Rice World Gas Trade Model: Russian Natural Gas and Northeast Asia

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Overview and motivation

Worldwide, the demand for natural gas is rising:

- Environmental pressure for cleaner fuels
- Wholesale electricity market competition raised the demand for smaller scale electricity plant, which CCGT satisfied

The share of gas may continue to rise:

- Gas may supply transport fuel needs (GTL, oil shale, fuel cell)
- A possible contrary influence is that coal gasification, solar, hydro and/or nuclear power, perhaps assisted by falling costs of HVDC, could displace gas in electricity generation

Source: EIA
Overview and motivation

- World gas supply potential is large, but:
  - It is concentrated in areas remote from markets
  - Production and transport infrastructure is required
  - Prices need to rise in real terms to finance the investments
  - Unstable political regimes may make investments unattractive

- Russia could be a big supplier of natural gas to both Europe and Asia, making developments there critical

- Demand growth in China, Japan and South Korea also make Northeast Asia critical to the world gas market

- The Rice World Gas Trade Model, based on economic and geological fundamentals, can be used to examine political and economic influences on the world market for natural gas
Rice World Gas Trade Model

- Model framework: Market Builder from Altos Partners calculates equilibrium prices and quantities for fixed locations and periods.

- Supply data is based on the USGS World Resource Assessment:
  - associated and unassociated natural gas resources,
  - conventional and CBM gas deposits in North America and Australia, and
  - conventional gas deposits in the rest of the world assessed in three categories:
    - proved reserves (updated 2003 Oil & Gas Journal estimates)
    - growth in known reserves (P-50 USGS estimates)
    - undiscovered resource (P-50 USGS estimates)

- Econometric model for forecasting demand developed using EIA, IEA and World Bank data related gas demand to:
  - The level of economic development (GDP/capita)
    - Energy demand increases with GDP/capita but at a decreasing rate
    - Natural gas share in primary energy demand increases with development
  - Population
  - Country-specific effects reflecting, for example, resource endowments or climate
  - Prices (wholesale industrial $/BTU) of natural gas, oil and coal

- From 2030, allow demand to be lost to new technologies at prices above $5 with up to 2.5% lost at $5.50 and 5% lost at $10:
  - Each year, the proportion of demand vulnerable to the backstop at each price above $5 increases until in 2040 all base case demand could be satisfied at a price of $10.
More detail on supply

- Cost estimates for North America (including Canada and Mexico) were applied elsewhere based on geological characteristics
  - The North American estimates (developed for the NPC) include:
    - capital cost of development,
    - operating and maintenance costs, and
    - cost changes by region and deposit type as resources deplete
- We also allowed for technological change in mining:

![Technology Curves in the Resource Extraction Industries](chart.png)

*Source: Adapted from "Balancing Natural Gas Policy" National Petroleum Council, 2003*
Example cost of 2002 supply curves

Comparative Cost of Supply Curves for Selected Regions

Cumulative Reserve Additions (Quadrillion BTU)

- Alaska
- Qatar
- Saudi Arabia
- Iran
- West Siberia

Sources: USGS, EIA, author calculations
Linking supply with demand
Representing transport networks

The North American and European pipeline networks are now the main transport systems

- LNG is only about 5% of world demand, but is important in Japan & Korea, and increasing elsewhere
- To facilitate calculations:
  - supplies and demands are aggregated into discrete “nodes”,
  - parallel pipes are aggregated into a single link,
  - LNG routes are represented by hubs and spokes, and
  - minor distribution and gathering pipes are ignored

The model chooses new or expanded transport capacity from supply sources to demand sinks based on:

- capital costs of expansion, and
- operating and maintenance costs of new and existing capacity

Transport links are inherently discrete

- We allow many potential pipeline links including ones that have been discussed and others that might appear profitable at prices calculated in initial iterations of the model
- The hub and spoke representation for LNG allows for many potential trading partners
LNG transportation network
Pipeline and LNG costs

