Update on U.S. Natural Gas Markets and Industry: January 2015

Benjamin Schlesinger and Associates, LLC
3 Bethesda Metro Center, Suite 700
Bethesda, Maryland 20814

UNECE Committee on Sustainable Energy
Group of Experts on Natural Gas
Shale gas production has increased quickly in North America, changing pipeline flows.

Source: EIA Administrator Adam Sieminski, 9/22/2014; from state administrative data collected by DrillingInfo Inc. Data are through July 2014 and represent EIA’s official tight oil & shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).
Increasingly productive Marcellus/Utica shales are now supplying 24% US market.

<table>
<thead>
<tr>
<th>Natural Gas Supplies (Dry)</th>
<th>Potential Production, Bcm</th>
<th>Est. Recoverable, Tcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yamal</td>
<td>310-350</td>
<td>16.7</td>
</tr>
<tr>
<td>Bovanenkovo (alone)</td>
<td>220</td>
<td>4.9</td>
</tr>
<tr>
<td>Marcellus/ Utica</td>
<td>190 (February 2015)</td>
<td>12.8</td>
</tr>
<tr>
<td>Qatar</td>
<td>159 (2013)</td>
<td>25.1</td>
</tr>
</tbody>
</table>

US Energy Dept. has approved 85 mtpa of LNG exports.

Issue: How much LNG will the US actually export?

- DOE has now approved about 85 mtpa of exports to non-FTA countries and South Korea.
- Deprived of grounds for rejection by its own studies, DOE recently announced suspension of further LNG export approvals to projects that have not been granted facilities certification from the FERC.
- FERC is likely to approve environmentally acceptable projects for which bone fide sponsors will assume commercial risk.
- The market, not the regulators, will decide: Global markets, with low oil-indexed prices, may reduce US LNG exports well below approved levels.

Source: BSA 2015, from BP 2014 Statistical Review.
Shale gas production has reduced spot gas prices at most North American hubs.

Alberta, $2.65
Rockies, $3.12
Southern California Gas, $3.27
So. Texas, $3.08
Henry Hub, $3.19
Dominion Hub, $1.75
New England, $11.67

Source: BSA 2015, January 2015 hub prices from Platts Inside FERC’s Gas Market Report; note: Dominion refers to Dominion Appalachia (South Point), New England refers to Tennessee Gas Pipeline, Zone 6.
Recent Items of Interest


- January 2014 – Pennsylvania Department of Environmental (DEP) issues findings from two-year study, concluding “there is little potential for harm to workers or the public from radiation exposure due to oil and gas development.” See [http://www.portal.state.pa.us/portal/server.pt/community/oil___gas_related_topics/20349/radiation_protection/986697](http://www.portal.state.pa.us/portal/server.pt/community/oil___gas_related_topics/20349/radiation_protection/986697).

Benjamin Schlesinger and Associates, LLC
The Bethesda Gateway
3 Bethesda Metro Center, Suite 700
Bethesda, MD 20814
Phone: (301) 951-7266  Fax: (301) 951-3381
Visit us at www.BSAenergy.com
Global shale gas development potential is estimated to exceed 200 Tcm.
Market expectations of oil price uncertainty have increased in recent months.
Natural gas burns 2x up to 2,590x cleaner than coal, and cleaner than oil as well.

Source: EIA - Natural Gas Issues and Trends 1998
Over 500 drillers report fluids on Frac-Focus, as required by all top producing states.

- First hydraulic fracturing in the 1940s.
- Since then, the process has become routine, used on over 1 million producing wells.
- As the technology continues to develop and improve, operators now fracture as many as 35,000 wells of all types (vertical and horizontal, oil and natural gas) each year.
- 55,978 well sites report fluid contents to FracFocus.

Source: FracFocus website.
EPA investigations show nearly all groundwater contamination pre-exists fracking.

