

The Future of Russian Natural Gas Exports

The Global Energy Market: Comprehensive Strategies to Meet Geopolitical and Financial Risks

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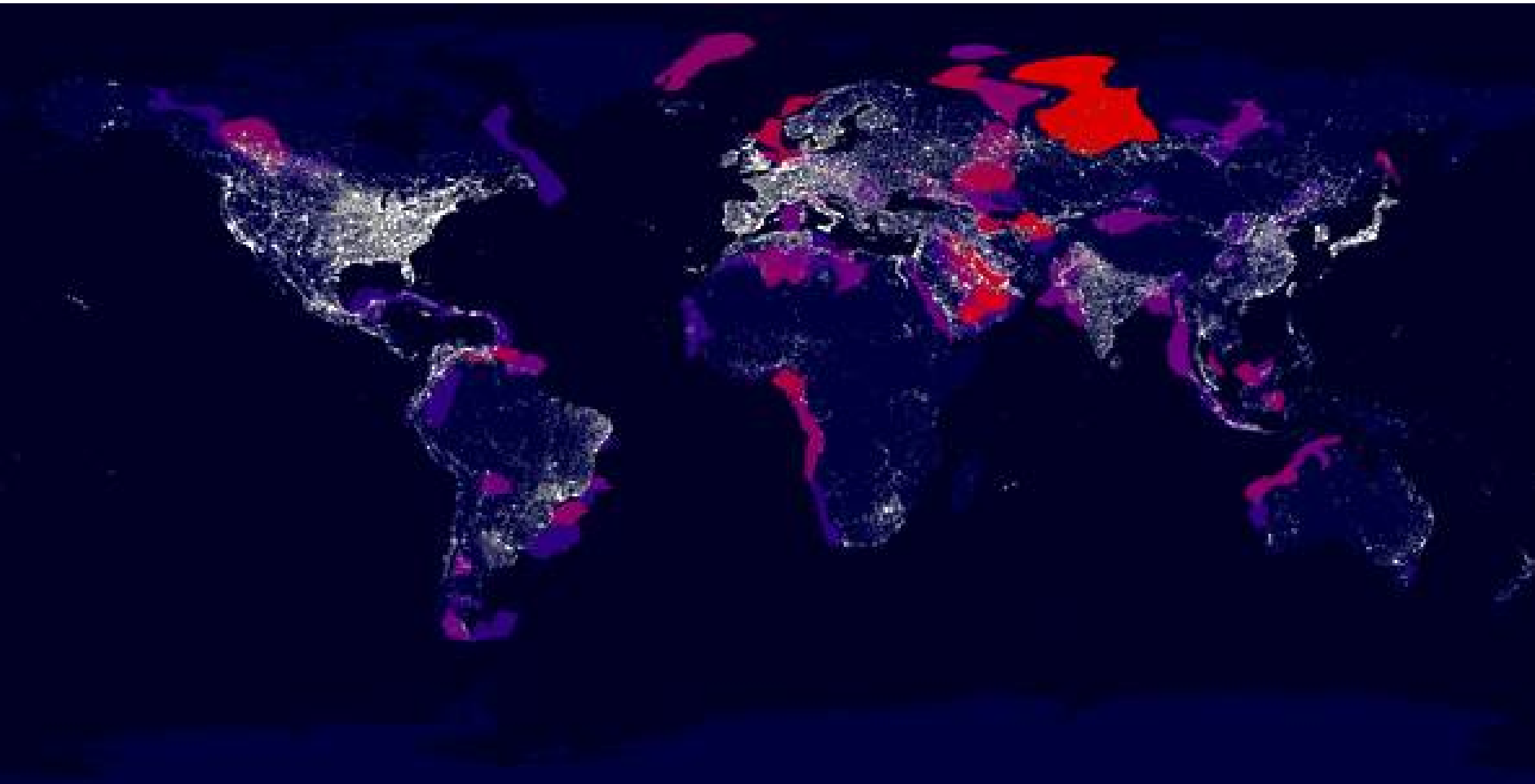
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Russia in a Global Gas Market



- **According to the USGS, global natural gas supply potential is large.**
- **Connecting resources and demand can be difficult.**
- **Geology, geography, and geopolitics shape the global gas market**

The Rice World Gas Trade Model

Modeling a Global Natural Gas Market

- The Rice World Gas Trade Model (RWGTM) is a dynamic spatial general equilibrium model that allows possible future developments of the global natural gas market to be examined
- Capacity expansion, both greenfield and brownfield, is based on capital, operating and maintenance costs, and anticipated revenues
- The model predicts regional prices, regional supplies and demands and inter-regional flows and associated capital investments
- Regions are defined at the country and sub-country level, with extensive representation of transportation infrastructure
- The model is non-stochastic, but it allows analysis of many different scenarios. Geopolitical influences can alter otherwise economic outcomes
- Uses *MarketBuilder* software from Altos Management Partners
- For more detail see:
 - Hartley, Peter and Kenneth B Medlock III, “The Baker Institute World Gas Trade Model” in *Natural Gas and Geopolitics From 1970 to 2040*, ed. Jaffe, Amy, David Victor and Mark Hayes, Cambridge University Press (2006)

RWGTM: Supply

- Oil and Gas Journal (2006), USGS World Resource Assessment (2000), and other sources for...
 - proved natural gas reserves,
 - conventional and unconventional gas resources in North America and Australia, and
 - conventional gas resources in the rest of the world
- ... assessed in three categories:
 - proved reserves (2006 Oil & Gas Journal estimates)
 - growth in known reserves (USGS and NPC estimates)
 - undiscovered resource (P50 USGS and NPC estimates)
- North American cost estimates were related to geological characteristics and applied globally
 - Required return on investment varies by region (using ICRG and World Bank data) and project type
 - Technological change can reduce mining costs
- Supply is distributed by major basin throughout the world.

