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Scenarios for Russian Natural Gas Exports: The Role of Domestic Investment, the Caspian, and LNG

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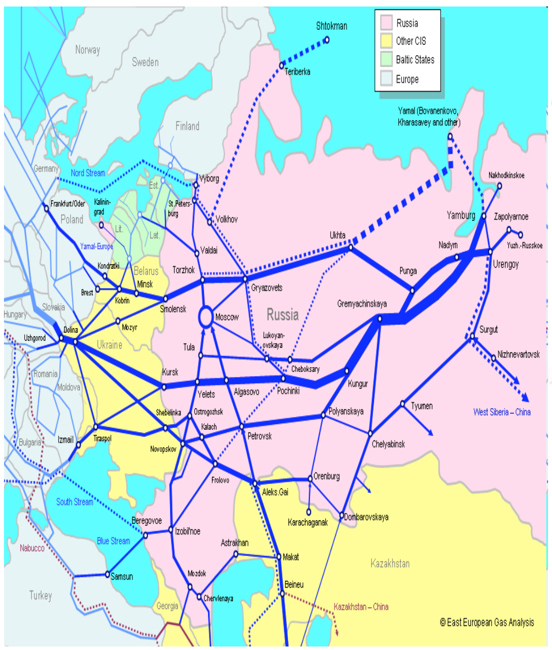

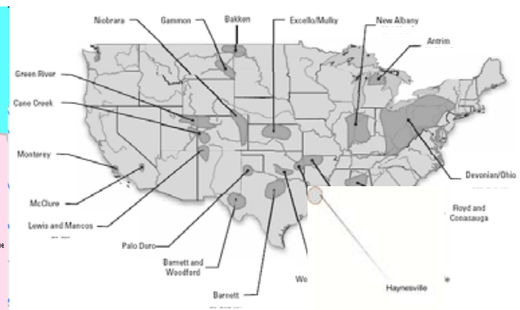

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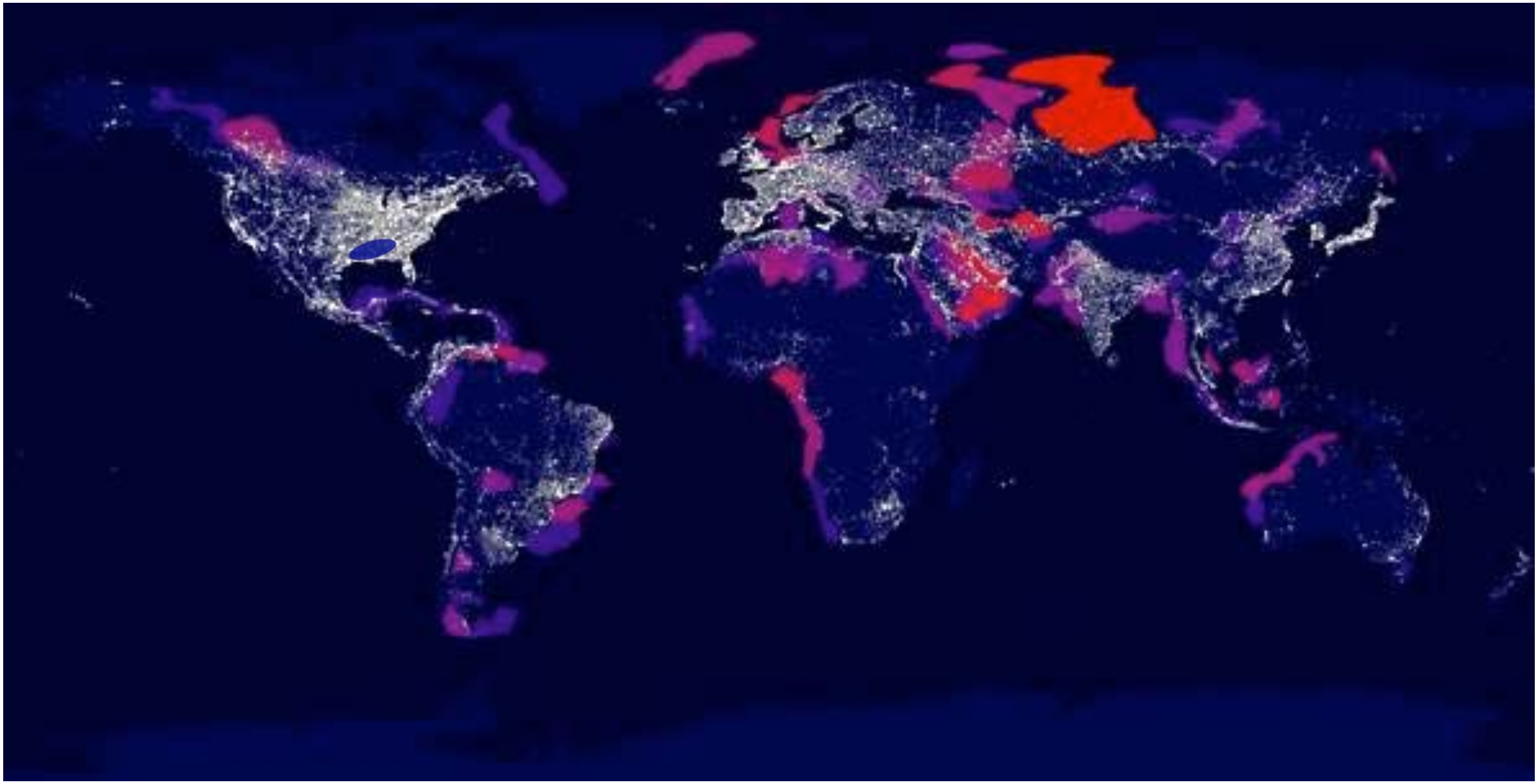
Resources and Demand



- Geography and geology put Russia in a prominent role in the global gas market
- The Middle East is also large, but marketing opportunities are different, at least initially.
- How will regions interact in a longer term view of a global gas market?

