Changing International Landscape of Global Oil and Natural Gas Impacts of U.S. Shale

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American Petroleum Institute
“Changes call for innovation, and innovation leads to progress”  Li Keqiang – Premier of China

“The times they are a changin’”  
Bob Dylan – American Poet

“Ch-Ch-Changes – turn and face the strange”  
David Bowie – International Poet
US Crude Oil Production

Peaked in 1970

Growth in Texas and North Dakota

Average 2008: 5.0 MMbbl/d
Average 2015: 9.4 MMbbl/d

+4.4 MMbbl/d 88%

Source: EIA
US Natural Gas Marketed Production

Peak – early 70’s

Decline – 2000 to 2005

Shale Revolution Begins 2006 – (Barnett in Texas)

+50 %
Changing US Oil Landscape
Reduced Our Net Imports

Source: EIA
Changing US Natural Gas Landscape
US LNG Terminals

55 Proposed LNG Terminals
(43 in the U.S.)
US Oil and Natural Gas Short Term Outlook

Will US Production Increase?

Recent oil peak – Early 2015

Source: EIA Short Term Outlook – March 2016
Oil Rig Count vs Spot Price (WTI)

2014 to Today
Price -70%
Rigs -75%
Production -6%
(from 2015 peak)

Source: EIA, Baker Hughes
Gas Rig Count vs Spot Price (HH)

Source: EIA, Baker Hughes
We went from “Hunting” Traps to “Farming” Source Rocks

**Cap Rock**
Nonporous
Nonpermeable

**Reservoir**
Porous and Permeable

**Source Rock**
Carbon Rich
Good Stuff = 150 – 350 Million years old
Example:
Why this is a game changer

In 1983 Harold Hamm drilled 17 dry holes in a row - almost went bankrupt.

Continental Resources has drilled over 1,000 wells in the Bakken since 2009.
All producers.
Efficiency is Key to Winning the Shale Game

Geology is similar across wide areas.
vs. conventional

Core vs. noncore

Two main ways:
Increase production per well (better Fracking)

Keep costs down.
(better drilling)

Hydraulic fracturing is not new – it has been done for the last 60 years. We are just getting better at it therefore it is becoming more common.
Oil Rig Productivity

Bakken Region
New-well oil production per rig

Source: EIA Drilling Productivity Report
ND Industrial Commission

More Wells per Rig
2011 - 1,528 wells - 182 rigs - 8 w/r/yr
2015 - 1,363 wells - 91 rigs – 15 w/r/yr
Source: EIA Drilling Productivity Report
Pennsylvania DEP

Same Wells per Rig
2011 - 1,958 wells - 101 rigs - 19 w/r/yr
2015 - 758 wells - 40 rigs - 19 w/r/yr

Natural Gas Rig Productivity
Main short-term drivers of US oil and natural gas production?

Oil – World oil price

Natural gas - Markets
The gas needs a place to go.
Short Run Oil Price Projection
EIA and NYMEX

Source: EIA, Short-Term Energy Outlook, February 2016
World Growth Petroleum Liquids Consumption between 1 and 1.5 MMBbld / year

Source: EIA, Short-Term Energy Outlook, February 2016
Global OECD Crude Oil Storage Inventories

End of 2017 - 3,300 Million Barrels

Average 2,650 Million Barrels

Projection +650 Million Barrels above historical averages.
Does not include Non OECD Storage.