RWGTM: Demand

- Econometric models used to forecast demand. Details available upon request.
- In the US and Canada, demand is modeled as residential, commercial, industrial and power. Determinants are sector-specific.
- 282 regions defined at the country and sub-country level.
- Rest of World demand is determined by a system in which
 - ... economic growth is based on conditional convergence to historical US growth rates at various levels of per capita income.
 - ... energy intensity declines as income rises.
 - ... the natural gas share of total energy increases with income, reflecting natural gas as a premium fuel, but declines with relative price increases.
 - Demand is modeled as 2 sectors (direct use and power) where data is available.
- We allow demand to be lost to IGCC from 2010 and unspecified new technologies from 2020
 - Demand lost to coal gasification is concentrated in large coal producing countries and is limited to electricity generation
 - After 2020, the proportion of demand vulnerable to the unspecified backstop at a price above \$7/MMBtu increases until in 2060 all reference demand could be satisfied at a price of \$10

RWGTM: Transportation

- Supplies and demands are aggregated into discrete “nodes”
- Some “corridor” representation of pipelines
 - US pipeline architecture is based on EIA data and the 2003 NPC study data
 - The European pipeline architecture is based on data provided by *Gas Strategies*
 - Potential routes also allowed
- Pipeline costs are split into fixed and variable costs
 - Fixed costs were based on a regression analysis of EIA cost data (annual cost per unit of capacity) for over 100 pipeline projects from 2002-2005
 - Determinants are pipeline length, capacity, and route
 - Variable costs based on FERC filed rates in the US and rate of return recovery elsewhere
- We represent LNG routes by hubs and spokes
 - This allows for many potential trading partners
 - Shipping distances were obtained from the National Imagery and Mapping Agency
- LNG costs were based on various industry sources
 - Shipping costs are represented as lease rates
 - Liquefaction costs are represented as fixed costs plus variable costs
 - Regasification costs are represented as fixed costs (varying by location primarily due to land costs) and variable costs (fuel and operating costs)
 - Technological change reduces LNG costs at rates based on IEA *World Energy Investment Outlook*

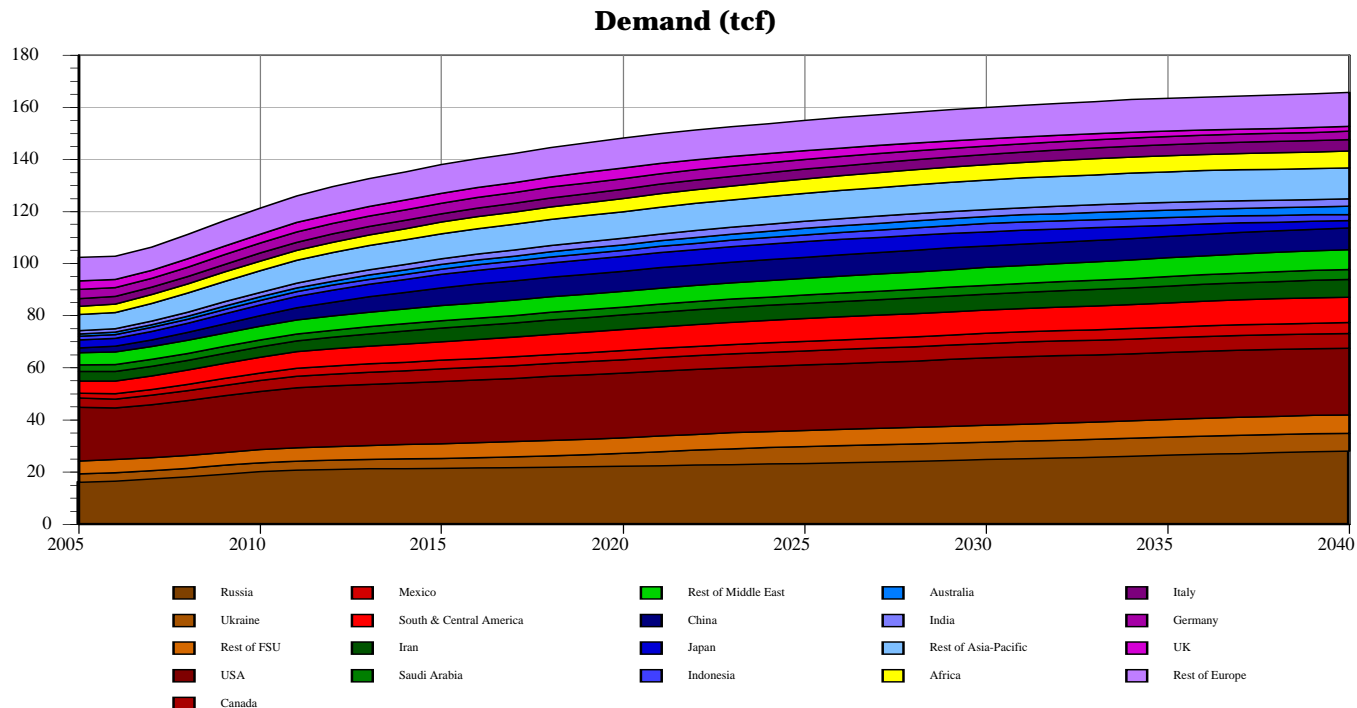
The Reference Case

Reference Case Results Summary

- North America becomes the largest LNG importing region
 - Alaska merely offsets declines in other North American production
 - Prices in the US exceed prices in Europe and eventually Asia
- The Middle East becomes an important supply region
 - Qatar is largest exporter in the region
 - Later growth in Iran
 - Iran and later Iraq are the primary sources of pipeline gas exports (both east and west) from the Middle East
- Russia is a dominant exporter in the global gas market
 - Pipelines to Europe
 - Sakhalin gas to Japan and the Korean peninsula (partly as LNG)
 - East Siberian gas to China
 - LNG from the Barents Sea region beginning in the late 2020s
- European LNG imports also grow substantially as Europe diversification of supply is an economic outcome
- South American gas is consumed primarily in South America
 - Trinidad LNG export growth is limited to the near term
 - Peru exports LNG from the beginning of next decade, but growth is moderate
 - Venezuela eventually begins exporting LNG