The Rice World Gas Trade Model

The RWGTM

- The Rice World Gas Trade Model (RWGTM) has been developed to examine potential futures for global natural gas, and to quantify the impacts of geopolitical influences on the development of a global natural gas market.
- The model predicts regional prices, regional supplies and demands and inter-regional flows.
- 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
- The model is constructed using the *MarketBuilder* software from Altos
  - Dynamic spatial general equilibrium linked through time by Hotelling-type optimization of resource extraction
  - Capacity expansion is determined by current *and* future prices along with capital costs of expansion, operating and maintenance costs of new and existing capacity, and revenues resulting from future outputs and prices.

The RWGTM (cont.)

- Demand
  - Over 290 regions.
    - North America (Residential, Commercial, Industrial, Power Gen)
    - Rest of World (Power Gen, Direct Use, EOR)
  - Population growth taken from the UN median case projection to 2050.
  - Economic growth is based on conditional convergence.
  - Energy intensity falls as income rises (see Medlock and Soligo, *EJ* 2001)
  - The natural gas share of total energy increases with income, reflecting natural gas as a premium fuel, but declines with relative price increases.
    - Price elasticity is decreasing in the natural gas share of TPES. This captures rigidities associated with capital deployment.
- Supply
  - Over 120 regions
  - Natural gas resources are represented in three categories
    - proved reserves (updated 2006 Oil & Gas Journal estimates)
    - (GTK) growth in known reserves (P-50 USGS estimates and NPC estimates)
    - (YTF) undiscovered resource (P-50 USGS estimates and NPC estimates)
  - Long run costs increase with depletion.

The RWGTM (cont.)

- Reserves are not the best indicator of a region's supply potential – they are not even an economic measure of potential. We focus on *resource*, recognizing that *technically* recoverable resources may become *economically* recoverable as price rises going forward. This captures the effect of higher prices on E&D activity.
- Global undiscovered technically recoverable resources
  - 5,336 tcf (YTF) + 3,660 tcf (GTK) = 8,996 tcf
    - Unconventional data is limited
      - Some information about location of potential resources but less about size;
      - Detailed data available for North America and Australia;
      - Limited data available for China and India – focused mostly on CBM
- Russia has a prominent position in the *current* natural gas market
  - Russia has 27% of stated global gas *reserves* (1,680 tcf of 6,254 tcf)
- Russia *should* have a prominent position in the developing global gas market for the foreseeable future
  - Russia has 17% (1,168 tcf (YTF) + 339 tcf (GTK)) of the mean estimate of technically recoverable undiscovered global natural gas *resource.*

The RWGTM (cont.)

- Required return on investment varies by region and type of project (using ICRG and World Bank data)
- Detailed transportation network
  - Pipelines aggregated into corridors where appropriate.
  - Capital costs based on analysis of over 100 pipeline projects relating project cost to various factors.
  - Tariffs based on posted data, where available, and rate-of-return recovery.
  - LNG is represented as a hub-and-spoke network, reflecting the assumption that capacity swaps will occur when profitable.
  - LNG shipping rates based on lease rates and voyage time.
- For all capital investments in both the upstream and midstream, we allow for existing and potential pipeline links, then “let the model decide” optimal current and future capacity utilization.
- **For detailed information please see Peter Hartley and Kenneth B Medlock III, “The Baker Institute World Gas Trade Model” in *The Geopolitics of Natural Gas*, ed. Jaffe, Amy, David Victor and Mark Hayes, Cambridge University Press (2006).**

Results

RWGTM: List of Model Cases Considered

- **Reference Case:** Economic considerations dominate outcome.

