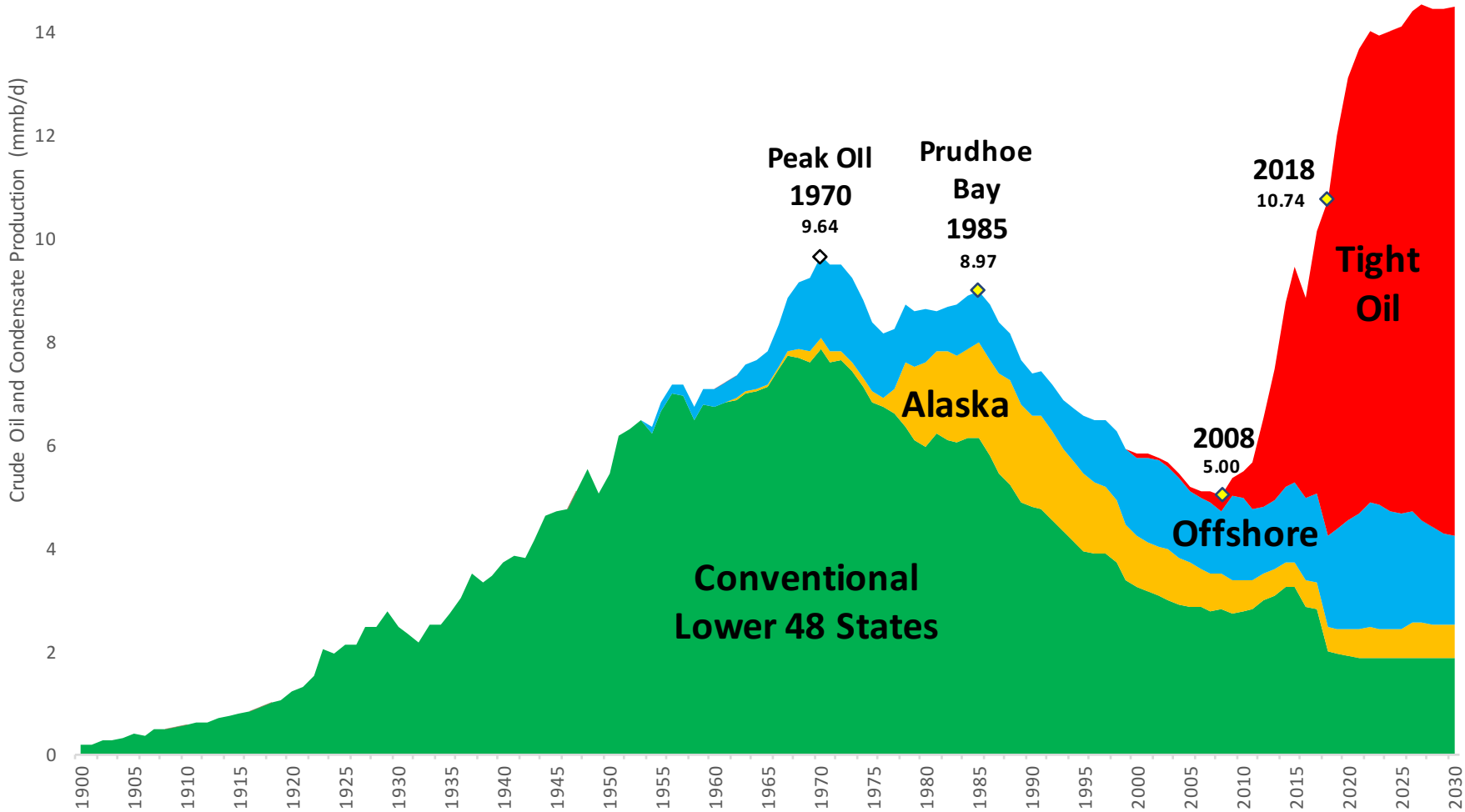
Energy is the Economy
For now, that means oil, natural gas and coal



Source: EIA & Labyrinth Consulting Services, Inc.

Table_1.3_Primary_Energy_Consumption_by_Source

U.S. oil production peaked in 1970 & declined by almost 50% by 2008
Production surpassed its previous peak in 2017 because of tight oil



Source: EIA, EIA AEO 2019 , Drilling Info & Labyrinth Consulting Services, Inc.

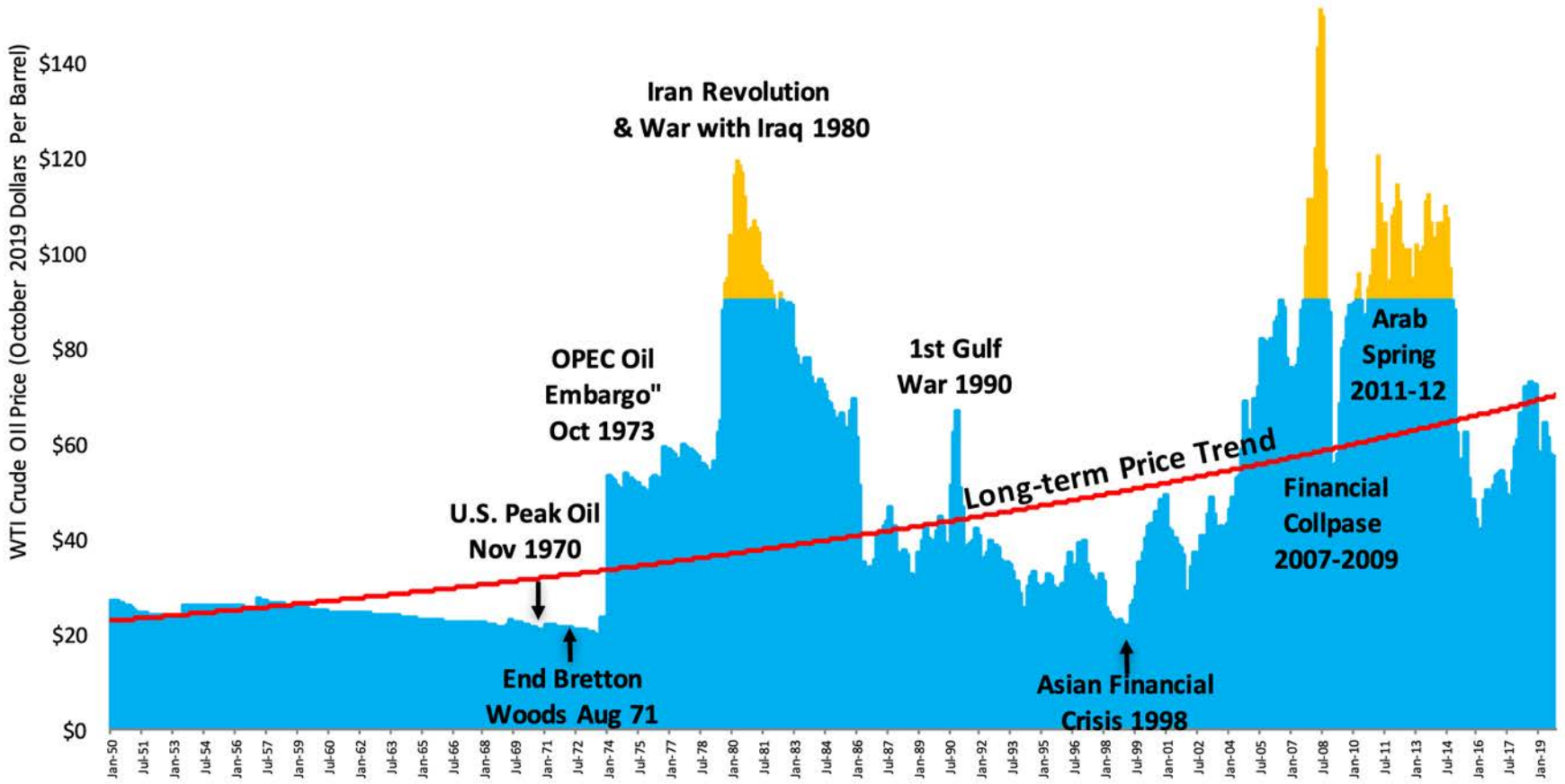
EIA 2019/Monthly Updates/CRUDE OIL PRODUCTION ANNUAL.xlsx.

The End of Cheap Oil

Low, stable oil prices ended in 1973

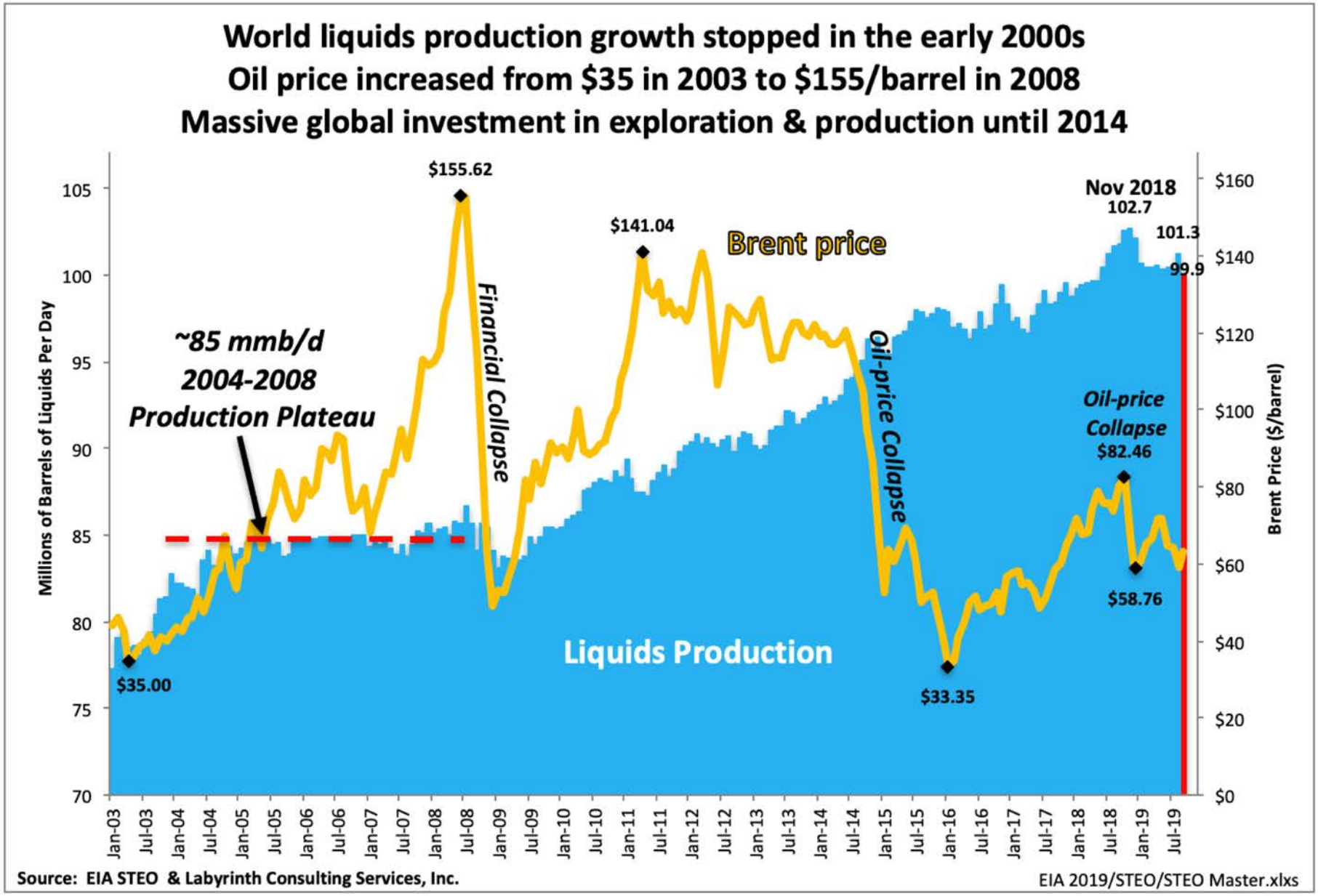
Higher oil prices have been a key factor in the global economy ever since

All values in October 2019 dollars



Source: EIA , Federal Reserve Bank & Labyrinth Consulting Services, Inc.