- Regressed EIA cost data (annual cost per unit of capacity) for 52 pipeline projects on:
  - Pipeline length
  - Pipeline capacity
    - Higher capacity reduces per unit costs as a result of scale economies
  - Indicator variables for whether the pipeline
    - crosses mountains;
    - moves offshore or crosses a lake or sea; or
    - crosses more populous areas

- LNG costs from 2003 EIA report and industry sources
  - Shipping costs split into a fixed capital cost for ship development plus operating costs of:
    - 2.25% of fixed cost of development
    - fuel use during transit (0.15% per day)
  - Liquefaction costs are a fixed cost ($4.11/mcf/yr) plus a variable feed gas cost (model calculated)
  - Regasification costs vary by location (primarily because land costs vary)
  - Allowed for technological change to reduce LNG costs at rates of change based on a statistical fit to the IEA World Energy Investment Outlook
Supply Projections

Europe and US shrink, Russia, Middle East and Australia expand

Source: RWGTM, Hartley and Medlock (2005)
Demand projections

Source: RWGTM, Hartley and Medlock (2005)
Natural gas trades

Source: RWGTM, Hartley and Medlock (2005)
**LNG export projections**

**Dominant feature:** Growth in the Middle East

Source: RWGTM, Hartley and Medlock (2005)
LNG import projections

Dominant feature: Growth in US Imports

Source: RWGTM, Hartley and Medlock (2005)
Selected price projections

Source: RWGTM, Hartley and Medlock (2005)
Some implications of the Reference Case

- Russia becomes the dominant exporter in the global gas market
  - Russian pipeline gas continues to be important for Europe
  - Russia also becomes a major supplier of natural gas to China, Korea and Japan
    - Sakhalin gas goes to Korea and Japan and East Siberian gas goes to China next decade
    - Korea shifts to pipeline gas from Russia and stops importing LNG
    - Gas is also piped east from West Siberia in the 2030’s
    - Japan continues to import LNG as a national gas grid is prohibitively costly
  - Russia also enters the LNG market possibly supplying the US
    - “Net-back” prices in Russia have to be equilibrated

- Middle East will also become an important supply region, exporting both LNG and pipeline gas
  - Major exporters in the region are Qatar, Iran, UAE and later on Saudi Arabia
  - From 2002-2040 Australia, Qatar and Indonesia are the largest suppliers of LNG (>40% of total), but in 2040 Iran, Russia and Saudi Arabia join Australia and Qatar to supply more than 60% of LNG exports

- Other long-haul international pipelines are constructed
  - The trans-Saharan pipeline (Nigeria to Algeria) is constructed in 2012
  - India imports Iranian gas via pipeline from 2020
  - Europe also imports gas from Iran, Iraq and Saudi Arabia via Turkey in substantial amounts from 2020
  - A pipeline from West Siberia to East Siberia is constructed in the mid 2030’s to supply NE Asia

- North America becomes a major importer of LNG
  - Alaskan gas replaces declines in other North American production with little effect on prices
  - Gas prices in the US eventually exceed prices in Japan
  - Russia, Middle East, Australia retain low gas prices

- Europe also imports more LNG than Northeast Asia from the middle of next decade

- South American gas is consumed primarily in South America
  - Trinidad LNG export growth is limited to the near term, but Venezuela is significant later
  - Brazil imports Bolivian and Venezuelan supplies
  - Argentina imports Bolivian supplies before importing LNG

- A backstop technology is implemented almost everywhere by 2040, but is used most heavily in the US, western Europe and Japan
Two scenario analyses

1. Pipelines from Nahodka & NE China through North Korea are blocked
   - Political relations with North Korea prevent them
   - An undersea pipeline to South Korea from China can still be built
   - Sakhalin pipeline to Japan still is possible
     - Connections between South Korea and Japan are also permitted, but these are too expensive to use

