U.S. and Global Oil & Gas Dynamics

IEEJ, June 23, 2016, Tokyo
Framing the Challenge

A large independent: “I can’t run a company on single well economics. The whole portfolio has to make sense. Is there a viable business model for US unconventionals that reflects full cycle cost for portfolios?”

A major: “Asset quality is not good. People want too much for Tier 2.”

A keen observer in Canada (August 2015): “When in the last 40 years has the price of oil and the cost of producing the stuff gone in opposite directions at such a high rate?”

Supply, Demand, Price: A Multitude of Caveats

Supply side – demonstrated recovery from tight rock plays BUT:
• Producer distress – credit and capital markets
• Recovery in prices to support capex
  – Higher oil price supports “high GOR, cheap methane byproduct” wells (AG and NAG with some ethane)
  – Higher gas (methane) price supports dry and NAG wells
  – NGLs can provide “uplift”
  – Midstream distress – credit and capital markets
  – Capacity for deliverability (Appalachia – Marcellus/Utica)
• Impact of regulations (and politics) – “parking lot”

Demand side – multiple challenges for monetization:
• Viable offtake markets for NGLs, condensates (LTO)
• Robust power demand for gas, including baseload
• International trade
Mainly Oil Producers

To rebuild cash positions companies will need returns substantially better than 10%

CEE producer benchmarks, 16 companies (top tier, best in class in major basins), SEC filings
See http://www.beg.utexas.edu/energyecon/thnkcrnr.php for various postings
Mainly Gas Producers

To rebuild cash positions companies will need returns substantially better than 10%

CEE producer benchmarks, 16 companies, SEC filings
*“What’s in YOUR barrel?”

The complexity of realized price attainment with hedging for producers:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Oil Price Strength, Weakness; NGLs and Methane Relative to Oil (% of Oil Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>$S\ S\ S\ W\ W\ W\ S\ W$</td>
</tr>
<tr>
<td>NGLs</td>
<td>$S\ S\ W\ W\ W\ S\ W\ S$</td>
</tr>
<tr>
<td>Methane</td>
<td>$S\ W\ W\ W\ S\ S\ S\ W$</td>
</tr>
</tbody>
</table>

What liquids cut (%) and which liquids will preserve well/field/portfolio economics & value OR what gas (Henry Hub or HH) price??

*Based on Capital One bank card campaign, “What’s in YOUR wallet?”*
Big Resource Endowment, but “Location, Location, Location”

Breakeven Economics, 10% IRR
But many producers now face much higher cost of capital

See [http://www.beg.utexas.edu/shale/pubs.php](http://www.beg.utexas.edu/shale/pubs.php) for the publications on individual plays.
Lessons in (Liquids) Well Economics
What the U.S. is Producing

Lightening Slate + Transportation Cost = Netbacks Below NYMEX

Central Oklahoma

Blaine 46.53
Kingfisher 42.63
Canadian 43.22
Garvin 49.32
Stephens 55.36

## Comparison of Crude Qualities

<table>
<thead>
<tr>
<th>Crude Types</th>
<th>API</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakken</td>
<td>40-43</td>
</tr>
<tr>
<td>WTI</td>
<td>37-42</td>
</tr>
<tr>
<td>LLS</td>
<td>36-40</td>
</tr>
<tr>
<td>Eagle Ford</td>
<td>47.7</td>
</tr>
<tr>
<td>Eagle Ford Light</td>
<td>58.8</td>
</tr>
<tr>
<td>Brent</td>
<td>37-39</td>
</tr>
<tr>
<td>Western Canada Select</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Source: NDPC Study

Contract Terms

- **Quality penalties** associated with higher gravity have crept into contracts
  - $.02 cents per every one-tenth of a degree of gravity higher than 60 deg

- In addition there are **volumetric deductions** for higher gravity
  - 60.1-64.9 deg API equals a 3% deduction
  - 65.0-79.9 deg API equals a 6% deduction
  - 80.0 and above equals a 20% deduction

