Permian Basin & Eagle Ford Shale from a Global Perspective

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Permian Basin & Eagle Ford Shale from a Global Perspective: The Big Picture

- **Energy underpins natural systems**
  - Most people think that the economy is based on money. Money is nothing but a call on work-energy.
  - Energy is the economy.

- **There is nothing on earth like oil**
  - 1 barrel of oil = 5,700,000 BTU = 1,760 kWh: converted to work = 700kWh.
  - 1 human = 0.6kWh/day of work 700/0.6 = 1167days: **4.5 YEARS OF HUMAN WORK.**

- **The world ran out of cheap oil 20 years ago**
  - Today’s WTI oil price $71.51 is 96% higher than the average constant dollar price from 1986-2004 of $36.58.
  - That underlies most of the economic problems of today’s world.
  - The working class has figured out that their lives are much worse today than 2 decades ago & that is why Donald Trump is President of the U.S.
  - Few understand that American greatness lasted only 20 years after WWII & was a singular event.

- **Technology does not create energy**
  - It is a spigot that allows access to energy.
  - Debt has made things seem affordable by selling our energy future forward
  - This led to the miracle of tight oil & shale gas.
  - People want to believe: a few tweaks by politicians and better technology will make America great again.

- **Climate change is real & resulted mainly from over-population.**
- **There are no easy solutions except conserving what we need for the future & learning to live with less.**
Putting the Shale Revolution in Perspective

- The 1st Bubble 1974-1980: oil shocks and price increase from $23 to $117/barrel led to massive E&P investments, over-production, demand destruction & oil-price deflation until 1998.
- After the 2008 Financial Collapse, OPEC cut production then, declining OPEC spare capacity, falling OECD inventories, & near-zero interest rates—led to the longest period of high oil prices in history from 2011-2014.
- Over-investment resulted in a massive over-supply, much of it from the United States and Canada. The 2nd bubble burst in 2014 and prices collapsed.
Petroleum Age after WWII produced unprecedented economic growth.

Oil shocks of 1974-1986 threatened to end that party.

Demand destruction & oil production bubble resulted in 18 years of cheap energy.

Debt re-started economic growth & debt-based growth of China challenged oil supply after 2004.

Second oil shock made unconventional oil possible. Zero-interest rates led to 2nd oil bubble.

Longest period of high oil prices in history.

That bubble burst in 2014 and oil prices collapsed but without demand destruction.

Now, we are near the end of long-term debt cycle but in denial that the economic basics have fundamentally changed since the post-war era.
Low Interest Rates Created A Capital Bubble For Tight Oil & The Permian Basin

- The oil-price collapse coincided with the end of QE 3 and the beginning of U.S. interest rate increases.
- Continued low interest rates caused margin hunters to focus first on tight oil and then, specifically on the Permian basin.
- $30 oil prices brought large capital flows to a select group of producers seen as winners.
- Tight oil and Permian rig counts have more than doubled since August 2016. Rig counts increase with expectation of $55+ oil prices.
- Increased rig count and fear of ongoing over-supply is a major drag on oil prices.
- OPEC production cuts have balanced oil markets since early 2017 & some are now questioning the lower-for-longer paradigm that dominated the last 3 years.
The False Premise that Tight Oil Plays Are the New Swing Producer

- No factual support for widespread belief that there is a price war between OPEC & U.S. tight oil.
- OPEC/Saudi Arabia reacted pragmatically to price collapse & recovery.
- Prime directive *not* to repeat mistake of 1982-1986 production cuts.
- “Just-in-time production” is another baseless theory.
- Shale output reacts to price just like all plays—slowly & in long-period cycles.
- Idea that U.S. shale is the new swing producer of the world also has no basis.
- Being a swing producer means that there is sufficient spare capacity to turn on and off based on market signals. Shale plays have no spare capacity (they are just-in-time).
- Even if DUCs provide some spare capacity, there is no decision-making process that governs 1000s of independent producers.
Lower costs of shale production widely attributed to technology and efficiency.

Price deflation accounts for 90% of lower costs because of a depression in the oil industry; 10% is because of technology & efficiency.

That is over for now and prices increased 8% in 2017.

Shale growth has more to do with outside capital supply than break-even prices.

Investors need to believe that significantly higher prices are coming.

“Buy low, sell high” not a sophisticated concept but was responsible for capital flow into tight oil after price bottom in early 2016.

Smart money has always believed in limits to oil supply.

