Shale Gas: Analyzing Risks and Opportunities

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Society for Risk Assessment
Boston University – April 9, 2012
Overview – Natural Gas Risks and Opportunities:

Shale Gas: Game Changer or Something Else?

- Context for my comments
- What’s happening with shale gas
- Some implications
Natural Gas: Shale Gas

CONTEXT FOR MY COMMENTS:
Recent Involvement in NPC and SEAB Studies
Overview and background:

Who: SEAB Board Natural Gas Subcommittee
  - Deutch, Holditch, McGinty, Krupp, Yergin, Tierney, Zoback

What: Presidential request to Secretary Chu
  (Blueprint for Secure Energy Future Charge):
  - examine steps to improve the safety and environmental performance of shale gas development
  - not regulation, *per se*

When: Initial report: mid-August 2011
      Final report: mid-November 2011
Overview and background:

Who: National Petroleum Council

What: Energy Secretary Request to NPC

- Assessment of the size of the oil and natural gas resource base in North America
- Assessment of the role of natural gas in GHG reductions

When: Start – early 2010

Report: September 15, 2011

- “Prudent Development: Realizing the Potential of North America’s Abundant Natural Gas and Oil Resources”
Natural Gas: Shale Gas

WHAT’S HAPPENING
What does shale gas look like? ROCK

Shale Gas Outcropping – Marcellus
What does shale gas look like? REGIONS

Source: Energy Information Administration based on data from various published studies. Updated: March 10, 2010
What does shale gas look like?

TECHNOLOGY

Drill site
Stored water
Drinking water
Steel casing and cement
Borehole
Hydraulic fracturing
Horizontal drilling

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What does shale gas look like? FRACTURING DEPTH

Fracture Height Determination – Microseismic

Thousands of feet of separation

Top of fractures

Bottom of deepest aquifers
What does shale gas look like? SURFACE ACTIVITIES

What does shale gas look like? ENVIRONMENTAL RISKS

Phil Nguyen, Regulatory Options and Challenges in Hydraulic Fracturing, WISE, 2010

Risks from past practices and events
What does shale gas look like? PRODUCTION GROWTH
Past decade.....

Marcellus
Shale plays

BILION CUBIC FEET PER DAY

YEAR

2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

12 -
8 -
4 -

BARNETT
MARCELLUS
FAYETTEVILLE
EAGLE FORD
WOODFORD
HAYNESVILLE
HORN RIVER
MONTNEY & DUVERNEY

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NPC, Prudent Development, 2011
What does shale gas look like? PRODUCTION GROWTH
Past decade ........... versus past two years
What does shale gas look like?

PACE OF DEVELOPMENT

Marcellus shale gas permits issued and wells drilled in Pennsylvania 2007 – 2011 (Dec)

Marcellus Shale Gas Commission, July 2011, Figures 22 and 23;
http://www.dep.state.pa.us/dep/deputate/minres/oilgas/Marcellus%20Wells%20permited-drilled%20NOVEMBER%202011.gif
What does shale gas look like? ATTENTION (+ and -)
What does shale gas look like? SUPPLY ESTIMATES

Changing estimates of the U.S. natural gas resources*
1999-2011

*Technically recoverable

The effect of a reduction in EIA’s Marcellus estimate from 410 Tcf to 84 Tcf (the new USGS estimate, up from 2 in 2002)
What does shale gas look like? LOWER GAS PRICES

Average delivered price of coal to electric utilities
Average delivered price of coal to IPPs
Average price of natural gas to electric generators

Source: Natural gas prices: EIA, [http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm](http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm);
Natural gas prices – before shale gas……

U.S. Natural Gas Price History, 1976 to 2008
(Nominal Dollars)

Natural gas prices – before shale gas......

U.S. Natural Gas Price History, 1976 to 2010
(Nominal Dollars)

What does shale gas look like?  LOWER GAS PRICES

Source: Natural gas prices:  EIA, [http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm](http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm);
What does shale gas look like? LOWER GAS PRICES

Natural Gas Futures – Henry Hub

$/mcf

Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20

3-2007 3-2008 3-2009 3-2010 3-2011 3-2012

January 2012

April 9, 2012

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What does shale gas look like? MEETING DEMAND

U.S. Energy Consumption by Sector - 2010

What does shale gas look like? LOWER INPUT PRICES
Meeting industrial demand (directly, indirectly)

Announcements by Dow Chemical, Shell, Williams
Companies: new chemical facility investments

Total power production cost structure

Aluminum manufacturing cost structure

Source: IHS Global Insight

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What does shale gas look like? BOOST TO OUTPUT

Industrial demand

![Graph showing annual average price index and net exporter/importer balance over time.](image)

- **WTI Price Index (Year Avg)**
- **Henry Hub Price Index (Year Avg)**
- **US Chemicals Real Trade Balance**

Key events:
- **Deterioration of Gas Cost Advantage**
- **Natural Gas Constrained Supply**

**Net Exporter** to **Net Importer** transition over the years.
What does shale gas look like?
PRESSURE ON COAL PLANTS

U.S. Major Coal-Fired Power Plants

Impacts from electricity produced at coal power plants

National Mortality Effects from Existing Power Plants (Annual Persons/100,000)
- < 3
- 3-7
- 7-10
- 10-14
- > 14

Annual Mortality Due to Individual Power Plants (Persons)
- <25
- 25-75
- > 75

Clean Air Task Force, “Toll from Coal,” 2010 (Google Maps programs)
What does shale gas look like?  ALTERNATIVES TO COAL
Power plants affected by EPA MATS Rule
Coal plant capacity – Without emission controls,

Coal Units Without Emissions Controls
(Total GW – 2009)

Notes:
[1] Totals do not include Alaska or Hawaii.
[2] Units without emissions are those units without SCR or FGD systems.