- Quality penalty to be deducted from price at rate of $0.02 per 0.1 degree of gravity above 45 deg

- If gravity exceeds 59.9 degrees, volumes will be reduced by an additional 2% loss allowance
Efficiency Improvements are Mainly Portfolio Effects

**Oilier**

**Gassier**

**NOTE: data points are total production, MMBOE**

High grading acreage for better geology, higher liquids cuts facilitates drilling improvements

CEE producer benchmarks, 16 companies, SEC filings
All Companies: Consequences for Gas Yield of Chasing Crude

**An Equivalent Barrel**

- **US NGL Production (MMB)**
- **US Oil and Liquids Production (MMB)**
- **US Gas Production (MMBOE)**

**Natural Gas Share of Annual Production**

- **US Total Production (MMBOE)**
- **Natural Gas Production: Total U.S. Production**

**NOTE: data points are total production, MMBOE)**
All Companies, 2009-2015

Annual Waterfall: (All), (Multiple Items)

$/BOE

CEE producer benchmarks, 16 companies, SEC filings
All Companies, Annual Cash Flow and Capex

$/BOE


CF Capex

CEE producer benchmarks, 16 companies, SEC filings
Being upside down is not a new problem...

...but it does raise a serious question: do shale plays need external capital (like, forever)?

Bernstein Research, used with permission
The Brute Force Method

• Industry actions
  – Vertical to horizontal
  – “Core of core” (bias in reporting)
  – More proppant, more pressure (the oil service money maker)
    • “Super fracs”
  – Longer laterals

• **But** (all from Bernstein Research proprietary report):
  – “Shale efficiencies have improved a remarkable **21% CAGR** since 2012 in oily basins;
  – Drilling efficiency (wells/rig) grew **13% CAGR** but has slowed and will plateau;
  – Variable cost efficiency (longer laterals spreading fixed costs across more 'rock') grew **7% CAGR** but lateral lengths now stand at ~7,400 feet, will grow only modestly from here;
  – **Production efficiency (liquid rate per unit length) grew 0%.”**
How much more in cost reductions?

Both oil price driven (strategic) and service cost response (tactical)

Completions (fracking) are typically 1/2 to 2/3 of total well cost

2014-2015 change in:
Development Capex -51%
Production Cost -8%
Realized Oil Price -44%

CEE producer benchmarks, 16 companies, SEC filings
Two Players: (1) Larger, Oilier

Cost Stack with 10% Return ($/BOE)

Cost Stack with 10% Return ($/BOE)

An Equivalent Barrel

NOTE: data points are total production, MMBOE

CEE producer benchmarks, 16 companies, SEC filings

Cash Flow Waterfall 2009-2015

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Two Players: (2) Smaller, Gas Focused

Cost Stack with 10% Return ($/BOE)

An Equivalent Barrel

NOTE: data points are total production, MMBOE

CEE producer benchmarks, 16 companies, SEC filings

Cash Flow Waterfall 2009-2015
“The most pervasive delusion is the Halo Effect. When a company's sales and profits are up, people often conclude that it has a brilliant strategy, a visionary leader, capable employees, and a superb corporate culture. When performance falters, they conclude that the strategy was wrong, the leader became arrogant, the people were complacent, and the culture was stagnant. In fact, little may have changed... “ (Amazon leader)
Impact of Low Prices: U.S. Production Plateaus

The rig count “metric” does not mean the same as before
• Cluster drilling: more wells per rig
• Infill drilling: less production @ less cost (?) in areas with proven high productivity

But well count and overall rig activity still matter
• Sustain output
• Offset declines
Midstream: That Sinking Feeling

~500 miles, 30”, ~140KBD capacity, under construction

Texas Railroad Commission data on Granite Wash

Proof of play and commodity price risks
Is the midstream in crisis?