Source: EIA Short-term Energy Outlook
Long - Run Oil Price Projection  
IEA, EIA

<table>
<thead>
<tr>
<th>Energy Information Administration</th>
<th>2020</th>
<th>2040</th>
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<tbody>
<tr>
<td>Reference Case 2015</td>
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<td>High Resource Case</td>
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<tr>
<td>Low Oil Price</td>
<td>$58</td>
<td>$76</td>
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<table>
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<th>International Energy Agency</th>
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<td>New Policies</td>
<td>$80</td>
<td>$128</td>
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<tr>
<td>Low Oil Price</td>
<td>$50-$60</td>
<td>$85</td>
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API does not forecast commodity prices.
Long - Run Natural Gas Price Projection

Natural Gas is priced regionally not globally

IHS estimates that the US has 1,400 Tcf of natural gas resource that can be developed at $4 /MMBtu or less with current technology

High resource case most likely scenario

Source: EIA Annual Energy Outlook 2015
Optimistic projection for US crude oil production

Source: EIA Annual Energy Outlook 2015
Optimistic projection for US natural gas production

Source: EIA Annual Energy Outlook 2015
US will need Oil and Natural Gas Over 60% of US Energy in 2040

Source: EIA, Annual Energy Outlook 2015 Reference case
One of many reputable global energy forecasts.
  • Exact numbers are not important – look for general trends.

Includes both energy policies that have been adapted by 2015 and proposed policies not yet implemented.

Includes pledges from countries leading up to the 2015 climate conference in Paris.

Includes Clean Power Plan in the US
Fossil fuel subsidies are phased out in all countries that have promised to do so.

Real price increases in residential and electricity for places such as Russia. Equalize domestic and export fossil fuel prices.

Energy market reforms in China and other price controlled markets.

Various country renewable energy targets.

Various country energy efficiency programs – cars, buildings, industrial etc.
The World will need Oil and Natural Gas Over 50% of Energy Use in 2040


The US will be part of the solution
US will increasingly become a larger trader in crude and refined products

AEO 2015 assumed export ban still in place. Potential crude oil trade by 2040
Net crude Imports 4 to 7.5 MMbbl/d
2.5 - 3 MMbbl/d export / 7-10 MMbbl/d import

US crude will trade light sweet out with heavy sour in – even if US is a net importer

Source: EIA, Annual Energy Outlook 2015
US Refined Products Imports and Exports

Source: EIA, Annual Energy Outlook 2015

Potential Trade 8-14 MMbbl/d

Trade 1975 2 MMbbl/d
Trade 2015 6 MMbbl/d

US became a net exporter in 2011

High Resource
Net Imports
Exports

Net Imports
Imports
Exports
US will become a major LNG Exporter with pipeline exports to Mexico

Source: EIA Annual Energy Outlook 2015 – Reference Case
North American Approved LNG Export Terminals

Import Terminals

U.S.
APPROVED - UNDER CONSTRUCTION - FERC
1. Corpus Christi, TX: 0.4 Bcf/d (Cheniere – Corpus Christi LNG) (CP12-507)

APPROVED – NOT UNDER CONSTRUCTION - FERC
2. Salinas, PR: 0.6 Bcf/d (Aguirre Offshore GasPort, LLC) (CP13-193)

APPROVED – NOT UNDER CONSTRUCTION - MARAD/Coast Guard
3. Gulf of Mexico: 1.0 Bcf/d (Main Pass McMoRan Exp.)
4. Gulf of Mexico: 1.4 Bcf/d (TORP Technology-Bienville LNG)

Export Terminals

U.S.
APPROVED - UNDER CONSTRUCTION - FERC
5. Sabine, LA: 2.76 Bcf/d (Cheniere/Sabine Pass LNG) (CP11-72 & CP14-12)
6. Hackberry, LA: 1.7 Bcf/d (Sempra-Cameron LNG) (CP13-25)
7. Freeport, TX: 1.8 Bcf/d (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction) (CP12-503)
8. Cove Point, MD: 0.82 Bcf/d (Dominion–Cove Point LNG) (CP13-113)
9. Corpus Christi, TX: 2.14 Bcf/d (Cheniere – Corpus Christi LNG) (CP12-507)
10. Sabine Pass, LA: 1.40 Bcf/d (Sabine Pass Liquefaction) (CP13-552) ★

APPROVED – NOT UNDER CONSTRUCTION - FERC
11. Lake Charles, LA: 2.2 Bcf/d (Southern Union – Lake Charles LNG) (CP14-120)

Canada
APPROVED – NOT UNDER CONSTRUCTION
12. Port Hawkesbury, NS: 0.5 Bcf/d (Bear Head LNG)
13. Kitimat, BC: 3.23 Bcf/d (LNG Canada)
14. Squamish, BC: 0.29 Bcf/d (Woodfibre LNG Ltd)

★ Trains 5 & 6 with Train 5 under construction

7 approved by both DOI and FERC 12.8 Bcfd capacity
25 Additional Proposed LNG Export Terminals
(22 in the U.S.)