- All Scenarios are compared to the Reference Case
  - ***Scenario 1*:** Resources in the Yamal Peninsula and Kara Sea remain undeveloped throughout the model time horizon
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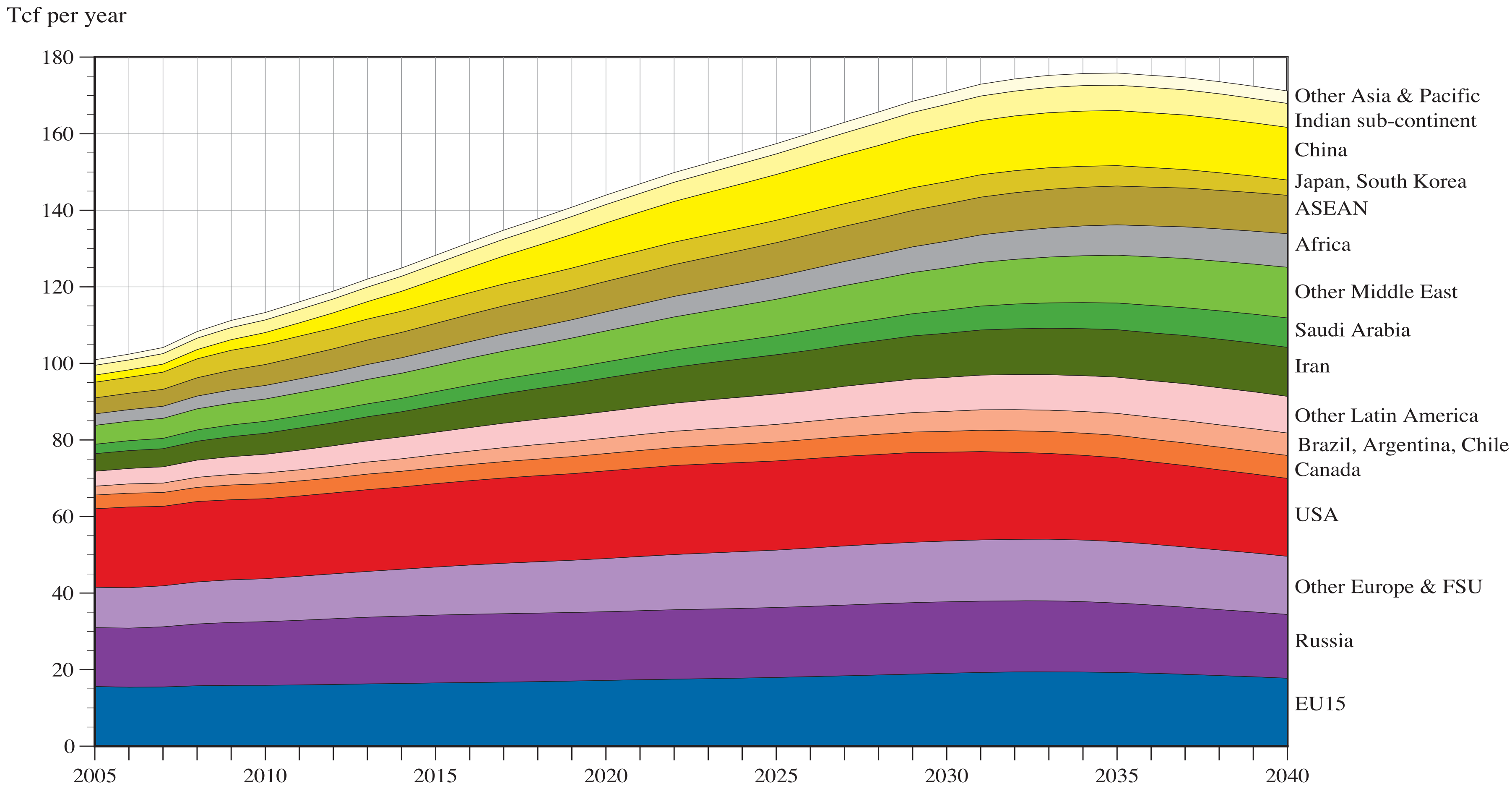
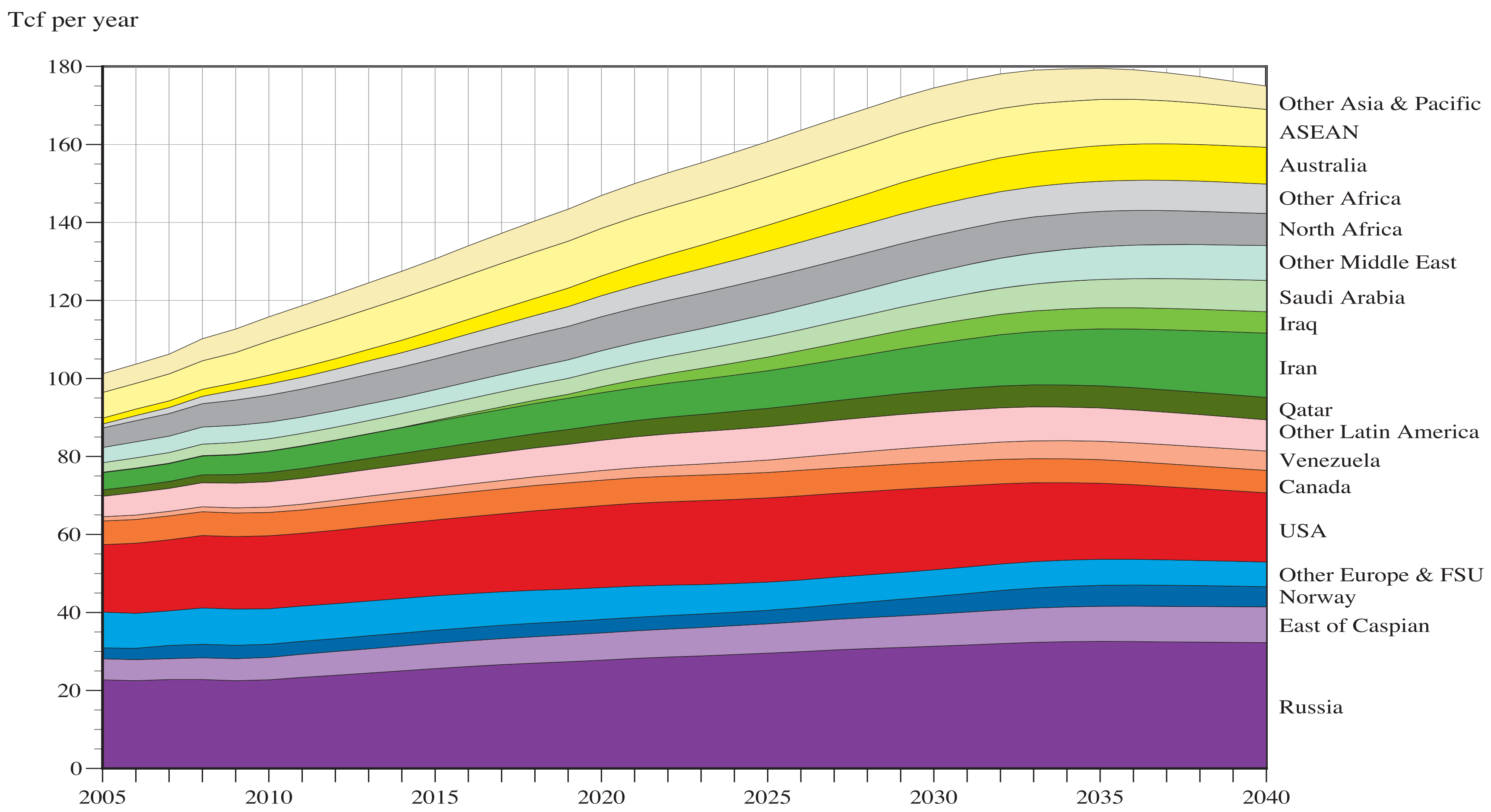
Reference Case: Global Demand

- Demand growth rates are strongest in Asia and the Middle East.
- Alternatives emerge more quickly post-2030, especially in EU and North America
- Demand in Russia grows to a max of 19.6 tcf in 2030 (about 0.8% p.a.)