- Since Q1:14, 22 MLPs reduced or suspended distributions (WF: Feb 2016)
- Value dropped ~40% in 2015 (Bloomberg)
- Processing margins down ~67%
- 11 downgrades as of Oct, 2015; 13 companies on negative watch
- Lower midstream outlooks: capex cuts by E&P companies that funded infrastructure projects and other factors
- MLP activity now concentrated in: Barnett (gas); Eagle Ford (NGLs); EF and Permian (oil) (WF Feb 2016)
- New signals are: slow down, delay, cancellation of Marcellus-Utica projects, with implications for gas supply, deliverability going forward

[Graph and chart]

Could a strong “demand stack” for U.S. gas develop, and what would this mean?

AEO 2016 v AEO 2015 Ref:
- Dry gas production close to 2015 High Oil and Gas Resource scenario levels.
- Exports are larger in later years, but higher pipe, lower LNG.
- Even with CPP, gas use in power generation is not as large as CEE High Case or even AEO 2015 High OGR.
- 100-200 GW of additional renewables by 2040

CEE analysis; EIA AEO 2015; see http://www.beg.utexas.edu/energyecon/thnkcrnr.php for various postings
Uncertainties

• ~114 GW of wind and ~38 GW of solar
• Extension of PTC & ITC (BNEF: $73B increase in investment → 19 GW of wind and 18 GW of solar between 2016 and 2021)
• Renewable Energy Buyers Alliance: 60 GW by 2025
• KPMG survey of energy executives:
  – 62% believe half of US power from clean energy sources by 2045
  – 41% of utility executives expect "significant change" towards a significantly more distributed, unbundled system
• Interest in DER (Brookings: “Net metering is a net benefit”)
• Declining cost of PV (utility-scale and rooftop)
• Long-term PPAs offered by utilities, munis, coops
Competitive Price Formation is not Efficient nor Fully Transparent

- Energy-only markets are the exception, and
  - Price caps limit their effectiveness
  - There is no/incomplete demand-side participation (FERC Order 745 might help)
- Capacity markets “fill the gap,” but
  - They can be inefficient
  - Non-transparent uplift payments are still needed
- Prices are also distorted by
  - Renewables (subsidies, RPS programs, long-term PPAs)
  - DER, EE, storage
- Retail prices have not followed wholesale prices down
“The Times They Are A-Changin’” – Creative Destruction?

- “Early” retirements raise reliability concerns, inducing more out-of-market solutions (Ohio, Maryland, New York, Illinois)
- DER reduces revenues for utilities ➔ regulatory corrections
- DR and EE might have similar impacts if provided by non-utility competitors
- Load profiles might change significantly with attendant uncertainty of market prices
- Is gas-fired generation as backup to renewables economic? Gas-power harmonization?
- Large grids where wind & solar balance each other
  - Can needed transmission be built (ROW, jurisdiction)? Who pays?
  - Grid security?
- Storage can be a game-changer but large uncertainties exist regarding technology, cost, market rules, minerals value chain issues

http://www.beg.utexas.edu/energyecon/thinkcorner/CEE_Research_Note_BatteryMaterialsValueChain_Apr16.pdf
So, What Future do you Expect?

Consumption of NG in Power Generation (2014=1)
Cheap NGLs Aiding an Industrial Renaissance

**U.S. Reference Case:**
83 Projects worth $65 billion; 2.3 BCFD demand add

**U.S. High Case:**
112 Projects worth $98 billion; 3.5 BCFD demand add

**Texas Reference Case:**
$26.5 billion; 0.8 BCFD demand add

**Texas High Case:**
$33 billion; 0.9 BCFD demand add

*CEE industrial database and analysis, www.beg.utexas.edu/energecon/thinkcorner*
CEE Dispatch Modeling: NG Burn Increases Significantly Even With More Renewables

Current work is an update of U.S. Gas-Power Linkages: Building Future Views:

• REGS: MATS, CAIR/CSAPR, 316(b). We did not model CPP.
• Renewables: ~58 GW of wind and ~27 GW of solar
Retail Power Costs Buck Trends

Figure 1 - Average Electricity Retail Price in U.S. 50 States + D.C.