Oil & Gas General/CPI-Adj WTI Oil Price GT $90


World liquids production growth stopped in the early 2000s
Oil price increased from $35 in 2003 to $155/barrel in 2008
Massive global investment in exploration & production until 2014
Millions of Barrels of Liquids Per Day
Brent Price ($/barrel)
105
100
95
90
85
80
75
70
$160
$140
$120
$100
$80
$60
$40
$20
$0
$155.62
$141.04
Brent price
Nov 2018
102.7
101.3
99.9
~85 mmb/d
2004-2008
Production Plateau
Financial Collapse
Oil-price Collapse
Oil-price
Collapse
$82.46
$58.76
Liquids Production
$35.00
$33.35
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
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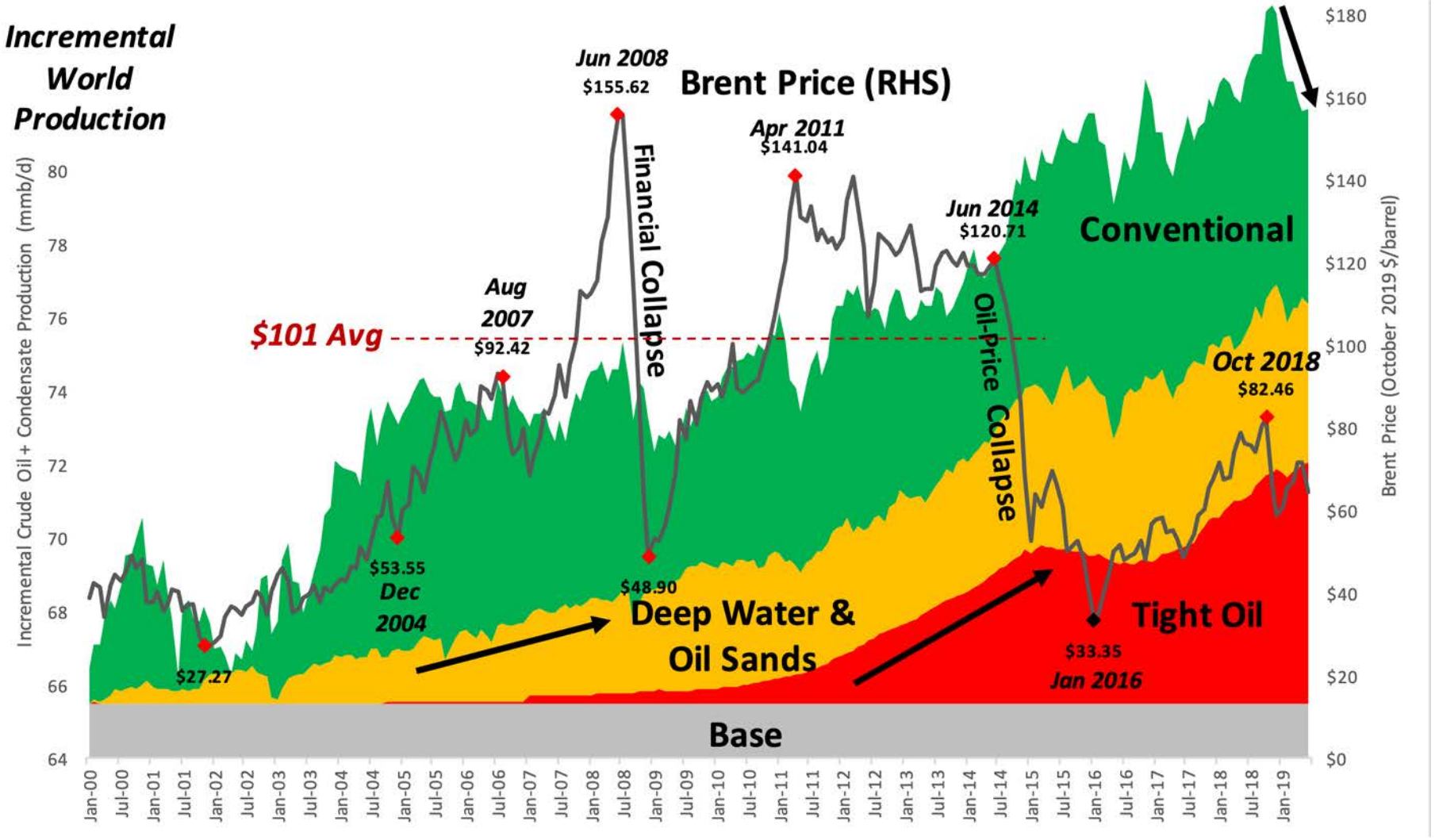
Jul-19
Source: EIA STEO & Labyrinth Consulting Services, Inc.
EIA 2019/STEO/STEO Master.xlxs

2014-16 oil price collapse caused by over-supply of tight oil, deep water oil and oil sands

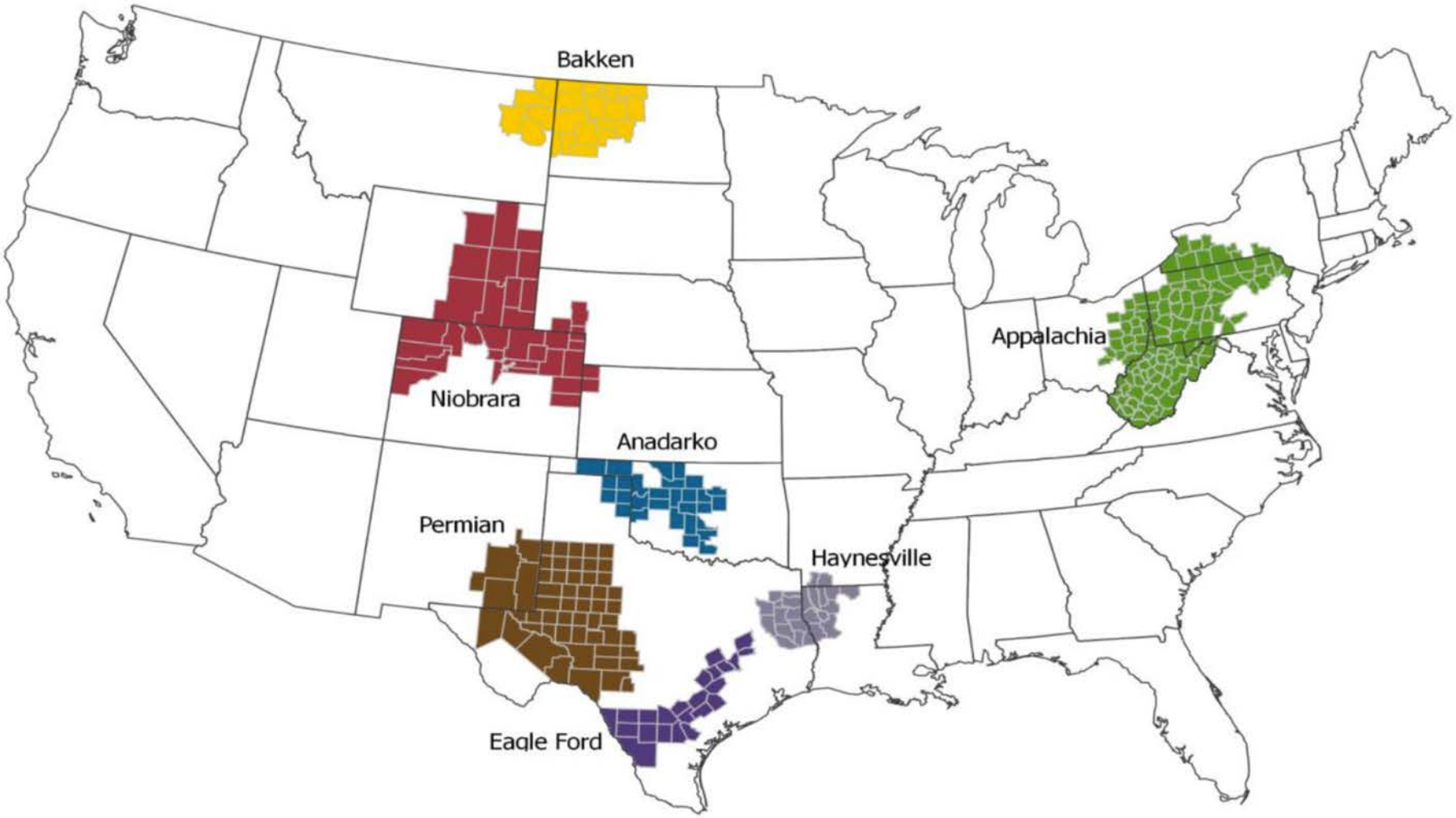
Unconventional oil development possible because of $101 average oil price 2005-2014



Source: EIA, Cansim, Drilling Info & Labyrinth Consulting Services, Inc

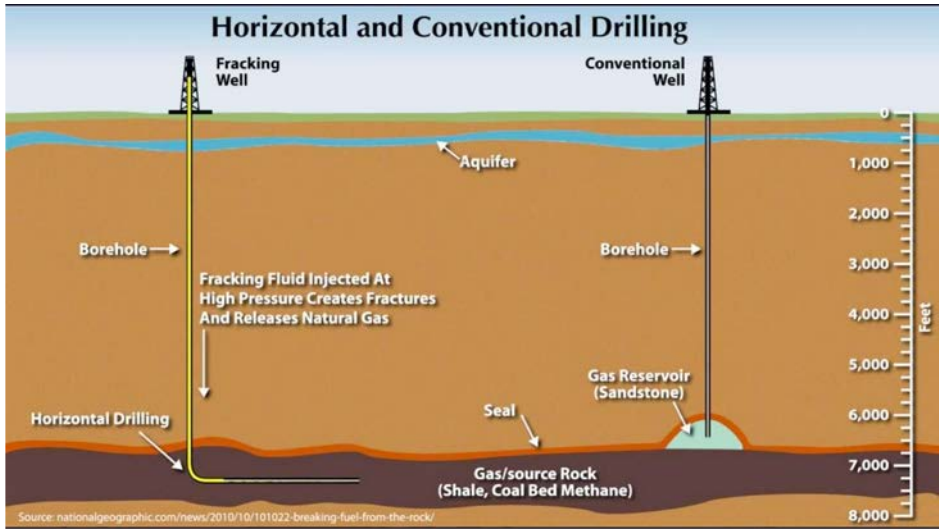
EIA/EIA International/International_data MASTER.xlsx