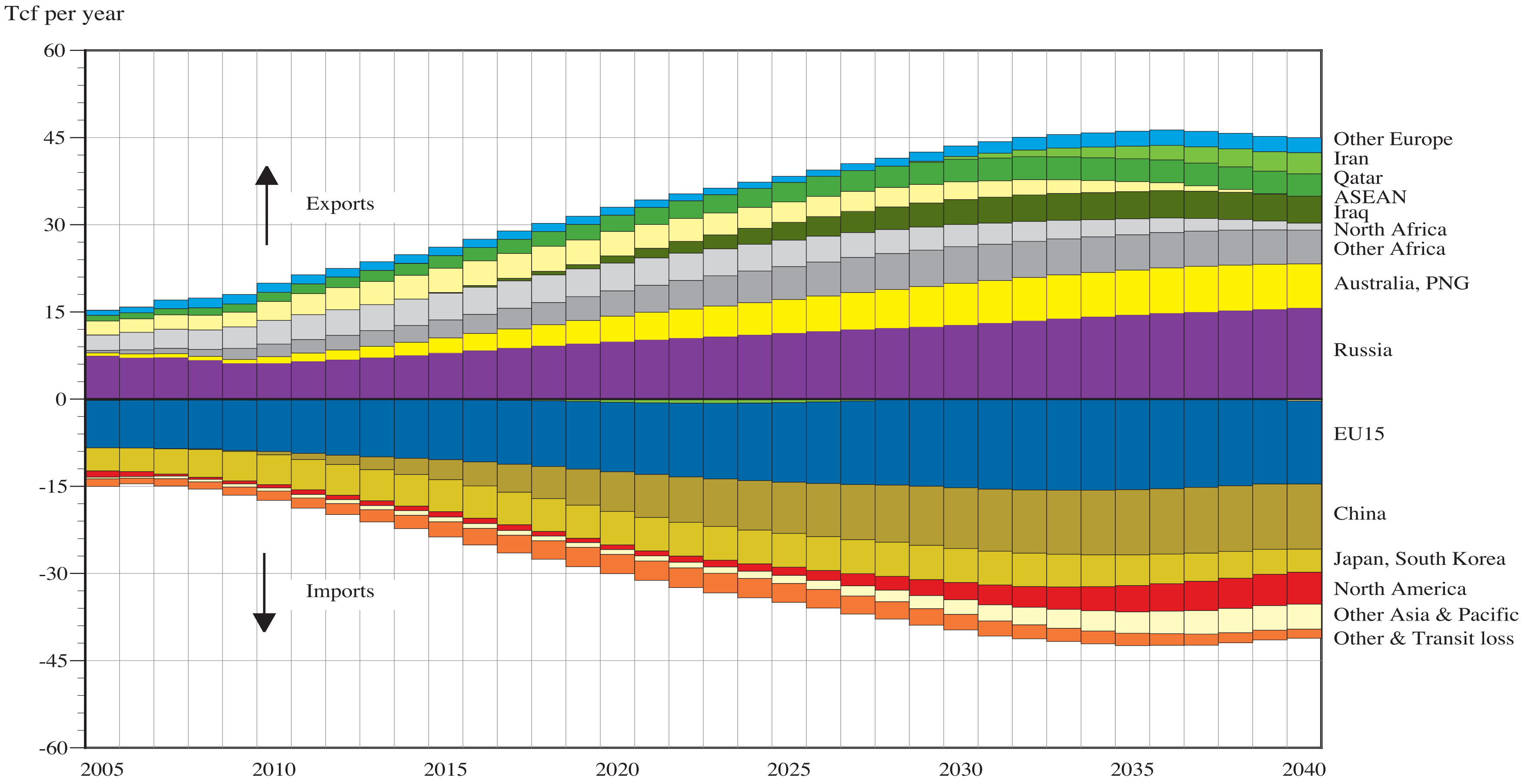
Reference Case: Global Supply

- Russia and the Middle East are largest suppliers.
- Middle East growth is strongest, driven by internal demand and growing exports.
  - Exports are initially LNG with pipeline options to Europe and India longer term