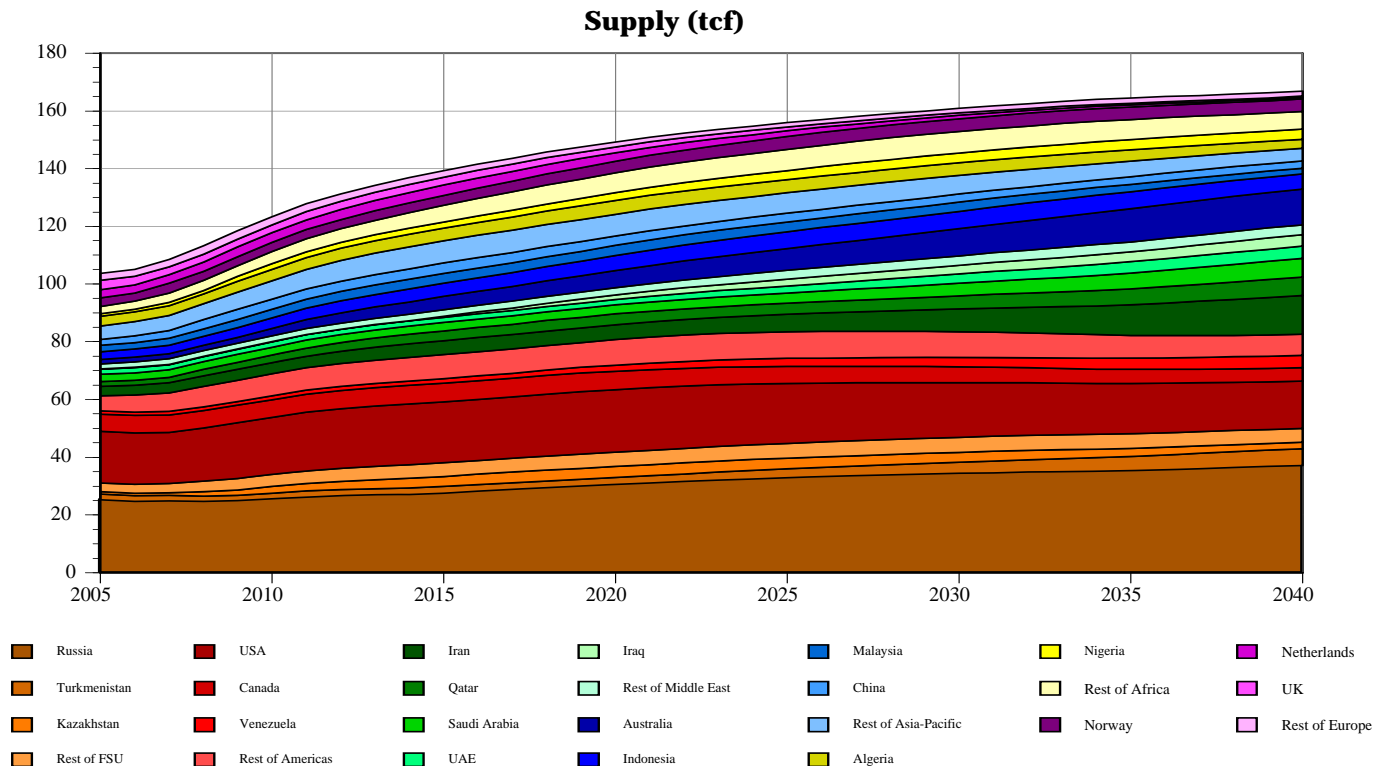
Reference Case Demand

- Through 2030, global demand grows at 1.8% pa
 - Global demand growth driven primarily by power generation demand
 - Strongest demand growth in China (5.9% pa) and India (3.3% pa)
 - Demand growth in North America (1.3% pa) and Europe (1.0% pa) is moderate
 - Demand growth in Russia is strong (1.7% pa)



