Shale Gas and Tight Oil Development: A Game Changer for the U.S. Energy Markets and the Rest of the World

for
Gasification Technologies Council
October 30th, 2012| Washington, DC

by
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Industry Economist
Primary energy use by fuel, 1980-2035
…in absolute terms, all fuels grow except petroleum liquids

U.S. energy consumption
quadrillion Btu

Source: EIA, Annual Energy Outlook 2012
Shale gas offsets declines in other U.S. natural gas production sources

U.S. dry gas production
trillion cubic feet per year

Source: EIA, Annual Energy Outlook 2012

Aloulou Fawzi
Gasification Technologies Council, Washington, DC, October 30th, 2012
Underground sources of oil and natural gas
North American shale plays
(as of May 2011)

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Shale gas production can grow rapidly once access, technology, market, labor, water and environmental issues are addressed.

**Barnett**


**Eagle Ford**


*Aloulou Fawzi*

Gasification Technologies Council, Washington, DC, October 30th, 2012
Domestic production of shale gas and tight oil has grown dramatically over the past few years.

Sources shale gas: LCI Energy Insight gross withdrawal estimates as of September 2012 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play. 

Source tight oil: Drilling Info (formerly HPDI), Texas RRC, North Dakota department of mineral resources, and EIA, through June 2012.
## Foreign joint venture investment in U.S. shale plays

<table>
<thead>
<tr>
<th>Foreign Partner</th>
<th>Country</th>
<th>Domestic Partner</th>
<th>Shale Play</th>
<th>Amount ($B)</th>
<th>Year</th>
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Source: EIA, from trade press reports as of August 2nd 2012

Aloulou Fawzi
Gasification Technologies Council, Washington, DC, October 30th, 2012
Initial assessment of shale gas resources in 48 major shale basins in 32 countries indicates a large potential

The shale gas & tight oil technology story is only beginning, with much yet to be written.
Proved reserves of oil and natural gas are only a small part of technically recoverable resources

- **Technically recoverable resources**: estimated volumes of oil and natural gas that is technically producible using currently available technologies and industry practices.
  - includes inferred any yet-to-be discovered resources
  - no economic test

- **Proved reserves**: volumes of oil and natural gas that geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions
The shale gas & tight oil uncertainty

• **Uncertainty** is illustrated through scenario analysis of key variables
  - resource volume, how well we understand geology characteristics, productivity of wells across a play and over time, and how many wells can be drilled
  - Technically Recoverable Resources is only one measure of production potential
  - others considerations include: depth, access, labor and infrastructure availability, which all play a role in the cost of production
U.S. crude oil and natural gas resource uncertainty

• The AEO2012 contains 3 scenarios of alternative resource estimates for domestic oil and gas resources. Estimates vary by play.

• The *Low Estimated Ultimate Recovery (EUR)* case assumes that the EUR per tight oil or shale gas well is 50 percent lower than in the Reference case.

• The *High EUR* case assumes that the EUR per tight oil or shale gas well is 50 percent higher than in the Reference case.

• In the *High Technically Recoverable Resources (TRR)* case, the well spacing for all tight oil and shale gas plays is increased, and the EUR per tight oil or shale gas well is assumed to be 50 percent higher than in the Reference case.
Multiple factors have contributed to crude oil resource estimate increases over the years

U.S. crude oil and lease condensate resources in non-prohibited areas

billions of barrels

AEO Edition

- Unproved Alaska
- Unproved L48 Offshore (1)
- Unproved Tight Oil (2)
- Unproved Other L48 Onshore
- Proved Reserves
- Cumulative production since 2000

(1) Prior to AEO2009, resources in Pacific, Atlantic, and Eastern GOM OCS were under moratoria and not included.

(2) Includes shale oil. Prior to AEO2011, tight oil is included in unproved other lower-48 onshore category.

Source: EIA, Annual Energy Outlook 2012
Technically recoverable resources are dynamic and reflect the changing understanding of geology, technology and economics.

U.S. dry gas resources
trillion cubic feet

- **Unproved shale gas**
- **Unproved other gas (including Alaska* and offshore)**
- **Proved reserves (all types and locations)**
- **Cumulative production since 2000**

*Alaska resource estimates prior to AEO2009 reflect resources from the North Slope that were not included in previously published documentation.