U.S. Tight Oil & Shale Gas Plays

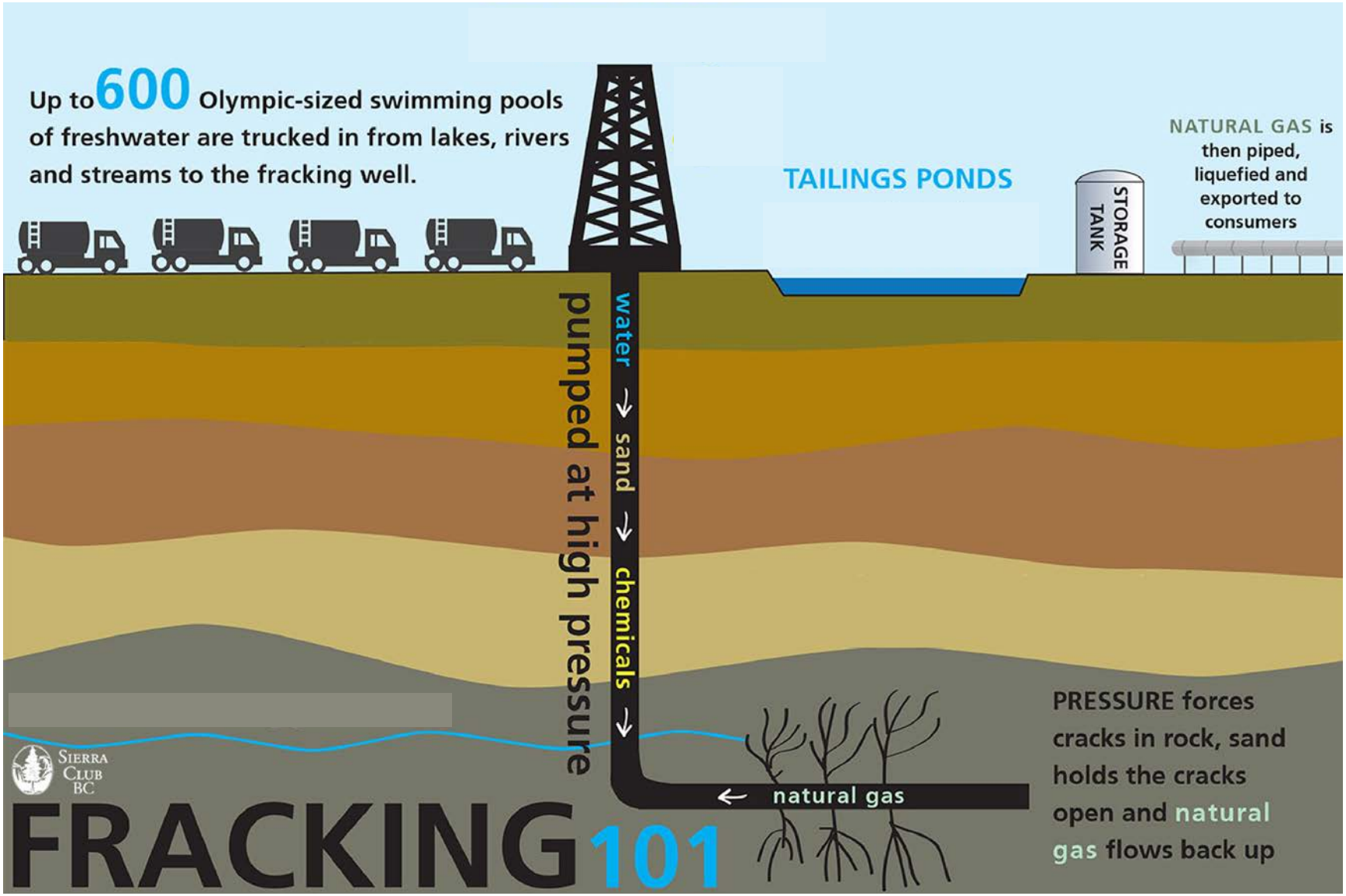


Conventional and Unconventional Oil

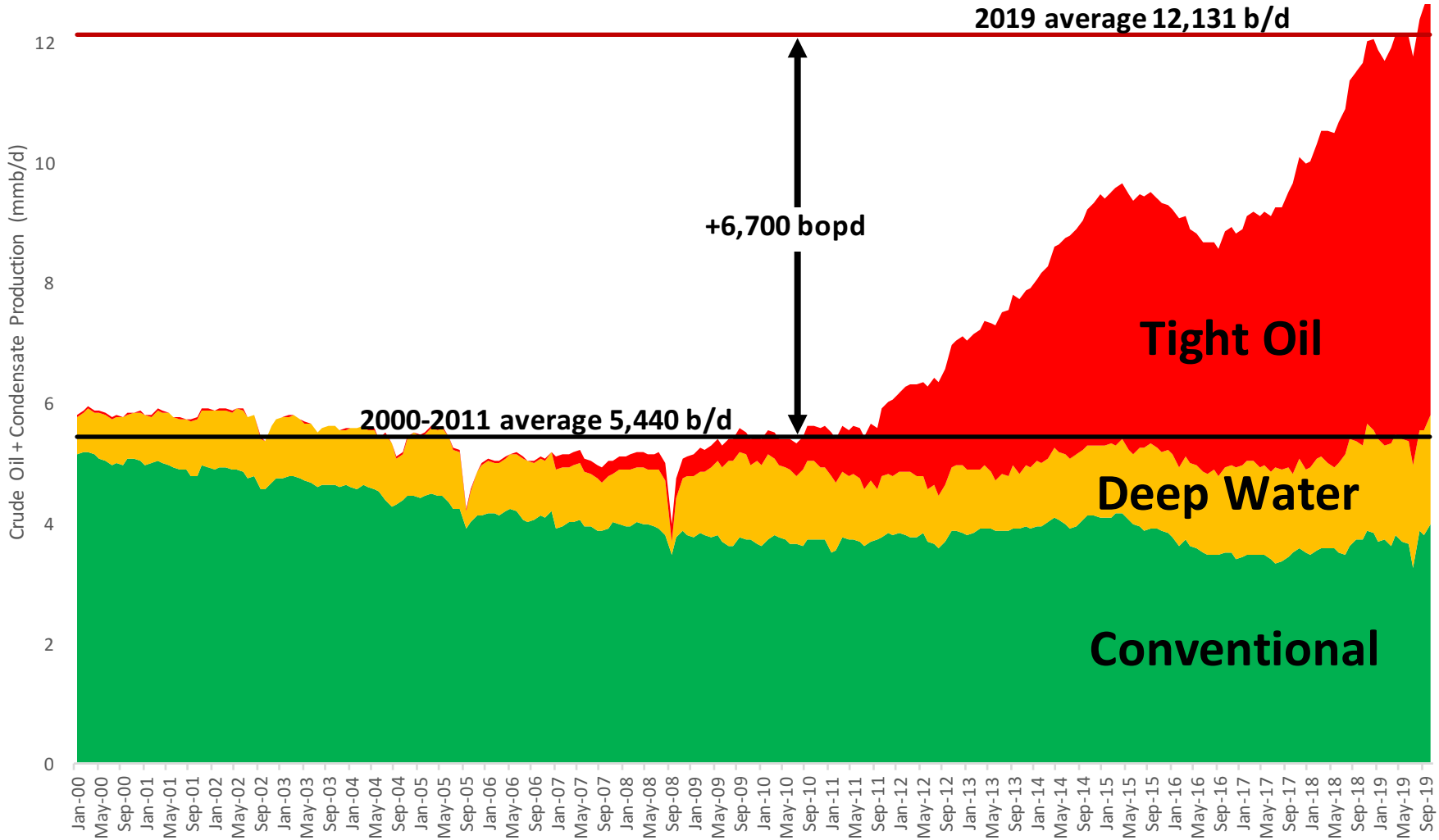
	Low-Permeabilty Reservoir	High-Permeabilty Reservoir
Medium to Light Oil	Tight Oil Horizontal Drilling Fracking	Conventional Oil Vertical Drilling Fracking
Heavy Oil	Immature Oil "Oil Shale" Mining	Heavy Oil Bitumen - Oil Sands SAGD/Mining



- Conventional oil plays involve drilling reservoir rocks with vertical wells.
- After all the commercially attractive conventional fields in the U.S. were discovered and were in depletion, unconventional plays were the only option.
- Tight oil plays (fracking) involve drilling the source rock with horizontal wells.
- Tight oil horizontal wells cost 2-3 times more to drill and complete than conventional vertical wells.
- There is considerable fanfare about the new volumes of oil but little discussion about the cost of the technology and its effect on the price of oil.


Up to 600 Olympic-sized swimming pools of freshwater are trucked in from lakes, rivers and streams to the fracking well.
TAILINGS PONDS
STORAGE TANK
NATURAL GAS is then piped, liquefied and exported to consumers
water
sand
chemicals
pumped at high pressure
natural gas
PRESSURE forces cracks in rock, sand holds the cracks open and natural gas flows back up
SIERRA CLUB BC
FRACKING 101

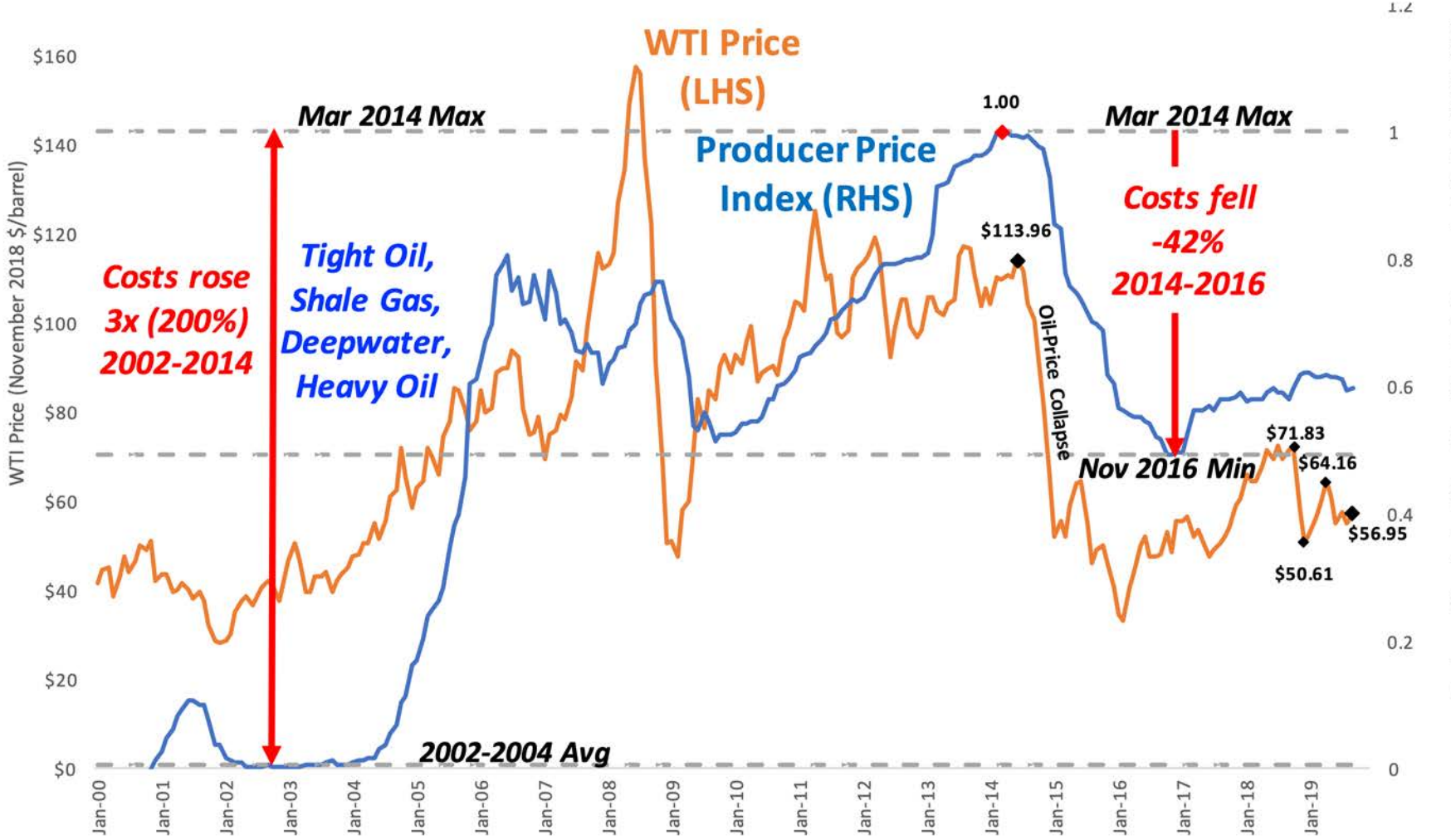
All increase in U.S. production since 2011 has been tight oil
55% of U.S. crude + condensate production is from tight oil plays
14% is from deep water and 31% is from conventional plays



Source: EIA DPR, Drilling Info & Labyrinth Consulting Services, Inc.

EIA 2019/DUC-DPR/U.S.UNCONVENTIONAL VS CONVENTIONAL MASTER

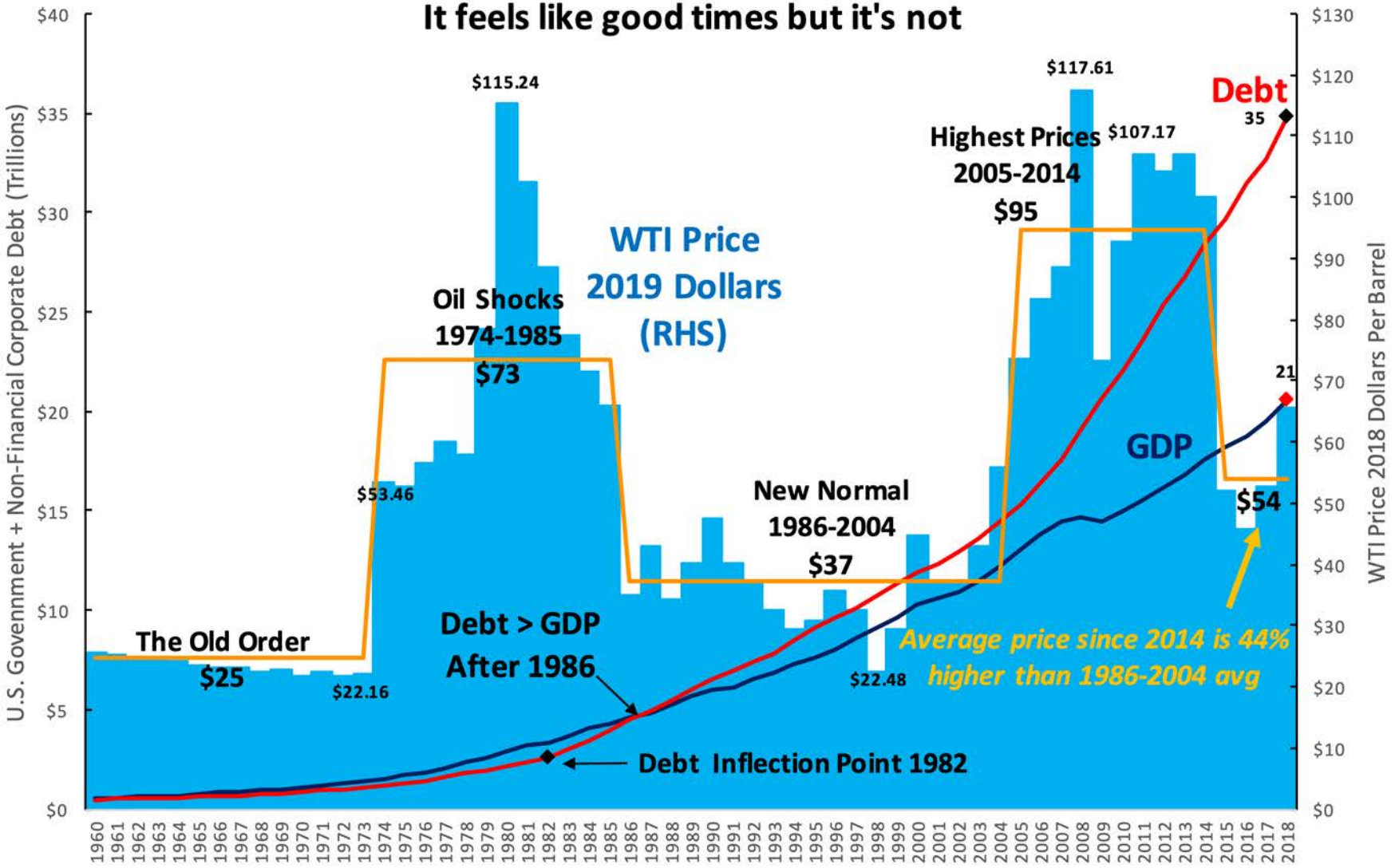
Oil & gas drilling costs increased 3x (200%) from 2002-2014 because of cost of unconventional oil & gas technology Costs of drilling fell -42% after 2014 as oil price & services were devalued



Source: Fed Reserve Bank, EIA & Labyrinth Consulting Services, Inc.

Oil & Gas General/PRODUCER PRICE INDEX DRILLING O&G WELLS.xlxs

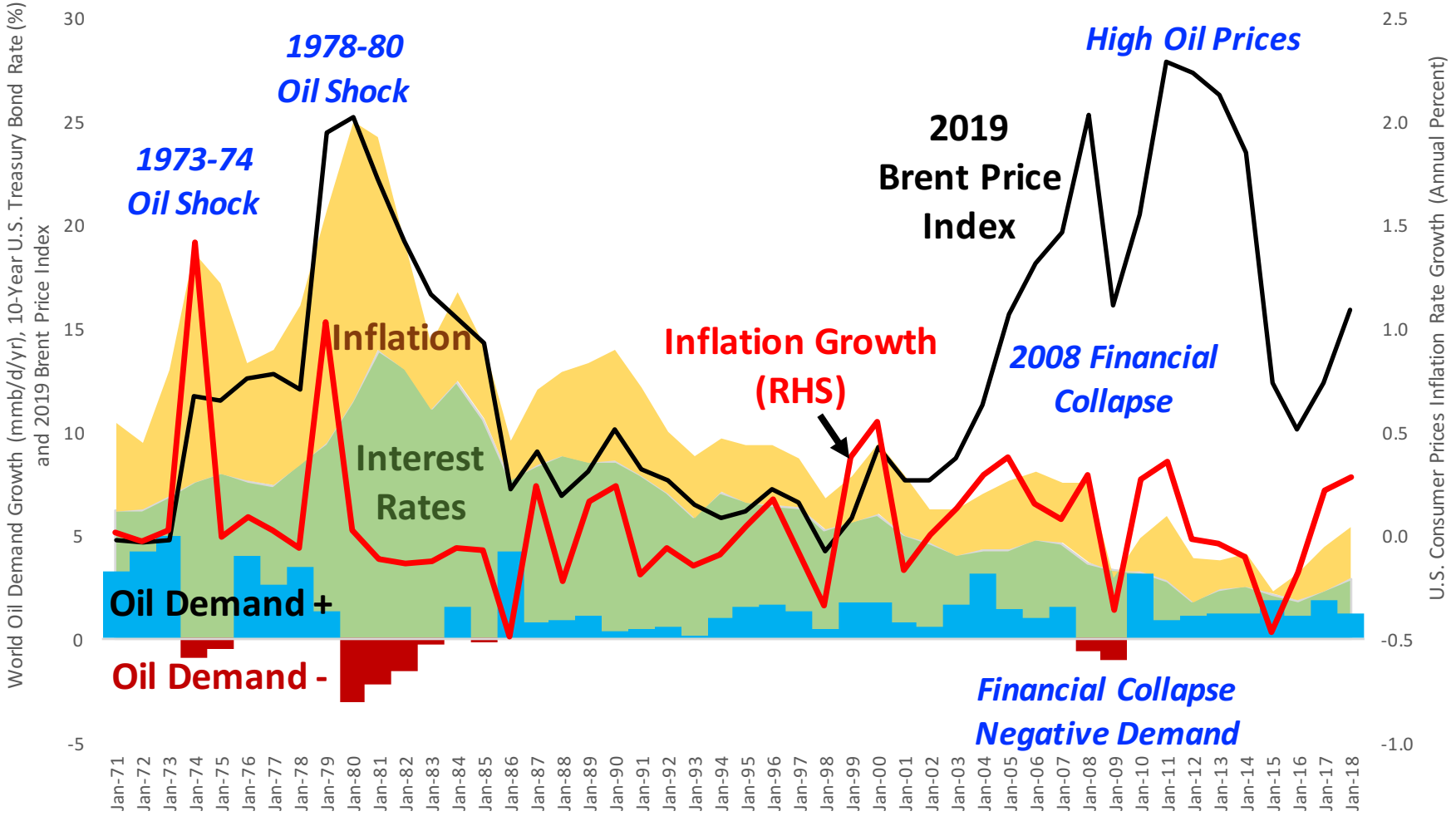
U.S. Debt began increasing during oil shocks & exceeded GDP By 1986
U.S. and the world have been borrowing forward on their surplus energy
It feels like good times but it's not