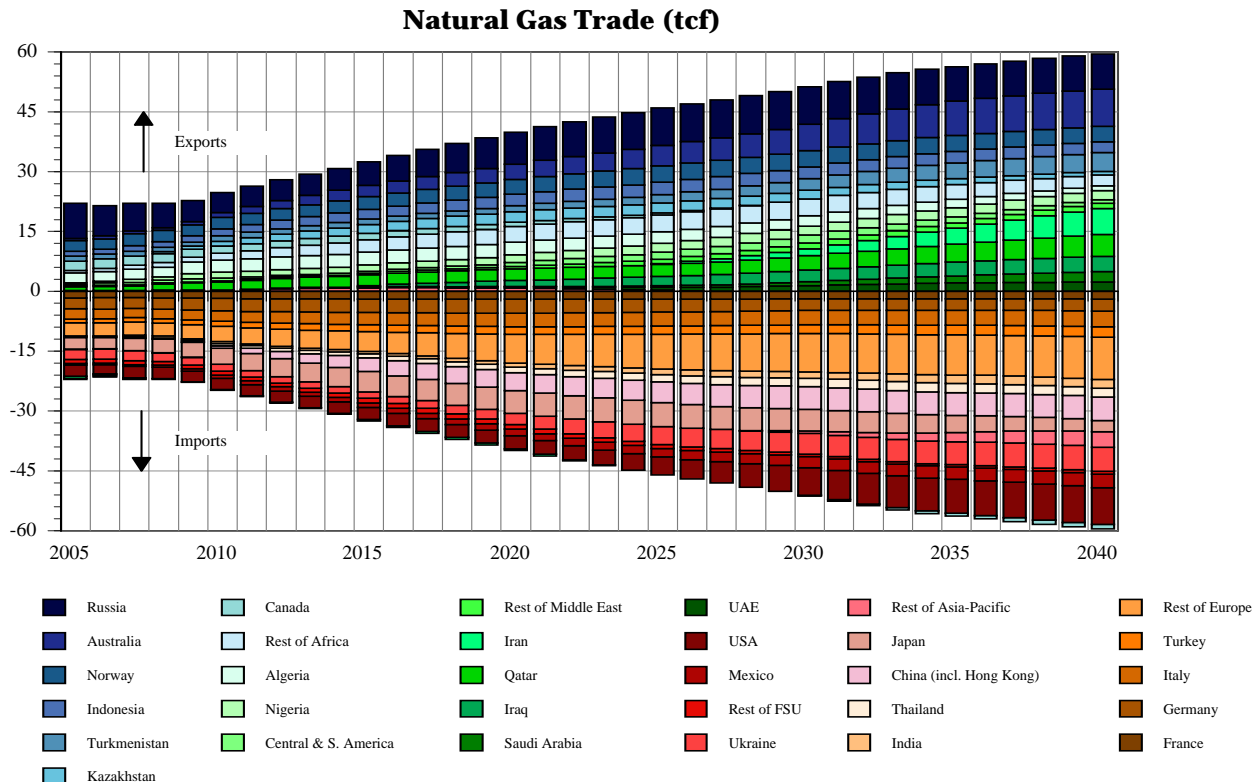
Reference Case Supply

- Strongest areas of supply growth are the Middle East (collectively), Australia, and Southeast Asia (incl. Brunei, Indonesia, Malaysia, and Vietnam)
- Declines apparent in North America and Europe
- Supply from Russia remains strong and grows steadily



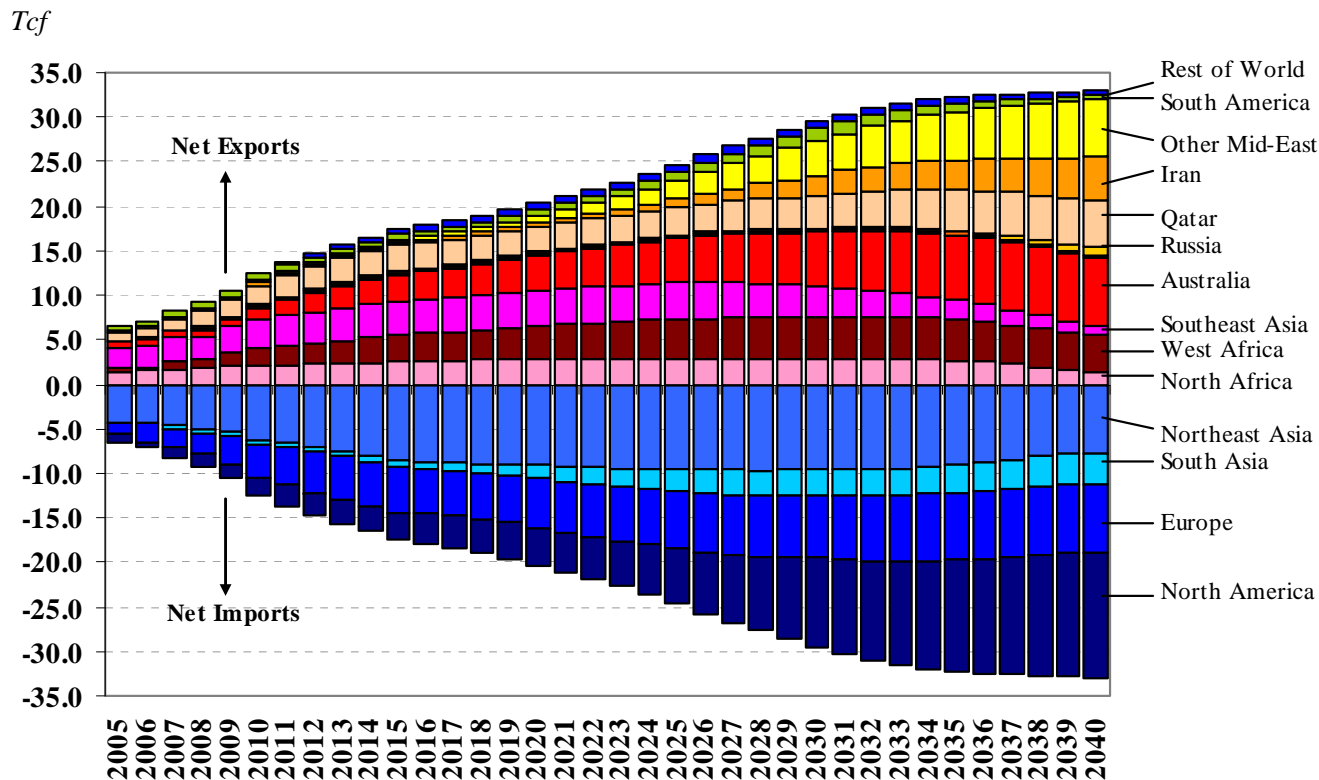
Reference Case Natural Gas Trade

- Russia and the Middle East (collectively), Are the largest exporters of natural gas
- North America and Asia grow the strongest, with Europe close behind
- There is a diverse set of suppliers and demanders in global natural gas trade
 - This point is important to understanding the global and regional response to disruptions in any one country