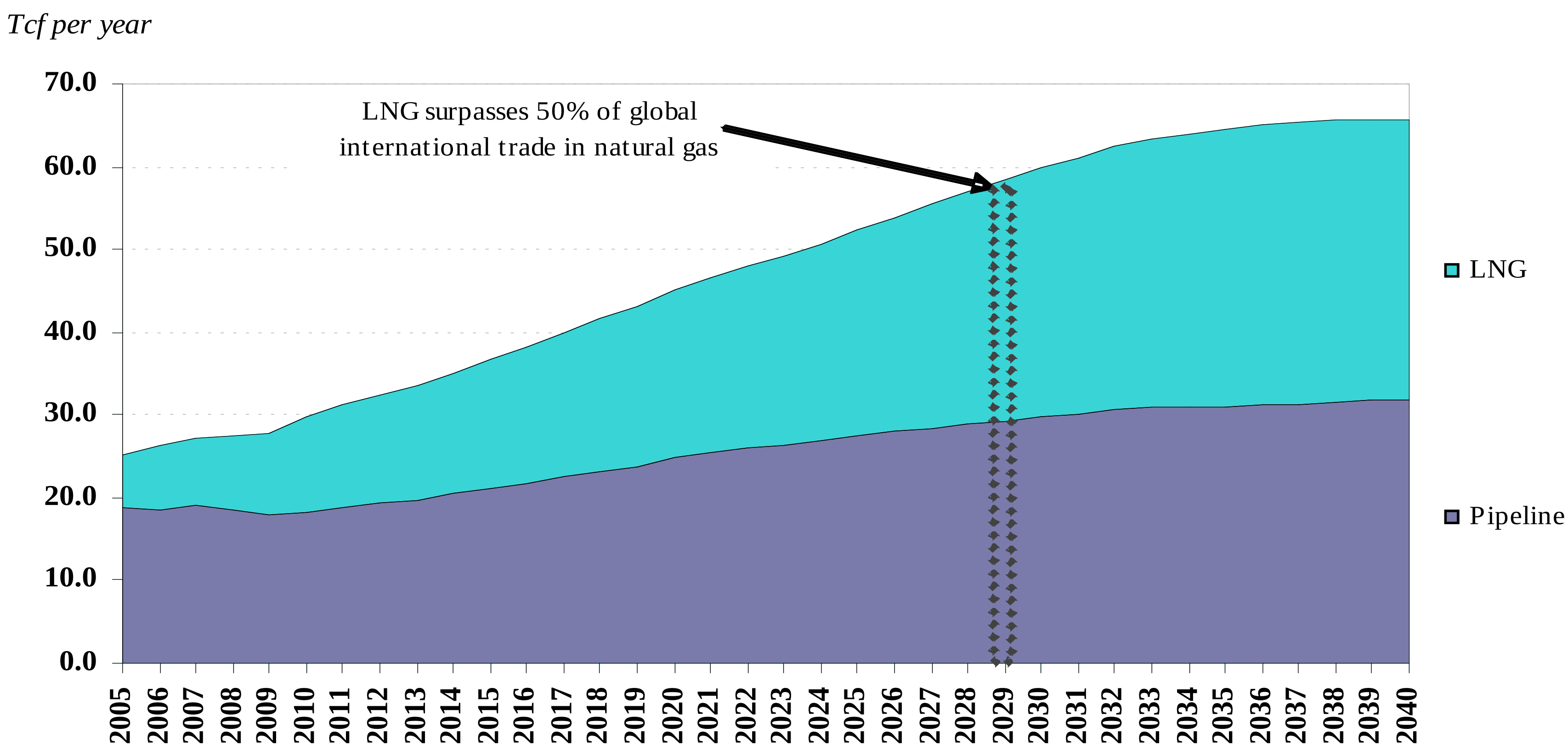
Reference Case: Global Trade

- Asian imports grow most dramatically, driven primarily by China.
- Exports grow strongly from Australia and the Middle East as LNG demand grows
- Russia remains crucial to the global balance, but loses market share as new supplies emerge with demand growth in non-traditional markets.



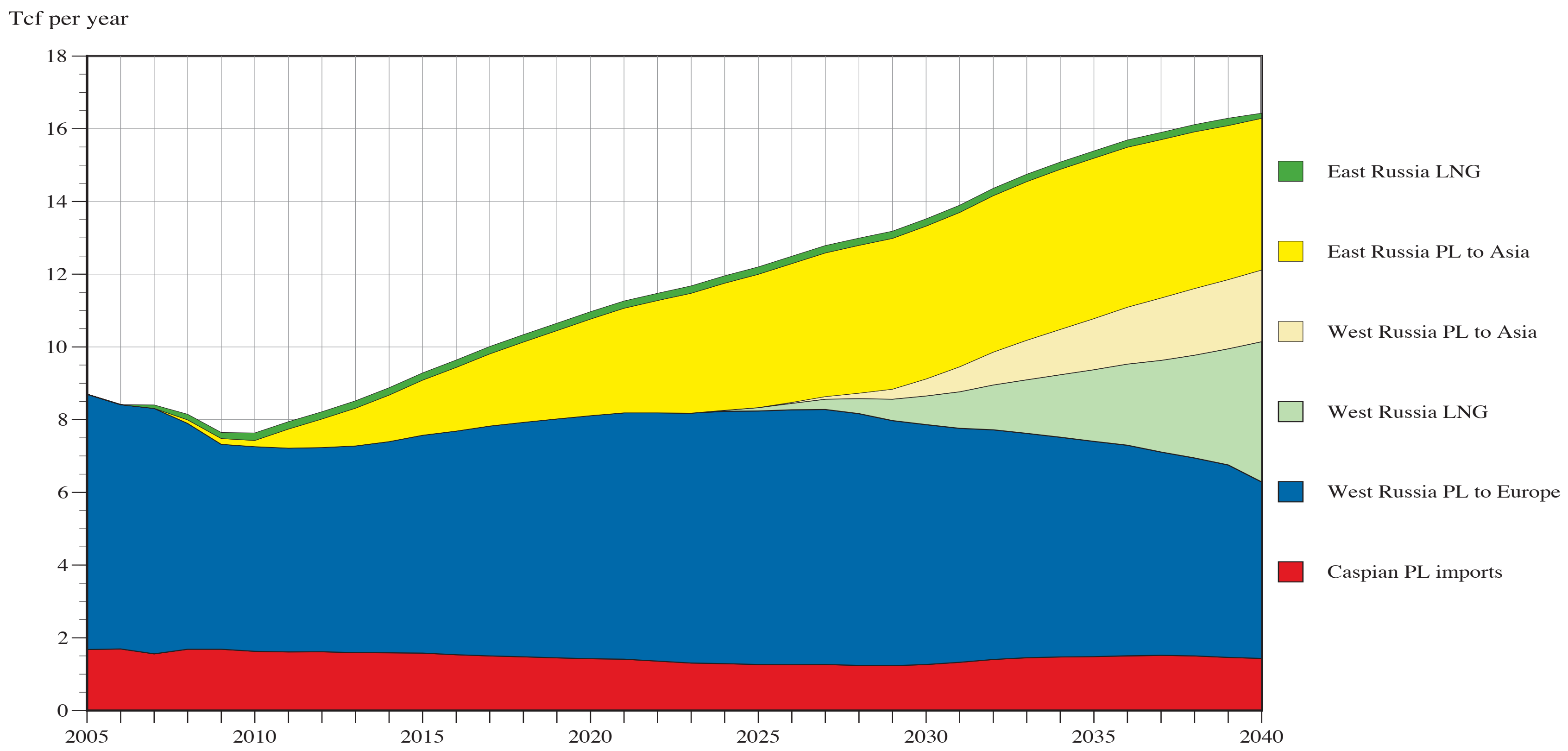
Reference Case: LNG vs. Pipeline Trade

- LNG growth is strong, reaching about 50% of total international natural gas trade by the late 2020s.
  - This date moves under different scenarios, but the pace of growth in LNG is generally stronger than pipeline trade.