Source: U.S. Federal Reserve Bank, U.S. Bureau of Labor Statiistics, World Bank, EIA & Labyrinth Consulting Services, Inc.

Oil & Gas General/U.S. Public Debt

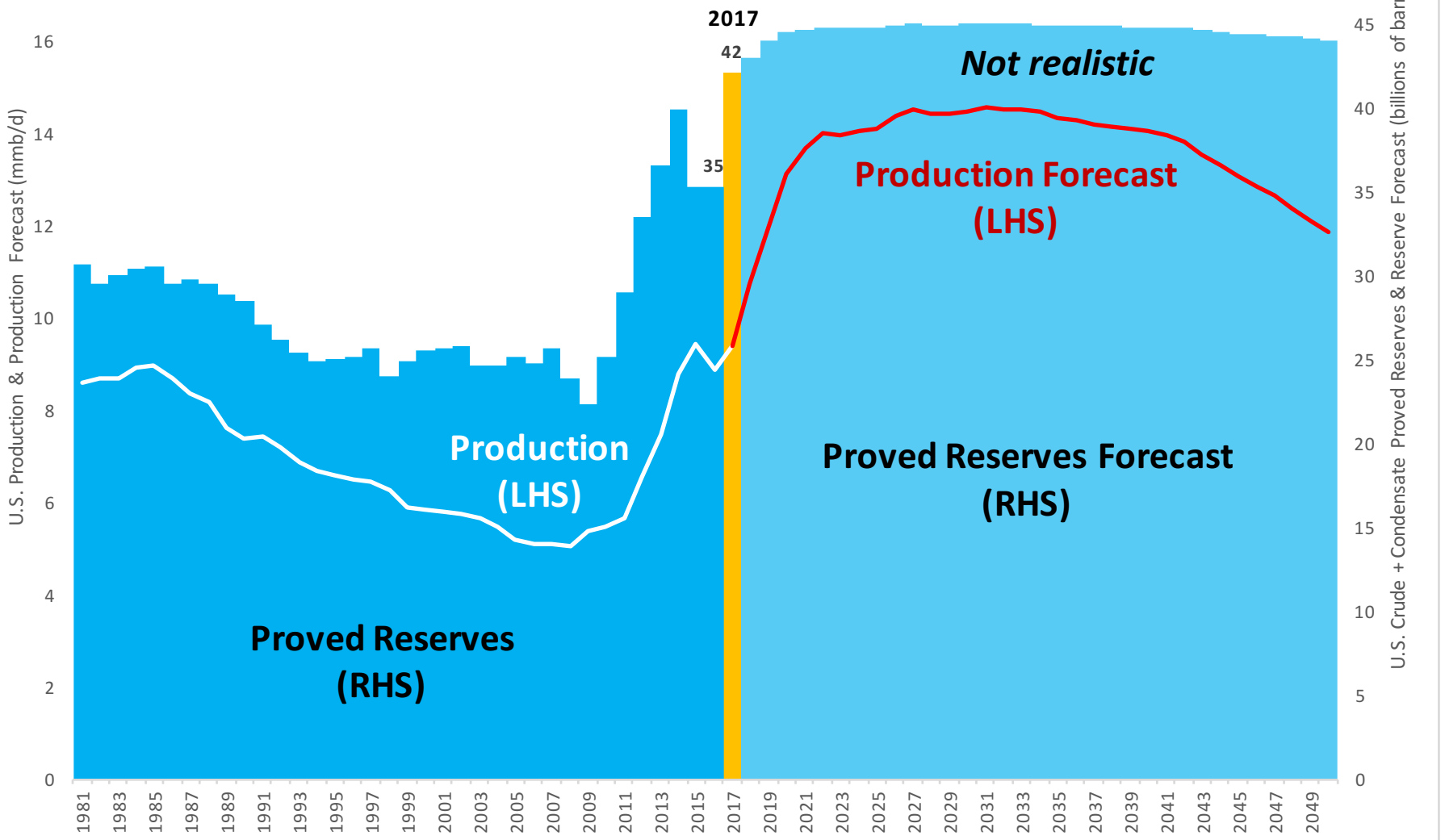
High oil prices & inflation caused negative demand growth during oil shocks of 1970s
2011-14 high oil prices not accompanied by negative demand growth
possibly because of long-term decline in interest rates & inflation



Source: EIA & Labyrinth Consulting Services, Inc.

Oil & Gas General/Inflation Annual Master

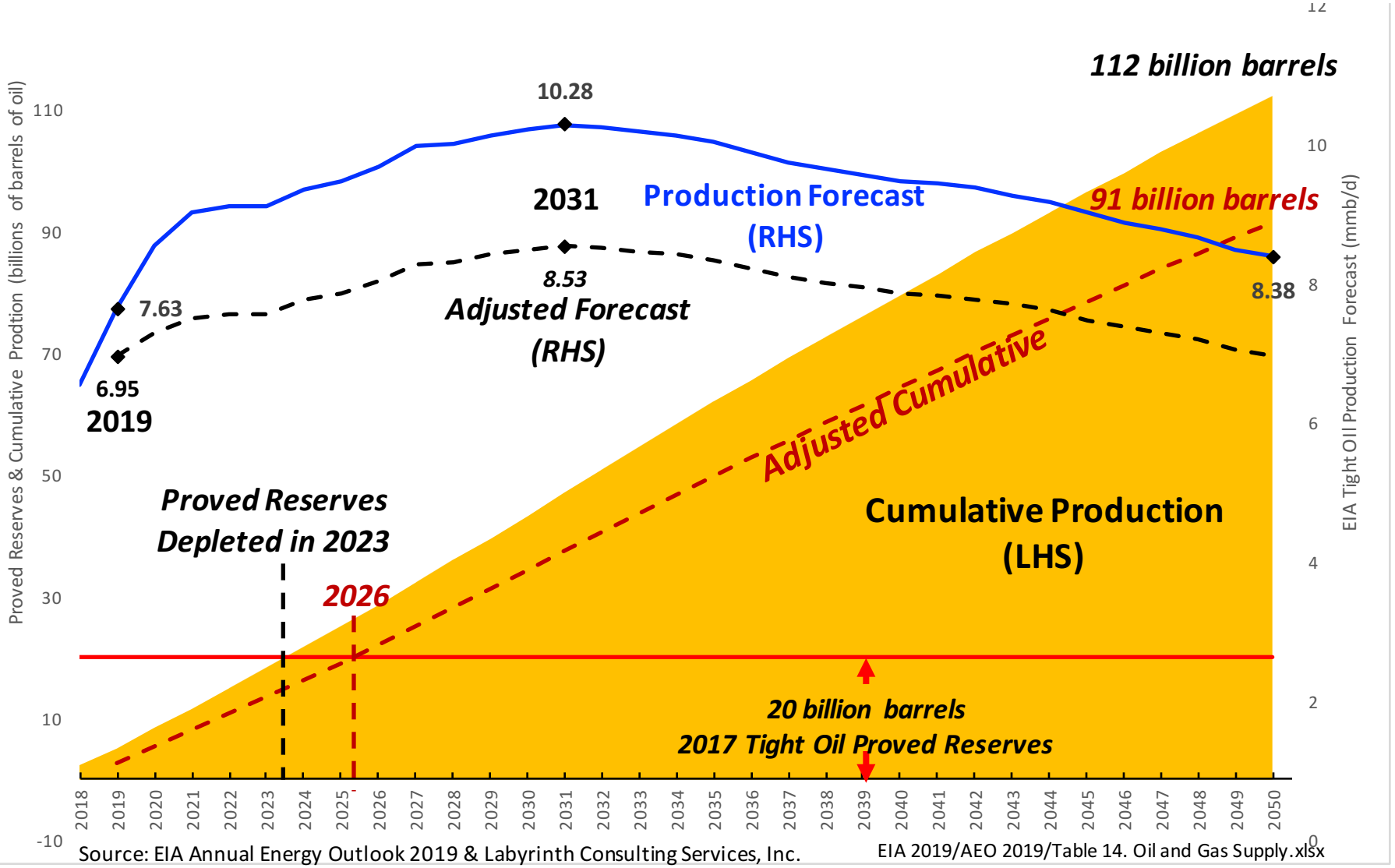
42 Billion 2017 Reserves Highest in U.S. History from +4.4 Billion Tight Oil Increase
Reserve forecast based on production forecast implies step-change in U.S. reserve levels
2018-2030 annual reserve additions based on 2009-2017 historical average



Source: EIA, EIA Annual Energy Outlook 2019 & Labyrinth Consulting Services, Inc.

EIA 2019/AEO 2019/Table 14. Oil and Gas Supply.xlsx

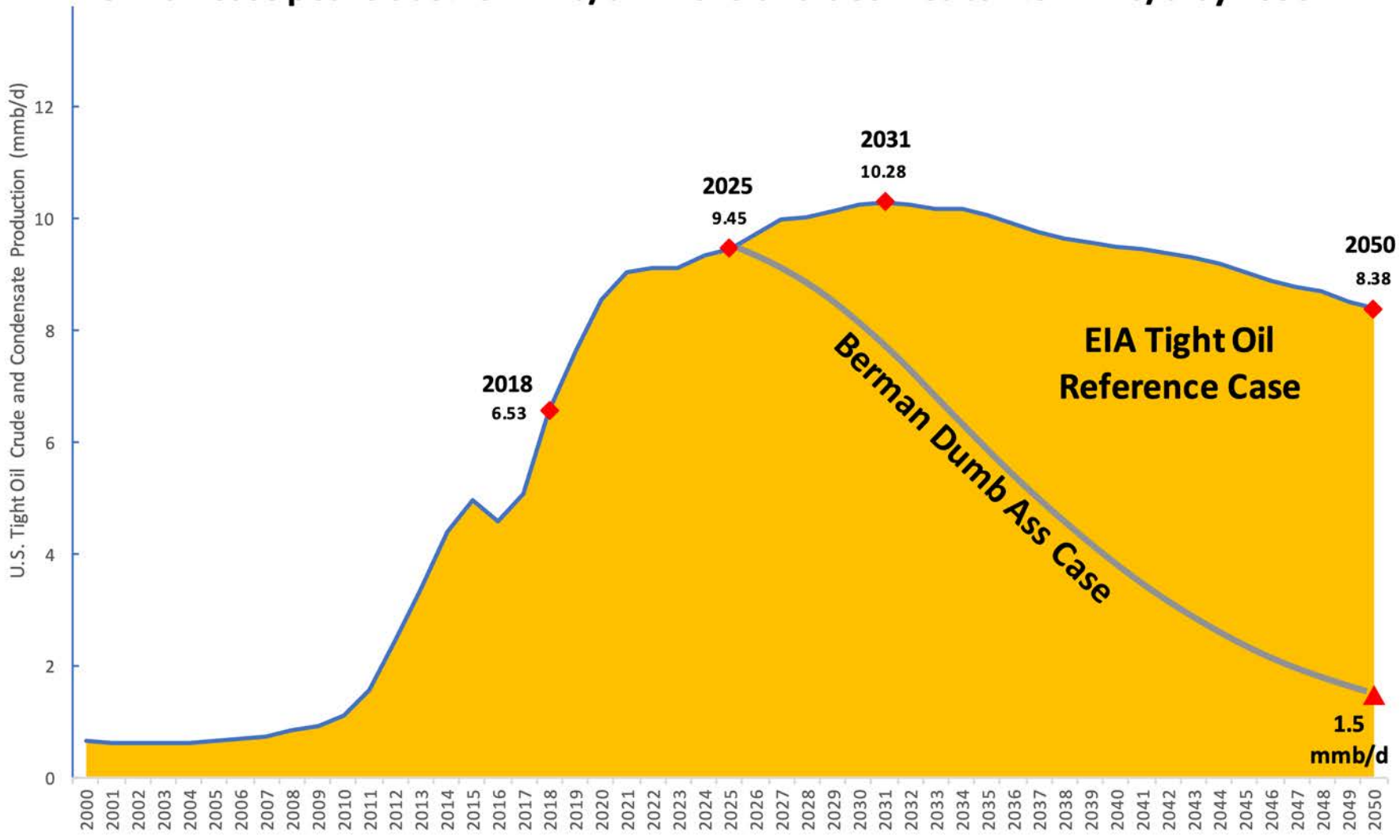
IEA tight oil forecast for 11 mmb/d in 2030 exceeds EIA AEO 2019 forecast by 7%
2019 EIA estimate already +0.7 mmb/d (+10%) too high
Adjusted forecast suggests peak tight oil production of 8.5 vs 10.3 mmb/d in 2031



Source: EIA Annual Energy Outlook 2019 & Labyrinth Consulting Services, Inc.

