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Geopolitics and World Gas Trade

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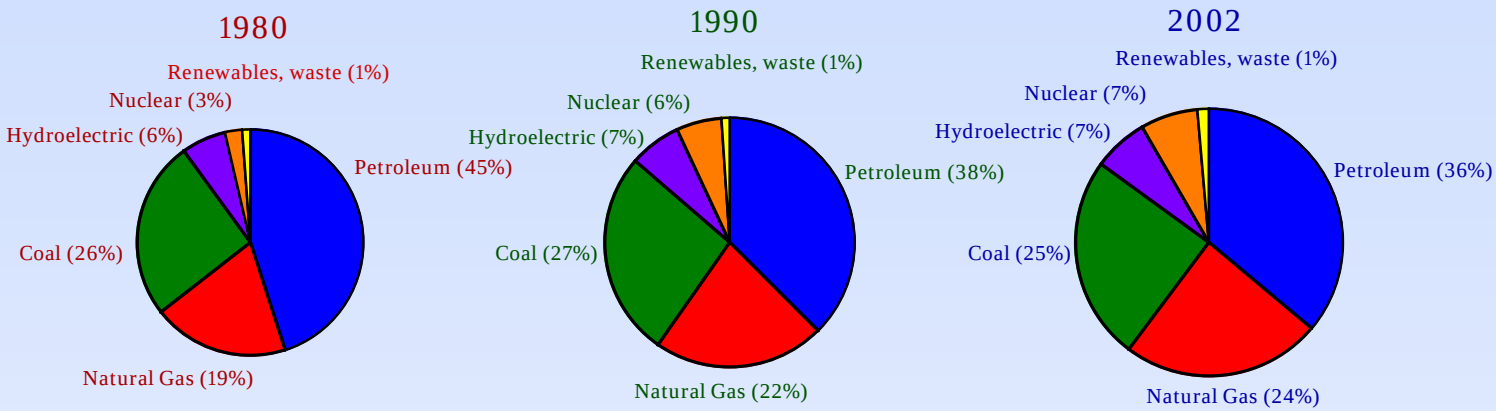
Overview and motivation

- Worldwide, the demand for natural gas is rising:



Source: EIA

- Key reasons for the increase in demand :
  - Environmental pressure for cleaner fuels
  - Wholesale electricity market competition raised the demand for smaller scale electricity plants, which CCGT (an improved technology relative to older gas turbines) satisfied
- The gas share may continue to rise if gas supplies transport fuel needs (GTL, oil shale, fuel cell)
- Possible challenges to a gas future include:
  - Lack of investor confidence in investing in many gas-rich nations
  - "Resource curse" – might the growing rents from gas provoke political instability?
  - NIMBY and terrorism – might this stymie regasification plants in the US?
  - Slowdown to electricity reforms – could disadvantage gas relative to other fuels
  - Alternative energy technologies – coal gasification, solar, hydro and/or nuclear power, perhaps assisted by falling costs of HVDC, could displace gas in electricity generation

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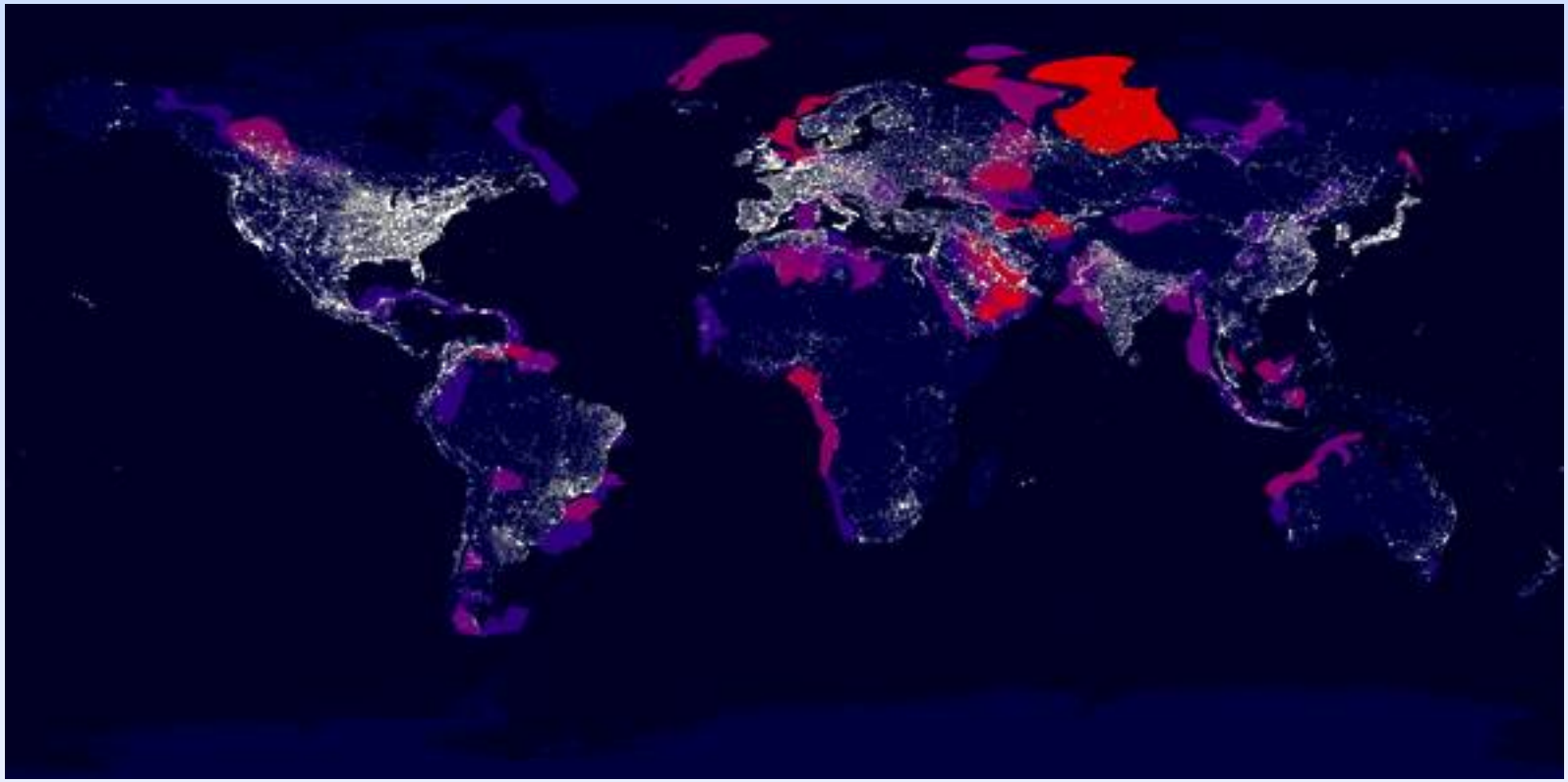
The Challenge: Linking supply with demand



Source: USGS

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

Likely Institutional Changes

- New Market Structures
  - Falling LNG production and transport costs facilitate global markets
    - Trades between regions transmit prices as well as gas
    - LNG imports result in gas on gas competition
  - Increased inter-fuel competition from higher gas share in electricity; while new technologies may link different network industries
    - Market inter-connections increase risks and potential opportunities
- Summary effects: greater reliance on
  - market prices (including derivative markets),
  - private operators and financing,
  - short-term opportunistic sales and purchases;

  less reliance on
  - regulation,
  - state enterprises,
  - long-term bilateral contracts
- Changing Roles for Governments?
  - From builder to a facilitator
  - But politics can also block otherwise viable projects

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Geopolitics and World Gas Trade

1. Russia could become a pivotal supplier of natural gas
   - Pipeline connections to both Europe and Asia
   - LNG supply to both the Pacific and Atlantic basins
   - Key arbitrage point between the major markets
   - Geopolitics: Does this increase Russian leverage on other issues?
2. US, Europe and Asia all to become major importers
   - US may also play a key role in arbitraging Pacific/Atlantic prices
   - All three may draw on supplies from Russia & Middle East
   - US and Europe may also compete for supplies from Africa, S. America
   - Geopolitics: Does such competition influence attitudes on other issues? Does it affect policies toward major producers?
3. Political relations between countries and gas trade
   - Poor inter-governmental relations can scuttle what otherwise would be economically viable projects such as pipelines through the DPR Korea
   - The attraction of consummating high surplus trades may also affect other political issues eg. Indian attitude to sanctions on the Islamic Republic of Iran or the Pakistan border dispute
4. Supply Security
   - Rising dependence on Middle East and Russia for exports
   - Historically, there have been few political disruptions to international gas trade, but the risks of these may be greater in the future

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The Rice World Natural Gas Trade Model

- RWGTM, based on geological and economic fundamentals, can be used to examine political and economic influences on the world gas market
- Model framework: *Marketbuilder* from Altos Partners, which calculates equilibrium prices and quantities for fixed locations and periods
  - Non-stochastic, but it allows analysis of many different scenarios
- Dynamic spatial general equilibrium linked through time by Hotelling-type optimization of resource extraction
  - Capacity expansion, both greenfield and brownfield, is based on...
    - ... capital costs of expansion,
    - operating and maintenance costs of new and existing capacity, and
    - revenues resulting from anticipated output and expected future prices...