PROPOSED TO FERC
Pending Applications:
1. Astoria, OR: 1.25 Bcf/d (Oregon LNG) (CP09-6)
2. Elba Island, GA: 0.35 Bcf/d (Southern LNG Company) (CP14-103)
3. Lake Charles, LA: 1.07 Bcf/d (Magnolia LNG) (CP14-347)
4. Sabine Pass, TX: 2.1 Bcf/d (ExxonMobil – Golden Pass) (CP14-517)
5. Pascagoula, MS: 1.5 Bcf/d (Gulf LNG Liquefaction) (CP15-521)
6. Freeport, TX: 0.34 Bcf/d (Freeport LNG Dev) (CP15-518)
7. Cameron Parish, LA: 1.41 Bcf/d (Venture Global Calcasieu Pass) (CP15-550)
8. Hackberry, LA: 1.41 Bcf/d (Sempra - Cameron LNG) (CP15-560)

Projects in Pre-filing:
10. Plaquemines Parish, LA: 0.30 Bcf/d (Louisiana LNG) (PF14-17)
11. Robinston, ME: 0.45 Bcf/d (Kestrel Energy – Downeast LNG) (PF14-19)
12. Jacksonville, FL: 0.075 Bcf/d (Eagle LNG Partners) (PF15-7)
13. Brownsville, TX: 0.54 Bcf/d (Texas LNG Brownsville) (PF15-14)
14. Brownsville, TX: 0.94 Bcf/d (Anona LNG Brownsville) (PF15-15)
15. Port Arthur, TX: 1.4 Bcf/d (Port Arthur LNG) (PF15-18)
16. Brownsville, TX: 3.6 Bcf/d (Rio Grande LNG – NextDecade) (PF15-20)
17. Freeport, TX: 0.72 Bcf/d (Freeport LNG Dev) (PF15-25)
18. Corpus Christi, TX: 1.4 Bcf/d (Cheniere – Corpus Christi LNG) (PF15-26)
21. Cameron Parish, LA: 1.84 Bcf/d (G2 LNG) (PF16-2)

PROPOSED TO U.S.-MARAD/COAST GUARD
22. Gulf of Mexico: 1.8 Bcf/d (Deflin LNG)

PROPOSED CANADIAN SITES
23. Kitimat, BC: 1.28 Bcf/d (Apache Canada Ltd.)
24. Douglas Island, BC: 0.23 Bcf/d (BC LNG Export Cooperative)
25. Prince Rupert Island, BC: 2.74 Bcf/d (Pacific Northwest LNG)
Global Oil and Natural Gas Forecast by Region
## Global Regional Petroleum Consumption - MMbbls/d

<table>
<thead>
<tr>
<th>Region</th>
<th>1990</th>
<th>2013</th>
<th>2020</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD Americas</td>
<td>19.8</td>
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<td>22.7</td>
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<tr>
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<td>6.5</td>
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<td>Eurasia</td>
<td>10.1</td>
<td>5.1</td>
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<td>OECD Asia</td>
<td>7.2</td>
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<tr>
<td>Asia</td>
<td>6.9</td>
<td>21.6</td>
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<td>2.9</td>
<td>7.5</td>
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<td>11.3</td>
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<tr>
<td>Africa</td>
<td>1.9</td>
<td>3.8</td>
<td>4.7</td>
<td>6.6</td>
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<tr>
<td>Total</td>
<td>65.2</td>
<td>87.2</td>
<td>93.6</td>
<td>100.4</td>
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* Includes crude oil and natural gas plant liquids