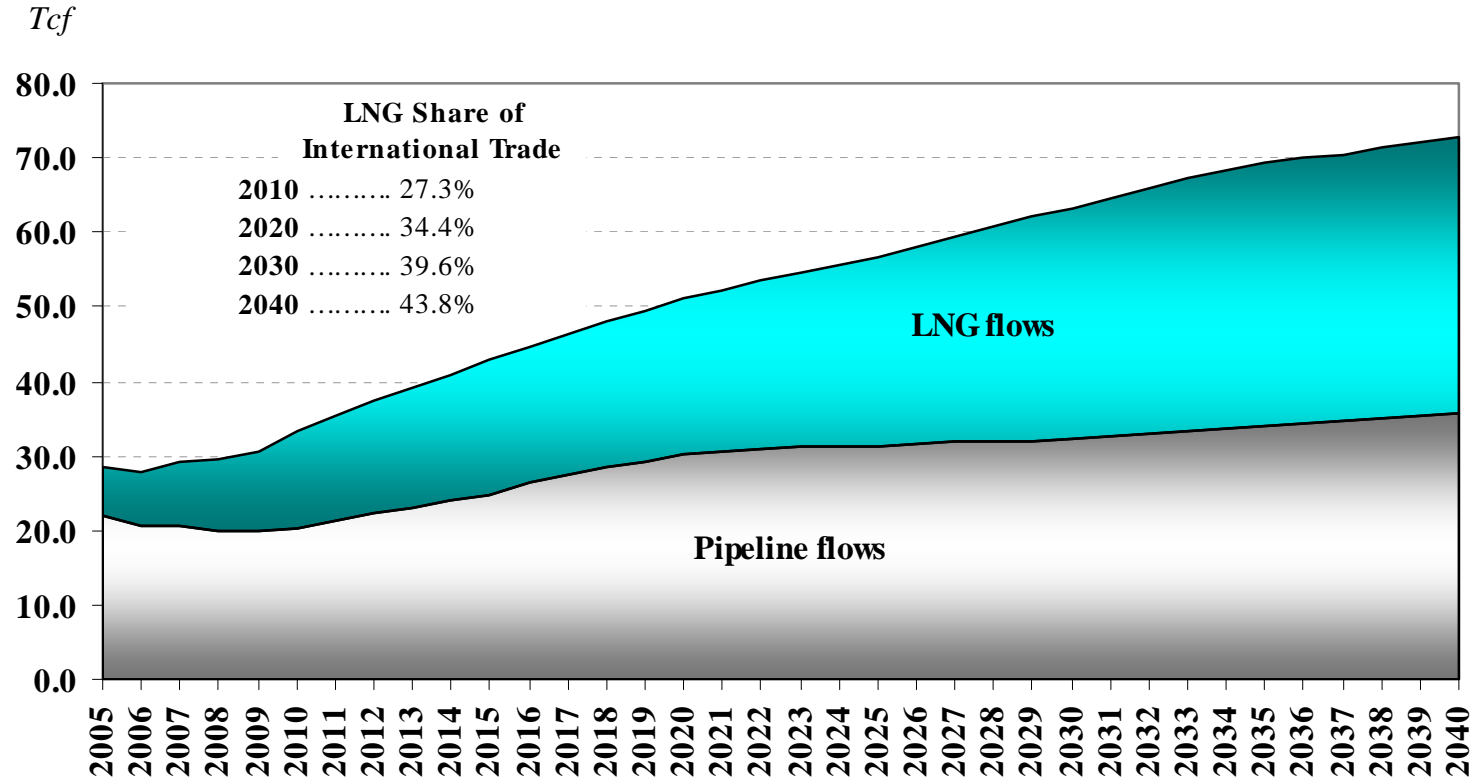


Reference Case LNG Trade

- North America becomes the largest LNG importer in the RWGTM Reference Case, with Asia and Europe close behind.
- The number of suppliers is diverse, but Australia, Qatar and other countries in the Middle East emerge as dominant LNG suppliers.



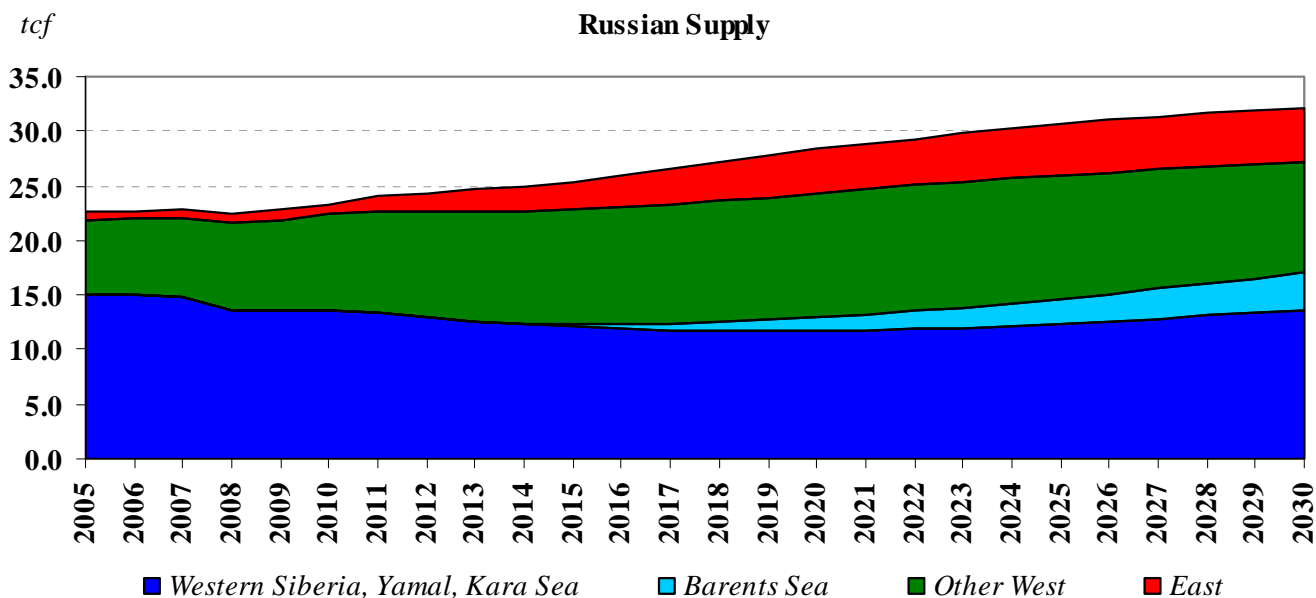
Global LNG Summary



- LNG gains share of international trade. This connects previously disconnected regional markets and leads to globalization of natural gas market.