Source: EIA, Annual Energy Outlook 2012

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**Technical Details**

- **AEO Edition**
- **Cumulative production since 2000**
- **2000**: 2,203
- **2001**: 482
- **2002**: 1,449
- **2003**: 273
- **2004**:
- **2005**:
- **2006**:
- **2007**:
- **2008**:
- **2009**:
- **2010**:
- **2011**:
- **2012**:

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Uncertainty surrounding shale gas resource estimates can result in significantly different futures for natural gas production.

U.S. dry natural gas trillion cubic feet per year

Source: EIA, Annual Energy Outlook 2012
U.S. imports of liquid fuels fall due to increased domestic production – including biofuels – and greater efficiency

U.S. liquid fuels consumption
million barrels per day

Source: EIA, Annual Energy Outlook 2012
U.S. natural gas price projections vary based on resource base assumptions but do not reach pre-recession levels

Lower-48 average natural gas wellhead price

2010 dollars per thousand cubic feet

Source: EIA, Annual Energy Outlook 2012
Levelized electricity costs for new power plants, excluding subsidies, 2020 and 2035

Costs for new U.S. electricity power plants
2010 cents per kilowatthour

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<thead>
<tr>
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<th>2020</th>
<th>2035</th>
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<tr>
<td>Natural gas combined cycle</td>
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Capital costs | Fixed costs | Variable costs, including fuel | Incremental transmission costs

Source: EIA, Annual Energy Outlook 2012
U.S. natural gas, wind and other renewables account for the vast majority of capacity additions from 2010 to 2035

2010 capacity

- Coal: 313 gigawatts (30%)
- Nuclear: 101 gigawatts (10%)
- Hydropower*: 101 gigawatts (10%)
- Other renewables: 17 gigawatts (2%)
- Natural gas: 350 gigawatts (34%)
- Other fossil: 111 gigawatts (11%)

1,037 gigawatts

Capacity additions 2010 to 2035

- Natural gas: 129 gigawatts (58%)
- Wind: 28 gigawatts (13%)
- Other renewables: 35 gigawatts (16%)
- End-use coal: 6 gigawatts (3%)
- Other fossil: 1 gigawatt (0.4%)
- Hydropower*: 4 gigawatts (2%)
- Nuclear: 10 gigawatts (4%)
- Coal: 10 gigawatts (5%)

222 gigawatts

* Includes pumped storage

Source: EIA, Annual Energy Outlook 2012
U.S. becomes a net natural gas exporter in 2022

U.S. dry natural gas (trillion cubic feet)

History | 2010 | Projections

Net imports, 2010: 11%

Consumption

Domestic production

Net exports, 2035: 5%

Source: EIA, Annual Energy Outlook 2012
U.S. dependence on imported petroleum declines … moves even lower in various “side case” scenarios.

U.S. liquid fuel supply
million barrels per day

Source: EIA, Annual Energy Outlook 2012
Oil prices (LLS) in the Reference case rise steadily; the AEO2012 includes a wide range of oil prices

annual average price of light low sulfur (LLS) crude oil
real 2010 dollars per barrel

Source: EIA, Annual Energy Outlook 2012
Ratio of low-sulfur light crude oil price to natural gas price, 1990-2035

Source: EIA, Annual Energy Outlook 2012

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Energy-related CO$_2$ emissions never get back to pre-recession levels in the AEO2012 Reference case

Energy-related CO$_2$ emissions never get back to pre-recession levels in the AEO2012 Reference case.

Energy carbon dioxide emissions
billion metric tons

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<th>History</th>
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<td>2035</td>
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</table>

*Source: EIA, Annual Energy Outlook 2012*
Some questions to consider:

What is possible? What are the risks?

• What do we know, and don’t know, about the resources?

• What is the possible rate and magnitude of production?
  – What is the breakeven cost, or profitability that is driving the industry?
  – What is the possibility that we aim too low or have overlooked some better prospects?
  – What are the technology factors that either could be improved upon, or have already been improved upon, to achieve that growth?

• What, if anything, is standing in the way of achieving the full potential of shale gas and tight oil?
  – Labor, access to resources, pipeline or rail capacity, refinery capacity and type
For more information


Short-Term Energy Outlook | www.eia.gov/steo

Annual Energy Outlook | www.eia.gov/aeo

International Energy Outlook | www.eia.gov/ieo

Monthly Energy Review | www.eia.gov/mer

World Shale Gas Resources: An Initial Assessment | www.eia.gov/analysis/studies/worldshalegas/

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