**Source:** IEA World Energy Outlook 2015 – New Policies Scenario
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<tr>
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<td>0.5</td>
<td>0.9</td>
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<td>6.0</td>
<td>7.9</td>
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Net Regional Imports
Petroleum - MMbbl/d

Net Regional Exports
Petroleum - MMbbld

Global Petroleum Flow

Takeaways

• Non-OECD Asia is the **only** net regional growth import market (India and China)
  +5 MMbbl/d by 2020, +18 MMbbl/d by 2040

• The Western Hemisphere (North and South America) could become a net petroleum exporter by 2020

• North America could become a net exporter of petroleum by 2040
  • US – switches from customer only to both a customer and supply competitor

• The Middle East will likely remain the major export region for the next several decades – their customers may change.
### Global Regional Natural Gas Consumption – Bcf/d

<table>
<thead>
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<tbody>
<tr>
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<td>62</td>
<td>89</td>
<td>97</td>
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<td>Europe</td>
<td>31</td>
<td>49</td>
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<td>Eurasia</td>
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<td>67</td>
<td>65</td>
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<td>Asia</td>
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<td>113</td>
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<td>Middle East</td>
<td>9</td>
<td>41</td>
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<td>72</td>
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<td>Africa</td>
<td>3</td>
<td>12</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>201</td>
<td>340</td>
<td>371</td>
<td>498</td>
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</table>

*Source: IEA World Energy Outlook 2015 – New Policies Scenario*
### Global Regional Natural Gas Production – Bcf/d

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<td>101</td>
<td>118</td>
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<tr>
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Net Regional Imports
Natural Gas (Pipe & LNG) – Bcf/d

Net Regional Exports
Natural Gas (Pipe & LNG) – Bcf/d

Global Natural Gas Flow
Takeaways

• Non-OECD Asia (China and India) is the major growth markets. Europe needs more natural gas through a combination of increases in demand and reductions in supply (North Sea). Asia in not the only game in town.

• Australia reduces net regional imports to OECD Asia – significant regional supplier.

• Eurasia (Russia and other Caspian suppliers) pipeline exports remain the major interregional natural gas supplier through 2040.

• North America is a significant LNG supplier in the future.
National Security

General Martin Dempsey, Chairman of the Joint Chiefs of Staff:

“An energy independent [U.S.] and net exporter of energy as a nation has the potential to change the security environment around the world – notably in Europe and in the Middle East. And so, as we look at our strategies for the future, I think we’ve got to pay more and particular attention to energy as an instrument of national power. And because it will very soon in the next few years potentially become one of our more prominent tools.”
Questions?
US Shale Development's and the US Economy
Shale Development’s Impact on the US Economy

- **IHS - America’s New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy; Volume 3: A Manufacturing Renaissance – September 2013**

  **Key Findings:**

  - **Total Supported Employment:**
    - 2.1 million jobs supported in 2012 (500K direct)
    - 3.9 million jobs supported in 2025 (800K Direct)
      - Including 515,000 manufacturing jobs
    - Jobs tend to high quality and high paying ($35/hr vs. $23/hr in general economy)
  
  - **Capital Expenditures:**
    - $121 billion in 2012, rising to $240 billion by 2025
    - $2.75 trillion in capex cumulative between 2012 and 2025
  
  - **Gross Domestic Product Impact**
    - $284 billion in value added contributions in 2012 (US GDP $16 Trillion)
    - Increases to $533 billion / year in 2025
# Shale Development’s Impact Goes beyond Producing States