    ... so that, at the margin, the maximized net present value of each project for the life of the investment is at least zero
  - Current *and future* prices determine the optimal size of expansions
    - No uneconomic decisions are made
    - The model iterates on price through time so that markets balance in each time period, and there are no opportunities for either spatial or intertemporal arbitrage
- The model predicts
  - Regional supplies and demands
  - Regional prices
  - Inter-regional flows

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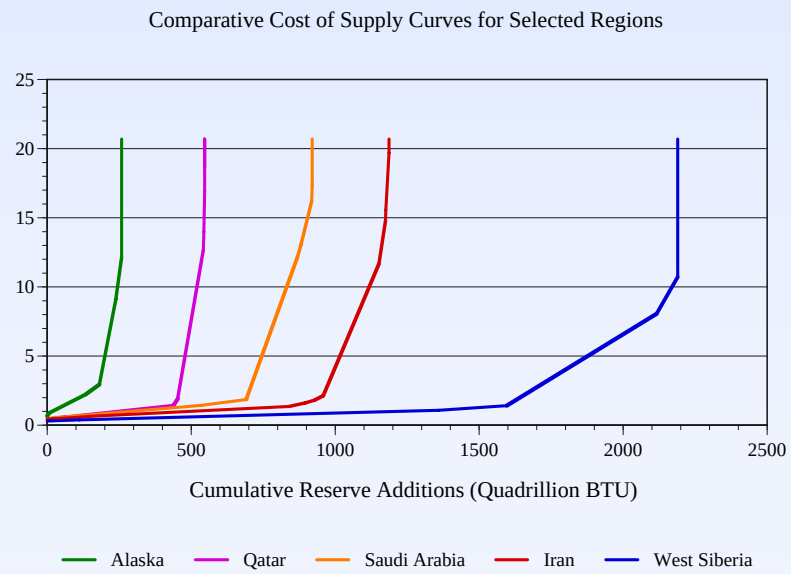
Rice World Gas Trade Model: Supply

- Oil and Gas Journal (2003), USGS World Resource Assessment (2000), other sources gave...
  - 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)
- North American cost estimates were related to geological characteristics and applied globally
  - But required return on investment varies by region (using ICRG and World Bank data) and project type
  - We also allow technological change to reduce mining costs
- Some cost of supply curves (indicating the capital cost of developing supplies):



Sources: USGS, EIA, author calculations

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Rice World Gas Trade Model: Demand

- Econometric model for forecasting demand developed using EIA, IEA and World Bank data relates gas demand to:
  - Economic development (real GDP/capita in PPP),
    - Primary energy demand increases with GDP/capita but at a decreasing rate (see Medlock and Soligo (2001))
    - Natural gas share in primary energy demand increases with development
  - Population
  - Prices (in $/MMBTU of natural gas, oil and coal); and
  - Country-specific effects
    - These could reflect, for example, resource endowments or climates
- We allow demand to be lost to new technologies from 2020 at prices above $5 with up to 2% lost at $5.50 and 4% lost at $10
  - Each year, the proportion of demand vulnerable to the backstop at each price above $5 increases until in 2055 all reference case demand could be satisfied at a price of $10
  - We took coal gasification costs as a benchmark for the cost of the backstop technology, but nuclear or solar are other alternatives

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Rice World Gas Trade Model: Transport

- To facilitate calculations of optimal capacity expansions
  - Supplies and demands are aggregated into discrete "nodes"
  - Existing parallel pipes are aggregated into a single link that can be expanded
  - We allow for many potential pipelines including ones that have been discussed and others that might appear profitable at prices calculated in initial iterations of the model
  - Represent LNG routes by hubs and spokes to allow many potential trading partners
- Pipeline costs were 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 52 pipeline projects:
    - Costs were allowed to be a function of pipeline length, pipeline capacity (to reflect economies of scale), and indicator variables for whether the pipeline crosses mountains, water or populous areas
  - Variable costs –FERC filed rates in US, tariff based on a rate of return recovery elsewhere
- LNG costs were based on a 2003 EIA report and various industry sources
  - Shipping costs are represented as lease rates
  - Liquefaction costs represented as fixed costs ($4.11/mcf/yr) plus variable costs (fuel and operating costs, and feed gas cost)
  - Regasification costs represented as fixed costs (vary by location primarily due to land costs) and variable costs (fuel and operating costs)
  - Allow for technological change to reduce LNG costs at rates of change based on a statistical fit to the IEA World Energy Investment Outlook

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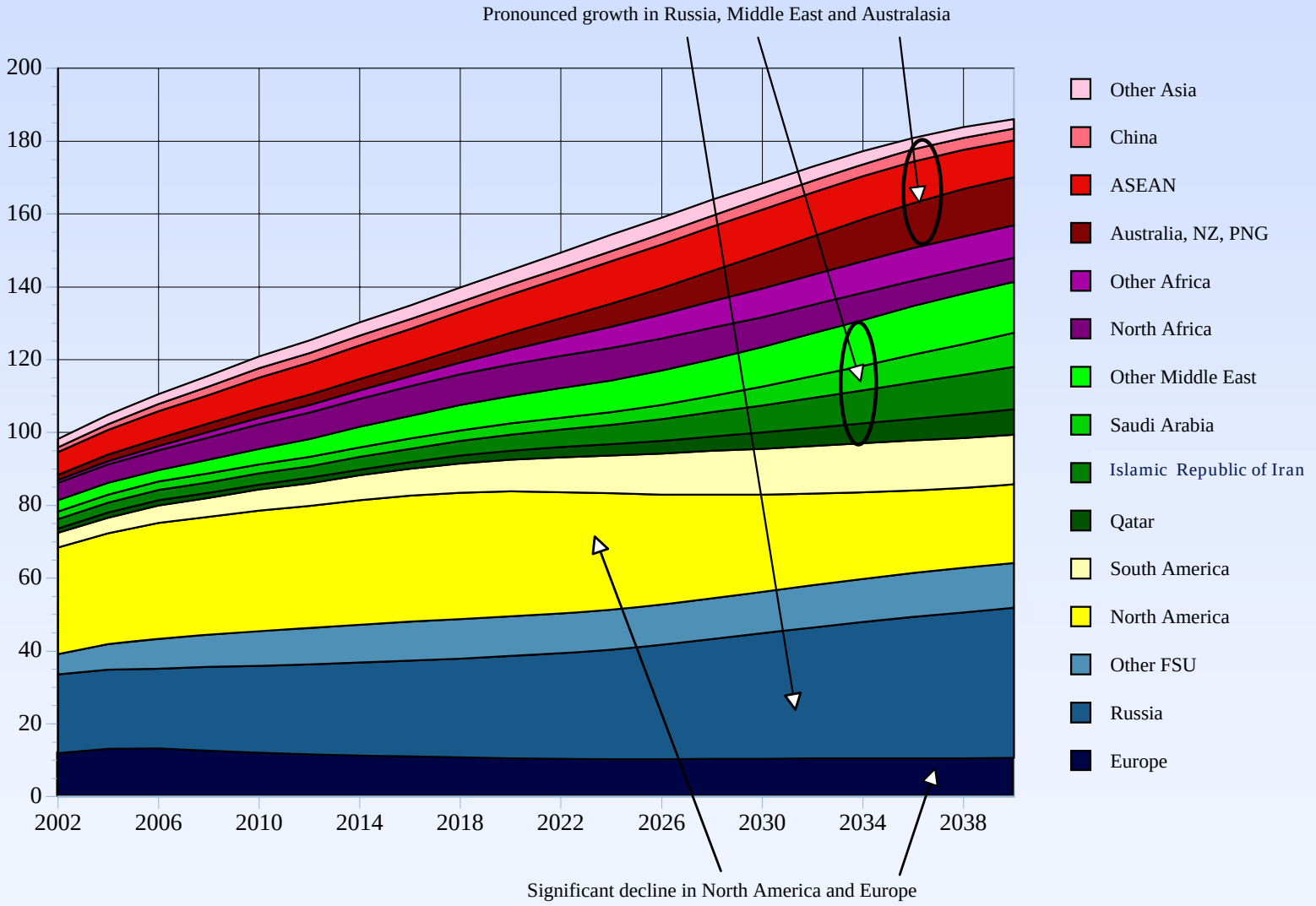
Reference Case Supply Projections