That will drive the next inflow of capital as markets understand the limits of tight oil supply.
Two of the Largest Tight Oil Plays are in Texas: Eagle Ford & Permian

- The Eagle Ford Shale play is expected to recover to 1.3 mmb/d by 2022 & then decline to 1.2 mmb/d by 2050.
- The Permian basin plays are anticipated to grow from 2.2 mmb/d in 2018 to more than 3.5 mmb/d by 2044 & then decline to 3.4 mmb/d by 2050.
Eagle Ford Shale Case History Provides a Different Perspective

- Top 6 Eagle Ford operators were evaluated: Chesapeake, ConocoPhillips, Devon, EOG, Marathon, & Sanchez.
- Standard rate vs time decline-curve analysis was used to match production and determine EUR (estimated ultimate recovery).
- EUR is decreasing because the play is over-drilled & wells are interfering.
- Better technology results in higher initial production rates but also higher decline rates.
- Technology does not create energy.
Belief About Improving Well Performance & Falling Break-Even Prices Re-Examined

2014 Was The Best Year for Top 6 Producers in the Eagle Ford Shale both in terms of EUR (estimated ultimate recovery) and break-even oil prices. EIA Annual Energy Outlook 2018 released in late March corroborates this. Popular belief about improving well performance & falling break-even prices must be re-examined.
2017 Well Performance Appears Even Worse Than 2016

EOG 2016 & 2017 Wells Eagle Ford Wells Have Steeper Decline Rate Than Wells From Previous Years Despite Higher Initial Production Levels

Conoco Phillips 2017 Eagle Ford Wells Have Steeper Decline Rate Than Wells From Previous Years Despite Higher Initial Production Levels

Sanchez Energy 2016 & 2017 Eagle Ford Wells Have Steeper Decline Rates Than Wells From Previous Years

Source: Drilling Info & Labyrinth Consulting Services, Inc.
This study shows that Eagle Ford wells for top operators average 300 kboe but many operators claim EURs that are considerably higher. Part of the disparity is explained by BOE conversion factors: a barrel of NGLs is counted the same as a barrel of oil even though its energy content and value are less than half of a barrel of crude oil. A 6:1 natural gas to boe conversion accurately reflects energy content but 14:1 better expresses value including NGLs. Sanchez shows how it arrives at 877 boe for an average Comanche Area well. Using the value-based approach, the average Sanchez Comanche well is 572 boe—a difference of 35%. 877 boe also represents a “3-Stream EUR” consisting of multiple zone completion in upper & lower Eagle Ford & Austin Chalk. This is somewhat misleading and represents “possible” not proven reserves. It is unclear how representative “Comanche Area 3” is of Sanchez’s average wells.
Proved Reserves vs Production Forecasts Do Not Agree

Table 2. Crude oil production and proved reserves from selected U.S. tight plays, 2015–16 (million barrels)

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<thead>
<tr>
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<tbody>
<tr>
<td>Williston</td>
<td>Bakken/Three Forks</td>
<td>ND, MT, SD</td>
<td>421</td>
<td>5,030</td>
<td>375</td>
<td>5,226</td>
<td>196</td>
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<tr>
<td>Permian</td>
<td>Bone Spring/Woodford</td>
<td>NM, TX</td>
<td>66</td>
<td>321</td>
<td>428</td>
<td>4,866</td>
<td>-6,427</td>
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<tr>
<td>Western Gulf</td>
<td>Eagle Ford</td>
<td>TX</td>
<td>565</td>
<td>4,295</td>
<td>438</td>
<td>4,163</td>
<td>-132</td>
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<tr>
<td>Anadarko</td>
<td>Woodford</td>
<td>OK</td>
<td>22</td>
<td>364</td>
<td>47</td>
<td>346</td>
<td>-6</td>
</tr>
<tr>
<td>Denver</td>
<td>Norhoto*</td>
<td>CO</td>
<td>58</td>
<td>460</td>
<td>16</td>
<td>225</td>
<td>-235</td>
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<tr>
<td>Appalachian</td>
<td>Marcellus*</td>
<td>PA, WV</td>
<td>16</td>
<td>143</td>
<td>13</td>
<td>139</td>
<td>-4</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>Barnett</td>
<td>TX</td>
<td>5</td>
<td>33</td>
<td>3</td>
<td>22</td>
<td>-11</td>
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<tr>
<td>Sub-total</td>
<td></td>
<td></td>
<td>1,153</td>
<td>11,127</td>
<td>1,298</td>
<td>15,124</td>
<td>3,997</td>
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<tr>
<td>Other tight</td>
<td></td>
<td></td>
<td>61</td>
<td>475</td>
<td>42</td>
<td>431</td>
<td>-44</td>
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<tr>
<td>U.S. tight oil</td>
<td></td>
<td></td>
<td>1,214</td>
<td>11,602</td>
<td>1,340</td>
<td>15,555</td>
<td>3,953</td>
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</table>

Notes: Includes lease condensate. Bakken/Three Forks oil includes proved reserves from shale or low-permeability formations reported on Form EIA-231. Bone Spring and Woodford includes proved reserves from shale or low-permeability formations reported on Form EIA-231, in TX, WY, CO, and NM. Other tight includes proved reserves from shale formations reported on Form EIA-231 not assigned by EIA to the Bakken/Three Forks, Barnett, Bone Spring, Eagle Ford, Marcellus, Norhoto, Woodford, or Western Gulf plays.
* The Norhoto estimate in 2016 was modified to include only proved reserves identified from shale reservoirs in the Denver basin in Colorado. The Marcellus play in this table refers only to portions within Pennsylvania and West Virginia.