EIA 2019/AEO 2019/Table 14. Oil and Gas Supply.xlsx

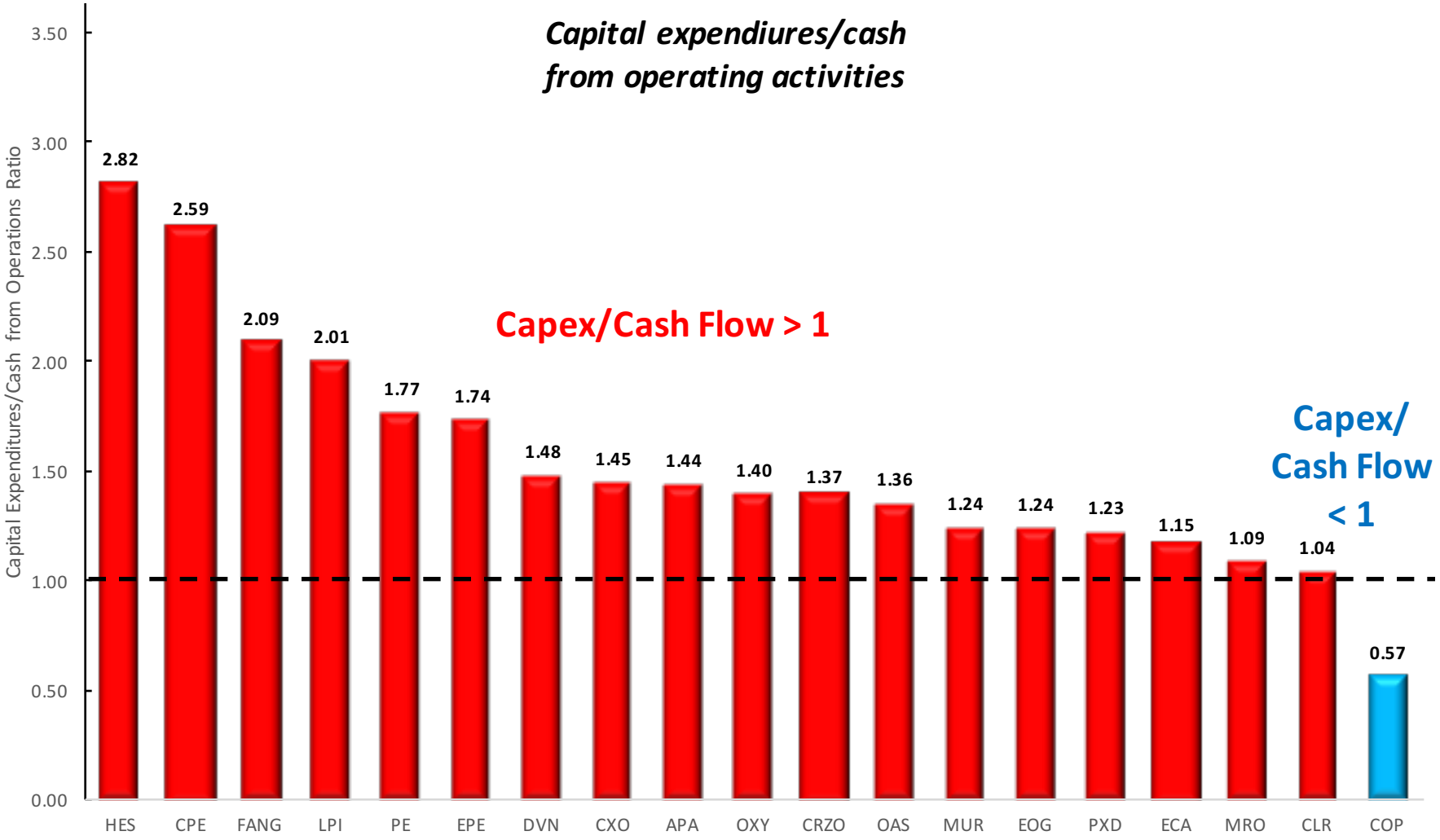
Willing Suspension of Disbelief: EIA tight oil reference case peaks at 10.28 mmb/d in 2031 & declines to 8.38 mmb/d by 2050
Berman case peaks at 9.45 mmb/d in 2025 and declines to 1.5 mmb/d by 2050



Source: EIA & Labyrinth Consulting Services, Inc.

EIA 2019/AEO 2019/CRUDE OIL PRODUCTION ANNUAL_FORECAST TO 2030

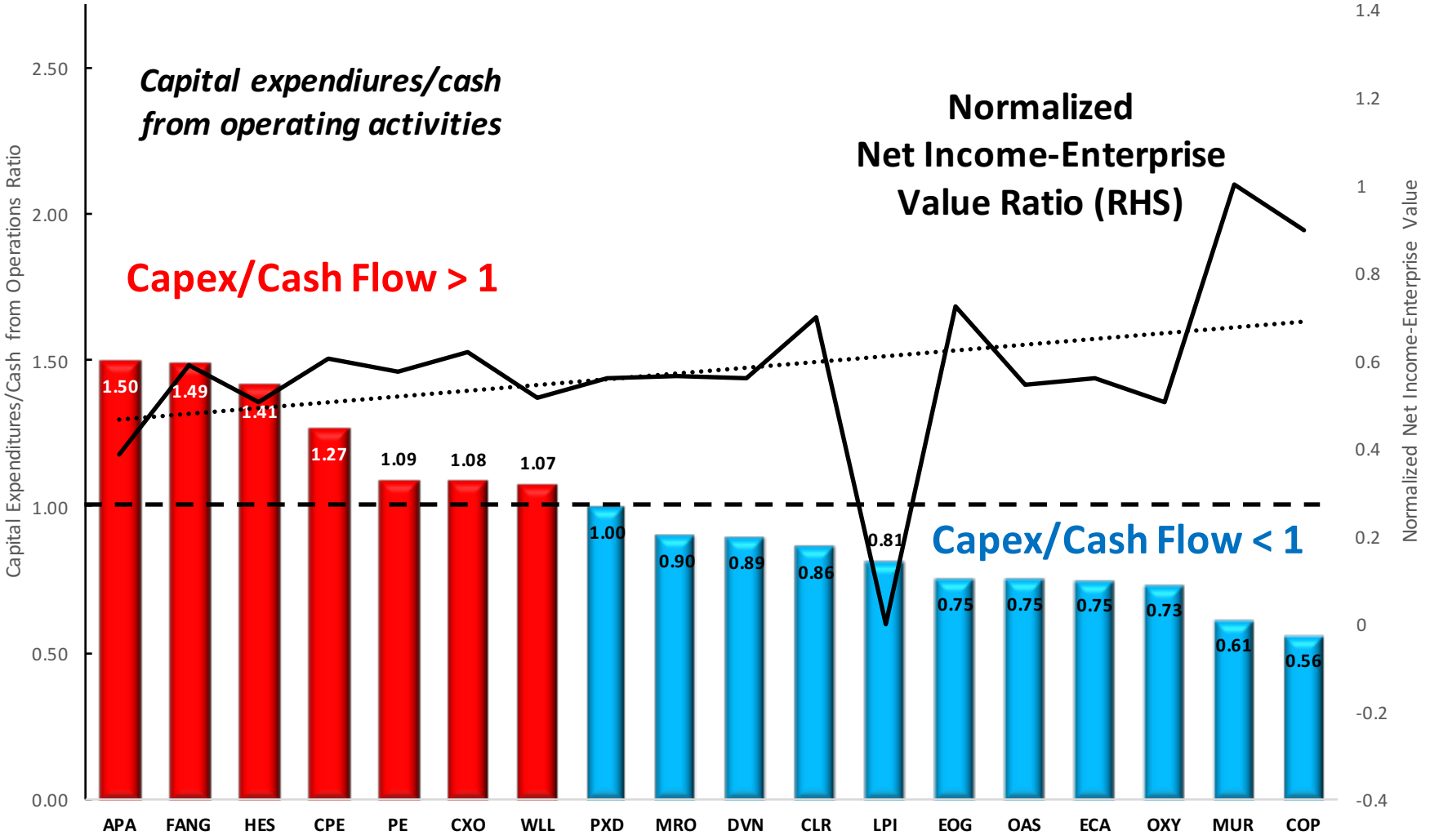
95% of sampled tight oil companies had negative cash flow in Q1 2019



Source: Yahoo Finance & Labyrinth Consulting Services, Inc

Oil & Gas General/Sampled E&Ps/Sampled E&Ps MASTER

61% of tight oil-weighted U.S. companies had positive cash flow in Q3 2019 compared to only 50% in Q2
Good correlation between cash flow & net income-to-enterprise value ratio



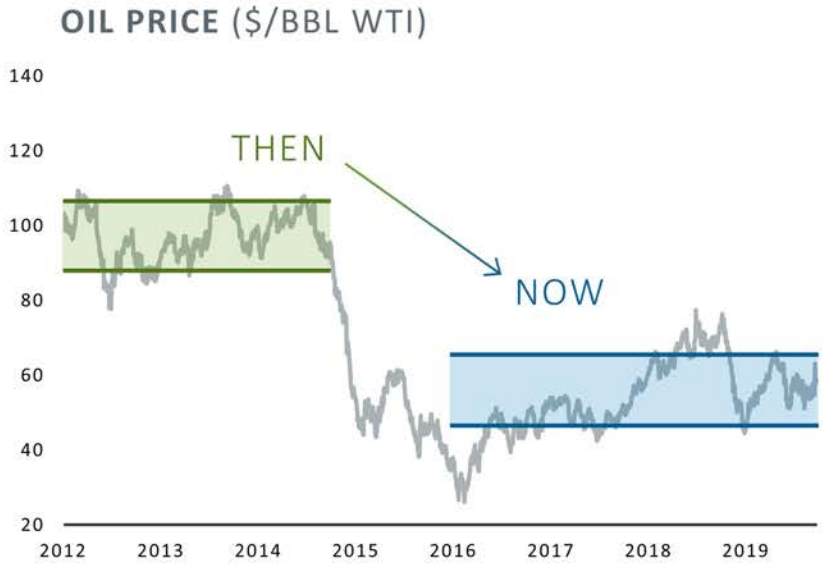
Source: Yahoo Finance, SEC 10-Q filings & Labyrinth Consulting Services, Inc

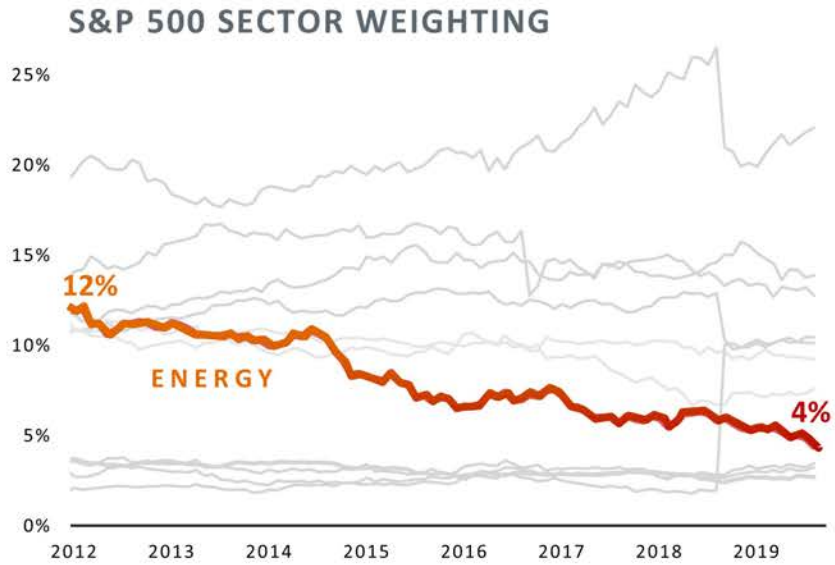
Oil & Gas General/Sampled E&Ps/Sampled E&Ps

MASTER

Oil prices have been substantially lower since 2014
And investment has fallen correspondingly

Two Charts We Can't Ignore





What Wins?

Consistent performance across cycles

Resilience to downside

Full exposure to upside

What Matters?

