The Role of Unconventional Gas in the Global Energy Future

Scott W. Tinker
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin
I am fortunate to have traveled...

> 300 speaking engagements
> 150 different organizations
~ 40 countries
Take Aways

I. Energy underpins modern economies

II. “Big Oil” is Transitioning from Public Corporations (IOCs) to State Owned Companies (NOCs)

III. Several nations in the developing world are acquiring fossil fuel resources

IV. Natural gas is globally abundant

V. Most alternate energy “fuels” produce electricity

VI. We do not use energy efficiently; but efficiency alone will not solve the Energy Challenge

VII. Energy transitions take time

VIII. Natural gas, and increasingly unconventional natural gas, represents a vital part of the 21st century energy portfolio
Outline

I. Global Energy and Economy

II. Conventional & Unconventional Natural Gas

III. Alternatives to Natural Gas

IV. Future Energy Trends
Global Energy Use

Energy Use (Quadrillion Btu)

Asia & Oceania
United States
Europe
Eurasia
Central & South America
Middle East
Canada & Mexico
Africa

87% Fossil Fuels

1 Quad ~ 1 Exajoule ~ 1 Tcf ~ 170 mmbo (~ 33 GWY)

Data: EIA, October 2007
Energy and GDP

1980-2004

~3 billion people

Source: UN and DOE EIA
Russia data 1992-2004 only

After: Koonin, 2008
US Economy and Oil Price

- GDP Growth (% change on 2000 chained 2000 dollars)
- Oil Domestic Wellhead Price ($)

Data: EIA February 2007 and US Department of Commerce

Year: Nixon, Ford, Carter, Reagan, Bush, Clinton, W Bush
US Economy and Oil Price

Energy Underpins Modern Economies

Year: Data: EIA February 2007 and US Department of Commerce
Outline

I. Global Energy and Economy

II. Conventional & Unconventional Natural Gas

III. Alternatives to Natural Gas

IV. Future Energy Trends
Respect those who seek the truth, but be wary of those who claim to have found it...

Mark Twain
U.S. Oil and Natural Gas Drilling Activity

**2010 Proposed O & G Tax Policies**

- Repeal Expensing of Intangible Drilling Costs
- Repeal Percentage Depletion
- Repeal Marginal Well Tax Credit
- Repeal Enhanced Oil Recovery Credit
- Repeal Manufacturing Tax Deduction
- Increase G and G Amortization Cost
- Excise Tax on Gulf of Mexico Production
- Fee ($4/acre) on “non-producing” GOM leases
- Carbon Tax (or Cap and Trade scheme)

**Crude ($2007)**

- “Windfall Profits” Tax (‘80-’88)

Data: EIA, 2007
Global Conventional Reserves

“Big Oil” is Transitioning from Public Corporations (IOCs) to State Owned Companies (NOCs)

P.S. Big oil does not set oil and gas prices...

Oil vs. Natural Gas Price (btu)

Why the decoupling?

Daily Gulf Coast Spot Price ($/MMBtu)

- No. 2 Fuel Oil
- Henry Hub Gas

After Steve Harvey, EIA
Global Natural Gas

Production

Data: BP, 2009

Global Natural Gas

USGS Estimates

~ 13,000 TcF Conventional Resources

Annual Production (Tcf)

Total World Production (Tcfs)

R/P

Data: BP, 2009
Global Natural Gas

Major Trade Movements

Major trade movements
Trade flows worldwide (billion cubic metres)

Data: BP, 2008
Several nations in the developing world are (aggressively) acquiring fossil fuel resources
U.S. Natural Gas

Production and Reserves

After Steve Harvey, EIA
U.S. Natural Gas Production

Annual Natural Gas Production (Tcf)

- Onshore unconventional
- Alaska
- Offshore
- Onshore conventional

After Steve Harvey, EIA
U.S. Natural Gas Production

EXHIBIT 8: UNITED STATES UNCONVENTIONAL GAS OUTLOOK (BCF/DAY)

A 20-year global preview!

Source: Modified from American Clean Skies, Seminar 2008

After Steve Harvey, EIA
Unconventional Gas

Characteristics

- Poor quality reservoirs (very low permeability)
- Require hydraulic stimulation and horizontal wells
- Associated with actively generating source rock
- Large lateral extent with sweet spots common
- Role of natural fractures (debated)
- Difficult to determine saturations from logs
- Low per-well reserves; sensitive to gas price
- Small well spacing = larger surface impact
- Resource and reserve numbers far from precise
Coalbed Methane Plays

Alaska: 57

Other Rockies: 30

Black: Resource values in TcF from EIA (2007), PGC 2002
Red: Production, TcF, from EIA 2007