Reference Case: Russian Exports

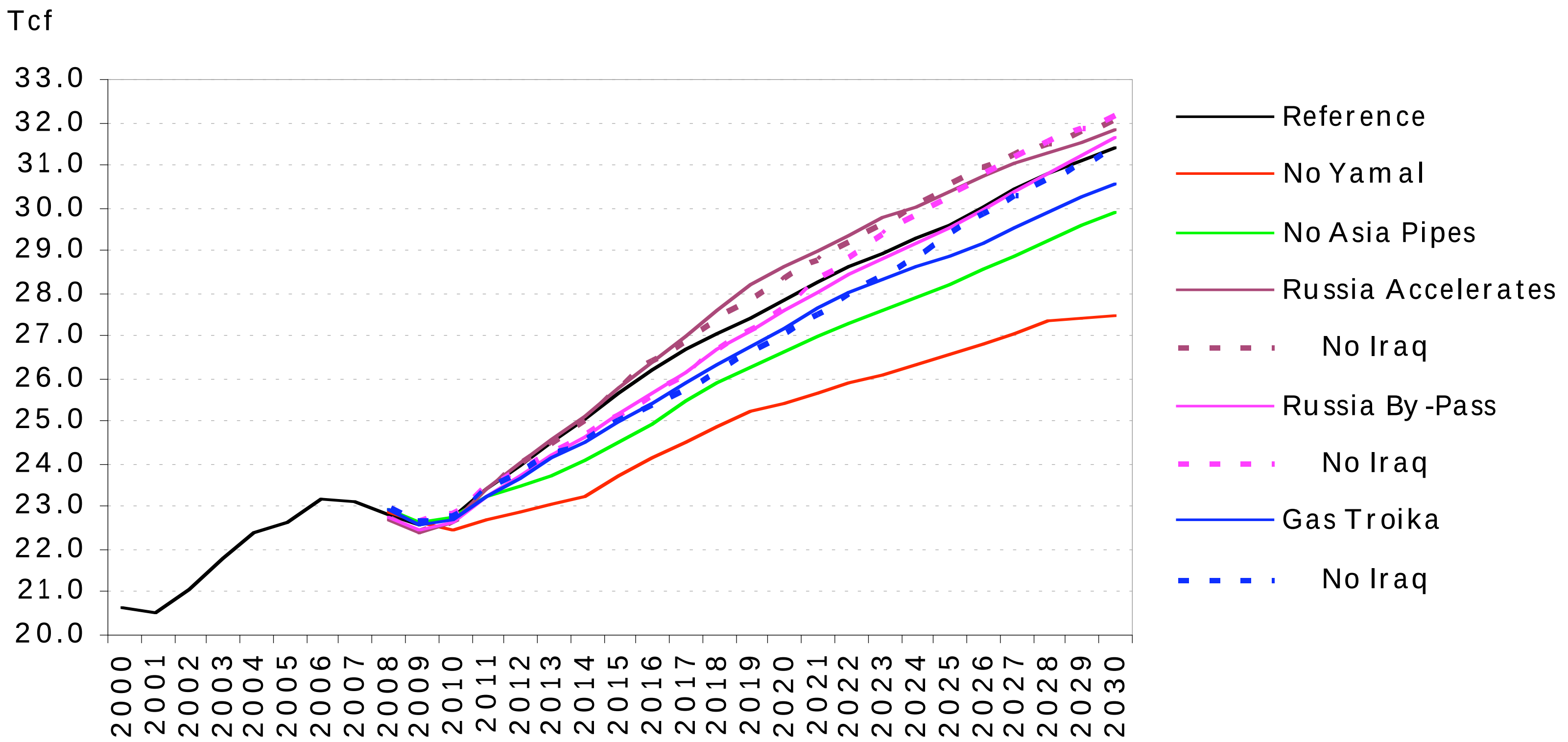
- Russian supply growth is primarily due to development in North and East.
- East Russian gas is exported as LNG and pipe, primarily the latter.
- Post-2030, Iraq emerges as an exporter to Europe via pipeline. This encourages a Russian push into the Atlantic LNG market, coinciding with US LNG demand growth.



Summary of All Scenarios

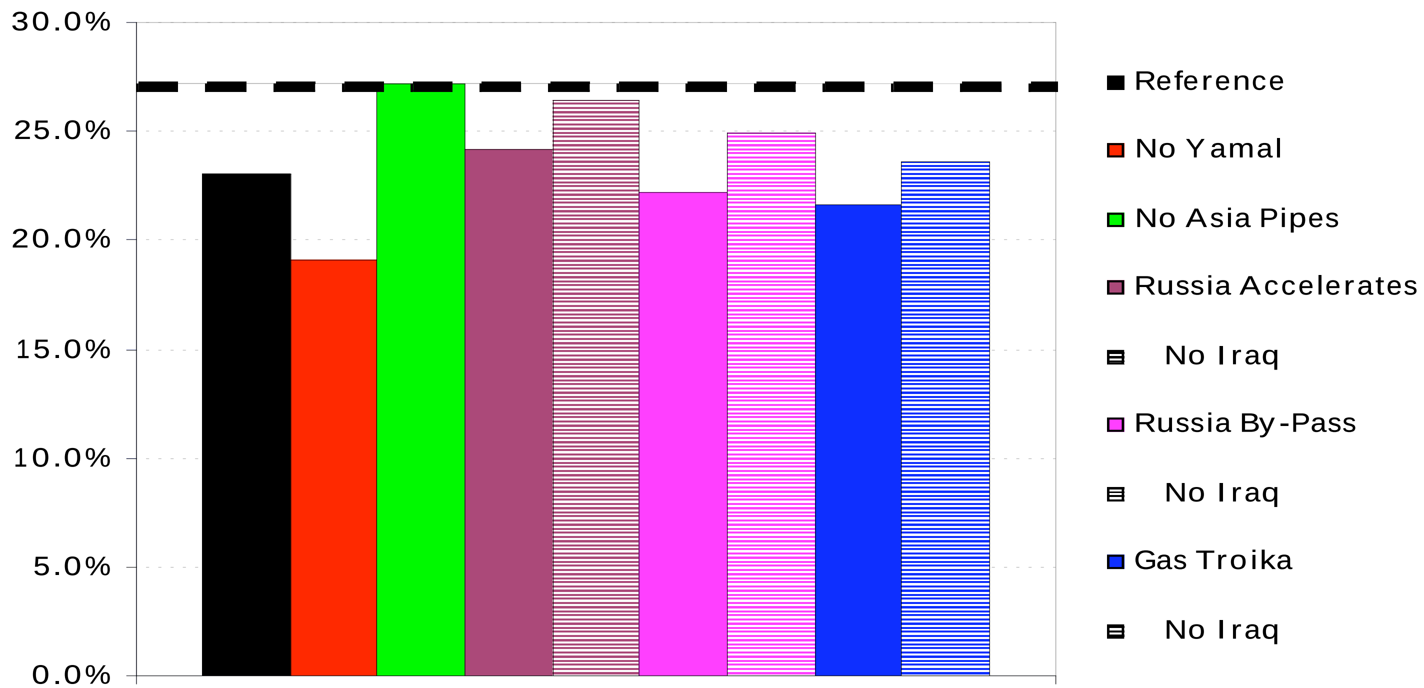
Russian Supply Across Cases

- Production differences range up to 5 tcf (bcm) by 2030.
- Lowest case is that in which Yamal developments are not allowed.
  - Disallows 400 tcf from development
- Highest case is that in which Russian developments are accelerated.
  - Consistent annual increase of over 1 tcf each year beyond 2015.