2. Russia to China pipelines also don’t get built
   - Political difficulties may also prevent this development
   - We also rule out the pipeline from Uzbekistan to China
     - It otherwise provides an indirect route for gas sales from the Volga-Urals region in Russia to China
   - Sakhalin pipeline to Japan with an extension to Korea still is possible
No North Korea pipes: Effects on NE Asia

**China**
- China imports more via pipeline and exports to South Korea

**Japan**
- Japan takes more pipeline gas, less LNG

**Korea**
- LNG and China pipeline share South Korean market

**Graphs:**
- Home production
- Pipeline imports
- LNG imports
- Exports
- Backstop

**Years:**
No North Korea pipes: Changes in Selected Prices

No North Korea pipes: Major Supply Changes

- Net supply changes most years are small
- Russian output declines most, but increased Russian exports to Europe also displace some Middle East pipeline exports
No North Korea pipes: Major Demand Changes

- Higher prices stifle South Korean, and to some extent Chinese, demand
- Demand reductions in other countries are more than compensated in other years
- Largest net demand increases are in Russia, Central Asia and Europe
No North Korea pipes: Major Changes in LNG Supply

- Sakhalin LNG exports after 2030 displace some Australian and Saudi exports
- Exports from Russian Atlantic and Greenland decline, and from Venezuela and Iranian expand, after 2030
- Australian and Southeast Asian exports expand up to 2020
No North Korea pipes: Major Changes in LNG Demand

- Korea is the only country to have a sustained increase in demand for LNG
- Other Pacific Basin importers – especially Japan, and to a lesser extent the US Pacific and China, experience reduced demand
- In most other countries, demand shifts are intertemporal
China & Korea pipes off: Effects on NE Asia

China

- China exports are now zero and China takes more LNG

Japan

- Japan takes even more pipeline gas and less LNG

Korea

- LNG beats a potential Sakhalin-Japan-Korea pipe
China & Korea pipes off: Changes in Selected Prices


Henry Hub  Tokyo  Buenos Aires  Seoul
Beijing  Zeebrugge  Delhi
China & Korea pipes off: Major Supply Changes

- Higher overall LNG demand leads to sustained expansions in the main LNG exporters (Australia, Iran, Qatar, Indonesia)
- US, Central Asian and Chinese domestic supply expand
- Largest reduction is in Russia, but outputs in Saudi Arabia, Nigeria, Greenland and Canada also fall in most years
China & Korea pipes off: Major Demand Changes

- Now Chinese demand decline exceeds the Korean one; remaining Pacific Basin importers are again adversely affected
- Main demand increases occur in Russia, Europe and the Middle East
China & Korea pipes off: Major Changes in LNG Supply

- Again Sakhalin LNG exports rise, but now the overall LNG market expands enough that few (only Greenland and Nigeria) LNG exports decline.
China & Korea pipes off: Major LNG Demand Changes

- Increased Korea and China LNG demand displaces other Pacific Basin importers
- North America Atlantic imports increase (mainly via Canada)
- Mexico shifts to pipeline imports from northern South America
Some implications of the Results

- In the coming worldwide market for natural gas, political disturbances in one area have global effects.
- The results illustrate the key role Russia will play in the future world gas market:
  - Russia not only has a lot of gas.
  - It also is strategically placed to ship gas either east or west and hence in a position to arbitrage between European and Asian markets.
  - Toward the end of the horizon, Russia also becomes a significant exporter of LNG, thus helping to solidify the link between LNG prices and pipeline gas prices around the world.
- North America and the Middle East also link Pacific and Atlantic gas markets:
  - Middle East producers can export LNG east or west, and also can ship gas via pipeline to Europe or the Indian sub-continent.
  - In North America, if Pacific Basin gas prices rise, more Atlantic Basin LNG is imported and the arbitrage point moves toward the west coast.
- Japan is a close competitor to South Korea for Pacific Basin LNG and increased Korean demand raises Japanese prices.