Map: EIA, 2009
Tight Gas Plays

Resource, Mean undiscovered values in Tcf from USGS, 1995 and later
Tight Gas

Couple matrix and fracture flow for realistic forecasts

Source: BEG-FRAC

Simpson Group, 13,404’, Grady Co., OK
US Shale Gas Plays

Tinker, 2009

Map: DOE Shale Gas Primer, 2009

Black = Resource values in Tcf, DOE Shale Gas Primer (Rockies PGC); Clean Skies, 2008
BARNETT & FORESTBURG FACIES

Central Ft. Worth Basin

Siliceous mudstone

Calcareous mudstone

Source: BEG-STARR

From Papazis (2005)
Barnett Shale

Nanopores in Organics

Orange dots are 20 nm in diameter

T.P. Sims #2; 7625'

After Reed, BEG
Shale Technology

~ 2.5 Tcf in 2009

American Clean Skies, Navigant Consulting, 2008

After Steve Harvey, EIA

Tinker, 2009
Shale Technology

After Steve Harvey, EIA

Vertical Well Count
Horizontal Well Count
Vertical Well Production
Horizontal Well Production

Production (Bcf)
Well Count (Thousands)

0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0
0 200 400 600 800 1,000 1,200 1,400 1,600

Tinker, 2009
U.S. Shale Gas

Implications

- Environmental
  - Traffic (-)
  - Noise/light (-)
  - Water (-)
  - Land Use (-)
  - Carbon (+/-)
- Energy Security (+)
- Fuel Diversity (+)
# Global Unconventional Gas Resource Estimates

<table>
<thead>
<tr>
<th>Region</th>
<th>Coalbed Methane</th>
<th>Shale Gas</th>
<th>Gas in Tight Sands</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>3,017</td>
<td>3,840</td>
<td>1,371</td>
<td>8,228</td>
</tr>
<tr>
<td>Latin America</td>
<td>39</td>
<td>2,116</td>
<td>1,293</td>
<td>3,448</td>
</tr>
<tr>
<td>Western Europe</td>
<td>157</td>
<td>509</td>
<td>353</td>
<td>1,019</td>
</tr>
<tr>
<td>Central and Eastern</td>
<td></td>
<td></td>
<td>235</td>
<td></td>
</tr>
<tr>
<td>Former Soviet</td>
<td></td>
<td></td>
<td>5,485</td>
<td></td>
</tr>
<tr>
<td>Middle East</td>
<td></td>
<td></td>
<td>3,370</td>
<td></td>
</tr>
<tr>
<td>Sub-Saharan</td>
<td></td>
<td></td>
<td>1,097</td>
<td></td>
</tr>
<tr>
<td>Centrally Planned Asia and China</td>
<td>1,215</td>
<td>3,526</td>
<td>353</td>
<td>5,094</td>
</tr>
<tr>
<td>Pacific</td>
<td>127</td>
<td>2,392</td>
<td>195</td>
<td>3,487</td>
</tr>
<tr>
<td>Other Asia Pacific</td>
<td>216</td>
<td>254</td>
<td>549</td>
<td>862</td>
</tr>
<tr>
<td>South Asia</td>
<td>39</td>
<td>0</td>
<td>196</td>
<td>235</td>
</tr>
<tr>
<td>World</td>
<td>9,051</td>
<td>16,103</td>
<td>7,406</td>
<td>32,560</td>
</tr>
</tbody>
</table>

Source: SPE Paper 68755

Natural Gas is Globally Abundant

32,560 TcF!
Unconventional Gas

Research Questions

- How do facies and depositional environment impact diagenesis; what impact does diagenesis have on production?
- Are there systematic controls on pore/fracture networks that can be described, classified and modeled?
- Are there common source and charge characteristics between different geographic basins?
- Can we model the rock physics and can we image rock/fluid variations seismically?
- How do we “contact” the molecules? What are the optimum stimulation and recovery methods?
Unconventional Gas

Practical Challenges

- Determining whether low-quality reservoirs covering large areas are continuous and can be developed as resource plays
- Finding the production “sweet spots”
- Developing advanced technologies for hydraulic fracturing and other primary stimulation approaches
- Secondary and tertiary recovery strategies
- Addressing adverse environmental effects required to produce low quality reserves – surface disturbance, compressor noise, water disposal, and others
HYDRATE OUTCROP: GREEN CANYON 234

Roger Sassen, Texas A&M University
Natural gas is abundant and found in more regions than oil
- this speaks to energy diversity and energy security
- deliverability is the near term challenge

LNG provides a global delivery infrastructure
- help stabilize energy prices on the macro-level
- make the transition to alternative energies smoother

Increased use of natural gas—to replace coal in power generation and oil in transportation—would help reduce atmospheric emissions relative to the current energy mix
Implications of Natural Gas

Natural Gas Challenges

- Deliverability
- Access
- Economic Development of Unconventionals
- CO₂ Emissions

Natural gas is abundant and found in more regions than oil. This speaks to energy diversity and energy security. Deliverability is the near-term challenge. LNG provides a global delivery infrastructure that helps stabilize energy prices on the macro-level. Making the transition to alternative energies smoother. Increased use of natural gas—to replace coal in power generation and oil in transportation—would help reduce atmospheric emissions relative to the current energy mix.
Outline

I. Global Energy and Economy

II. Conventional & Unconventional Gas

III. Alternatives to Natural Gas

IV. Future Energy Trends
Dave Barry

Never be afraid to try something new. Remember that a lone amateur built the Ark. A large group of professionals built the Titanic.
Electricity’s Role

Electricity is playing an ever greater role in energy end use.

