Tight Oil: A Solution to U.S. Import Dependence?

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The Shale Revolution

• Began with the application of high-volume, multi-stage, hydraulic-fracturing of shale for gas in the Barnett Field of eastern Texas.

• Now accounts for 40% of U.S. gas production.

• The technology was first applied to oil extraction in the Bakken Field of Montana and North Dakota.

• Allowed a 50% increase in U.S. oil production reversing the long standing decline from peak U.S. production in 1970.

• Nearly 35% of upstream investment in lower 48 exploration and development will be applied to the Bakken and Eagle tight oil plays in 2013.
Conventional Wisdom

• The United States is on the verge of Energy Independence thanks to the “SHALE REVOLUTION”.

• Shale Gas production will continue to grow for the foreseeable future (2040 at least) and prices will remain below $4.50/mcf for the next 10 years and below $6.00/mcf for the next 20 years.

• Shale Gas can replace very substantial amounts of oil for transport and coal for electricity generation.

• The way is clear for U.S. LNG exports to monetize the shale bounty.

• Tight Oil will allow U.S. production to exceed that of Saudi Arabia and U.S. imports will shrink to zero.
U.S. Natural Gas Supply Projection by Source, 2010-2040, EIA Reference Case 2013

- **LNG Imports**
- **Canada Imports**
- **Shale Gas**
- **Alaska**
- **Coalbed Methane**
- **Tight Gas**
- **Associated**
- **Conventional**
- **Offshore**

**55% increase in production by 2040**

**Exports**

**U.S. domestic consumption**

**50% of 2040 Production**

**Trillion Cubic Feet per Year**

- **Year**
  - 2010
  - 2015
  - 2020
  - 2025
  - 2030
  - 2035
  - 2040

**Shale Gas**

**Coalbed Methane**

**Tight Gas**

**Associated**

**Conventional**

**Offshore**

(data from EIA Annual Energy Outlook 2013, Tables 13 and 14, [http://www.eia.gov/forecasts/aeo/er/excel/yearbyyear.xlsx](http://www.eia.gov/forecasts/aeo/er/excel/yearbyyear.xlsx))

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Citigroup 2012 Projection of U.S. Shale Oil, 2010-2022

Source: Citi Investment Research and Analysis
U.S. Crude Oil Production Projection by Source and Region 2010-2040 (EIA 2013 Reference Case)

- Alaska
- Onshore EOR
- Onshore Shale/Tight Oil
- Lower-48 Onshore Conventional
- Lower-48 Offshore

Peak Production 2019

Million Barrels per Day

Lower-48 Offshore

Lower-48 Onshore Conventional Production

Shale/Tight Oil

Onshore EOR

Alaska

32% of 2040 Supply

2010 2015 2020 2025 2030 2035 2040

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(data from EIA Annual Energy Outlook 2013, EIA, 2012; International Monetary Fund)
U.S. Petroleum Liquids Supply by Source
2010-2040 (EIA 2013 Reference Case)

- Net Imports
- Natural Gas Liquids
- Coal and Gas to Liquids
- Biofuels
- Refinery Processing Gain
- Other Liquids and SPR
- Crude Oil Production

Net Imports 36%
Oil 32%

Million Barrels per Day
Year
2010 2015 2020 2025 2030 2035 2040

© Hughes GSR Inc, 2012
(data from EIA Annual Energy Outlook 2013, EIA, 2012; International Monetary Fund)
Shale Gas Production by Play, 2000-2012

Billion Cubic Feet per Day
Year

Other
Austin Chalk
Bone Spring
Bossier
Antrim
Niobrara
Bakken
Woodford
Eagle Ford
Fayetteville
Marcellus
Barnett
Haynesville

40% of U.S. production

© Hughes GSR Inc, 2012
(data from Drillinginfo, September, 2012, fitted with 3 month centered moving average including data up to June, 2012)
Shale Gas Production from Top Five Plays Comprising 80% of U.S. shale gas production, 2006 - 2013

Shale Gas Production (Billion cubic feet per day)

- Barnett
- Fayetteville
- Woodford
- Haynesville
- PA Marcellus
- WV Marcellus

(data from Drillinginfo, July, 2013, three month trailing moving average)
Shale Gas Production from Top Five Shale Gas Plays, 2006-June, 2013

