SLIDES: The Here and Now of U.S. Nat Gas

Michelle Michot Foss

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High Altitude

- 1970s & 1990s “redux” with regard to perceptions about reliability, deliverability
  - Similar policy/regulatory disconnects
  - Risk that demand will be encouraged while supply and deliverability are constrained
- Even without GHG policy, gas “push” is inevitable
  - Strategic opposition to electric power transmission hinders both coal and renewables
- Drilling is essential
  - Environment, oil and gas tax policies
Technically recoverable assessments of the U.S. natural gas endowment 1970 to 2009 increased four to six times: \(2,084 \text{Tcf in 2009}\)

**Source:** Modified from Bill Fisher et. al., BEG-UT; GTI
Shale Gas is A Hedge for Offshore

Technically recoverable resources; gold areas are moratoria; total 240.1 BBOE

Barnett Shale Experience

- Water use for “frac’ing” and other Barnett Shale development is less than 1% of total water use in affected counties (BEG)
  - Water use will grow, but rate of use will be lower with technology improvement and recycling/re-use
  - Operators are actively testing recycling and reductions to manage water demand and produced water
- NETL Produced Water MIS
  http://www.netl.doe.gov/technologies/PWMIS/
- NETL Frac Technologies

Texas RRC, TWDB (JP Nicot, BEG-UT)
The New “Nanodarcy” Universe of Technology

• Detection and advanced stimulation
  – Slow decline curves
  – Reduce drilling (fewer rigs, lower costs, smaller footprint)
  – Manage water disposal and other production issues

• Enhanced recovery
  – Extend field life

A Tough Business, Anyway

[Graph showing financial data]

Compiled by CEE based on company financial reports
Price Trends

- "Drill for oil, find gas? Drill for gas, hope it’s wet?"
- Overall, both drilling and marketed gas production are more responsive to oil price, but…….

Wellhead Price Eras

- Customers pay and producers sell on gas price basis.

CEE based on CME price data

CEE based on U.S. EIA
Price Level and Volatility Matter

 Compiled by CEE using CME (NYMEX) data; STDEV of LN daily, 1-yr MA annualized

 Average price ($2005)

<table>
<thead>
<tr>
<th></th>
<th>Wellhead</th>
<th>City Gate</th>
<th>Res</th>
<th>Comm</th>
<th>Ind</th>
<th>Elec. Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 99:12</td>
<td>2.82 a</td>
<td>4.39 b</td>
<td>8.96 c</td>
<td>7.04 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:01-09:11</td>
<td>5.30</td>
<td>6.73</td>
<td>11.99</td>
<td>9.61</td>
<td>6.68 d</td>
<td>6.49 e</td>
</tr>
<tr>
<td>Change</td>
<td>88%</td>
<td>53%</td>
<td>34%</td>
<td>37%</td>
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<td></td>
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</tbody>
</table>

 a 76:01-99:12; b 83:10-99:12; c 81:01-99:12; d 01:01-09:12; e 02:01-09:12

CEE-UT analysis
©CEE-UT, 16
### Price volatility ($2005)

<table>
<thead>
<tr>
<th></th>
<th>Wellhead</th>
<th>City Gate</th>
<th>Res</th>
<th>Com</th>
<th>Ind</th>
<th>Elec. Power</th>
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</thead>
<tbody>
<tr>
<td>Before 99:12</td>
<td>7.2%</td>
<td>6.0%</td>
<td>6.3%</td>
<td>2.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:01-09:11</td>
<td>12.2%</td>
<td>10.5%</td>
<td>7.7%</td>
<td>5.3%</td>
<td>11.4%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Change</td>
<td>71%</td>
<td>74%</td>
<td>22%</td>
<td>110%</td>
<td></td>
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</tr>
</tbody>
</table>

*a 76:01-99:12; b 83:10-99:12; c 81:01-99:12; d 01:01-09:12; e 02:01-09:12*  

*Std dev of change in price*
ERCOT Peak Day by Fuel Type

Does Renewable Energy Create Volatility?

April 26, 2009

MCPE ($/MWh)

Negative price intervals (15 min)

<table>
<thead>
<tr>
<th>Year</th>
<th>MCPE</th>
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<tbody>
<tr>
<td>2006</td>
<td>76</td>
</tr>
<tr>
<td>2007</td>
<td>338</td>
</tr>
<tr>
<td>2008</td>
<td>4,894</td>
</tr>
<tr>
<td>2009</td>
<td>3,069</td>
</tr>
<tr>
<td>2010</td>
<td>2,413</td>
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</tbody>
</table>

Compiled by CEE using ERCOT data
Dr. Michelle Michot Foss, CEE/BEG/JSG/UT

Price Observations

- **Volatility** is a sensitive issue for large users and regulated utilities; lack of data prevents analysis on changes over time
- Residential (and some commercial) customers are sheltered by regulators
- Wellhead price takers both suffer from and may contribute to volatility
- Electric power demand swings on marginal gas generators + impact of renewables may contribute to volatility

Dr. Michelle Michot Foss, CEE/BEG/JSG/UT

LNG “Optionality”

Compiled by CEE based on industry data
Beyond Unconventional

The Endless Resource?

“100 ft of pay, 50% porosity, 90% gas saturation”

Critical Role of Natural Gas in the U.S. Energy Mix

• Benefits of utilization – options for natural gas uses
  – For lower carbon electric power?
  – Industrial revitalization?
• Supply and price volatility
  – Frontiers, production management, frac and water issues
• Electric power dynamics – effective, optimal dispatch?