After Huber and Mills, 2005

Global Coal

Reserves/Production

Commericially Enabled CCS

+$

CMVA

EOR

BEG Gulf Coast Carbon Center
Coal Challenges

- CO₂
- Air Quality
- Fresh Water
- Mining Impacts
Hydro Challenges

- Fresh Water Capture
- Land Use & Topography
- Drought
Nuclear Challenges

- Public Perception
- Front End Cost
- Waste Disposal
- Permitting and Regulatory
Wind Challenges

- Transmission
- Energy Storage
- Materials
- Infrastructure
Solar

Spain

Solar Challenges

• Manufacturing
• Energy Storage
• Transmission
• Land Use
Geothermal Challenges

- Thermal Conversion
- Geology
Alternate Energy

- Wind
- Solar
- Hydroelectric
- Geothermal
- Tides
- Waves

- "Renewable"
- Cleaner
- Intermittent
- Lower Energy Density
- More Expensive

Most Alternate Energy Fuels Produce Electricity
Electricity Summary

- **Efficiency**
  - Fuel, lighting, electronics, insulation
  - *Challenge: Rebound effect*

- **Coal**
  - Abundant, reliable, cheap and dirty (CO₂)
  - *Challenge: Sequestration (IGCC w/ CCS), financing, public perception*

- **Nuclear**
  - Abundant, reliable, moderate price and cleaner
  - *Challenges: Waste disposal, security, front end cost, perception*

- **Natural Gas**
  - Abundant, reliable, volatile price, and cleaner
  - *Challenges: Global deliverability (LNG) and Access*

- **Alternatives (hydro, wind, solar, geothermal, tides, waves...)**
  - Cleaner, less reliable, can be more expensive
  - *Challenge: Intermittency, scale, cost*
Electricity Summary

- **Efficiency**
  - Fuel, lighting, electronics, insulation
  - **Challenge:** Rebound effect

- **Coal**
  - Abundant, reliable, cheap and dirty (CO₂)
  - **Challenge:** Sequestration (IGCC w/CCS), financing, public perception

- **Natural Gas**
  - Abundant, reliable, volatile price, and cleaner
  - **Challenge:** Global deliverability (LNG) and Access

- **Alternatives (hydro, wind, solar, geothermal, tides, waves)**
  - Cleaner, less reliable, can be more expensive
  - **Challenge:** Intermittency, scale, cost

---

**We do not use Energy Efficiently** but

**Efficiency Alone will not Solve the Energy Challenge**

---

**A Grand Challenge:**

- Improved Electricity Storage and Transmission

---

We do not use Energy Efficiently but Efficiency Alone will not Solve the Energy Challenge

---

A Grand Challenge:

- Improved Electricity Storage and Transmission
Outline

I. Global Energy and Economy
II. Conventional & Unconventional Gas
III. Alternatives to Natural Gas
IV. Future Energy Trends
Primary Energy Demand Forecast

1.25% annual demand growth

Historical Data: EIA October 2007

Global Energy Consumption (quads)

Petroleum
Coal
Natural Gas
Hydroelectric
Biomass, Geothermal, Solar & Wind
Nuclear

Tinker Forecast

Fossil Fuels

~255Q ~415Q ~495Q Fossil Fuels

1.25% annual demand growth

Global Energy Consumption (quads)

20% Non Fossil

Historical Data: EIA October 2007
CO₂ Emissions

Historical Data: EIA October 2007

Actual Emissions vs. Calculated CO₂ from Tinker Energy Forecast

- CO₂ Oil (million metric tons)
- CO₂ Gas (million metric tons)
- CO₂ Coal (million metric tons)

Global Energy Consumption (quads)

- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015
- 2020
- 2025
- 2030
Energy Transitions Take Time

The Bridge

Fossil Fuels

Non Fossil Energy
Take Aways

I. Energy underpins modern economies

II. “Big Oil” is Transitioning from Public Corporations (IOCs) to State Owned Companies (NOCs)

III. Several nations in the developing world are acquiring fossil fuel resources

IV. Natural gas is globally abundant

V. Most alternate energy “fuels” produce electricity

VI. We do not use energy efficiently; efficiency alone will not solve the Energy Challenge

VII. Energy transitions take time

VIII. Natural gas, and increasingly unconventional natural gas, represents a vital part of the 21st century energy portfolio
Let’s be thoughtful as we move into the future.

The global complexities are great and a desperate leap is unnecessary and unwarranted.