## Unconventional Oil and Gas Producing States: Top 10 Employment Contributions*

<table>
<thead>
<tr>
<th>State</th>
<th>2012</th>
<th>2020</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas</td>
<td>576,084</td>
<td>929,482</td>
<td>733,179</td>
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<tr>
<td>Pennsylvania</td>
<td>102,668</td>
<td>220,635</td>
<td>387,360</td>
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<tr>
<td>California</td>
<td>96,553</td>
<td>153,658</td>
<td>187,270</td>
</tr>
<tr>
<td>Louisiana</td>
<td>78,968</td>
<td>97,418</td>
<td>150,903</td>
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<tr>
<td>Colorado</td>
<td>77,622</td>
<td>121,398</td>
<td>175,363</td>
</tr>
<tr>
<td>North Dakota</td>
<td>71,824</td>
<td>114,240</td>
<td>57,267</td>
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<tr>
<td>Oklahoma</td>
<td>65,325</td>
<td>149,617</td>
<td>225,387</td>
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<tr>
<td>Utah</td>
<td>54,421</td>
<td>51,859</td>
<td>67,052</td>
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<tr>
<td>Ohio</td>
<td>38,830</td>
<td>143,595</td>
<td>266,624</td>
</tr>
<tr>
<td>Arkansas</td>
<td>33,100</td>
<td>52,539</td>
<td>56,418</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1,195,396</strong></td>
<td><strong>2,034,442</strong></td>
<td><strong>2,306,822</strong></td>
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### Producing Total

<table>
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<tr>
<th>State</th>
<th>2012</th>
<th>2020</th>
<th>2035</th>
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<tbody>
<tr>
<td>New York</td>
<td>44,429</td>
<td>74,007</td>
<td>78,645</td>
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<tr>
<td>Illinois</td>
<td>38,652</td>
<td>66,604</td>
<td>82,817</td>
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<tr>
<td>Michigan</td>
<td>37,848</td>
<td>64,551</td>
<td>78,632</td>
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<tr>
<td>Missouri</td>
<td>37,716</td>
<td>64,228</td>
<td>70,794</td>
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<tr>
<td>Florida</td>
<td>36,532</td>
<td>65,063</td>
<td>79,499</td>
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<tr>
<td>Wisconsin</td>
<td>19,760</td>
<td>33,112</td>
<td>35,976</td>
</tr>
<tr>
<td>New Jersey</td>
<td>19,753</td>
<td>34,455</td>
<td>40,537</td>
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<tr>
<td>Minnesota</td>
<td>19,103</td>
<td>34,815</td>
<td>42,691</td>
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<tr>
<td>North Carolina</td>
<td>18,665</td>
<td>32,477</td>
<td>37,439</td>
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<tr>
<td>Georgia</td>
<td>18,505</td>
<td>32,458</td>
<td>38,771</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>290,963</strong></td>
<td><strong>501,771</strong></td>
<td><strong>585,801</strong></td>
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### Non-Producing Total

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<th>State</th>
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<tbody>
<tr>
<td>Top 10 Total</td>
<td>474,144</td>
<td>816,563</td>
<td>955,491</td>
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## Unconventional Oil and Gas Non-Producing States: Top 10 Employment Contributions*

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<tr>
<td>Texas</td>
<td>576,084</td>
<td>929,482</td>
<td>733,179</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>102,668</td>
<td>220,635</td>
<td>387,360</td>
</tr>
<tr>
<td>California</td>
<td>96,553</td>
<td>153,658</td>
<td>187,270</td>
</tr>
<tr>
<td>Louisiana</td>
<td>78,968</td>
<td>97,418</td>
<td>150,903</td>
</tr>
<tr>
<td>Colorado</td>
<td>77,622</td>
<td>121,398</td>
<td>175,363</td>
</tr>
<tr>
<td>North Dakota</td>
<td>71,824</td>
<td>114,240</td>
<td>57,267</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>65,325</td>
<td>149,617</td>
<td>225,387</td>
</tr>
<tr>
<td>Utah</td>
<td>54,421</td>
<td>51,859</td>
<td>67,052</td>
</tr>
<tr>
<td>Ohio</td>
<td>38,830</td>
<td>143,595</td>
<td>266,624</td>
</tr>
<tr>
<td>Arkansas</td>
<td>33,100</td>
<td>52,539</td>
<td>56,418</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,195,396</strong></td>
<td><strong>2,034,442</strong></td>
<td><strong>2,306,822</strong></td>
</tr>
</tbody>
</table>