Figure 2 - Consumer Price Index - U.S. City Average (Seasonally Adjusted)

Figure 5 - Average Retail Residential Prices by State Renewable Portfolio Status

CEE Research Snapshot
March 2016
The Attraction
"Cost of Supply"
High Cost Delivery to Atlantic Basin
High Cost Delivery to Pacific Basin
Super High Cost Delivery to Pacific Basin
High Cost Pacific (Liq. Sunk Cost)

Shipping
Liquefaction
Field to Terminal
Henry Hub
2011-14 Asia spot
2011-14 NBP
Gorgon All-in Cost BE
Japan 2010
December 2015 Landed Prices (Avg)
Chile (Atlantic LNG)
Current A-P Spot
Gorgon Marginal Cost BE
Gazprom "Threat"

CEE analysis based on industry sources; BE = break even; NBP = National Balancing Point (UK); A-P = Asia Pacific; note that Dec 2015 landed prices are worldwide averages based on FERC
**Liquefaction Capacity – April 2016**

*Global demand 2014 about 241 mtpa (IGU)*

<table>
<thead>
<tr>
<th>Region</th>
<th>In Operation</th>
<th>Under Construction</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qatar</td>
<td>77.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Australia</td>
<td>46.0</td>
<td>40.2</td>
<td>-</td>
</tr>
<tr>
<td>USA</td>
<td>4.9</td>
<td>59.7</td>
<td>248</td>
</tr>
<tr>
<td>Canada</td>
<td>-</td>
<td>-</td>
<td>333</td>
</tr>
<tr>
<td>Russia</td>
<td>10.6</td>
<td>16.5</td>
<td>30</td>
</tr>
<tr>
<td>East Africa</td>
<td>-</td>
<td>-</td>
<td>70</td>
</tr>
<tr>
<td>Rest of M. East</td>
<td>23.4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rest of Pacific</td>
<td>70.8</td>
<td>6.3</td>
<td>20</td>
</tr>
<tr>
<td>Rest of Atlantic</td>
<td>88.9</td>
<td>1.2</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>322.1</strong>*</td>
<td><strong>123.9</strong></td>
<td><strong>721</strong></td>
</tr>
</tbody>
</table>

*24.1 mtpa in Yemen, Egypt and Angola is off-line*

Andy Flower, Independent Consultant, for CEE
Binding Long-term Commitments to U.S. LNG October 2011 to April 2016

49.5 mtpa

11.05 mtpa

in mtpa


Asian Buyers Aggregator European Buyers S. American Buyer

Andy Flower, Independent Consultant, for CEE
U.S. All-in Export Price v Average LNG Import Price in Japan, January 2010 to March 2016
All-in Cost of U.S. LNG in Europe and Price of Natural Gas in Northwest Europe January 2010 to April 2016

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CEE Global Gas Demand Deep Dive

• Lower than expected gas demand: Economic slow-down, Japan re-opening nuclear plants, increased & more effective use of renewables
  – **China**: Industrial overhang (zombies), credit and capital markets, coal, nuclear, gas pricing
  – **India**: Infrastructure to support imports and internal market, lack of internal resource development, credit and capital markets, gas pricing, coal
  – **Middle East**: Gas short, pricing, regional conflicts, export ambitions, credit and capital markets
  – **Small markets**: Credit and capital markets, suitable small scale options, power gen capacity, frameworks

• Alternative supplies (credit and capital markets):
  • Increased pipeline flows (Russia, Iran?)
  • World LNG market is in excess supply until at least the early 2020s
  • Domestic (shale) gas production globally (long-term?)
The Global “Swing”?

