JHS/APL Rethinking Seminar Series:
Rethinking U.S. Enduring Strengths, Challenges, and Opportunities
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Shaking Energy Landscape
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Major Events And Real World Oil Prices, 1970-2008Q1
(Inflation-adjusted 2008 dollars per barrel)

- 1973 Arab Oil Embargo
- Saudis abandon "swing producer" role
- 1973 Arab Oil Embargo
- Iranian Revolution; Shah Deposed
- Prices rise on OPEC cutbacks, increased demand
- 9/11 attacks
- Workers strike in Venezuela
- Asian economic crisis
- Iraq Invades Kuwait
- Gulf War Ends
- Import Refiner Acquisition Cost
Revenge of the Oil Price Cycle

Dollars per barrel

2007 2008 2009 2010 2011 2012 2013 2014
Hydraulic Fracturing

Hydraulic fracturing, or “fracking,” involves the injection of more than a million gallons of water, sand, and chemicals at high pressure down and across into horizontally drilled wells as far as 10,000 feet below the surface. The pressurized mixture causes the rock layer, in this case the Marcellus Shale, to crack. These fissures are held open by the sand particles so that natural gas from the shale can flow up the well.
US Production and Global Market

Dry gas production

LPG production

Crude oil production

Source: U.S. Energy Information Administration; LPG = Propane and Butane; Crude oil includes lease condensate
Unconventional Oil and Gas Revolution: Why the U.S.?

- Known geology and data availability
- Pricing liberalization
- Mineral rights ownership
- Large number of independent producers
- Stable tax regime and regulatory environment
- Competitive oilfield equipment and services sector
- Availability of investment funds
- Existing infrastructure, although inadequate now with boom
These seven regions accounted for 95% of U.S. oil production growth and all U.S. natural gas production growth from 2011-2013

Source: EIA, Drilling Productivity Report
Longer Term: Projected US Natural Gas Resources

U.S. dry natural gas production

History 2012 Projections

Non-associated onshore
Non-associated offshore
Associated with oil
Coalbed methane
Tight gas
Shale gas

Source: EIA, Annual Energy Outlook 2014 Early Release
Marcellus Production Exceeds Capacity of the Two Largest LNG Exporters

Billion cubic feet per day

- **Marcellus**: 14 billion cubic feet per day (18% US Demand vs. < 1% in 2005)
- **Qatar**: Operational capacity
- **Australia**: Under construction

Sources: EIA, FGE
Increased production allows U.S. to transition from net importer to net exporter of natural gas

U.S. dry gas production, trillion cubic feet per year

Henry Hub spot Prices
(2012 dollars per million Btu)

The U.S. is the largest producer of petroleum and natural gas in the world.

Estimated U.S., Russia, and Saudi Arabia petroleum and natural gas production, quadrillion Btu and million barrels per day of oil equivalent.

**Source:** U.S. Energy Information Administration

**Note:** Petroleum production includes crude oil, natural gas liquids, condensates, refinery processing gain, and other liquids, including biofuels; barrels per day oil equivalent were calculated using a conversion factor of 1 barrel oil equivalent = 5.55 million British thermal units (Btu)
US dependence on imported liquids declines

U.S. liquids supply growth since 2010 and unplanned supply disruptions

Source: U.S. Energy Information Administration; 2014 includes data through September
Growing U.S. oil production and rising demand in China have together made China the world’s largest net oil importer

Net imports for China and the United States

Million barrels per day

Note: Net oil imports are defined as total liquid fuels consumption less domestic production

Source: EIA, Short-Term Energy Outlook, October 2014
The main regions pushing global gas demand higher are China – which overtakes the EU as a gas consumer around 2035 – and the Middle East

Source: IEA World Energy Outlook 2014
U.S. Imports from ME/Gulf

- 2.1 million barrels daily
- <25% total net U.S. oil imports

Global Oil Demand

- 92 million barrels daily

Strait of Hormuz Traffic

- 17.7 million barrels shipped daily
- 32% globally traded oil

Map showing oil demand and traffic:
- U.S. Imports from ME/Gulf
- 26% Non-Asian markets
- 11% Non-Asian markets
- 4% Non-Asian markets
- 11% Non-Asian markets
- 22% Asian and eastern markets
- 18% Asian and eastern markets
- 15% Asian and eastern markets
- 12% Asian and eastern markets
- 6% Asian and eastern markets
- Singapore
- Others
- U.S.
- Others
- Europe
- Japan
- China
- India
Middle East and North Africa Still Critical to Global Oil Supply

Crude Oil Proved Reserves (Billion Barrels)

Source: EIA Data
Instability in the Middle East a major risk to oil markets

Oil production growth in United States, Canada, Brazil & the Middle East

The short-term picture of a well-supplied market should not obscure future risks as demand rises to 104 mb/d & reliance grows on Iraq & the rest of the Middle East

Source: IEA World Energy Outlook 2014
Asia’s crude oil import needs have caught up with volumes available from the Middle East, and it imports 7.7 mb/d of crude from the rest of the world by 2040.