### Producing Total

<table>
<thead>
<tr>
<th>State</th>
<th>2012</th>
<th>2020</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>44,429</td>
<td>74,007</td>
<td>78,645</td>
</tr>
<tr>
<td>Illinois</td>
<td>38,652</td>
<td>66,604</td>
<td>82,817</td>
</tr>
<tr>
<td>Michigan</td>
<td>37,848</td>
<td>64,551</td>
<td>78,632</td>
</tr>
<tr>
<td>Missouri</td>
<td>37,716</td>
<td>64,228</td>
<td>70,794</td>
</tr>
<tr>
<td>Florida</td>
<td>36,532</td>
<td>65,063</td>
<td>79,499</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>19,760</td>
<td>33,112</td>
<td>35,976</td>
</tr>
<tr>
<td>New Jersey</td>
<td>19,753</td>
<td>34,455</td>
<td>40,537</td>
</tr>
<tr>
<td>Minnesota</td>
<td>19,103</td>
<td>34,815</td>
<td>42,691</td>
</tr>
<tr>
<td>North Carolina</td>
<td>18,665</td>
<td>32,477</td>
<td>37,439</td>
</tr>
<tr>
<td>Georgia</td>
<td>18,505</td>
<td>32,458</td>
<td>38,771</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>290,963</strong></td>
<td><strong>501,771</strong></td>
<td><strong>585,801</strong></td>
</tr>
</tbody>
</table>

### Non-Producing Total

<table>
<thead>
<tr>
<th>State</th>
<th>2012</th>
<th>2020</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 10 Total</td>
<td>474,144</td>
<td>816,563</td>
<td>955,491</td>
</tr>
</tbody>
</table>

### Notes

*The rank for all years is based on the 2012 ranking.

Source: IHS Global Insight
Shale Gas Development’s Benefits to Consumers

Lower natural gas and electricity prices plus additional household income:

In 2012: $1,200 per household ($163 billion US Total)

Rising to:

$3,500 per household in 2025.

Shale Revolution Saves Consumers $’s at the Pump

Impacts on crude oil and gasoline

Without US Shale from 2008 to 2013:

• Crude oil prices per barrel would have averaged $122 to $150 in 2013 – an increase of $12 to $40.

• Gasoline and other refined products would have been $0.29 to $0.94 per gallon higher.

U.S. consumers saved an estimated $63 to $248 billion in 2013. From 2008 to 2013, the cumulative savings for U.S. consumers ranged from $165 to $624 billion.

Source: U.S. Oil Impacts: The Impacts of Horizontal Multi-stage Hydraulic Fracturing Technologies on Historical Oil Production, International Oil Costs, and Consumer Petroleum Product Costs
Eagle Ford – South Texas

Satellite Photo of activity

225 Rigs operating
Additional Questions?

Thank You..
Additional Slides
US Major Shale Crude Oil Plays

Current and prospective resources and basins in the continental US
US Major Shale Natural Gas Plays

Current and prospective resources and basins in the continental US
Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through December 2015 and represent EIA's official tight oil & shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).
The US is #1 in natural gas production and total liquids production (just behind Saudi Arabia in crude production)
Improved Technology Provides Economic Results

- Horizontal drilling and directional drilling allow drillers to consolidate gas wells onto one small pad site – resulting in as much as a 90% reduction in overall surface presence.
- By confining production to one pad site, companies are able to reduce the number of access roads and pipelines needed to service dozens of wells.
- Wells are initially drilled vertically from the surface but then branch out underground to tap the gas-bearing rock deep below.