Map presents a possible gas flow scenario; Foss, Ch. 3 in Pricing Internationally Traded Gas, Oxford, 2012; gas trade data from EIA

2014: U.S. is 21% of Canadian consumption

2014: U.S. is 28% of Mexican consumption

~2x current NA exports by 2020? ~9+ BCFD
Some Context

Oil and gas price trajectories need “good stories”

• In spite of capex cuts, oil price recovery not so easy to see
  – Shell: from “lower longers” to “lower forever”

• U.S. gas market dynamics may get more exciting, sooner

The global macro situation is

  – Gas price recovery 2017-2018 ahead of new drilling
  – Oil flat but at higher price deck than current
**“I Was Like, Oh My God”, Did I Really Say That? (Foss, IEEJ, 2007)**

<table>
<thead>
<tr>
<th>Probability</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Oil at $90, gas at $15: oil price pulls other costs, inflation, gas demand fundamentals</td>
</tr>
<tr>
<td>Medium (coin flip)</td>
<td>Oil at $48, gas at $8.28: approaching equilibrium and parity?</td>
</tr>
<tr>
<td>Higher</td>
<td>Oil $45-60, gas at $3-5: diverging fundamentals</td>
</tr>
</tbody>
</table>

*Based on NCIS; **Tribute to Billy Collins

*Rule number 99, “never throw away a good forecast”*
Spread: WTI minus Brent, $/BBL

Price, $/BBL

Cushing, OK WTI Spot Price FOB ($/Bbl)
Europe Brent Spot Price FOB ($/Bbl)
WTI-Brent Spread

Saudi Market Share Strategy I, 1985-86 to 1999
Cushing, OK WTI Spot Price FOB ($/Bbl)
Europe Brent Spot Price FOB ($/Bbl)
WTI-Brent Spread

China "Coming Out" Party, 2006-08
China - The Party's Over, 2008...

"Arab Spring" 2010

USD Neutral

Saudi Market Share Strategy II, 2014...

USD Neutral

Desert Storm, 1990

Asia Financial Collapse, 1997-99

Iraq War, 2003-06

9/11

U.S.-Europe Financial Collapse, 2008-09

US LTO Surplus

EIA, NYMEX, Federal Reserve Bank, other sources
Henry Hub Monthly Average Spot Price ($/MMBtu)

- Avg Feb 89-Feb 92 ($1.61)
- Avg Mar 92-Dec 98 ($2.11)
- Avg Jan 99-Dec 01 ($3.51)
- Avg Jan 02-Sep 09 ($6.32)
- Avg Oct 09-Present ($3.64)

GOM Hurricane Events:
- El Paso pipeline explosion, Carlsbad, NM August 19, 2000
- California market failure, 2000-2001

References:
- Feb 2007, "Henry Hub at $3 or $5" published (Foss, OIES NG 18)
- Dec 2011, "Henry Hub at $3 or $10" published (Foss, OIES NG 58)

1995 Energy Policy Act

1995 Energy Policy Act

U.S. shale gas drilling boom

U.S. shale oil drilling boom

Peak LNG imports with new regas capacity March-August 2007

"Polar Vortex Winter 2013-2014

Enron bankruptcy December 4, 2001

Lehman Brothers bankruptcy September 15, 2008

EIA, NYMEX, NOAA, other sources

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Summing Up: Gas Price Economics (2030)

Price events above $6 can happen

S-D interactions relative to supply cost, deliverability

Price events below $3 can happen

"Moderate" HH Price Deck

"High" HH Price Deck

Total Methane Supply

*Production (25-30+ TCF):

- HH price dependent (**70-80%), “NAG”, dry
- NGLs, Condensate, “NAG”, wet (oil linked, S-D, export drivers)
- HH price dependent (**20-30+%), “AG”

LNG Imports?

* Canadian gas production, pipe delivery subject to same conditions; **EIA reserves reporting, Nov 2015

Annual average, real price; Michot Foss, OIES NG 18 (2007) and NG 58 (2011); www.oxfordenergy.org

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Signposts

• Capital dependent industries and governments will be challenged by reduced capital formation as demographics unfold.
• Public attitudes on energy, environment are volatile in predictable ways and vested interests are motivated to act on that.
• You can count on human behavior to be *predictably irrational.
• No one ever wants to know how much it costs.
• There are good reasons for the political discord.
• Tail risks almost always have origins in the known knowns and known unknowns; the opportunity cost of hedging unknown unknowns is very high.

*Dan Ariely, 2009, Predictably Irrational, Harper Perennial