Disciplined capital allocation

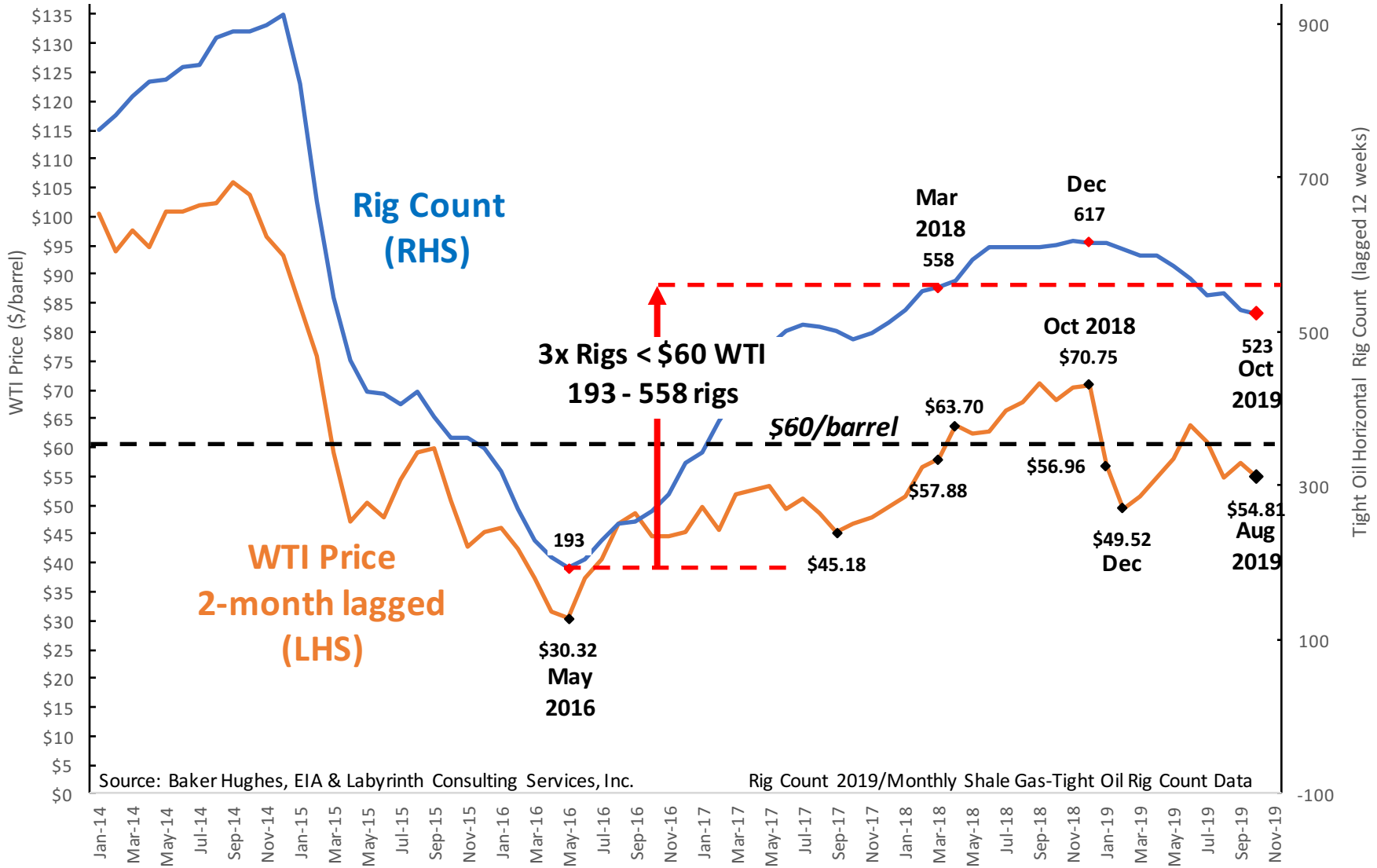
Returns *on* and *of* capital

Responsible execution

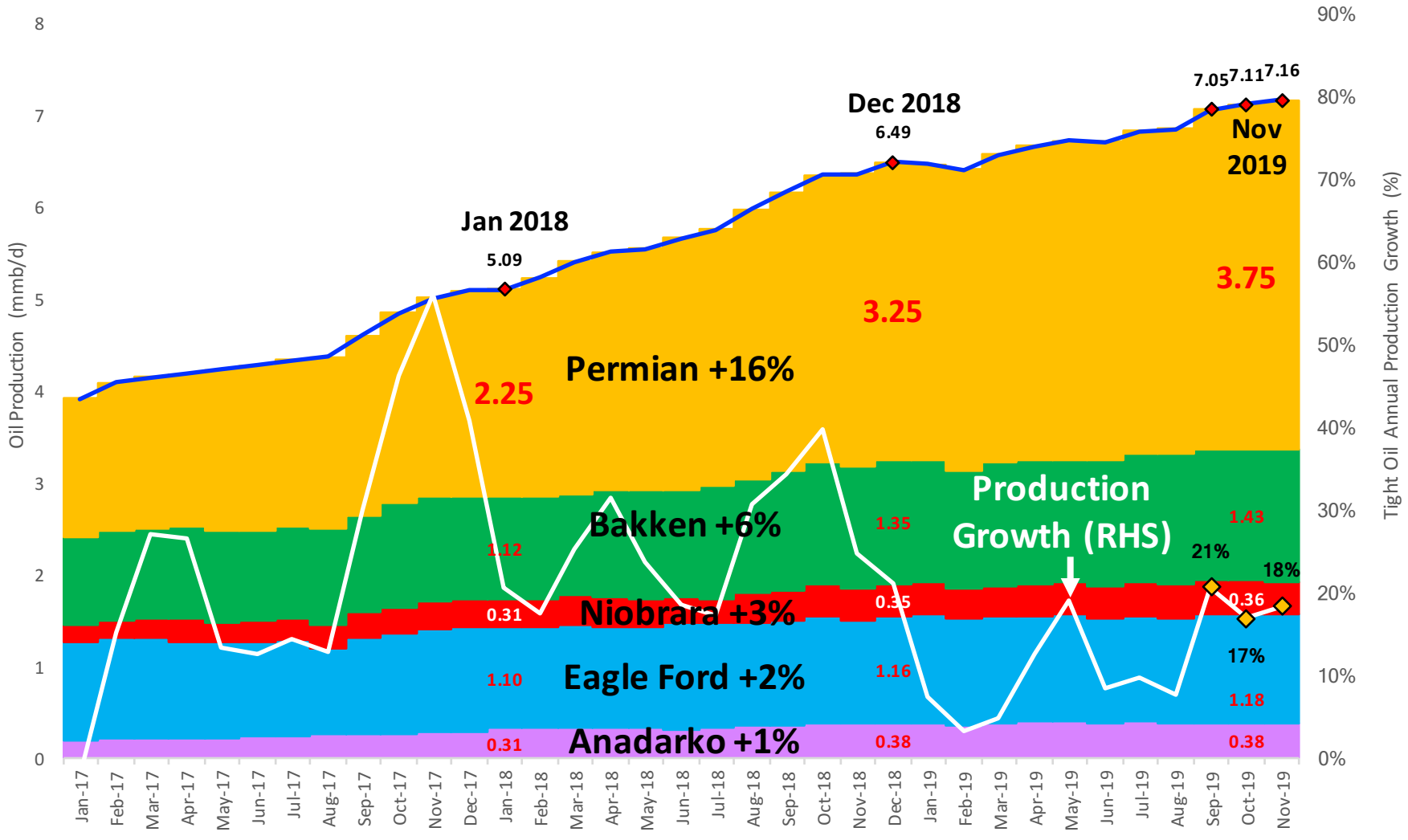
BUY LOW, SELL HIGH!

Tight oil rig count tripled (2.9x) May 2016 to Mar 2018 as WTI went from $30 to $60

It has decreased -94 since December 2018: SELL!!!



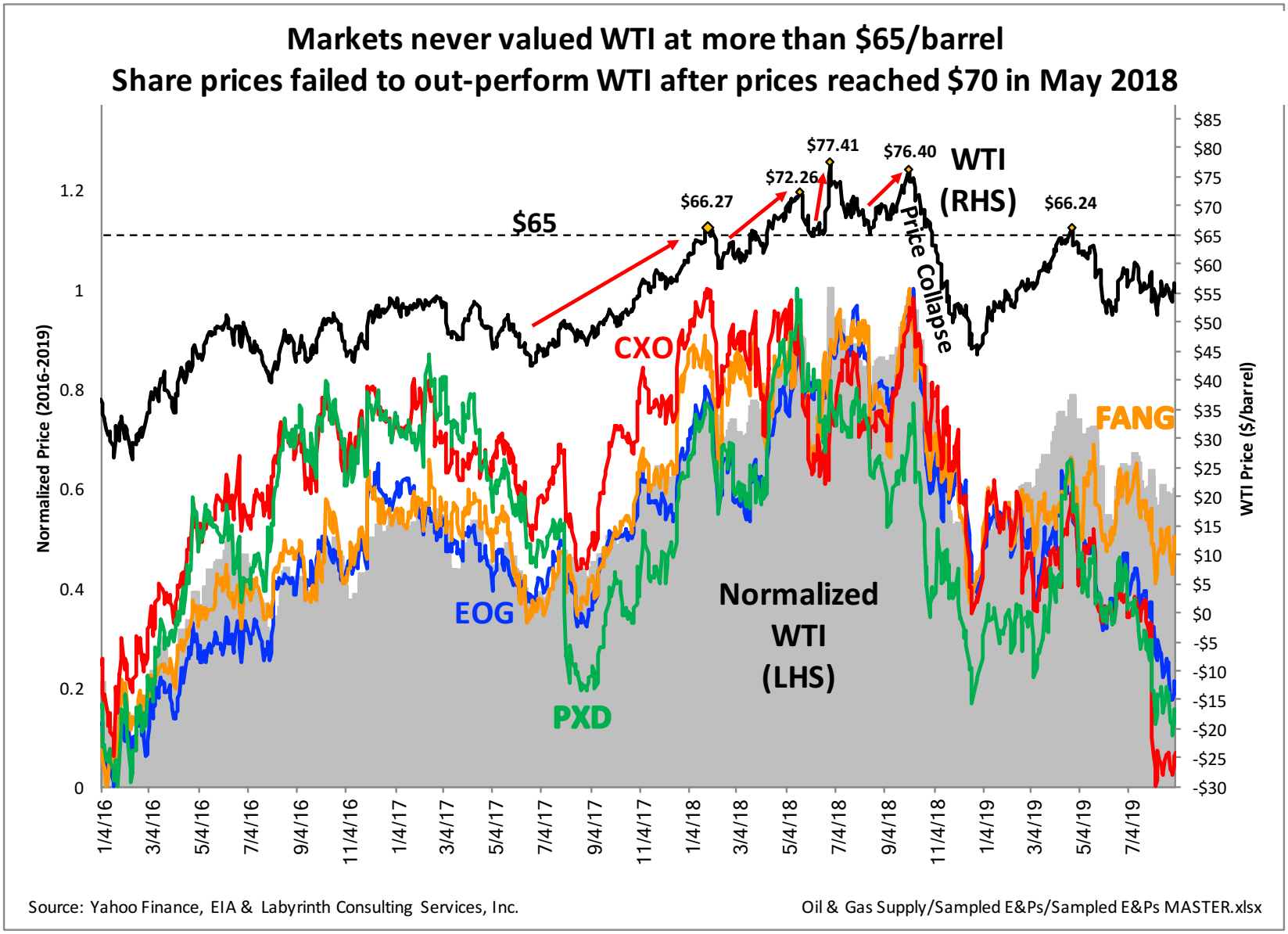
U.S. tight oil production increased from 7.05 to 7.11 mmb/d in October
Production growth is fairly flat at about 18% annualized
Most 2019 growth is in Permian (+16%) & in the Bakken (+6%)



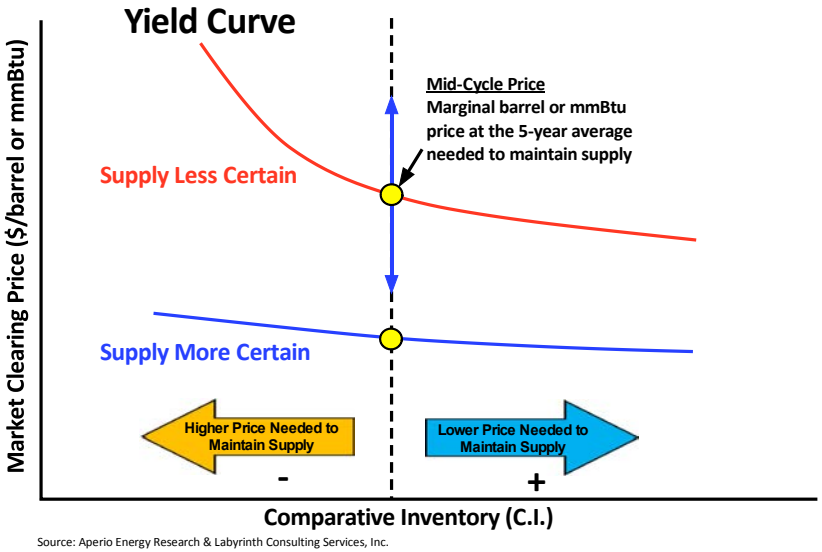
Source: EIA DPR, Drilling Info & Labyrinth Consulting Services, Inc.

