A Global Model of Natural Gas Markets: Some Case Results

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Overview and Motivation

- North America has essentially been self-sufficient for natural gas supplies until recently
- Current and projected tightness of the North American natural gas market has highlighted the need for new sources of natural gas
- LNG can provide much of the needed supply... but North America must become part of a larger marketplace.
- Most current modeling efforts assume LNG supply availability at certain costs at scheduled intervals into North America...
  - Ignores global competition for scarce resources
  - Ignores the dynamic aspect of profitability in the LNG value chain
  - Ignores comparative costs of delivery to disconnected markets, and the emerging relationship imposed by increased LNG capacity between those markets
Demand sinks and supply sources are regionally disconnected!

Source: USGS
An important point regarding supply

- Long term market influence determined by more than just proved reserves. Resource assessment matters…
Experiment #1: Technological Change in LNG

- Falling LNG transport, liquefaction, and regasification costs – capital and O&M
  - Rates of change based on statistical fit of WEIO rates

![LNG Capital Costs Graph]

- LNG Capital Costs
  - Total
  - Liquefaction
  - Shipping
  - Regasification

$/mcf

Experiment #2:
Russia as a Dominant Producer

- Raise the required rate of return on supply projects in Russia... monopoly rents
Comparing the Cases

- Henry Hub (long term)

### Average Price by Decade at Henry Hub by Case

<table>
<thead>
<tr>
<th>Case Type</th>
<th>2011-2020</th>
<th>2021-2030</th>
<th>2031-2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>$3.00</td>
<td>$4.50</td>
<td>$5.00</td>
</tr>
<tr>
<td>Russia Monopoly</td>
<td>$3.50</td>
<td>$5.00</td>
<td>$5.50</td>
</tr>
<tr>
<td>LNG Tech</td>
<td>$4.00</td>
<td>$5.00</td>
<td>$5.50</td>
</tr>
</tbody>
</table>
Comparing the Cases (cont.)

- Regional price comparisons
  - Price convergence is greater with increased LNG trade
Comparing the Cases (cont.)

- Price Delta to Base Case by Select Region

  - Asian impact generally larger in Russia case

**Russia Monopoly - Price Difference from Base Case**

- Henry Hub
- Zeebrugge
- Japan
- China

**LNG Tech - Price Difference from Base Case**

- Henry Hub
- Zeebrugge
- Japan
- China
Comparing the Cases (cont.)

- Production Share by region – Base Case

**2020 Production Share**

- ROW, 14.5%
- Russia, 23.5%
- South America (majors), 8.1%
- Africa (majors), 5.8%
- North Sea Region, 8.4%
- Australasia, 7.6%
- Mexico, 1.1%
- US (L48 and Alaska), 14.7%

**2040 Production Share**

- ROW, 15.2%
- Russia, 23.1%
- South America (majors), 9.8%
- Africa (majors), 5.2%
- North Sea Region, 5.5%
- Australasia, 7.0%
- Mexico, 0.4%
- US (L48 and Alaska), 6.0%
- Iran, 12.5%
- Canada, 1.4%
Comparing the Cases (cont.)

- Production Share by region – LNG Tech

2020 Production Share

- ROW, 14.8%
- Russia, 22.2%
- South America (majors), 8.1%
- Turkmenistan, 2.1%
- Kazakhstan, 1.8%
- Saudi Arabia, 2.8%
- Qatar, 1.5%
- Iraq, 1.6%
- Iran, 4.2%
- Canada, 2.8%
- Australasia, 7.5%
- US (L48 and Alaska), 14.1%

2040 Production Share

- ROW, 15.2%
- Russia, 22.6%
- South America (majors), 9.1%
- Turkmenistan, 2.0%
- Kazakhstan, 1.2%
- Saudi Arabia, 8.5%
- Qatar, 1.8%
- Iraq, 1.9%
- Iran, 14.1%
- Canada, 1.3%
- Australasia, 6.5%
- Mexico, 0.4%
- US (L48 and Alaska), 5.6%
Comparing the Cases (cont.)

- Production Share by region – Russia Monopoly

2020
Production Share

- Russia, 18.4%
- US (L48 and Alaska), 15.0%
- ROW, 15.1%
- Australasia, 7.8%
- Mexico, 1.1%
- North Sea Region, 8.5%
- South America (majors), 8.0%
- Africa (majors), 6.1%
- Turkmenistan, 2.8%
- Kazakhstan, 2.2%
- Saudi Arabia, 2.7%
- Qatar, 1.6%
- Iran, 6.2%
- Canada, 3.0%

2040
Production Share

- Russia, 19.2%
- US (L48 and Alaska), 6.6%
- ROW, 15.9%
- Canada, 1.5%
- Mexico, 0.4%
- Australasia, 7.1%
- North Sea Region, 5.5%
- South America (majors), 10.2%
- Turkmenistan, 2.5%
- Kazakhstan, 1.3%
- Saudi Arabia, 7.4%
- Qatar, 1.9%
- Iraq, 2.1%
- Iran, 13.0%
Comparing the Cases (cont.)

- LNG Share by region

**Base Case - LNG Share of World Supply by Region**

**LNG Tech - LNG Share of World Supply by Region**

**Russia Monopoly - LNG Share of World Supply by Region**
Comparing the Cases (cont.)

- Base Case - World Demand by Region

**2002 Consumption Share**

- US: 22.9%
- Canada: 3.3%
- Mexico: 1.6%
- EU: 19.9%
- Russia: 16.5%
- South Korea: 0.9%
- China: 1.3%
- Japan: 3.2%
- ROW: 25.3%
- South America: 4.0%
- India: 1.0%
- South Korea: 0.9%

**2040 Consumption Share**

- US: 12.6%
- Canada: 2.4%
- Mexico: 4.7%
- EU: 18.2%
- Russia: 14.4%
- India: 2.9%
- China: 7.2%
- South Korea: 1.1%
- Japan: 1.5%
- South America: 10.4%
- ROW: 24.5%

- 90 Tcf
- 263 Tcf
Comparing the Cases (cont.)