Gas Production (Billion cubic feet per day)

- PA Marcellus
- WV Marcellus
- Woodford
- Fayetteville
- Haynesville
- Barnett

Peak Excluding PA Marcellus August 2012 Now Down 12%

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(data from DrillingInfo, October, 2013, three month trailing moving average)
Rig Count for Selected Shale Plays, 2011-2013

- Barnett
- Woodford
- Eagle Ford
- Fayetteville
- Haynesville
- Marcellus
- Williston

(data from Baker-Hughes, October, 2013)
Type Gas Well Decline Curves for Top Five Shale Gas Plays Constituting 80% of Shale Gas Production

3-Year Decline
Haynesville = 89%
Marcellus = 79%
Barnett = 79%
Fayetteville = 80%
Woodford = 77%

Average 3-Year Decline = 84%

(data from Drillinginfo, March, 2013)
Overall Field Decline for Top Five Shale Gas Plays based on Production Decline from pre-2012 Wells

Field Decline (per year)
- Haynesville = 47%
- Marcellus = 29%
- Barnett = 28%
- Fayetteville = 35%
- Woodford = 44%

Average Field Decline = 37%

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(data from Drillinginfo, March, 2013)
Barnett Well Quality
Spatial Distribution of Peak Gas Production

Peak Daily Production
mcf/day

- > 3,119 (10% of wells)
- 2,335 - 3,119 (10% of wells)
- 1,499 - 2,335 (20% of wells)
- 967 - 1,499 (20% of wells)
- 511 - 967 (20% of wells)
- < 511 (20% of wells)

Gas Play
The Shale Play Life Cycle

• Discovery followed by leasing frenzy.

• Drilling boom follows to meet “held-by-production” lease requirements.

• Sweet spots identified, targeted and drilled off.

• Gas production rises rapidly and is maintained for cash-flow despite potentially uneconomic full-cycle costs.

• Sweet spots become saturated and well quality and field production decline.

• Plays like the Haynesville become middle aged after just five years.
Horizontal Well Quality Trends – Top Five Shale Gas Plays

- Marcellus – Youth
- Fayetteville – Early Middle Age
- Barnett – Middle Age
- Haynesville – Late Middle Age
- Woodford – Early Old Age

Average Initial Productivity per Well Indexed to 2010

© Hughes GSR Inc, 2013
(data from Drillinginfo, March, 2013)
Crude Oil and Other Liquids Production by Shale Play – mid 2012

Top 2 Plays = 81% of Total
Top 5 Plays = 92% of Total

(data from HPDI, September, 2012, for production in most cases through May-June, 2012)
Bakken/Three Forks Oil Production and Number of Operating Wells, 2005-2013

© Hughes GSR Inc, 2013
(data from Drillinginfo, October, 2013, three month trailing moving average)
Bakken/Three Forks Type Oil and Barrels of Oil Equivalent Well Decline Curves Including Montana and North Dakota

Oil Decline
First Year = 70%
Second Year = 34%
Third Year = 23%
Fourth Year = 21%

3-Year Decline = 84%

Oil Production
BOE Production

© Hughes GSR Inc, 2013
(data from Drillinginfo, October, 2013)
Bakken Field Production Decline – Oil Production from all Wells Drilled Prior to 2012

First Year Field Decline = 44%

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(data from Drillinginfo, October, 2013)
Bakken and Three Forks
Type Oil Well Decline Curves in North Dakota

First Year = 71%
Second Year = 34%
Third Year = 22%
Fourth Year = 23%

Bakken

First Year = 70%
Second Year = 39%
Third Year = 25%
Fourth Year = 23%

Three Forks

3-Year Decline
Bakken = 86%
Three Forks = 85%

(data from Drillinginfo, October, 2013)

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Bakken/Three Forks Production By County, North Dakota and Montana, June, 2013

Total Production = 787 Kbbls/day
Top 2 counties = 52% of production
Top 4 counties = 85% of production

Production (Thousands Barrels per day)