Source: SNL data.

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**ISO-NE**

<table>
<thead>
<tr>
<th>Load (GW)</th>
<th>Coal Price</th>
<th>Gas Price</th>
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<tbody>
<tr>
<td>10</td>
<td>$31.7</td>
<td>$95.1</td>
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<tr>
<td>20</td>
<td>$39.0</td>
<td>$43.4</td>
</tr>
</tbody>
</table>

@20 GW load, gas price is 3x coal @10GW load

@20 GW load, gas price is 1.1x coal @10GW load

What it means for NE electricity consumers.....

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SNL Financial Data, accessed 3-1-2012
What does shale gas look like?
MORE NEW GAS-FIRED POWER PLANTS

Gas-fired combined cycle and peaking plants are the fuel/technology of choice for new plants (except renewables)

<table>
<thead>
<tr>
<th>Year</th>
<th>Under Const. (GW)</th>
<th>Adv’d Dev (GW)</th>
<th>Annc’d (GW)</th>
<th>Total (GW)</th>
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</thead>
<tbody>
<tr>
<td>2011</td>
<td>2</td>
<td>0</td>
<td>0.2</td>
<td>2.2</td>
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<tr>
<td>2012</td>
<td>5.6</td>
<td>0.6</td>
<td>5.7</td>
<td>11.9</td>
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<tr>
<td>2013</td>
<td>5.2</td>
<td>1.2</td>
<td>4.4</td>
<td>10.7</td>
</tr>
<tr>
<td>2014</td>
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<td>8.6</td>
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<td>2015</td>
<td>0</td>
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<td>9.8</td>
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<tr>
<td>2016+</td>
<td>0</td>
<td>0</td>
<td>13.8</td>
<td>13.8</td>
</tr>
</tbody>
</table>
Markets:
Gas-fired plants are now the fuel/technology of choice

Natural gas prices:
- Already putting pressure on many coal plants
- Possible to sign long-term fuel contracts
More gas-powered generation ahead
ISO-NE Interconnection Queue* (new generation projects)

Natural gas prices:
- Already putting pressure on many coal plants, but also other technologies (renewables, nuclear)
- Increasingly able to sign long-term fuel contracts, but may require alignment between capacity markets, firm transportation service, and other market rules

* ISO-NE, “Active FERC” Queue, as of 2-1-2012 (does not include transmission projects or equipment replacement)
Gas will be needed even more as renewables ramp up

Significant increases in renewable energy needed in upcoming years to meet RPS requirements – with push and pull from gas market conditions and operations

Implications for Massachusetts and the Region

OPPORTUNITIES AND CHALLENGES
A huge opportunity for U.S. energy markets

NPC report:

- “N. America’s natural gas resource base is enormous – with potential benefits to the economy, environment and energy security”

Secretary of Energy Advisory Board report:

- “extremely important for U.S. energy security, with potentially large economic impact on local communities and states” and well as benefits for customers of natural gas and electricity
Implications of U.S. gas supply/demand scenarios:

High demand, advanced technology, moderate development cost

WELLHEAD DEVELOPMENT COST
2007 DOLLARS PER MILLION CUBIC FEET

LOW DEMAND
HIGH DEMAND

RANGE OF CUMULATIVE DEMAND
2010–2035

TRILLION CUBIC FEET

MIT MEAN RESOURCE CASE
MIT ADVANCED TECHNOLOGY CASE
MIT HIGH RESOURCE TECHNOLOGY CASE

NPC, Prudent Development, 2011
U.S. Gas demand outlooks – driven by power sector

The chart illustrates the projected gas demand outlooks for different sectors for the years 2020 and 2030. The sectors include Vehicle, Commercial, Transmission, Industrial, Residential, and Power. The chart shows the data for the years 2000, 2010, AEO 2010, AEO 2011, MAX, MED, and MIN. The data are presented in billions of cubic feet per day.
But this depends upon doing it right …..

NPC report: ‘benefits depend on prudent development’

- Everywhere, responsible practices are needed.
- Regulators must evolve their requirements.
- Such steps are necessary for public trust, protection of health, safety and the environment – and for maintaining access to the natural gas resources.
But this depends upon doing it right ….

SEAB report: ‘genuine environmental urgency’

- There are potentially serious environmental impacts.
- These impacts need to be prevented, reduced and, where possible, eliminated as soon as possible.
- Absent effective control, public opposition will grow, thus putting continued production at risk.
SEAB’s “environmental urgency” related to shale gas:

Areas of concern:

- Water – possible pollution of drinking water (methane, chemicals), water consumption, disposition/management of flow back water
- Air pollution – GHG (methane), ozone precursors
- Community disruption during shale gas production
- Preservation of unique and/or sensitive areas
- Cumulative adverse impacts (traffic, noise, visual, odors, intensity) on communities and ecosystems, wildlife
Natural gas can help lower GHG emissions

Reduction Pathways
- Coal displacement
- Natural gas end-use technologies
- EPA non-GHG regulations
- Price on carbon

Deep reductions require CCS or other zero-carbon technologies
GHG reductions …
Depend on addressing methane emissions from gas….

Comparison of NG and Coal Burnertip GHG Emissions in Recent LCAs

Variation in total footprint is largely due to uncertainty in methane

Source: Armond Cohen, Clean Air Task Force, “Natural Gas and Climate Bridge, Highway, or Destination?” EUEC presentation, 1-30-2012
Shale gas – and energy markets

Shale gas development provides opportunities for:

- lower building heating costs than previously expected
- lower power prices than previously expected – and less differential than in traditional coal regions
- lower emissions profile of power plants in upwind regions

But ....

- greater challenges with meeting renewables’ targets
- greater need for integration of gas/electric market operations
- increased attention by many players to the GHG from gas
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