- EIA estimates of Eagle Ford proved reserves have been quite stable for several years at about 4 billion barrels.
- Converting EIA’s production forecast indicates that proved reserves will be reached by 2025.
- Another 12 billion barrels will subsequently be produced at modestly increasing forecasted oil prices.
- This combined with the well performance study suggests that Eagle Ford production growth is unlikely and that reserves should be exhausted at current production rates in ~7 years.
Proved Reserves vs Production Forecasts Do Not Agree

EIA estimates of Permian proved reserves have grown but latest forecast is ~5 billion barrels.

Converting EIA’s production forecast indicates that proved reserves will be reached by 2022.

Another 36 billion barrels will subsequently be produced at modestly increasing forecasted oil prices.

This suggests that while Permian production growth is likely, reserves will be exhausted in ~4 years.
Permian Proved Reserves Are Greater than EIA 2016 Estimate

<table>
<thead>
<tr>
<th></th>
<th>2017 Proved Reserves PDP</th>
<th>2017 Proved Reserves PUD</th>
<th>TOTAL 2017 RESERVES</th>
<th>TOTAL 2017 RESERVES</th>
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<tbody>
<tr>
<td></td>
<td>kb liquids &amp; mcf gas</td>
<td></td>
<td>Barrels of Oil Equivalent</td>
<td>Barrels of Oil Equivalent</td>
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<tr>
<td></td>
<td>Oil</td>
<td>NGL</td>
<td>Gas</td>
<td>Oil</td>
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<tr>
<td>Pioneer</td>
<td>442,364</td>
<td>189,434</td>
<td>1,629,451</td>
<td>40,525</td>
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<tr>
<td>Concho</td>
<td>336,000</td>
<td>0</td>
<td>1,512,000</td>
<td>164,000</td>
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<td>Energen</td>
<td>264,297</td>
<td>166,359</td>
<td>1,110,436</td>
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<tr>
<td>Laredo</td>
<td>164,453</td>
<td>78,238</td>
<td>753</td>
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<td>Devon</td>
<td>143,907</td>
<td>52,882</td>
<td>342,616</td>
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<td>Anadarko</td>
<td>141,246</td>
<td>35,412</td>
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<td>Cimarex</td>
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<td>Apache</td>
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<td>52,550</td>
<td>131,374</td>
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<tr>
<td>EOG</td>
<td>106,668</td>
<td>30,162</td>
<td>133,116</td>
<td>154,667</td>
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<td>EP</td>
<td>87,326</td>
<td>56,887</td>
<td>476,280</td>
<td>17,872</td>
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<td>Diamondback</td>
<td>68,877</td>
<td>60,441</td>
<td>371,946</td>
<td>10,536</td>
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<tr>
<td>Parsley</td>
<td>67,542</td>
<td>7,164</td>
<td>52,325</td>
<td>53,898</td>
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<tr>
<td>RSP Permian</td>
<td>25,300</td>
<td>24,400</td>
<td>160,000</td>
<td>29,900</td>
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<td>SUB TOTAL</td>
<td>2,075,358</td>
<td>803,679</td>
<td>6,351,375</td>
<td>1,068,416</td>
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<td>TOTAL TIGHT OIL</td>
<td>4,150,716</td>
<td>1,607,358</td>
<td>12,702,750</td>
<td>2,136,831</td>
</tr>
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</table>

Source: Company 2017 10-K SEC Filings & Labyrinth Consulting Services, Inc.

- SEC 10-K filings for the largest Permian producers were used to compile company estimates of 2017 proved reserves.
- Results were scaled according to their percentage of 2017 total production.
- Crude & condensate proved reserves are estimated to be 6.3 billion barrels. All but 300 mmb of this increase were because of higher oil prices in 2017 vs. 2016.
- About 1/3 of proved reserves are undeveloped.
- This analysis suggests that at present production rates, Permian tight oil reserves will last approximately 7 years (2024).
Tight oil plays are an important, late addition to world oil supply.
Tight oil has added substantial short-term volumes that have disrupted oil markets.
Permian basin and Eagle Ford plays have respectable 3rd tier reserves compared with world producing countries.
Reserve estimates should not be taken too literally because the record of discovering new supply beyond reserve expectations has been consistent.
Still, unconventional oil was only possible with higher oil prices, zero-interest rates & massive outside capital.
Tight oil has consistently lost money & lost money in 2017.
The perception that recent prices are low must be placed in constant-dollar context.
Our rush to produce, consume and export as fast as possible is based on a false belief that supply is inexhaustible.
The assumption that a seamless transition to renewable energy is as delusional as most popular misconceptions about oil. Humans have never gone from higher to a lower density source of energy.
Energy is the economy & a lower energy density economy will be nothing like the post-WWII U.S. economy.