EIA 2019/DUC-DPR/dpr-data_MASTER

Markets never valued WTI at more than $65/barrel
Share prices failed to out-perform WTI after prices reached $70 in May 2018



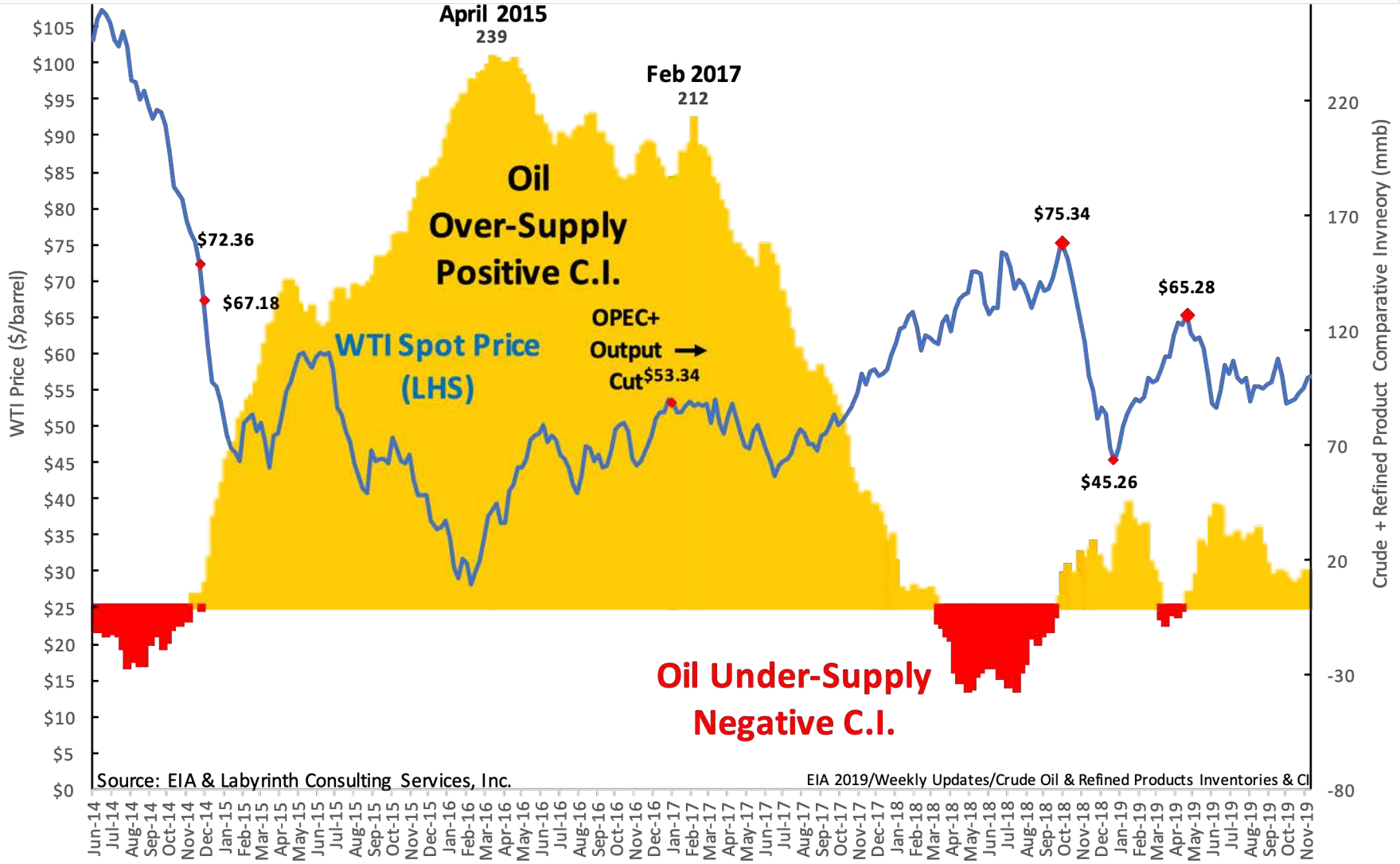
Market Clearing Price
Comparative Inventory-Price Yield Curve



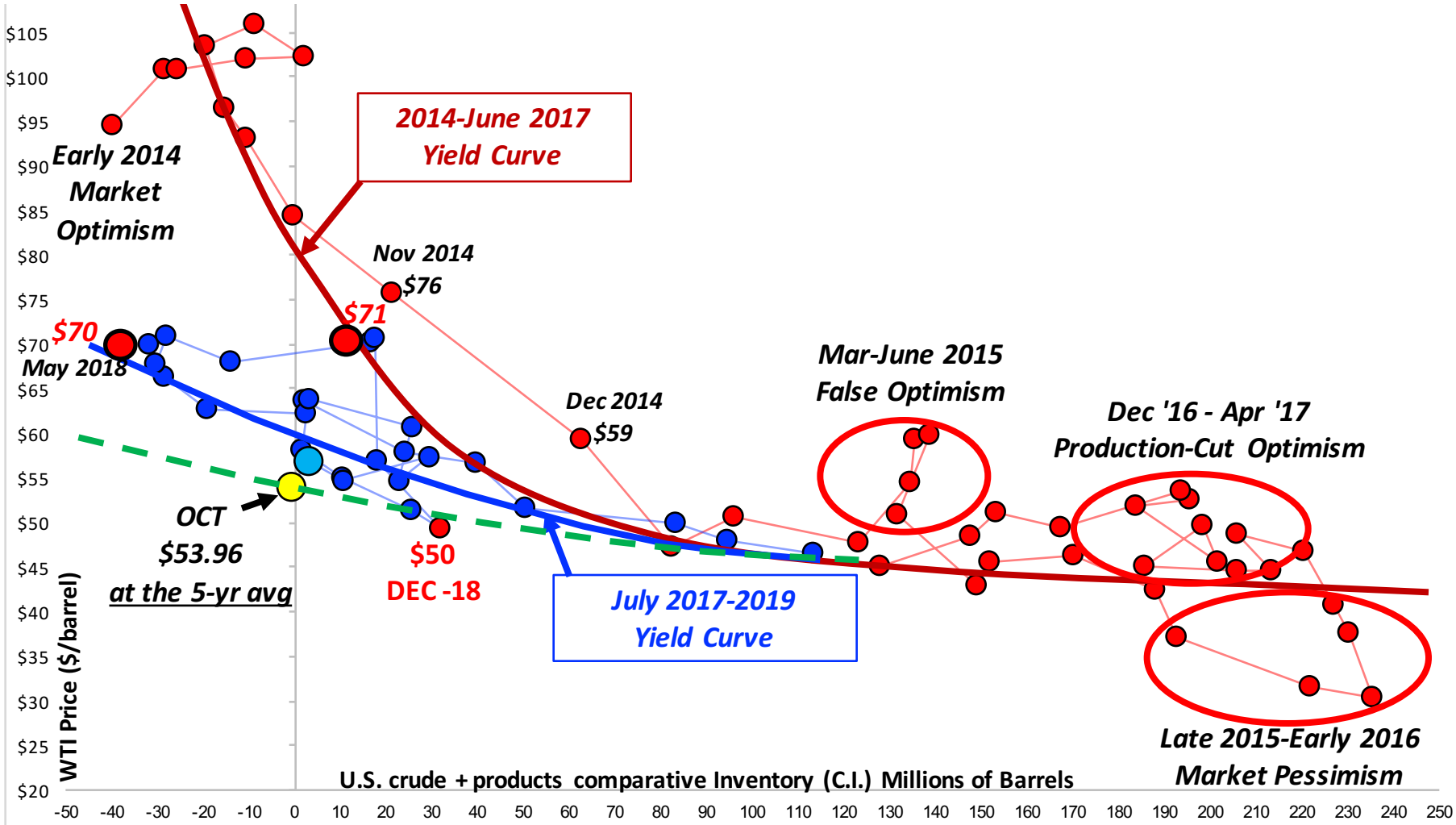
Source: Aperio Energy Research & Labyrinth Consulting Services, Inc.

- Inventory is part of supply. Demand is consumption, net imports & movements into & out of inventory.
- A cross-plot of C.I. vs price results in a yield curve.
- The comparative inventory yield curve uses C.I. instead of maturity & oil price instead of yield.
- The concept is identical.
- The yield curve crosses the y-axis at the 5-year average.
- That is the “mid-cycle” price, the market-clearing price of the marginal barrel needed to maintain supply.
- The market is short on oil price when C.I. is positive, or more than the 5-year average, & long when C.I. is negative or less than the 5-year average.
- The slope of the yield curve reflects the market’s sense of urgency about supply.

Comparative inventory accurately reflects market price response to supply & demand fundamentals



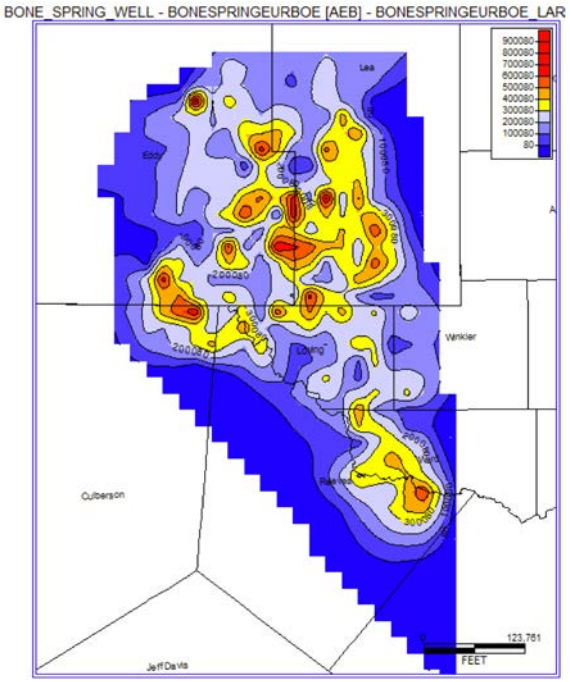
WTI comparative inventory continues to indicate $60 mid-cycle price on blue yield curve but October C.I. is at the 5-year average suggesting that price may have been devalued to the green yield curve



Source: EIA & Labyrinth Consulting Services, Inc.- Aperio Energy Research

EIA 2019/Monthly Updates/MER/ Table_3.4_Petroleum Stocks_MASTER

Good and Bad News About Permian Production



PERMIAN	Reserves (mmboe)	PUD* Reserves	NPV-10 of PUD	Break-Even Fixed Costs	Variable OPEX	Break-Even Price	PUD/Proved
PXD	565	43	$721	$48.96	$5.32	$54.28	8%
CXO	512	183	$2,202	$53.54	$5.49	$59.03	36%
FANG	462	164	$1,964	$53.56	$5.98	$59.53	35%
PE	522	210	$1,860	$56.72	$3.16	$59.88	40%
CPE	239	110	$927	$57.12	$3.14	$60.27	46%
LPI	238	21	$139	$58.97	$6.66	$65.63	9%
WTD AVG	**423**	**122**	**$1,711.59**	**$54.88**	**$4.60**	**$59.48**	**36%**

PUD = PROVED UNDEVELOPED RESERVES

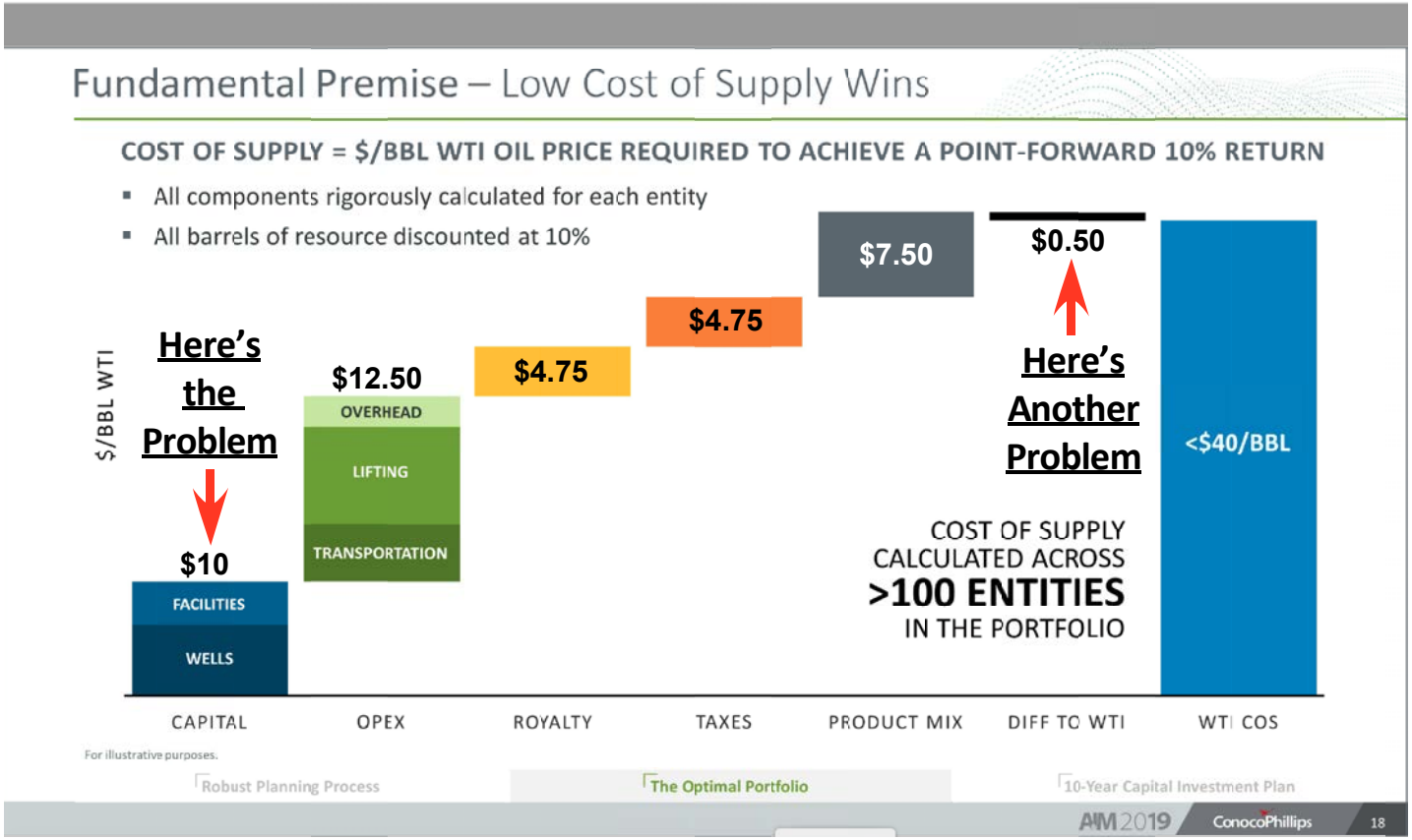
NPV-10 = NET PRESENT VALUE OF FUTURE CASH FLOWS AT A 10% DISCOUNT USING FIXED PRODUCTION COSTS ONLY

BREAK-EVEN FIXED COSTS = SEC PRICE ($65.66) - ($NPV-10/ PUD RESERVES)