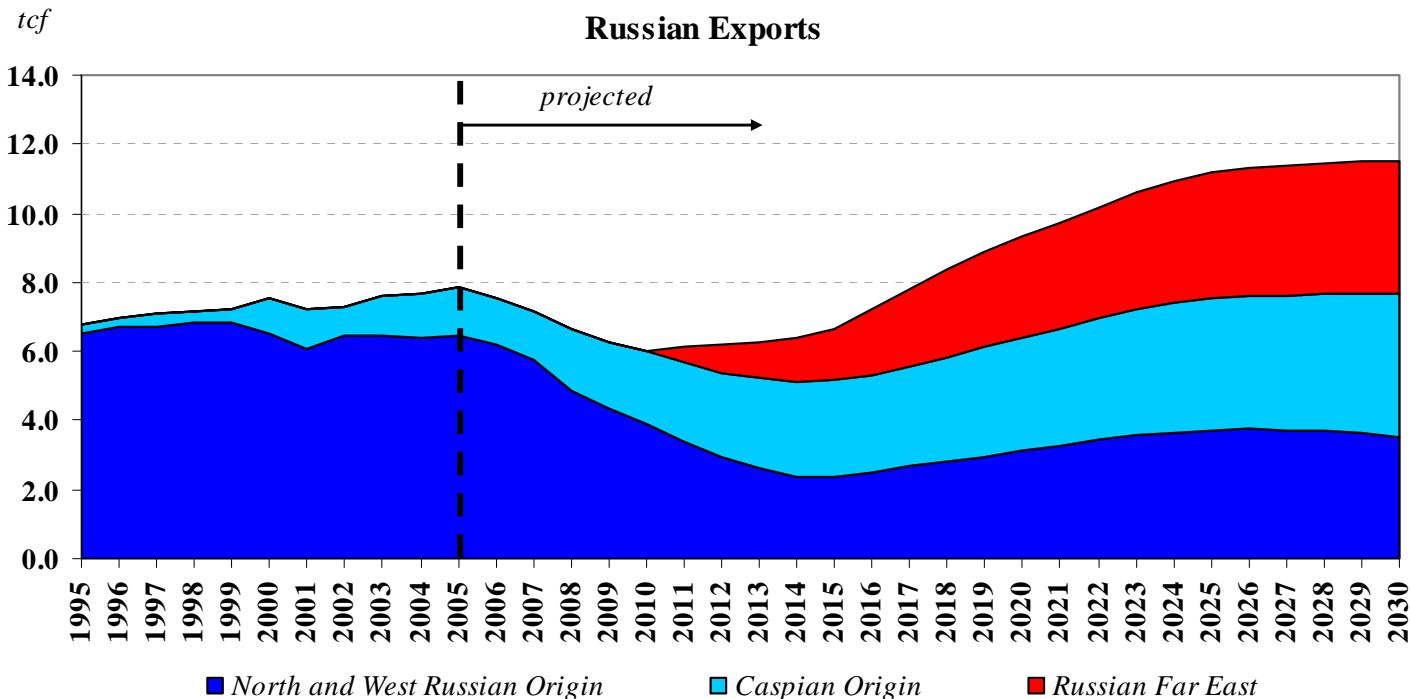
Russian Supply

- Supply in Russia grows steadily
 - Major growth areas are in the east and Arctic
 - Modest growth in the Black Sea, Caspian and Volga Urals production regions
 - Declines in West Siberia

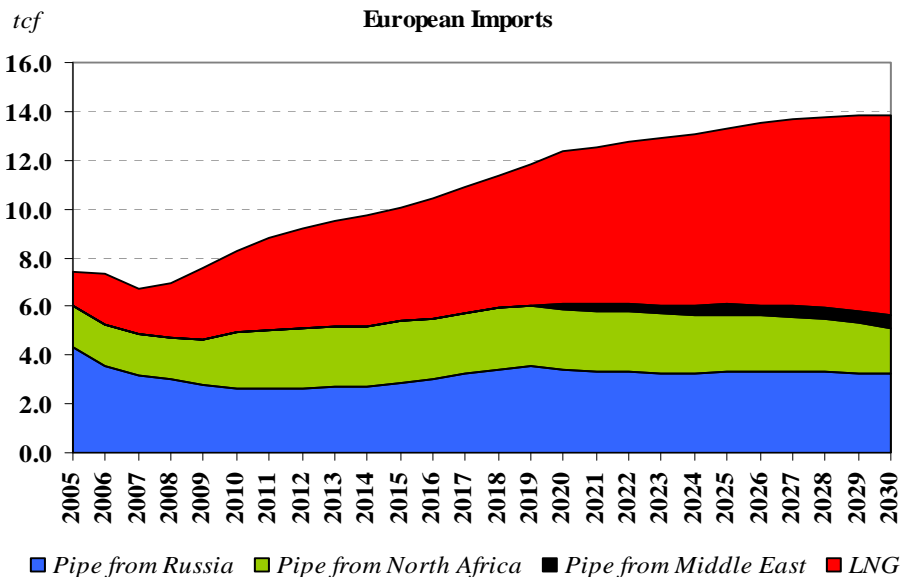


Russian Natural Gas Exports

- Russian exports initially decline
 - Domestic demand growth is a major factor
- Caspian countries are needed to maintain exports
- Areas of growth include Northern and Eastern Russia.
 - LNG emerges in the east, but not the west until the mid 2020s.