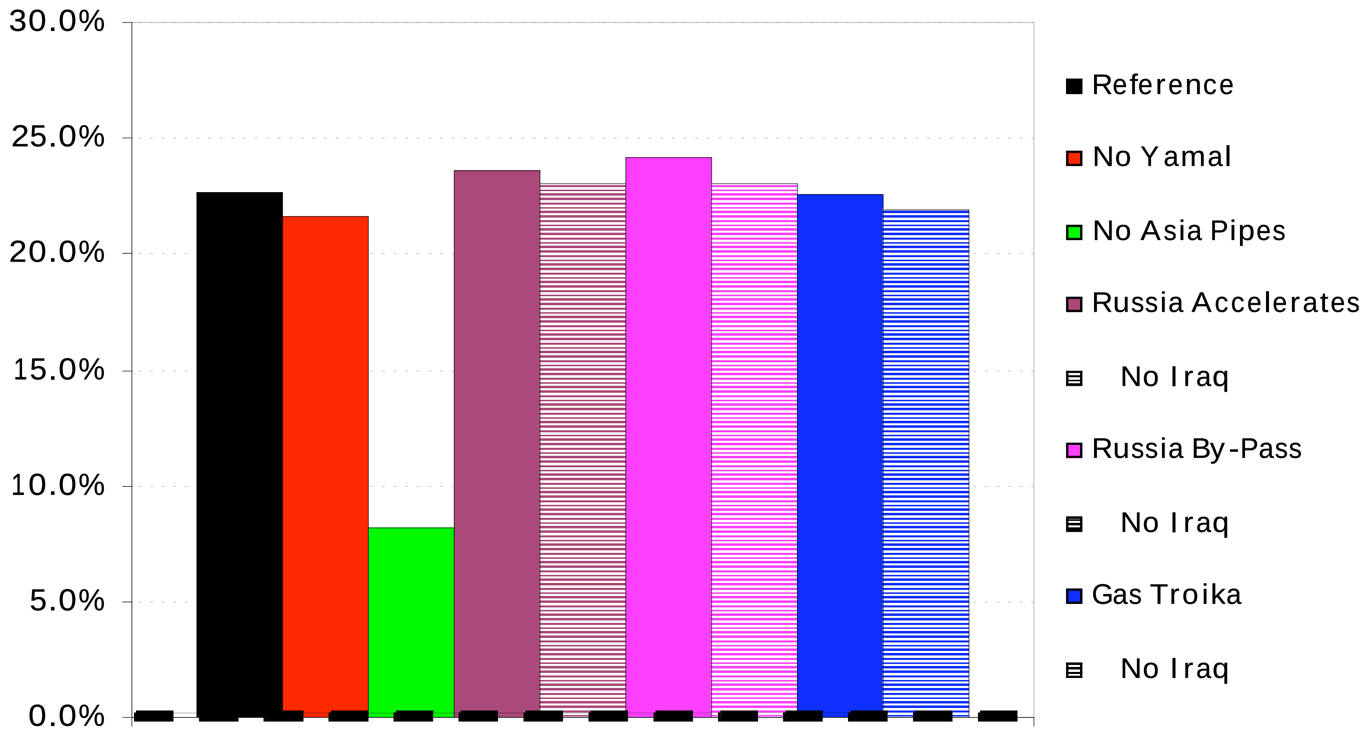
Russian Market Share in Europe, 2030

- European Market share ranges from 18% to 27% in 2030.
- Again, the lowest case is that in which Yamal developments are not allowed.
  - Disallows 400 tcf from development
- Here, the highest case is that in which Asian developments are not allowed.
- All cases in which Iraq is not allowed result in an increase in EU market share.



Russian Market Share in Asia, 2030

- Asian market share ranges from 8% to 24% in 2030.
  - Asia is defined for this purpose as NE Asia, which includes China, Korea, and Japan
- The lowest case is that in Asian pipelines are not allowed (LNG is allowed).
- The highest case is that in which Caspian developers attempt to by-pass Russia.
- All cases in which Iraq is not allowed result in a decrease in Asia market share.



Selected results

In all scenarios, there are a collection of global reactions. For the sake of brevity, we focus only on Russian exports in what follows. Please reference the paper for a more complete discussion of the scenarios.

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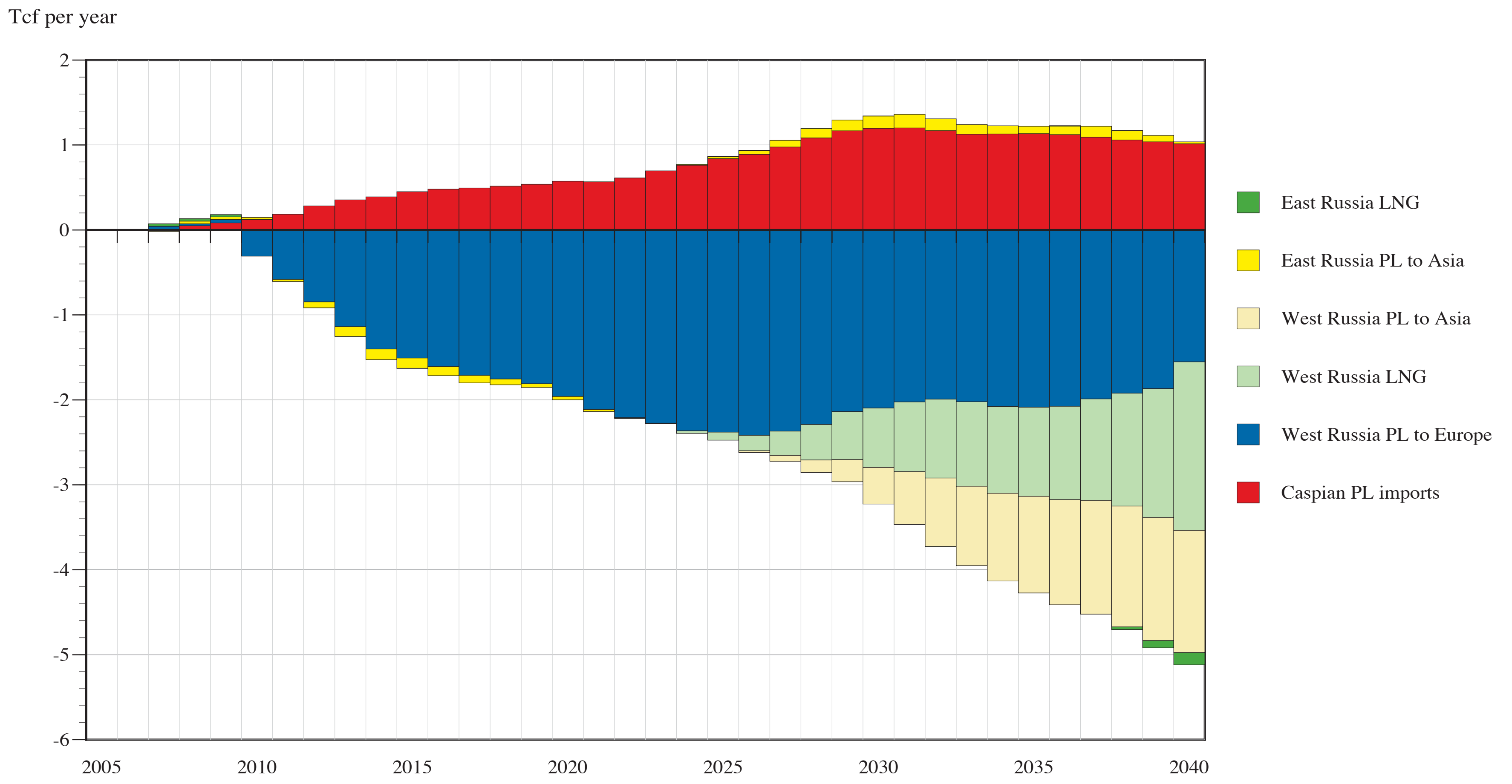
Scenario 1: No Yamal