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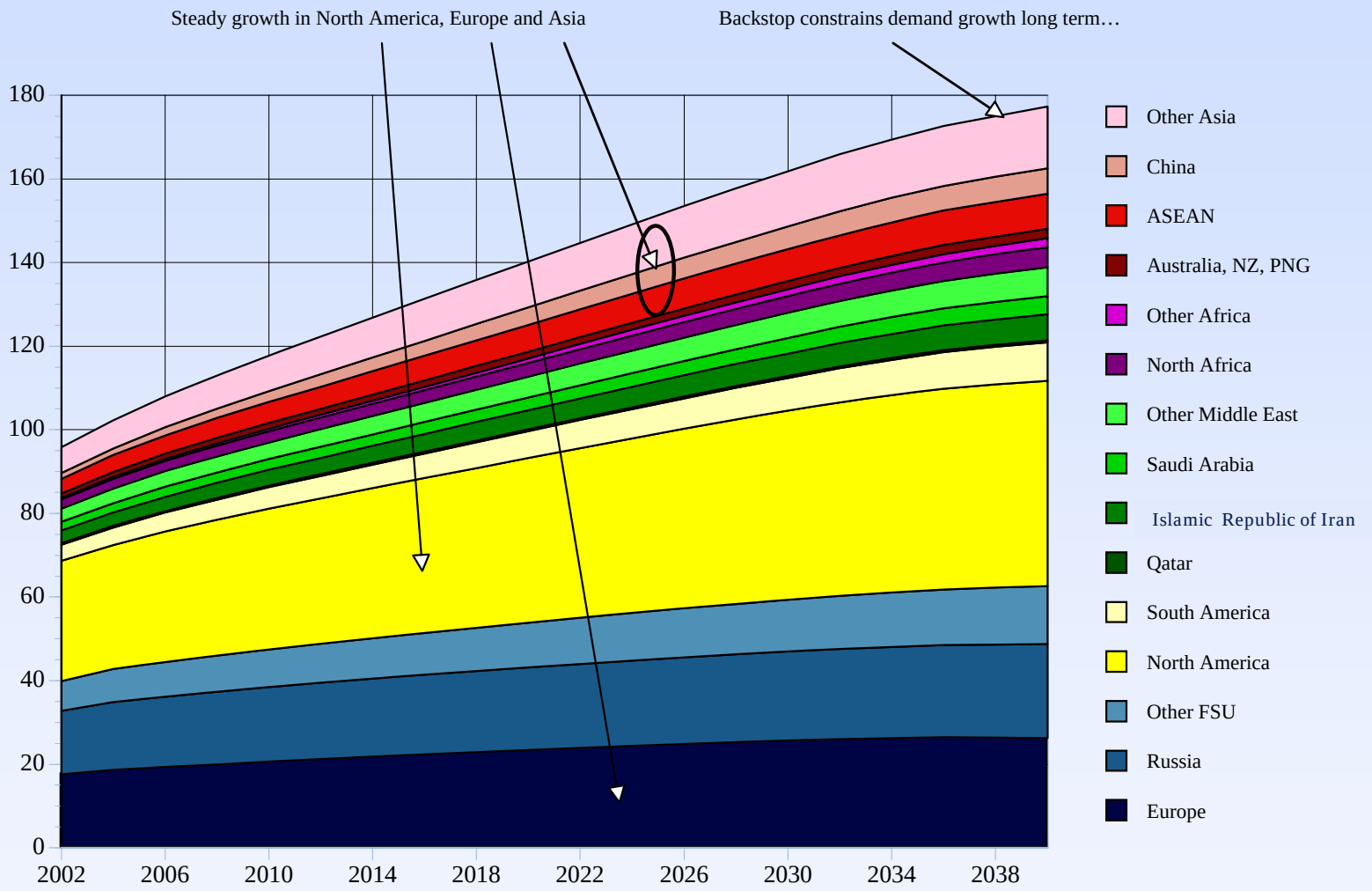
Reference Case Demand Projections



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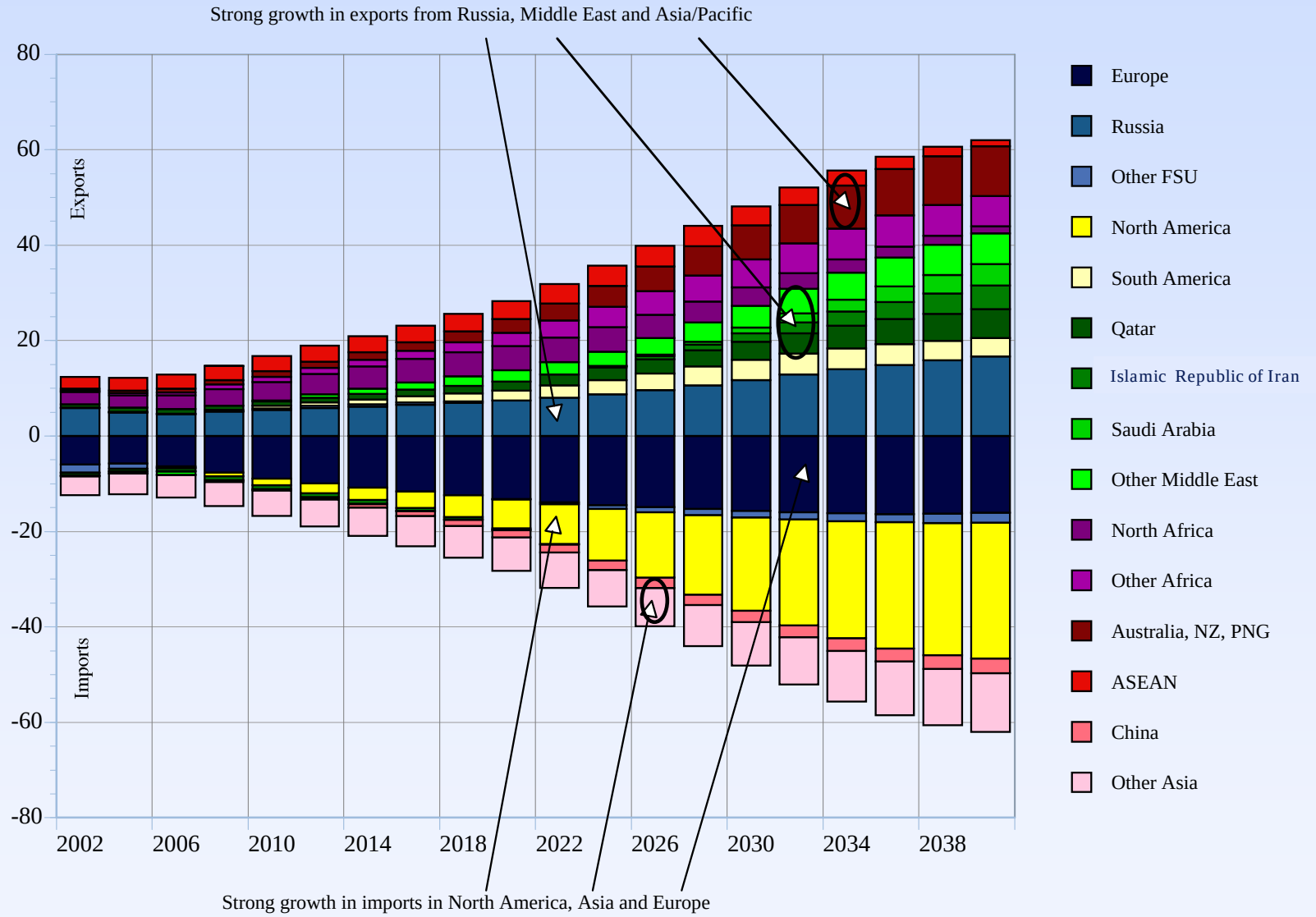
Reference Case Imports and Exports



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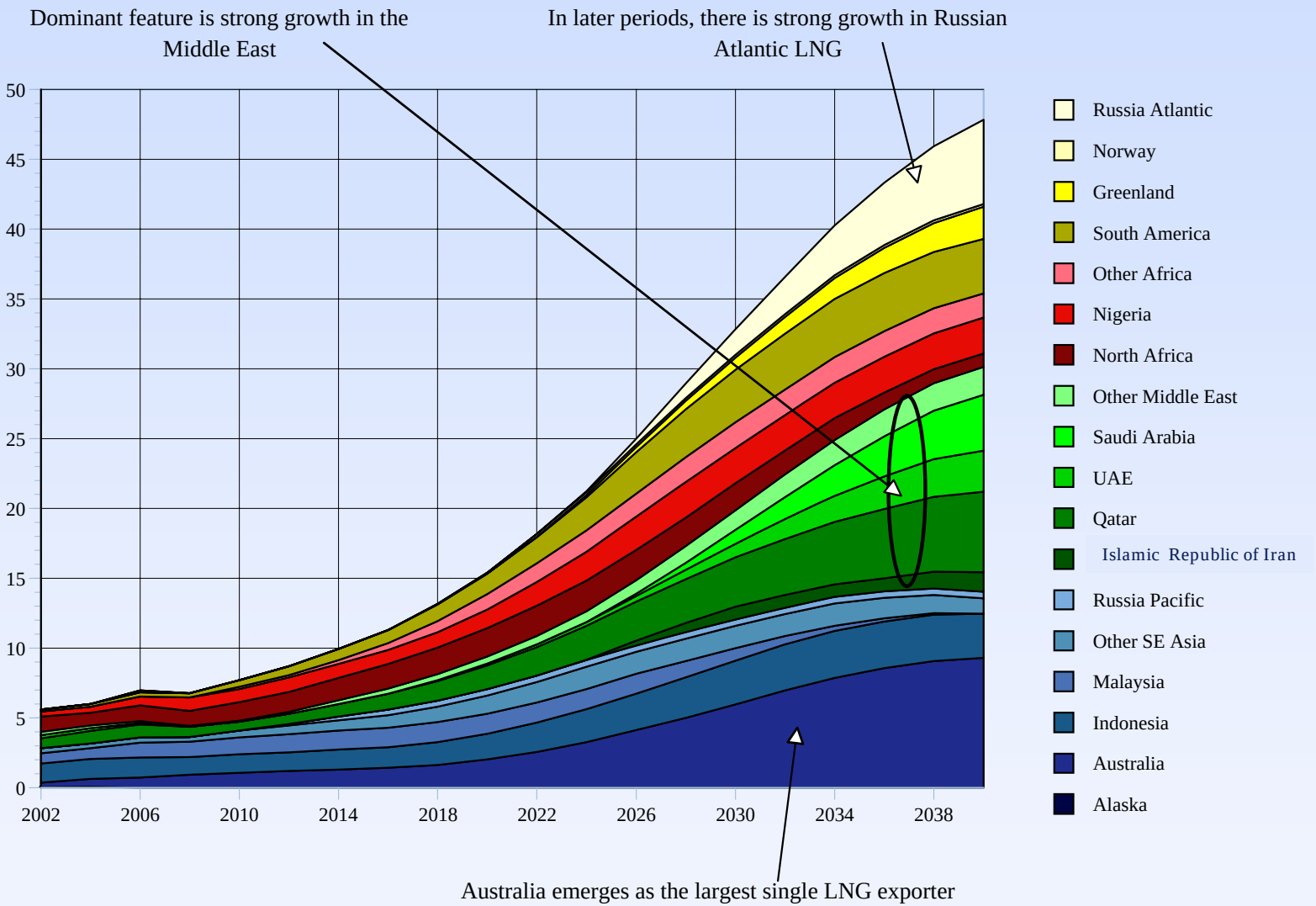
Reference Case LNG Exports