BREAK-EVEN PRICE = BREAK-EVEN FIXED COSTS + VARIABLE OPEX

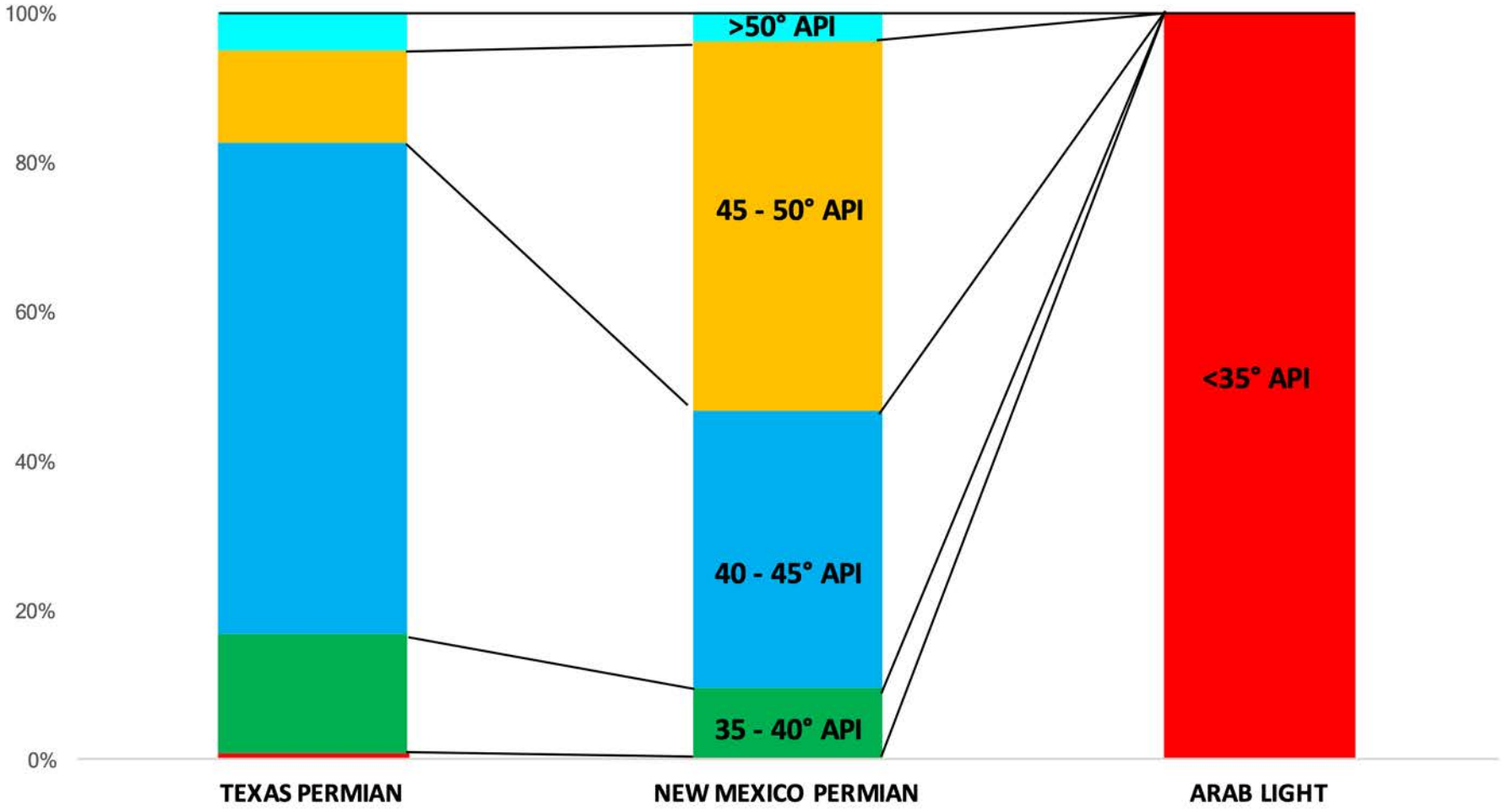
- Bone Spring evaluation indicates commercial area is 1.2 mm acres with 3,807 wells = ~300 acre/well spacing—lots of room for “Tier 1” infill.
- Average break-even price is $60/barrel based on company-stated future cash flows from proved reserves.

Keeping Them Honest



2018 10-K	Future Cash Flow	Proved Reserves	CF/boe	SEC Price	Breakeven	Variable OPEX	Break Even Price
COP	$43,363.00	4,383	$9.89	$65.56	$55.67	$4.01	$59.68

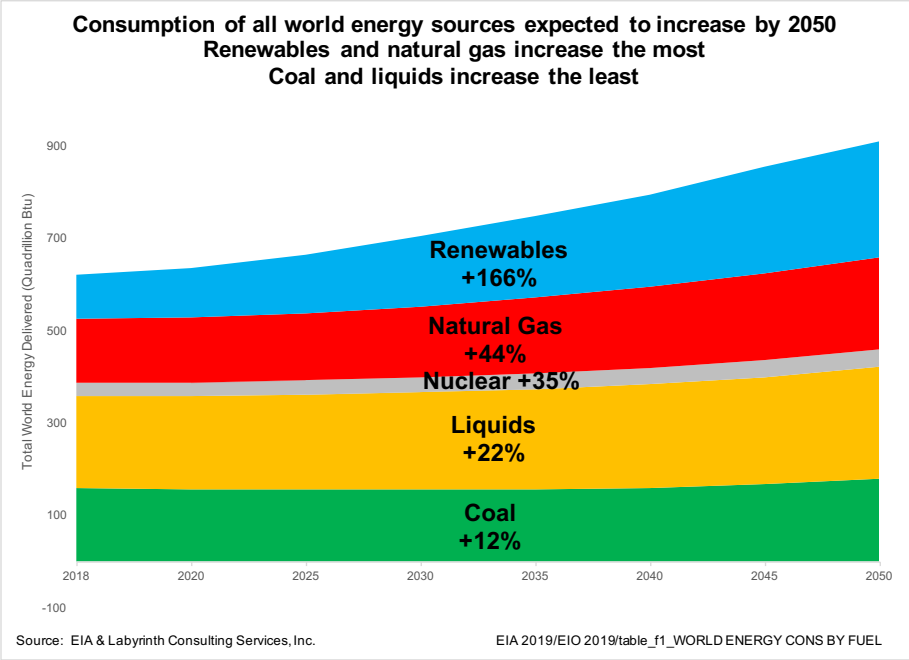
Oil Quality Matters: U.S. tight oil is ultra-light
Doesn't contain heavier molecules needed for diesel & many refined products
30-35° API gravity is average world refinery input quality
99% of Permian basin oil is lighter than 35° API gravity

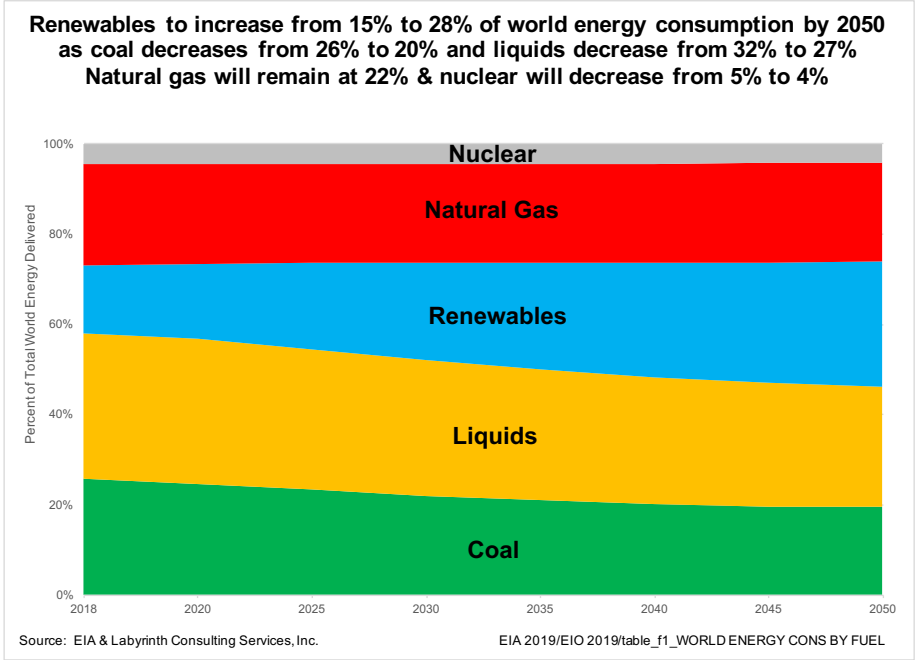


Source: Drilling Info & Labyrinth Consulting Services, Inc.

EIA 2019/Light Oil/Tight Oil API Components JAN 2018

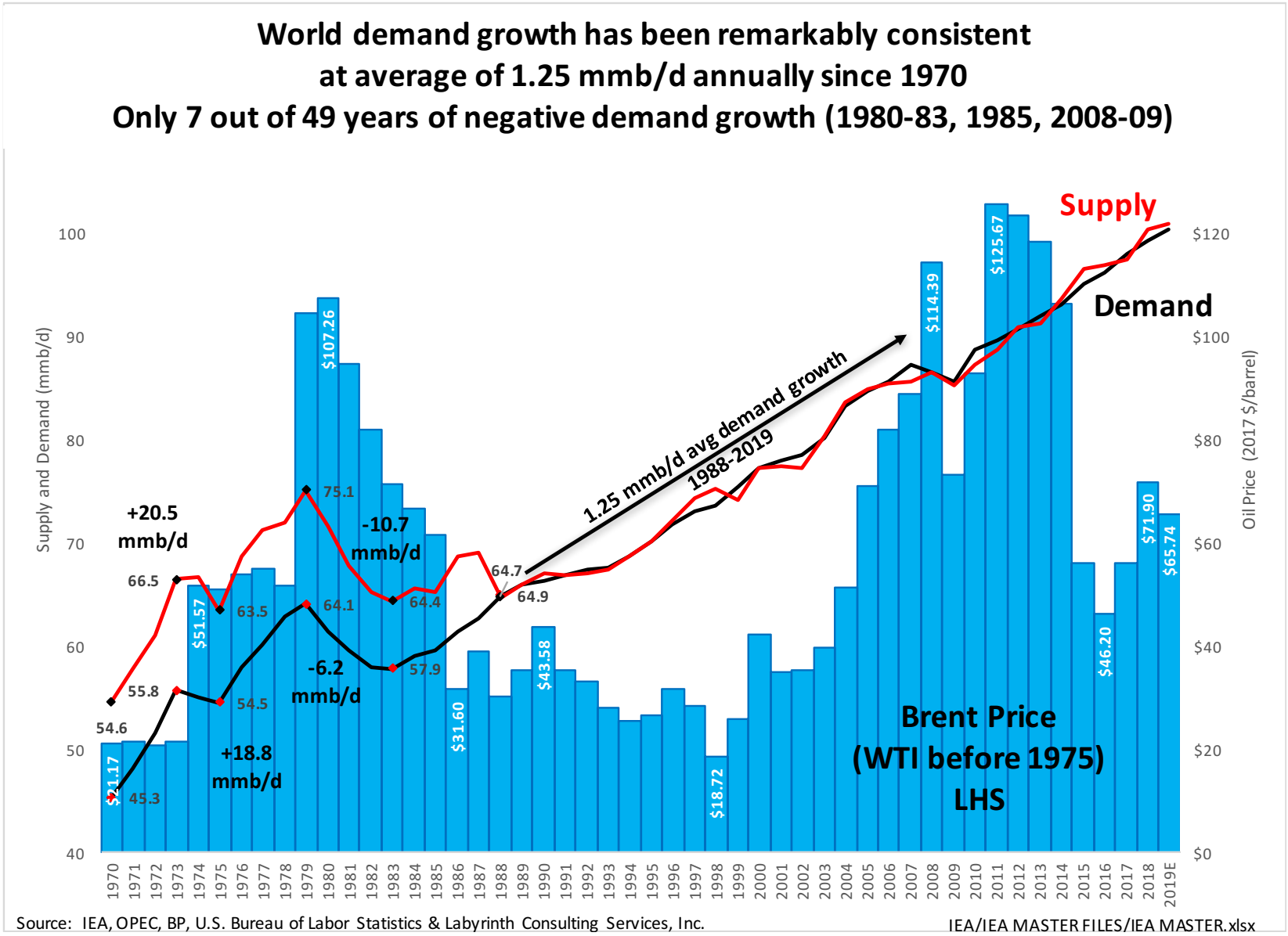
End of the Age of Oil?





- Consumption of all world energy sources expected to increase by 2050.
- Renewables and natural gas increase the most.
- Coal and liquids increase the least.
- Renewables to increase from 15% to 28% of world energy consumption by 2050.
- Coal decreases from 26% to 20% and liquids decrease from 32% to 27%.
- Natural gas will remain at 22% & nuclear will decrease from 5% to 4%.

Peak Demand?


World demand growth has been remarkably consistent
at average of 1.25 mmb/d annually since 1970
Only 7 out of 49 years of negative demand growth (1980-83, 1985, 2008-09)
Supply
Demand
Supply and Demand (mmb/d)
Oil Price (2017 $/barrel)
1.25 mmb/d avg demand growth
1988-2019
+20.5
mmb/d
-10.7
mmb/d
-6.2
mmb/d
+18.8
mmb/d
Brent Price
(WTI before 1975)
LHS
$21.17
$51.57
$107.26
$31.60
$43.58
$18.72
$114.39
$125.67
$46.20
$71.90
$65.74
54.6
55.8
66.5
63.5
75.1
64.1
54.5
64.4
57.9
64.7
64.9
45.3
Source: IEA, OPEC, BP, U.S. Bureau of Labor Statistics & Labyrinth Consulting Services, Inc.
IEA/IEA MASTER FILES/IEA MASTER.xlsx

Concluding Thoughts

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- Energy is the economy and oil is the master energy resource.
- Oil will continue to dominate the world energy landscape for decades because no other energy source can meet global needs.
- Unconventional oil has bought the world a few decades of high density energy but does not offer a meaningful long-range alternative.
- Humans have never gone from higher- to a lower-density energy source.
- While increased use of renewable energy is inevitable and desirable, it is not a satisfactory substitute for oil.
- A transition away from an oil-weighted energy supply will be complex, costly and lengthy despite supporting arguments or preferences.
- There is no clear way forward that includes sustaining current levels of energy use.
- The best path forward is to stop looking for improbable solutions that allow us to live like energy is still cheap, and find ways to live better with less.