Source: IEA World Energy Outlook 2014
# Top ten countries with technically recoverable shale resources

## Shale gas

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Trillion cubic feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>China</td>
<td>1,115</td>
</tr>
<tr>
<td>2</td>
<td>Argentina</td>
<td>802</td>
</tr>
<tr>
<td>3</td>
<td>Algeria</td>
<td>707</td>
</tr>
<tr>
<td>4</td>
<td>United States</td>
<td>665</td>
</tr>
<tr>
<td>5</td>
<td>Canada</td>
<td>573</td>
</tr>
<tr>
<td>6</td>
<td>Mexico</td>
<td>545</td>
</tr>
<tr>
<td>7</td>
<td>Australia</td>
<td>437</td>
</tr>
<tr>
<td>8</td>
<td>South Africa</td>
<td>390</td>
</tr>
<tr>
<td>9</td>
<td>Russia</td>
<td>285</td>
</tr>
<tr>
<td>10</td>
<td>Brazil</td>
<td>245</td>
</tr>
<tr>
<td></td>
<td><strong>World total</strong></td>
<td><strong>7,299</strong></td>
</tr>
</tbody>
</table>

## Shale oil

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Billion barrels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russia</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>United States</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Argentina</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>Libya</td>
<td>26</td>
</tr>
<tr>
<td>6</td>
<td>Venezuela</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>Mexico</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>Pakistan</td>
<td>9</td>
</tr>
<tr>
<td>9</td>
<td>Canada</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>Indonesia</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td><strong>World total</strong></td>
<td><strong>345</strong></td>
</tr>
</tbody>
</table>

*Source: United States: EIA and USGS; Other basins: ARI.*
Necessary Conditions

- Prices
- Regulatory structure
  - Mineral rights
  - Industry structure
  - Fiscal regimes
- Infrastructure
  - Markets
  - Governance
- Environmental concerns
EIA Reference scenario shows world tight oil production increasing to almost 8 million b/d in 2025

tight oil production
million barrels per day

Tight oil production remains focused in the United States, but is joined increasingly by other players.

Source: IEA World Energy Outlook 2014
Oil-revenue dependency and breakeven prices

Break Even Price

$/bbl

Percent of budget from oil and gas revenues

Break Even Price

- Yemen
- Russia
- Algeria
- Nigeria
- Iran
- Bahrain
- Iraq
- Venezuela
- Libya
- Saudi Arabia
- Angola
- Kuwait
- Qatar
Russia is more of a petro-state than the Soviet Union. Oil and gas equal more than 50% of budget revenue and 70% of export earnings.
LIVE LONG, BUY OUR GAS AND PROSPER
European gas imports become more diverse over time, as North African supply bounces back, the southern corridor enables new supply and LNG supply grows.

Source: IEA World Energy Outlook 2014
In the last 5 years, almost 30% of global oil & discoveries were in sub-Saharan Africa; the region has vast untapped renewables potential, notably hydropower & solar

Source: IEA World Energy Outlook 2014
In sub-Saharan Africa, 620 million people – two-thirds of the population – live without electricity. Only a handful of countries have electrification rates above 50%.

Source: IEA World Energy Outlook 2014
The region remains a major global supplier, although regulatory uncertainty, unrest & oil theft in Nigeria make Angola the main producer of crude oil until the 2020s

Source: IEA World Energy Outlook 2014
Africa as new global gas player

Increase in gas production in selected countries & regions, 2012-2040

LNG export is the anchor for the east coast gas discoveries, but half of the overall increase in gas output goes to domestic power generation & industry

Source: IEA World Energy Outlook 2014
Takeaways

• Unconventional/shale story in the US is transformative, though still in early stages for tight oil
• Infrastructure and delivery system still evolving
• Unclear how international developments will play out
• Refinery investments/choices depend on policy
• Challenges still considerable, including climate considerations
• Middle Eastern and North African supplies still critical to global markets
• U.S. is heading towards 90% energy self-sufficiency but still part of a global market
• Foreign and defense policy implications?