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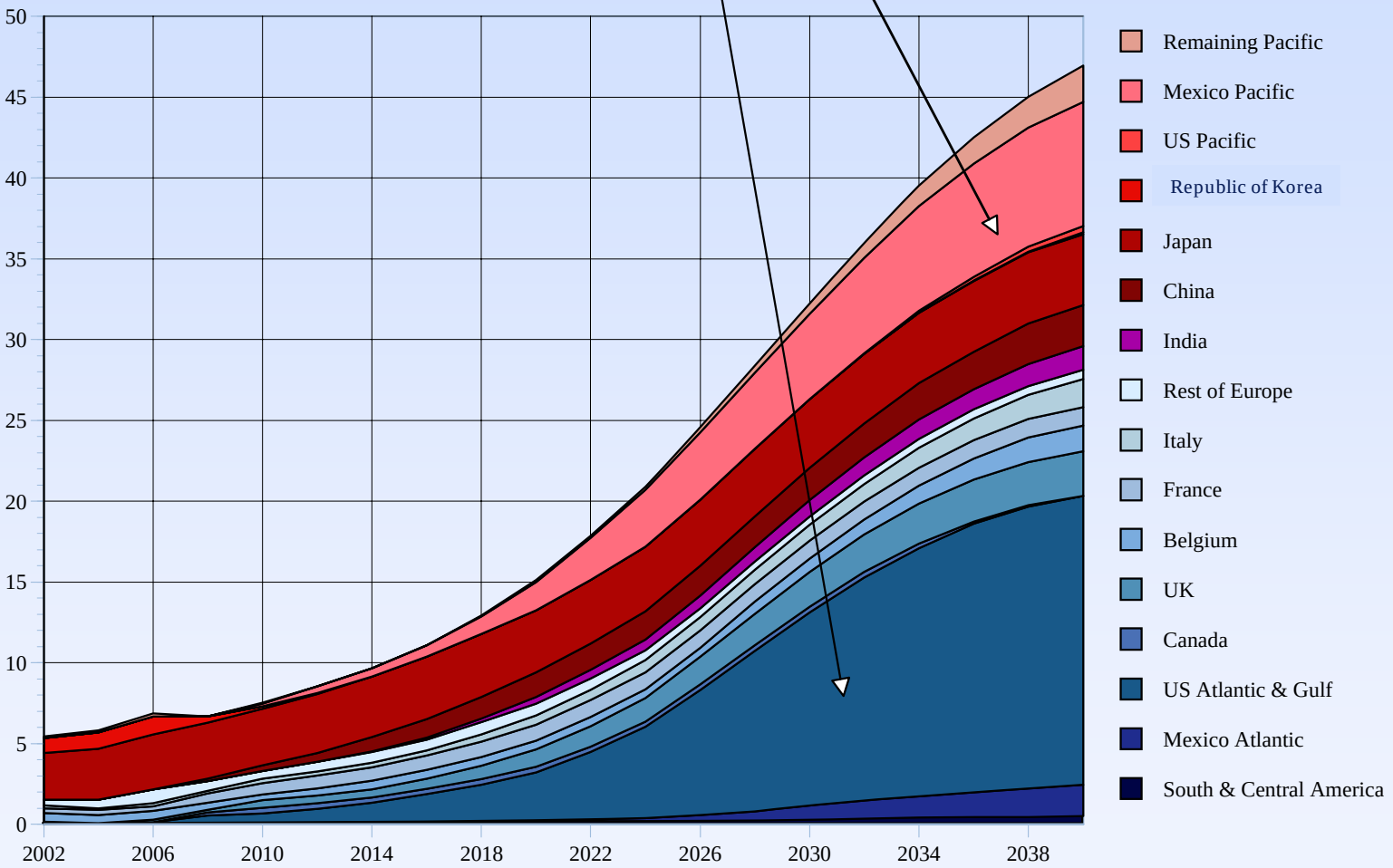
Reference Case LNG Imports

All regions, except Japan and Rep. of Korea, experience strong growth. The dominant feature, however, is growth in US imports (shown as US Atlantic and US Pacific)…



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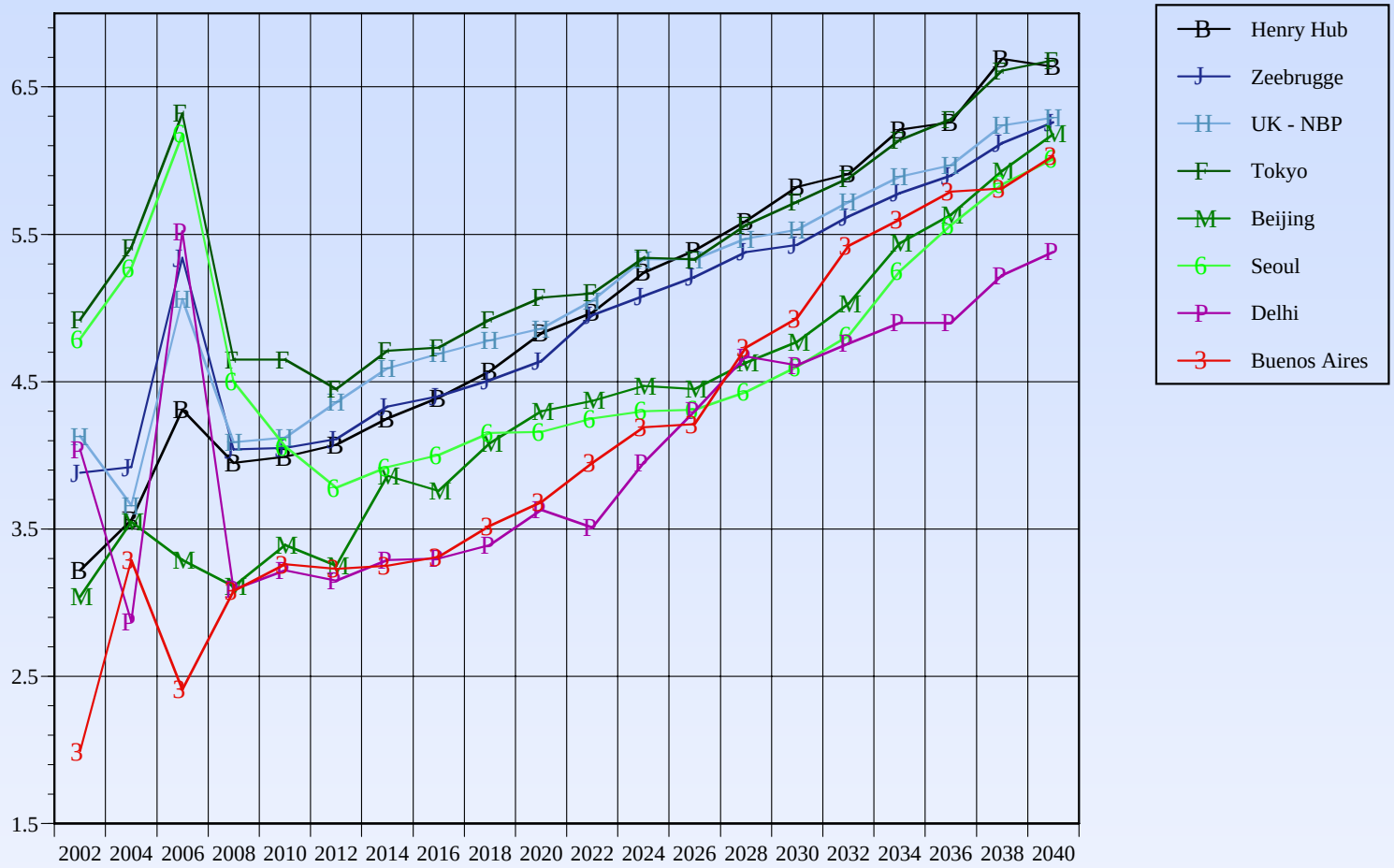
Selected Price Projections



- Prices are more equal when markets become linked via pipeline and LNG trade.
- US and European prices track each other closely until the mid 2020's.
- Seoul prices are initially linked to Tokyo (via LNG) but later more closely track Beijing as both China and the Republic of Korea import gas via pipeline from Russia.