Conventional vertical drilling requires many wells spaced out over a wide area to effectively produce oil or gas.
Frac Jobs Don't Contaminate Groundwater!

Marcellus Mapped Frac Treatments - Ohio and Pennsylvania

Hydraulic fracturing fluid is 99.5% water and sand.

### Fracturing Fluid Components

<table>
<thead>
<tr>
<th>Compound</th>
<th>Purpose</th>
<th>Common application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids</td>
<td>Helps dissolve minerals and initiate fissure in rock (pre-fracture)</td>
<td>Swimming pool cleaner</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>Allows a delayed breakdown of the gel polymer chains</td>
<td>Table salt</td>
</tr>
<tr>
<td>Polyacrylamide</td>
<td>Minimizes the friction between fluid and pipe</td>
<td>Water treatment, soil conditioner</td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Prevents scale deposits in the pipe</td>
<td>Automotive anti-freeze, deicing agent, household cleaners</td>
</tr>
<tr>
<td>Borate Salts</td>
<td>Maintains fluid viscosity as temperature increases</td>
<td>Laundry detergent, hand soap, cosmetics</td>
</tr>
<tr>
<td>Sodium/Potassium Carbonate</td>
<td>Maintains effectiveness of other components, such as crosslinkers</td>
<td>Washing soda, detergent, soap, water softener, glass, ceramics</td>
</tr>
<tr>
<td>Glutaraldehyde</td>
<td>Eliminates bacteria in the water</td>
<td>Disinfectant, sterilization of medical and dental equipment</td>
</tr>
<tr>
<td>Guar Gum</td>
<td>Thickens the water to suspend the sand</td>
<td>Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces</td>
</tr>
<tr>
<td>Citric Acid</td>
<td>Prevents precipitation of metal oxides</td>
<td>Food additive; food and beverages; lemon juice</td>
</tr>
<tr>
<td>Isopropanol</td>
<td>Used to increase the viscosity of the fracture fluid</td>
<td>Glass cleaner, antiperspirant, hair coloring</td>
</tr>
</tbody>
</table>
Timeline of a Well

**EXPLORATION**
3-5 years

**PLANNING**
12 – 18 months

**SITE & WELL CONSTRUCTION**
2-3 months

**HYDRAULIC FRACTURING**
3 – 5 DAYS

**PRODUCTION**
30 + Years
What is the surface impact after hydraulic fracturing?

Before

After

Reclaimed Marcellus Horizontal Well Site
Key federal regulations governing shale development include:

- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act
- National Environmental Policy Act
- Resource Conservation and Recovery Act
- Emergency Planning and Community Right to Know Act
- Endangered Species Act
- Occupational Safety and Health Act
Natural gas generates more electricity from less land than other power sources.

Natural gas has the smallest footprint of any energy source.

Acres of land needed to produce the fuel and generate enough electricity to serve 1,000 households for one year

- Natural Gas: 0.3 Acres
- Coal: 0.4 Acres
- Biomass: 0.8 Acres
- Nuclear: 1.2 Acres
- Wind: 6 Acres
- Solar: 6 Acres

Source: R.W. Beck and Black and Veatch for NGSA
Crude oils are **NOT** the same.

Crude varies in weight and sulfur content.
Each refinery

---

**Crude Oil Characterisation**

- **Light Sweet**: Brent, Low sulphur 0.32, Low Carbon Residue, Low Ni and V
- **Light Sour**: Arab Light, High Sulphur 1.78, Med Carbon Residue, High Ni and V
- **Heavy Sweet**: Daqing, Low Sulphur 0.1, Low Carbon Residue, Low Ni and V
- **Heavy Sour**: Arab Heavy, High Sulphur 2.79, High Carbon Residue, High Ni and V

---

**Comparison of Refinery Yields by Crude Type**

- API 42
- API 39
- API 31
- API 27
- API 21
- API 32

The graph shows the percentage of different refinery products (Resid, Cat Feed, Distillate, Gasoline, C3/C4) for each API gravity range.