<table>
<thead>
<tr>
<th>County</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mountrail (ND)</td>
<td>192</td>
</tr>
<tr>
<td>McKenzie (ND)</td>
<td>207</td>
</tr>
<tr>
<td>Williams (ND)</td>
<td>111</td>
</tr>
<tr>
<td>Dunn (ND)</td>
<td>168</td>
</tr>
<tr>
<td>Divide (ND)</td>
<td>98</td>
</tr>
<tr>
<td>Remaining ND counties</td>
<td>65</td>
</tr>
<tr>
<td>Richland (MT)</td>
<td>53</td>
</tr>
<tr>
<td>Remaining MT counties</td>
<td>25</td>
</tr>
</tbody>
</table>

© Hughes GSR Inc, 2013
(data from Drillinginfo, October, 2013)
Bakken/Three Forks Type Oil Well Decline Curves by County and Region

- Divide (ND)
- Dunn (ND)
- McKenzie (ND)
- Mountrail (ND)
- Williams (ND)
- Other ND Counties
- Richland (MT)
- Other MT Counties

(data from Drillinginfo, October, 2013)
Bakken/Three Forks Estimated Ultimate Recovery per Well
By County, North Dakota and Montana (over 30-year life)

Cumulative Production (Thousand Barrels)

- Mountrail (ND)
- McKenzie (ND)
- Williams (ND)
- Dunn (ND)
- Divide (ND)
- Remaining ND counties
- Richland (MT)
- Remaining MT counties

47% to 61% of oil is recovered in first four years

All wells hit stripper status within 11-24 years (10 barrels per day)

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(data from Drillinginfo, October, 2013)
Bakken Average First Year Well Production by County and Region, 2008-2012

Average First Year per Well Production (Barrels/day)

- Mountrail (ND)
- McKenzie (ND)
- Williams (ND)
- Dunn (ND)
- Divide (ND)
- Other ND Counties
- Richland (MT)
- Other MT Counties
- ND Average
- MT Average
- Bakken Average

© Hughes GSR Inc, 2013
(data from Drillinginfo, October, 2013)
Rig Count for Selected Shale Plays, 2011-2013

- Barnett
- Woodford
- Eagle Ford
- Fayetteville
- Haynesville
- Marcellus
- Williston

(data from Baker-Hughes, October, 2013)
Horizontal Well Development in the Parshall Area
Sweet Spot of the Bakken

© Hughes GSR Inc, 2013 (data from North Dakota DNR, 2013)
Bakken Oil Production - Declining Drilling Rate Scenario, (2000 wells/year declining to 1000 wells/year), 2005-2035

- Peak Year: 2015 - 2016
- Max Number of Wells: 25,974
- Total production: 5 billion bbls
- Last Well Drilled: 2026

Oil Production (Thousand Barrels/day)

Number of Producing Wells
Bakken Oil Production - Constant Drilling Rate Scenario, (2000 wells/year), 2005-2035

Max Number of Wells = 26474
Total production = 5.2 billion bbls
Peak Year = 2017
Drilling rate = 2000 wells/y

Peak 2017
Last Well Drilled 2023

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(data from Drillinginfo, October, 2013)
Bakken Oil Production - Declining Drilling Rate Scenario, Risked at 80% for locations versus Unrisked, 2005-2035

Risked Wells = 21474
Unrisked Wells = 25974
Risked total production = 4.5 billion bbls
Unrisked total production = 5.0 billion bbls.
Max Drilling rate = 3500 wells/y
Final Drilling rate = 2000 wells/y

Peak 2015

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(data from Drillinginfo, October, 2013)
Eagle Ford Gas and Oil Well Distribution through mid-2013

© Hughes GSR Inc, 2013
(data from Drillinginfo, October 2013)
Eagle Ford Type Oil and Barrels of Oil Equivalent Well Decline Curves

Oil Decline
First Year = 59%
Second Year = 29%
Third Year = 76%
Fourth Year = 58%

3-Year Decline = 91%

(data from Drillinginfo, October, 2013)
**Eagle Ford Field Production Decline – Oil Production from all Wells Drilled Prior to 2012**

First Year Field Decline = 34%

- **Total Oil Production**
- **Number of pre-2012 Wells**

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(data from Drillinginfo, October, 2013)
Eagle Ford Well Distribution through mid-2013

(data from Drillinginfo, October 2013)
Eagle Ford Oil Production By County, June, 2013

Total Production = 749 Kbbls/day
Top 2 counties = 36% of production
Top 5 counties = 75% of production