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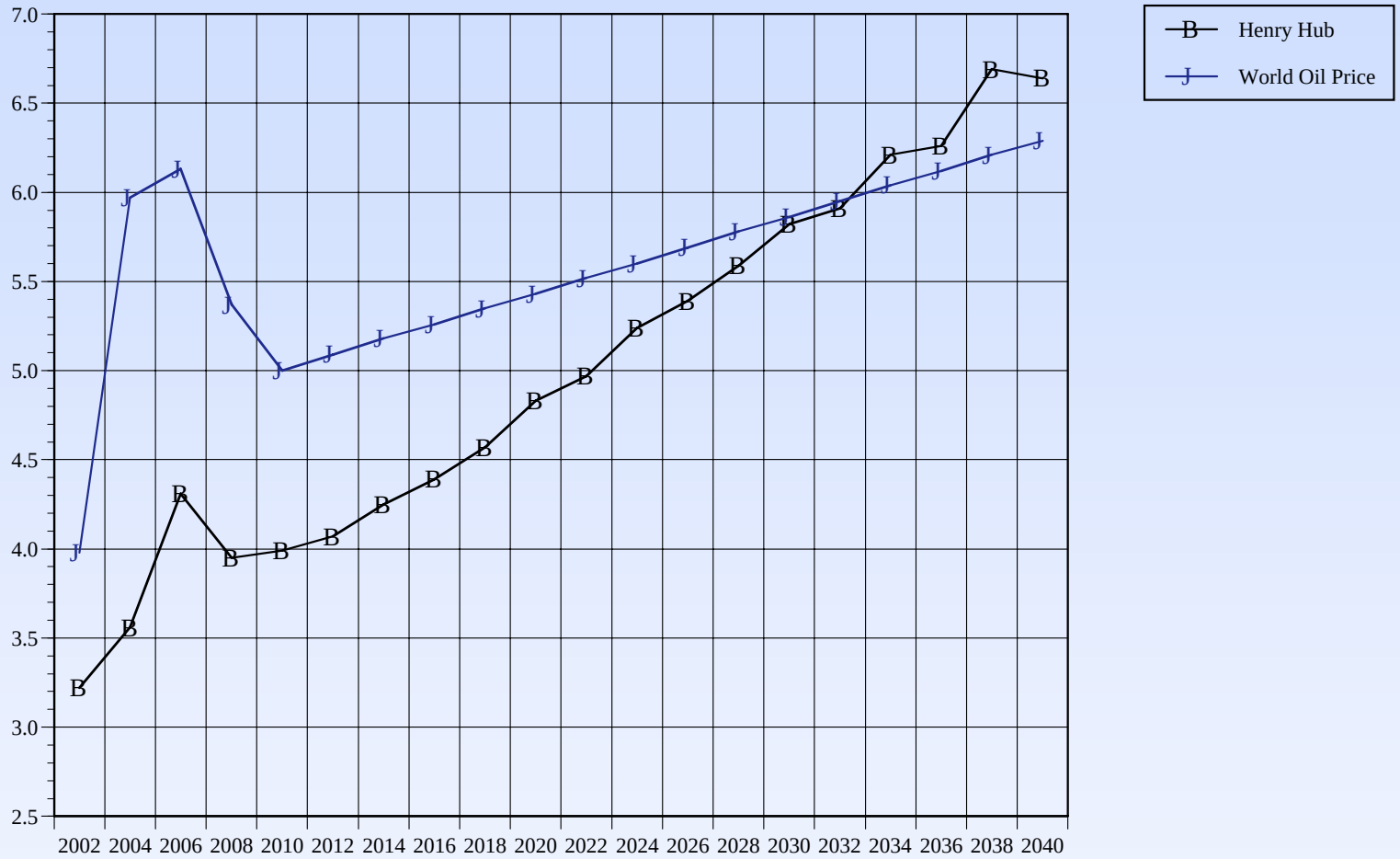
Gas and Oil Prices are linked



- The gas and oil prices are linked via the estimated cross- elasticity of substitution between gas and oil. In addition, the assumption that the share of gas tends to rise with economic development raises the gas to oil price relativity over time.
- The oil price is exogenous in our model. We use the latest EIA median forecast. In principle, one could solve for the oil price in the same way that we solve for the gas price.

Reference Case Results – Summary

- 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, Republic of Korea and Japan
    - Sakhalin gas goes to the Korean peninsula and Japan, and East Siberian gas goes to China next decade
    - The Republic of Korea shifts to pipeline gas from Russia at the expense of LNG imports
    - Japan continues to import LNG as a national gas grid is prohibitively costly
  - Russia also enters the LNG market
    - Sakhalin LNG serves the Pacific Basin near term and holds fairly steady throughout the model time horizon.
    - LNG is provided to the Atlantic Basin beginning in 2022 from deposits in the Barents Sea region. Growth here is strong as supply deficits in Europe and North America grow rapidly.
- The Middle East will also become an important supply region, exporting both LNG and pipeline gas
  - Major exporters in the region are Qatar, Islamic Republic of Iran, UAE and, later on, Saudi Arabia
  - Islamic Republic of Iran is the primary source of *pipeline* gas exports from the Middle East
  - Qatar is the largest Middle East supplier of LNG, but Saudi Arabia, UAE and Islamic Republic of Iran also become significant after 2025
- Several long-haul international pipelines are constructed
  - The trans-Saharan pipeline (Nigeria to Algeria) is constructed in 2014
  - India imports gas via pipeline from the Islamic Republic of Iran beginning in 2024
  - European imports from the Middle East via Turkey increase dramatically post-2020
  - Gas is also piped east from West Siberia to western China by 2038 and to East Siberia (& China and the Republic of Korea) by 2045
- North America becomes a major importer of LNG
  - Alaska merely offsets declines in other North American production with little effect on price
  - Gas prices in the US eventually exceed prices in Europe and Asia
- Europe imports more LNG than Northeast Asia from the early to middle 2030's
- South American gas is consumed primarily in South America
  - Trinidad LNG export growth is limited to the near term
  - Peruvian LNG exports begin in 2010, but do not grow to be large
  - Venezuelan LNG is significant in later time periods (post-2025)
  - Brazil imports Bolivian and Venezuelan supplies via pipeline
  - Argentina imports from Bolivia, Paraguay and Uruguay via pipeline
  - Chilean imports from Argentina are later displaced by Bolivian gas and ultimately some LNG
- A backstop technology is used almost everywhere by 2040, but is used most in the US, Europe and Japan

Illustrative Geopolitical Scenarios

- The Reference Case solution reflects geology, geography and economics but no constraints arising from politics
- Scenario analysis can inform us of possible outcomes in a world where political constraints exist
- One type of scenario eliminates specific projects, for example:
  - Pipelines through the DPR Korea cannot be constructed
  - Iran-India pipeline is not constructed
- Other disruptions could be more pervasive, such as the possibility that OPEC members slow development to earn higher returns on exports
  - Current gas exports are more concentrated than the distribution of reserves – Russia has 29%, and the top 7 (as of 2004) have 79% of exports – but...
    - Qatar is the only significant Middle East exporter with 3.8%, and
    - Canada, Norway and Netherlands with 27% of exports are unlikely to join a cartel
  - Nevertheless, in the Reference Case, OPEC members' share of exports is around 32% in 2020 and rises to around 43% by 2040
    - Islamic Republic of Iran shows strong growth in pipeline gas
    - Saudi share (LNG) becomes important after 2030
  - While more widespread development will create many supply sources, many big consumers will also become big importers, so a cartel might be possible

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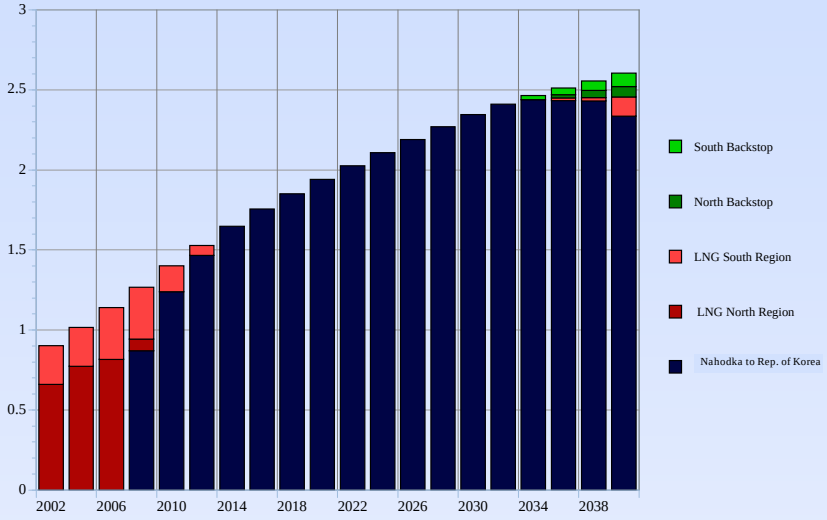
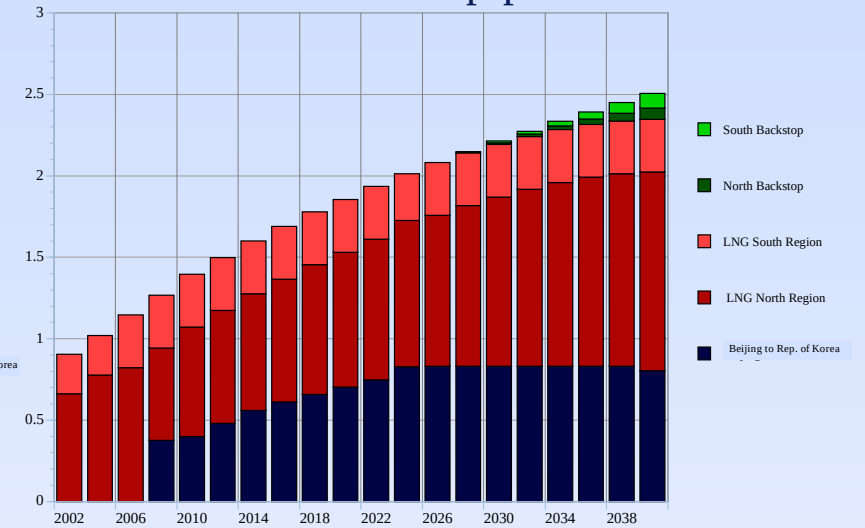
No DPR Korea pipes: Effects on the Republic of Korea & China