- Shale seams co-located with conventional gas, but lie far below groundwater tables.
- Shell, Range Resources and other drillers are recycling return waters in TX, PA.
- Drillers in arid regions are increasingly using waterless and air fracking systems.
- State environmental laws and the CWA prevent dumping of return wastes.
- What pathways are left? Operator error! Well bores?

Methane leakage from shale ops can be minimized through “green completions.”

- EDF completed in 2014 the first of 16 methane leakage investigations.
- UT, WVU, CSM, NOAA staff, and others are involved in this series.
- Initial findings of high methane leakage rates (from over-flights) were found to be greatly overstated.
- Obama Administration and producing states are adopting regulations based on EDF’s work.
- Gas producers, pipelines, distributors and users can and are tightening methane handling to minimize leakage.
Some near-term surplus gas is replacing coal in aging power plants.

Source: BSA 2012, coal plants in 20 Northeast and Mid-West states from EIA, plus Ontario; map from AEP.
The good news: Replacing old coal with new gas reduces CO₂ emissions by 63-72%.

| 2009 | 50 | 12 | 0.5 | 67.7% |
| 2010 | 54 | 35 | 1.5 | 69.4% |
| 2011 | 62 | 31 | 2.5 | 63.3% |
| 2012 | 56 | 57 | 8.9 | 63.9% |
| 2013 | 55 | 14 | 2.1 | 71.7% |
| 2014 | 57 | 34 | 4.7 | 64.4% |
| 2015 | 57 | 61 | 9.9 | 63.1% |

GHG reduction due to:
- Chemical advantage: Gas burning emits 46% less CO₂ than coal.
- Efficiency advantage of new gas CCGTs versus old coal boilers: 55-60% vs. 31-33%.
- Carbon emissions savings from fuel cycle as well.

Other criteria air emissions reduced/prevented, especially sulfur, particulates, oxidants.

But the “low-hanging fruit” might all be picked by 2020.

Source: BSA 2012, from EIA and Siemens data.
Natural gas (CNG and LNG) has begun to find markets trucking, rail and ships.

But natural gas demand in vehicles will take decades to evolve in the US.

Source: Westport Innovations Inc., Vancouver, BC.
Issue: Why doesn’t America have 20 million NGVs by now?

- Economics have been highly favorable for 3 decades!
- Natural gas is best used in large vehicles, high-mileage fleets:
  - Municipal trucks, buses
  - UPS, Dulles Flyer
  - Forklifts, compressors
- Lower mileage personal vehicles are headed toward electricity:
  - $4 pipeline gas vs. $26 gasoline, both per MMBtu
  - 61% efficient CCCTs vs. 26% efficient piston engines
  - No wonder electricity = 79 c/gal!

Source: BSA 2014, from NYMEX, Gas Buddy, BSA estimates.
Gas-fired electricity means battery EVs are, in effect, just very high-efficiency NGVs.

- Production of methanol and gasoline from natural gas (GTL) will also become options, as price differentials remains favorable.

Source: Schlesinger / Tesla Motors.
Global firms plan to spend more than $110 billion on new US gas-based industries.

- 175 new manufacturing plants in development:
  - Chemicals & petrochemicals
  - Fertilizers
  - Steel & aluminum
  - Tires, plastics
  - Gas to liquids
- Most sited near shales (see count of # plants at right).
- Increased gas demand will range from 2.1-3.2 Bcf/day by 2025.

Source: BSA 2014, from American Chemical Society, Dow Chemical; BSA estimates.
Newer LNG delivery concepts can deliver surplus shale gas to under-served areas.

Moored Buoy System with pipeline to shore
- Special ships moor to buoy
- Regasification done on board the ship
- Ship departs once LNG regasified

Floating Storage and Regasification Unit
- Terminal is a specially designed moored vessel
- LNG storage and regasification done on board
- Natural gas piped to shore

Gravity Based Structure
- Terminal is submerged concrete structure
- LNG storage and regasification done on terminal
- Natural gas piped to shore

Source: Center for LNG.