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(note that this is 79% of total liquids production, the balance being NGLs; data from Drillinginfo, October, 2013)
Eagle Ford Type Oil Well Decline Curves by County and Region

Oil Production (Barrels per Day)

- Dewitt
- Karnes
- Gonzales
- Dimmit
- Lasalle
- Other Counties

(data from Drillinginfo, October, 2013)

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Eagle Ford Average First Year Well Production by County and Region, 2008-2012

Average First Year per Well Production (Barrels/day)

Year

2009 2010 2011 2012

Eagle Ford Average Dewitt

Dewitt

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(data from Drillinginfo, October, 2013)
Eagle Ford Oil Production - Declining Drilling Rate Scenario, (3500 wells/year declining to 2000 wells/year), 2008-2035

Max Number of Wells = 45302
Total production = 7.3 billion bbls
Peak Year = 2017
Max Drilling rate = 3500 wells/y
Final Drilling rate = 2000 wells/y

© Hughes GSR Inc, 2013
(data from Drillinginfo, October, 2013)
Eagle Ford Oil Production - Constant Drilling Rate Scenario, (3500 wells/year), 2008-2035

- Max Number of Wells = 45302
- Total production = 7.5 billion bbls
- Peak Year = 2017
- Drilling rate = 3500 wells/y

Last Well Drilled 2024
Pea k 2018

(data from Drillinginfo, October, 2013)
Eagle Ford Oil Production - Declining Drilling Rate Scenario, Risked at 80% for locations versus Unrisked, 2008-2035

Risked Wells = 37052
Unrisked Wells = 45302
Risked total production = 6.3 billion bbls
Unrisked total production = 7.5 billion bbls.
Max Drilling rate = 3500 wells/y
Final Drilling rate = 2000 wells/y

(data from Drillinginfo, October, 2013)
Bakken and Eagle Ford Oil Production – Declining Drilling Rate Risked at 80% for locations, 2005-2035

Bakken Risked Wells = 21474
Eagle Ford Risked Wells = 37052
Bakken risked total production = 4.5 billion bbls
Eagle Ford risked total production = 6.5 billion bbls.
Max Drilling rate = 5500 wells/y
Final Drilling rate = 3000 wells/y

Eagle Ford

Bakken

Peak 2016
There is no such thing as a FREE LUNCH

There has been a great deal of pushback by many in the general public – and in State and National governments – to environmental issues surrounding hydraulic fracturing.

(eg. Global Frackdown held October 19, 2013, involving 250 protests in 26 countries)
A Reality Check?

"We are all losing our shirts today. We're making no money. It's all in the red."
(Rex Tillerson, CEO of Exxon Mobil, Wall Street Journal, June 2012)

The United States oil and gas industry has “over fracked and over drilled”
(Mattihus Bichsel, projects and technology director, Royal Dutch Shell Plc., October 17, 2013)

Shell writes down $2.2 billion in shale assets and puts Eagle Ford properties up for sale
(Reuters September 30, 2013)
Tight Oil Takeaways

• Tight oil production from the top two plays is likely to peak in 2016-2017 timeframe.

• High field decline rates mandate sustained high levels of drilling to maintain production.

• Increasing drilling rates over current levels in the Bakken and Eagle Ford, which account for one third of U.S. E&P investment, would only increase peak production slightly and move it forward by perhaps a few months.

• Increases in the number of available drilling locations will increase ultimate recovery but will not change the timing of peak production at current drilling rates.

• High quality shale plays are not ubiquitous:
  • 88% of shale gas production comes from 6 of 30 plays.
  • 70% of tight oil production comes from 2 of 21 plays.
Implications for the U.S.

- The “Shale Revolution” has been a “game-changer” in that it has temporarily reversed a terminal decline in supplies from conventional sources. Long-term sustainability is highly questionable and environmental impacts are a major concern.

- Almost all eggs are in the shale basket as a hope in meeting U.S. energy supply growth projections from oil and gas.

- US “Energy Independence” and freedom from oil imports with the forecast energy consumption trajectory is highly unlikely, barring a radical reduction in consumption.

- The “Shale Revolution” has provided a temporary respite from declining oil and gas production, but should not be viewed as a panacea for increasing energy consumption – and exporting the bounty. Rather, it should be used as an opportunity to create the infrastructure needed for a lower energy throughput and alternative energy sources.