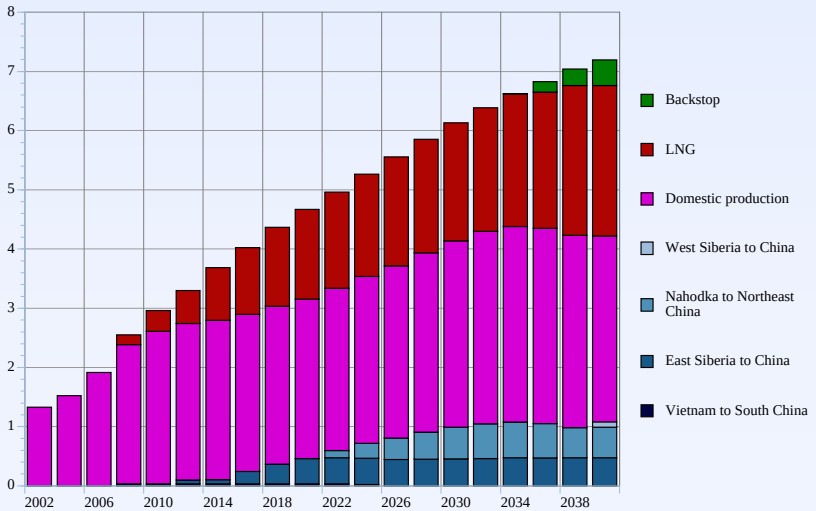
Republic of Korea – Reference case



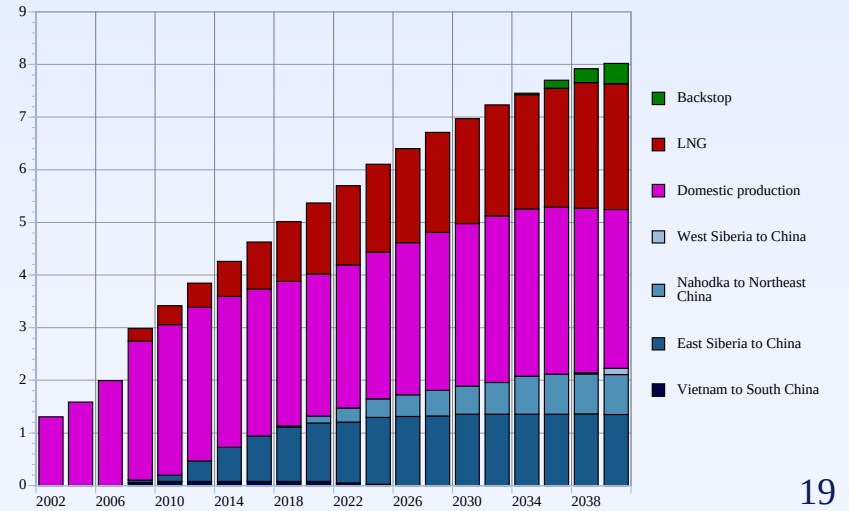
Republic of Korea – No DPR Korea pipes



China – Reference case



China – No DPR Korea pipes



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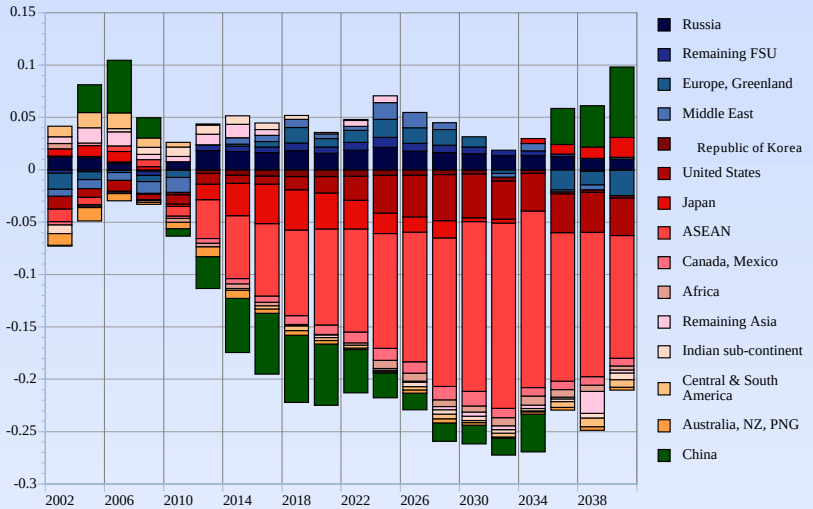
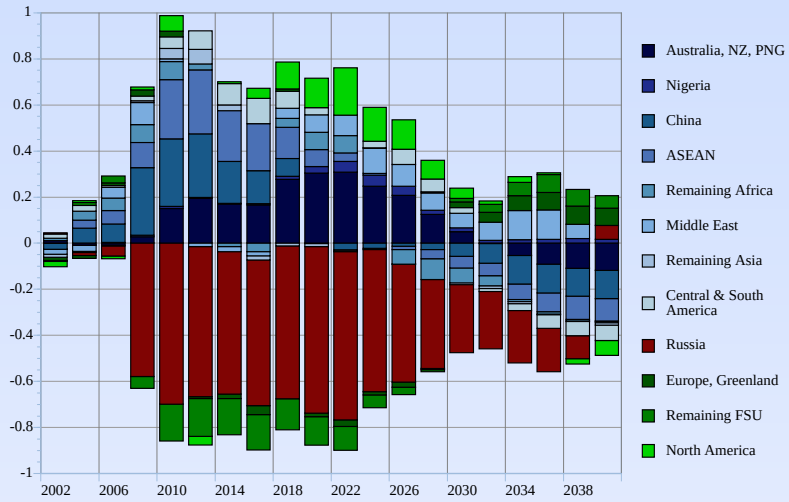
No DPR Korea pipes: Some other Effects