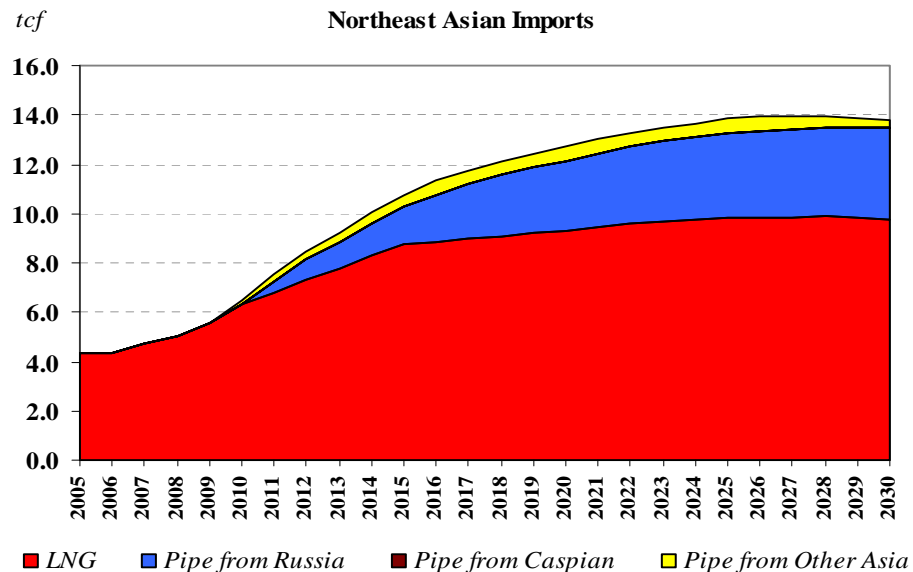


Imports in Northeast Asia and Europe



- In Europe, diversification is the story...
 - LNG gains import share in Europe
 - Russia maintains volume but loses market share
 - Pipeline imports from North Africa increase through time
 - Middle East imports begin after 2020

- In Northeast Asia...
 - LNG gains share as Chinese imports increase
 - The development of a pipeline network sees Russia supply Japan, China and South Korea by pipeline
 - China begins to import gas via pipeline from Myanmar



Scenario Results for Russian Gas Exports

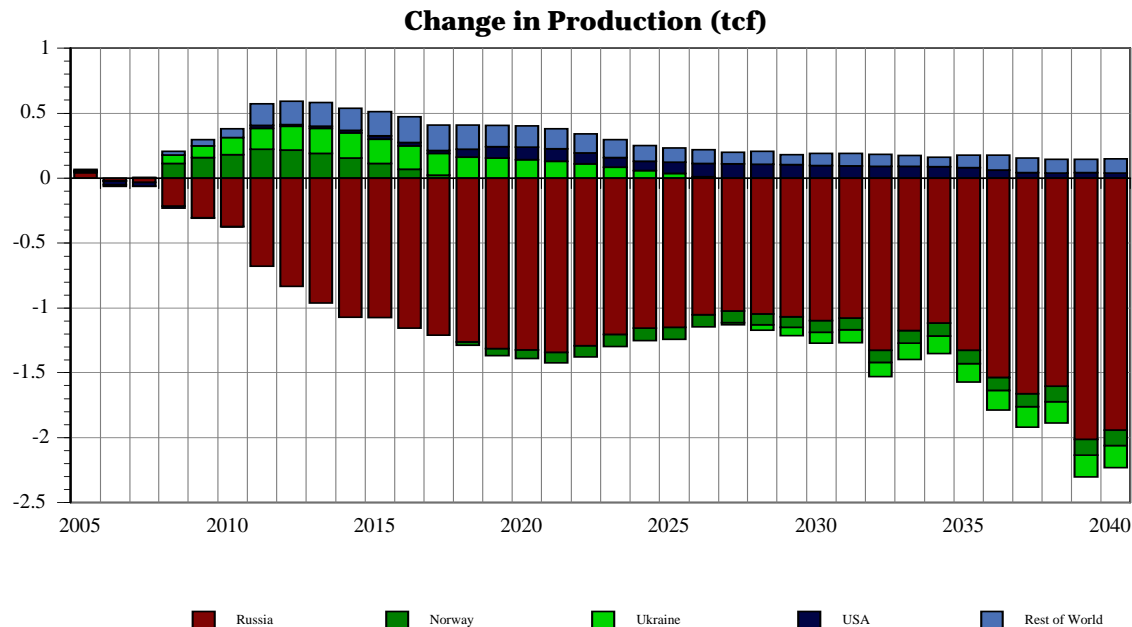
Scenario 1: Yamal Peninsula and Kara Sea resources remain undeveloped

Scenario 2: Russian exports are severely reduced in 2010, perhaps for political reasons

Scenario 3: Asian pipeline infrastructure from Russia remains undeveloped

Scenario 1: No Yamal or Kara Sea Development

- Strong supply response in Norway, Ukraine, and a collection of small changes in the rest of Europe also account for some of the “lost” supply.
- European imports shift toward LNG (not pictured)
 - LNG imports are almost 1 bcf/d higher.
 - Higher imports from sources other than Russia do not completely offset the reduction in imports from Russia.
 - Demand also adjusts in Europe due to higher prices, on average about 6% higher through 2030.



Scenario 1: No Yamal or Kara Sea Development (cont.)