- LNG Tech - World Demand by Region

2002 Consumption Share

- US 22.9%
- ROW 25.3%
- Canada 3.3%
- Mexico 1.6%
- Russia 16.5%
- EU 19.9%
- Japan 3.2%
- China 1.3%
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90 Tcf

2040 Consumption Share

- US 12.7%
- Russia 14.3%
- EU 18.3%
- South America 10.3%
- India 2.9%
- China 7.3%
- South Korea 1.2%
- Japan 1.5%
- Mexico 4.8%
- Canada 2.4%

265 Tcf
Comparing the Cases (cont.)

- Russia Monopoly - World Demand by Region

2002 Consumption Share

- US 22.9%
- Canada 3.3%
- Mexico 1.6%
- EU 19.9%
- Russia 16.5%
- Japan 3.2%
- South Korea 0.9%
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90 Tcf

2040 Consumption Share

- US 12.7%
- Canada 2.4%
- Mexico 4.7%
- EU 18.2%
- Russia 14.3%
- Japan 1.5%
- South Korea 1.1%
- China 7.2%
- India 2.9%
- South America 10.4%
- ROW 24.6%

260 Tcf
Comparison of Select Results

- Japan
  - LNG Tech: No Sakhalin pipeline.

- South Korea
  - All Cases: 2015 - Pipeline from Nahodka. Market served by both LNG and pipe.

- China
  - Base Case
    - 2012 - East Siberian pipeline to North China.
    - 2020 - LNG to South China.
    - 2030 - Kazakhastan pipeline to West China.
  - LNG Tech
    - 2012 - East Siberian pipeline to North China.
    - 2020 - LNG to South China.
    - No Kazakhastan pipeline.
  - Russia Monopoly
    - 2012 - East Siberian pipeline to North China.
    - 2020 - LNG to South China.
    - 2035 - Kazakhastan pipeline to West China. Lower Russian production pulls supply away.
Comparison of Select Results (cont.)

- **India**
  - **Base Case**
    - 2025 - Iran to India (trans-Pakistan) pipeline.
    - 2020 - Bangladesh to India pipeline.
    - No LNG.
  - **LNG Tech**
    - 2025 - Iran to India (trans-Pakistan) pipeline.
    - 2020 - Bangladesh to India pipeline.
    - 2030 - LNG Imports begin
  - **Russia Monopoly**
    - 2025 - Iran to India (trans-Pakistan) pipeline.
    - 2020 - Bangladesh to India pipeline.
    - No LNG

- **Russia**
  - **Base Case**
    - 2030 - West Siberia to East Siberia Pipeline… access to China.
    - 2030 - Barents Sea LNG
  - **LNG Tech**
    - 2035 - West Siberia to East Siberia Pipeline… access to China.
    - 2025 - Barents Sea LNG
  - **Russia Monopoly**
    - 2035 - West Siberia to East Siberia Pipeline… access to China.
    - No Barents Sea LNG

- **Venezuela**
  - All Cases: 2020 - LNG exports begin.
Comparison of Select Results (cont.)

**EU**

- **Base Case:**
  - LNG market share:
    - 1.9% by 2010 (1.2 bcfd), 4.7% by 2025 (4.1 bcfd), and 11.6% by 2035 (13.3 bcfd).

- **LNG Tech:**
  - LNG market share:
    - 2.2% by 2015 (1.3 bcfd), 10.7% by 2025 (9.4 bcfd), and 20.6% by 2035 (23.7 bcfd).

- **Russia Monopoly:**
  - LNG market share:
    - 3.5% by 2015 (2.1 bcfd), 6.0% by 2025 (5.2 bcfd), and 12.1% by 2035 (13.7 bcfd).

**US**

- **Base Case:**
  - 2015 - Alaska pipeline.
  - 2030 - Demand reaches 30 Tcf.
  - Aggressive LNG import growth post-2015. LNG market share:
    - 7.5% by 2015 (5.3 bcfd), 20.9% by 2025 (17.0 bcfd), and 35.0% by 2035 (30.7 bcfd).

- **LNG Tech:**
  - 2015 - Alaska pipeline.
  - 2025 - Demand reaches 30 Tcf.
  - Aggressive LNG import growth post-2010. LNG market share:
    - 7.7% by 2012 (5.2 bcfd), 33.4% by 2025 (27.4 bcfd), and 63.1% by 2035 (56.0 bcfd).

- **Russia Monopoly:**
  - 2015 - Alaska pipeline.
  - 2030 - Demand reaches 30 Tcf.
  - Aggressive LNG import growth post-2010. LNG market share:
    - 7.2% by 2015 (5.1 bcfd), 20.4% by 2025 (16.5 bcfd), and 37.6% by 2035 (32.9 bcfd).
Future Work

- Continuing review of model architecture
  - Infrastructure and data as information is made available.

- From experiments to scenarios
  - Experiments involve singular changes…
    - No Sakhalin to Japan Pipeline
    - No Nahodka to South Korea Pipeline
    - No Iran to Pakistan to India Pipeline
    - US LNG import terminals in Gulf Coast only
  - Scenarios involve multiple changes
    - Consider different states of the world and assess the resulting impact on the development of global natural gas market.