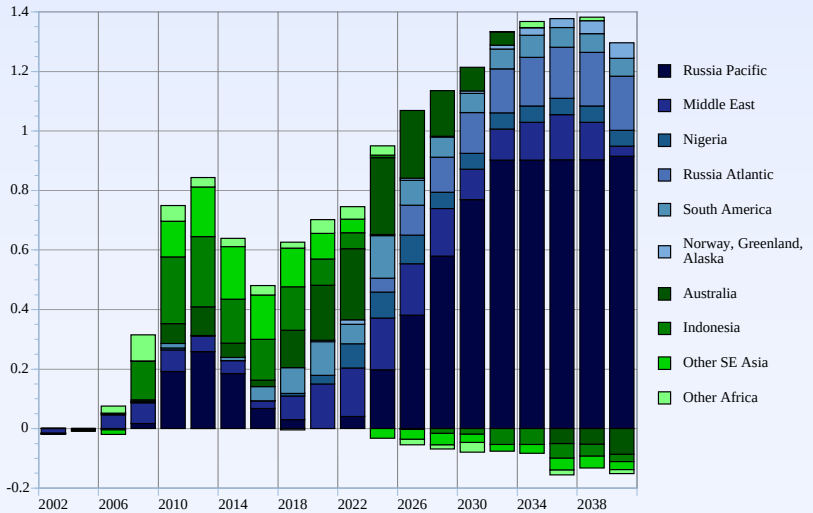
Changes in world demand



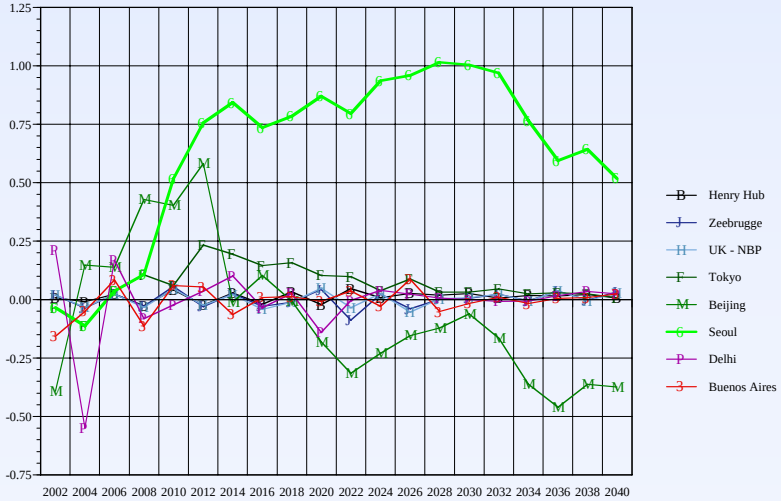
Changes in world supply



Changes in world LNG output



Changes in select prices



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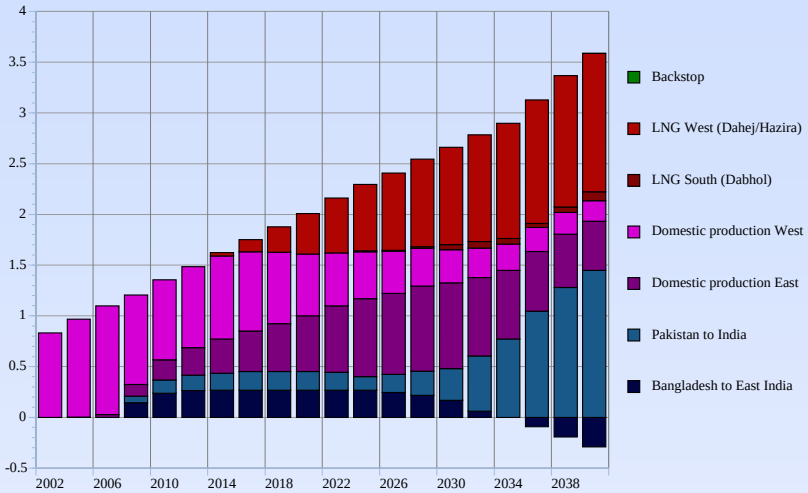
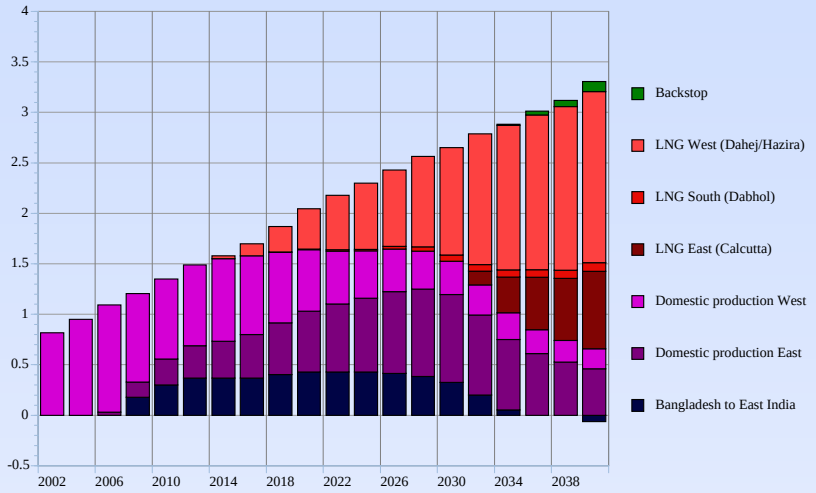
No Is. Rep. of Iran-India Pipe: Effects on India & Islamic Republic of Iran

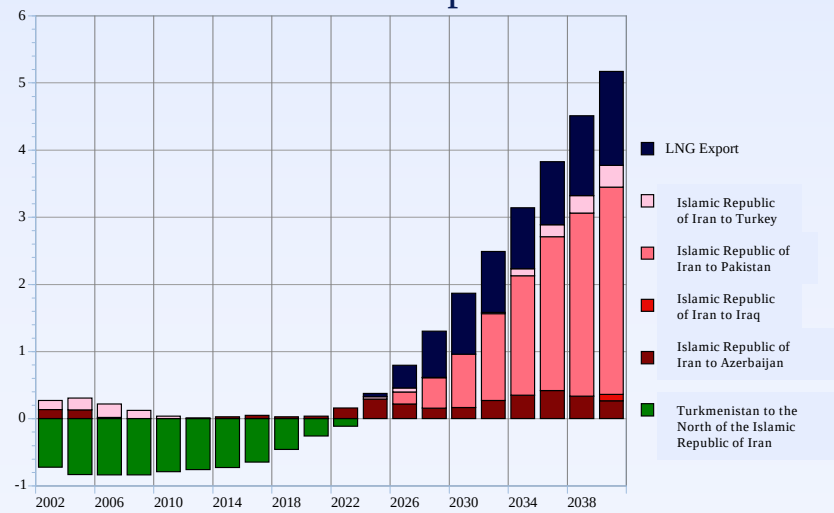
India – Reference case supply



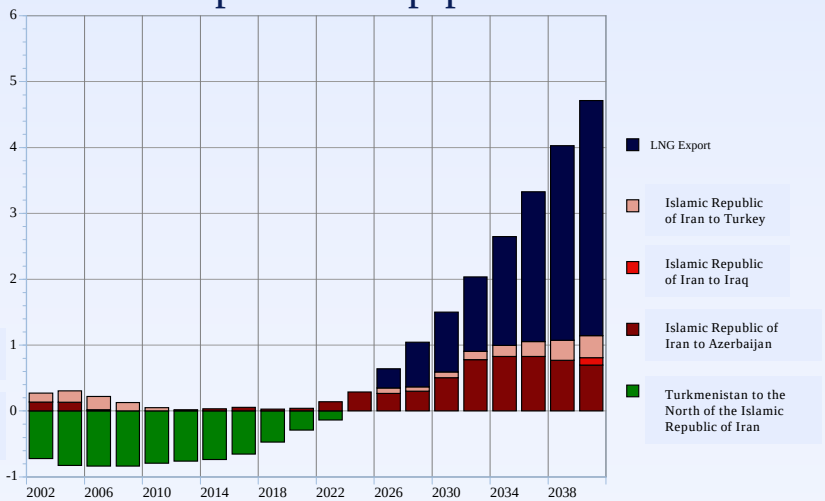
India – supply w/o pipeline



Islamic Republic of Iran – Reference case exports



Islamic Republic of Iran – exports w/o pipeline



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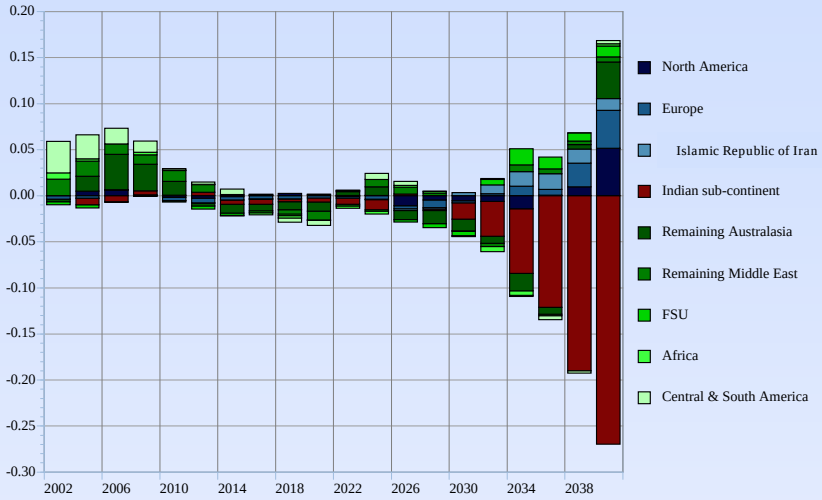
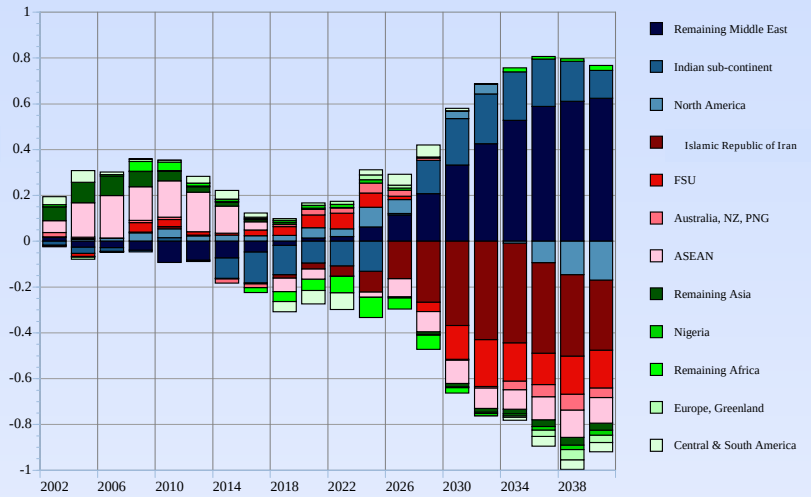
No Is. Rep. of Iran-India Pipe: Some Other Effects

