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

Balancing Our Energy Future

What do we want?

“Safe, clean, affordable, (abundant) energy”

“Reduced risk of disruptions, price volatility”

“Secure, commercially successful operations”

How do we get there?

Natural gas is a desirable alternative, but resource and infrastructure must be developed

Portfolio including both supply diversity and price sensitive, demand-side response

Domestic drilling, international trade subject to market and policy/regulatory constraints

“Best practice” design at a price the market will bear.
Natural Gas Can Bring Multiple Benefits

Technologies developed and applied in the U.S. unlock vast, low-cost gas supplies. International trade provides balance and options.

More competitive and flexible supply and delivery brings affordable reliability.

Gas storage, transport and delivery systems are mostly in place. Expansions, improvements will add flexibility, market responsiveness.

Positive economic and environmental impacts are created and distributed.

How Does Unconventional Gas Fit In?

The Story...
- “It’s a factory business…”
- “Have I got a shale deal to sell you…”
- “We can make money at $4…”

…and the “Back Story”
- Unknown unknowns in technology
- Shifting upstream business models
- Impact of oil directed drilling
  - Is natural gas price volatility “dead”?
- Private lands event driven by historical price marker
"Glubbausage"!

Searching for the bottom...

- Henry Hub Monthly Average Spot Price ($/MMBtu)
- Avg Feb 89-Nov 99 ($1.98)
- Avg Dec 99-Jan 09 ($6.00)
- Avg Feb 09-Apr 11 ($4.13)

$4? A Tough Business, Anyway

- 10% Return
- U.S. 10 Cash Exploration Costs $/MCFE
- U.S. 10 Cash Operating Costs $/MCFE
- U.S. All Source FD Costs 07-10 $/MCFE
- Henry Hub Spot Price $4/MCF

Not all companies report current cash exploration costs

Avg.
Cost reductions are real...

Impact of “Wall Street” technology

...but gainers, losers

Living with Negative Margins...

Production Phases

U.S. Dry Gas Production (Bcf)
U.S. Dry Gas Production 12-MO MA (Bcf)
Y-Y Chg Dry Gas Production (%), Jan 86-Feb 11
Canadian and U.S. natural gas producers are responding to the U.S. oversupply by shifting away from drilling activity that focuses solely on natural gas. Instead, companies are targeting oil and natural gas containing NGLs to capitalize on the rise in oil prices.

What are the demand side drivers?

Relatively small changes in supply, demand can swing price.
U.S. Net Generation by Energy Source

1996 Total Net Generation = 3.4 Billion Megawatthours
2010 Total Net Generation = 3.9 Billion Megawatthours
Net Difference = 506 Million Megawatthours

All in %: Change in shares of net generation, 1996-2010
(total net generation, 2010)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>1996</th>
<th>2010</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>10</td>
<td>1</td>
<td>-9</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>23</td>
<td>2</td>
<td>-21</td>
</tr>
<tr>
<td>Petroleum</td>
<td>2</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>Hydro</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other renewables</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Petroleum coke</td>
<td>-8</td>
<td>-1</td>
<td>-7</td>
</tr>
<tr>
<td>Other gases and other fuels</td>
<td>0</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>

Does Renewable Energy Create Volatility?

ERCOT
Negative price intervals (15 min)

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<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>4,445 (Nov)</td>
</tr>
</tbody>
</table>
Dr. Michelle Michot Foss, CEE/BEG/JSG/UT

**Estimated extra gas needed outside North America after the Japanese disaster**

**SG’s “orderly nuclear exit” for OECD outside of North America**

Source: BG Gross Asset Research

**Approx. 3.7 TCF by 2020; roughly 7% of current total OECD demand**

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

**Industrial Renaissance?**

"A robust supply of natural gas that is affordable and reliable would give the industrial sector, especially energy intensive industries, a global advantage creating investment and jobs in the United States."

**2002 = 6.3 TCF**

**2006 = 5.7 TCF**

NPC NARD Industrial Committee; U.S. EIA MECS
Environment Discontents

“Cleanest burning fossil fuel” but…

- Hydraulic fracturing
  - Water use, disposal, contamination (chemicals and methane)
  - Seismicity
- Air emissions
  - Drilling operations
  - Fugitive GHG; combustion GHG (power, industrial boilers)
- Infrastructure siting
- Is natural gas too cheap?

Solutions???

- State frac disclosure laws
- FracFocus
- STRONGER

How does LNG fit in?

---

Compiled by CEE based on industry data

©CEE-UT, 15

©CEE-UT, 16
How does LNG fit in?

- Crucial swing capacity to balance supply, demand
  - *How do players manage “optionality”?*
- Perceptions of the U.S. as a “closed system”, self supplied
  - *LNG at what cost when we need it?*
- Capacity expansions did not alter fundamental HH transportation basis
  - *Head room for shale gas?*

---

**Carpe Diem**

- Actual Ratio, Crude Oil (WTI, Bbl):Gas (HH, Mcf) Prices
- Rough 6:1 Oil:Nat Gas Ratio
- MMBtu Ratio, Oil:Gas

---

Compiled by CEE based on industry data ©CEE-UT, 17

Compiled by CEE based on CME, EIA ©CEE-UT, 18
Dr. Michelle Michot Foss, CEE/BEG/JSG/UT

How can we optimize natural gas utilization given its deep discount to petroleum products?

Will gas indexing and gas-gas competition take hold outside of North America?

Do we need relatively high oil prices to pursue shale gas?

Compiled by CEE based on CME, EIA ©CEE-UT, 19