- Russian exports decline substantially as production in West Siberian falls.
- Caspian producers react by expanding production, which is only a partial offset for exports... some is consumed in Russia.
- Greater competition for LNG raises price and...
 - prompts a response in the Russian Far East... both in Sakhalin and East Siberia
 - induces supply changes in North America leading to lower LNG imports and greater domestic production.



Scenario 2: Cutoff of Russian Exports in 2010

- European market is greatly affected, but proves fairly resilient.
 - Although, European prices in 2010 more than double.
- Supply response strongest in Ukraine and Norway
- Ripple effect on long term Russian production
 - Does not recover for a full decade
- LNG to Europe makes up only a portion of the lost supply. Demand adjustment to significantly higher prices accounts for the remainder.
 - The effect is spread across the globe. LNG imports to Asia and North America fall.



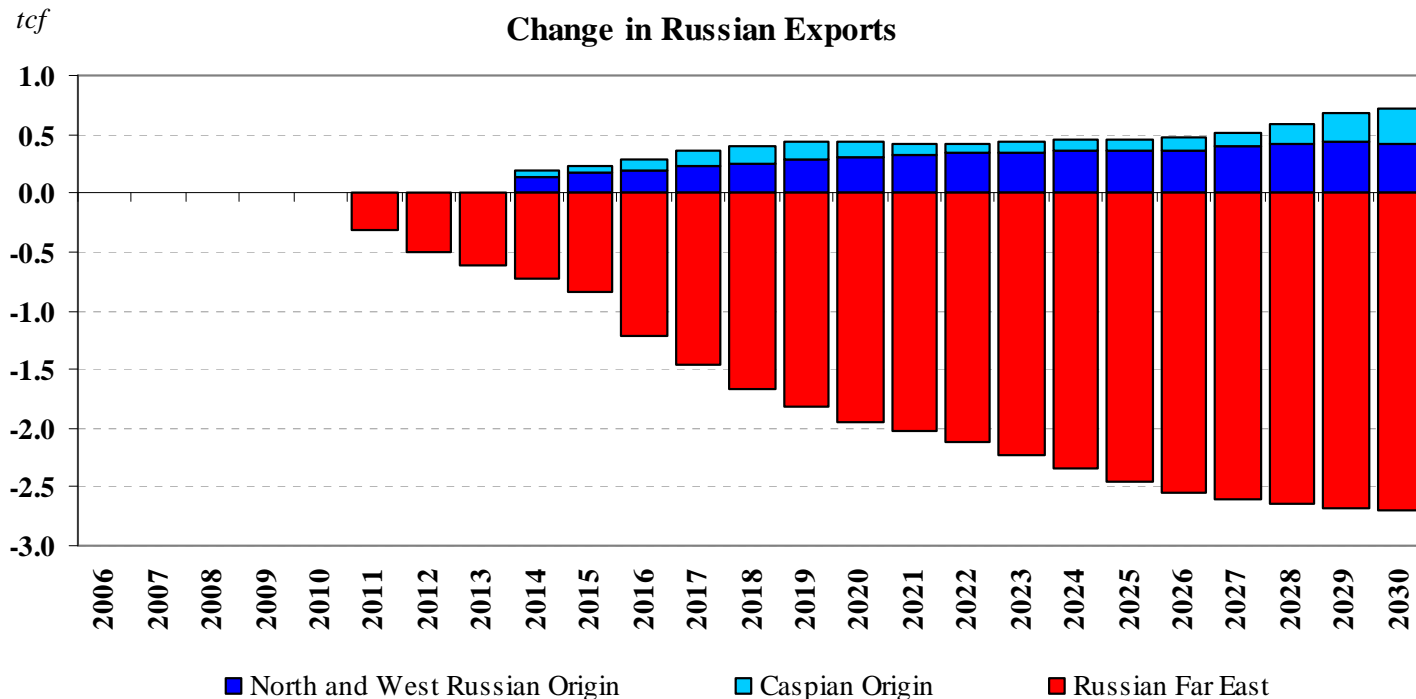
Scenario 2: Cutoff of Russian Exports in 2010 (cont.)

- Russian exports initially decline substantially in 2010.
- Post-2010 decrease is the result of “lost market”. The shock sets in motion a response that decreases reliance on Russian gas for a full decade.
 - Lower demand due to path dependency
- Caspian exports dip because they are captive to Gazprom infrastructure.



Scenario 3: Asian pipelines remain undeveloped (cont.)

- Russian exports to Northeast Asia fall substantially, although LNG exports increase due to reduced pipeline options
- East Siberian gas eventually flows West. This accelerates developments in the Caspian and Western Russia in the short and medium term, thereby enhancing exports to Europe.
- By “bottling up” East Siberian gas, price in Russia is lower. This causes a modest increase in domestic demand which further lowers exports.



Closing Remarks

Closing Remarks (cont.)

- Russian supply to EU will remain vital, and there is strong potential for growth of Russian supplies, especially to Asia.
- Constraints on exports in either direction will have dramatic implications for prices and flows.
 - Modeling indicates substantially higher prices in Asia, as the marginal supply that serves as a substitute is LNG from the Middle East.
 - Modeling indicates that *long run* European prices are not dramatically affected. North African and Middle Eastern supplies are close substitutes.
 - *Short run* implications are potentially substantial. Diversification is important!
- Modeling suggests falling EU reliance and rising Asian reliance on Russia will emerge as an economic outcome, barring constraints on other developments.
- Of the three major projects that are often discussed (South Stream, the Northern European PL and Nabucco), only the latter two are built. AND, Nabucco's viability is heavily contingent on Middle East gas emerging through Turkey.
- Other scenarios regarding Russia that we are considering include:
 - Forced infrastructure development
 - Coordination in production between Russia and other major suppliers
 - Lifting of price subsidies