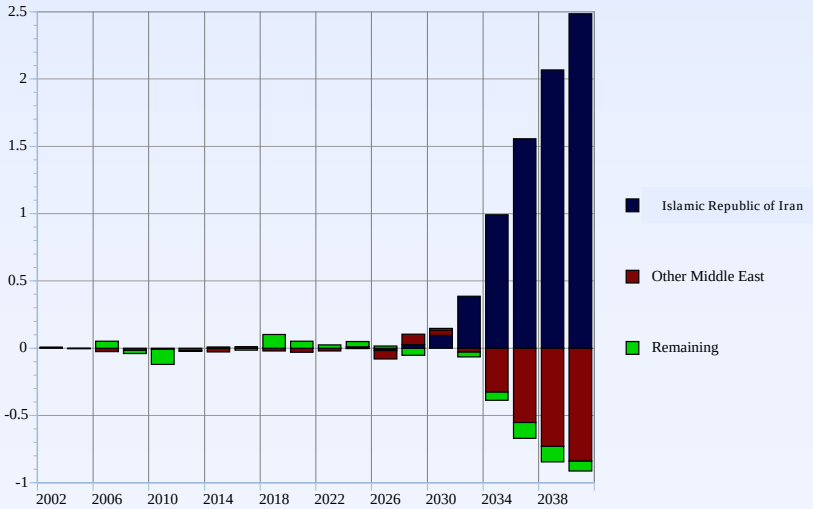
Changes in world demand



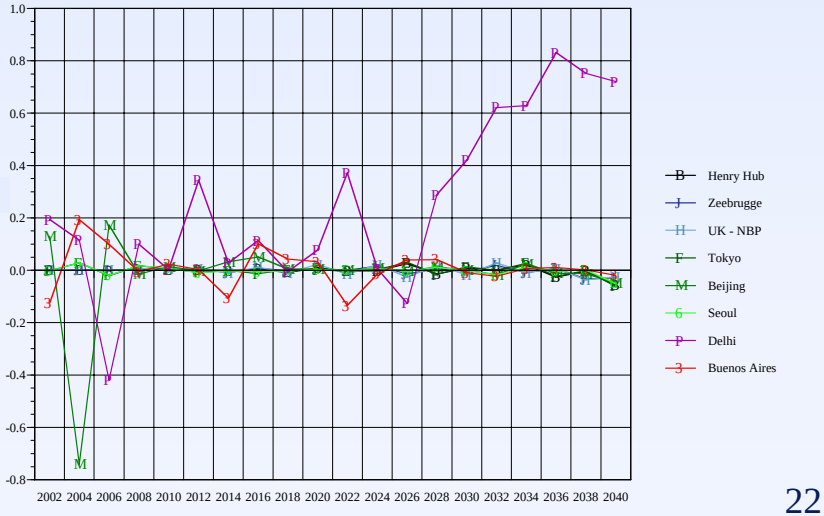
Changes in world supply



Changes in world LNG output



Changes in select prices



Restricted OPEC Development

- We assumed that the return on export infrastructure investment projects from all current OPEC members (Algeria, Nigeria, Libya, Qatar, Saudi Arabia, Islamic Republic of Iran, Iraq, UAE, Kuwait, Venezuela, Indonesia) is increased above the base level
  - The weighted average cost of capital for export pipeline projects was increased to 20% from the 8–10% assumed in the base case
  - The weighted average cost of capital for liquefaction projects also was increased to 20% from the 10–13% assumed in the base case
- Changing the required return will operate like a coordinated reduction in the rate of development of gas export projects
  - A major difference from a genuine cartel is that the higher revenue is not assumed to influence domestic demand in OPEC countries
- The alternative would be to postulate a price objective for the member countries and a production sharing agreement to support that objective
  - The ultimate consequence would be a reduced rate of project development, a higher rate of return on investments but also increased government revenue from the National Oil (or Gas) Company

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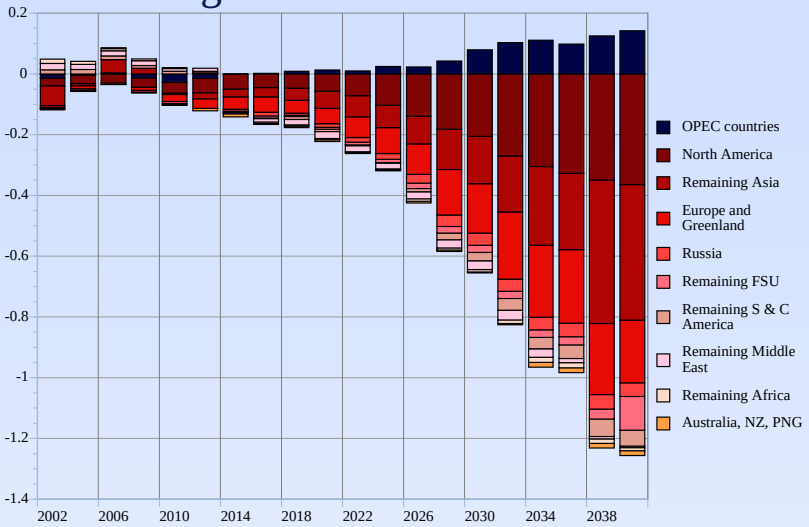
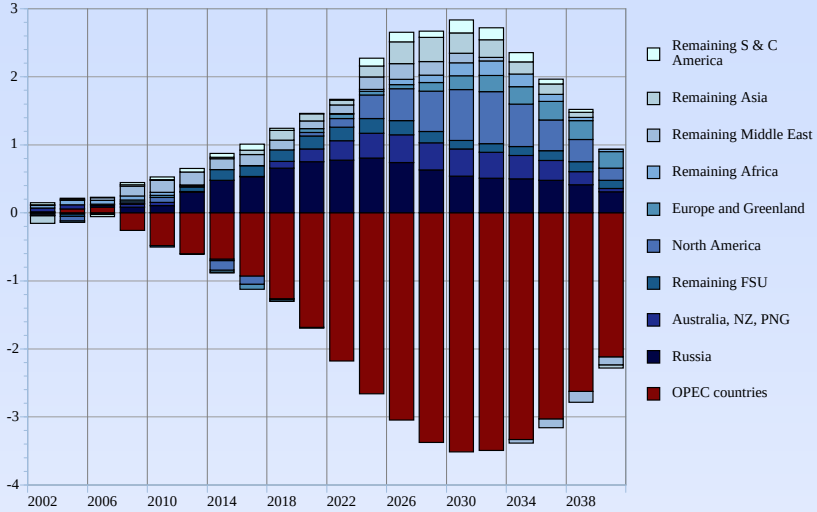
Effects of restricted OPEC development

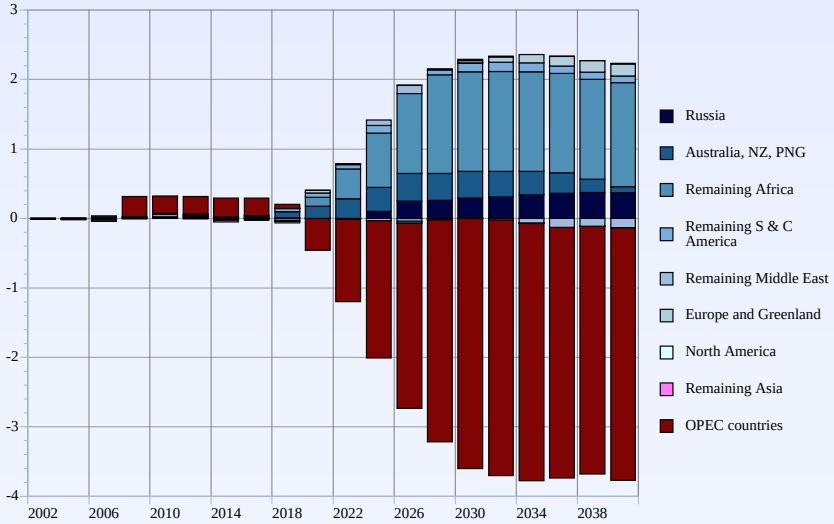
Changes in world demand



Changes in world supply



Changes in world LNG output



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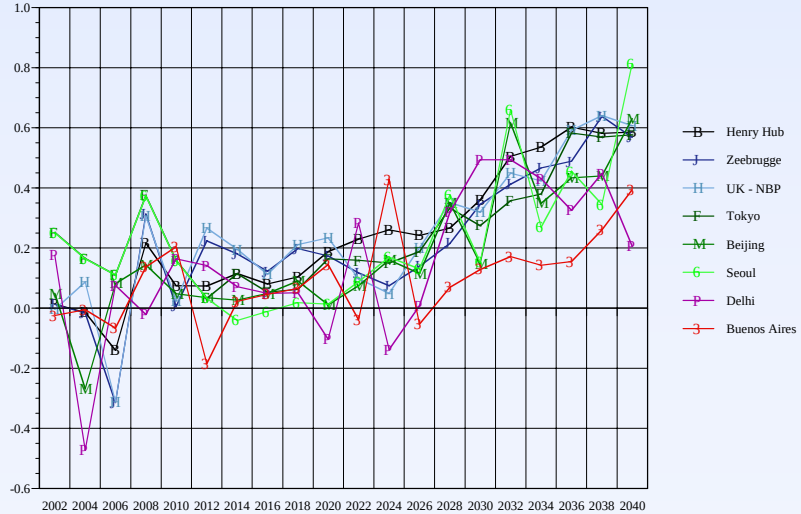

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Concluding Remarks

- The results illustrate the key role Russia will play in the 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 is 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 Middle East also link the Pacific and Atlantic 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
- Long distance international gas trade provides opportunities for countries to gain from cooperation, but also to lose from conflict
- Ultimately, there appears to be substantial gas available to satisfy demand at a reasonable price until the second half of the century when alternative backstop technologies should become competitive
  - The global supply curve for natural gas is reasonably elastic
  - Substantial known gas reserves may not be exploited since they are likely to be more expensive than the feasible alternatives