- Russian exports decline substantially relative to the Reference Case.
- Caspian producers react by expanding production.
- Far east production expands slightly as the EU increases demand for LNG, which lifts price in Asia and prompts a response in the Russian Far East.



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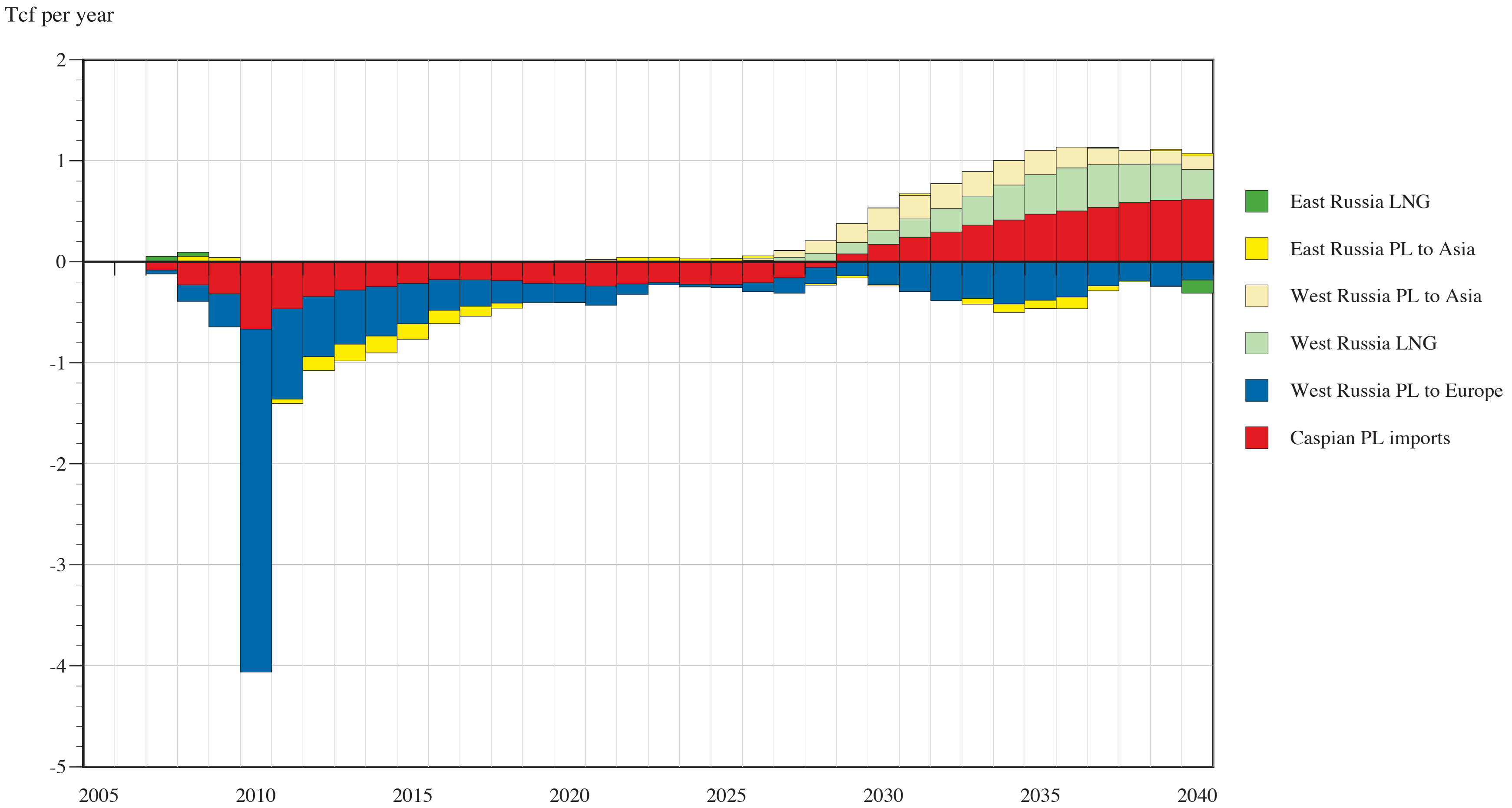
Scenario 2: Temporary cut-off

- Russian gas loses EU market for an extended period relative to the reference case. The threat of a disruption prompts some anticipatory response, but we see substantial investments made to diversify after the disruption occurs.



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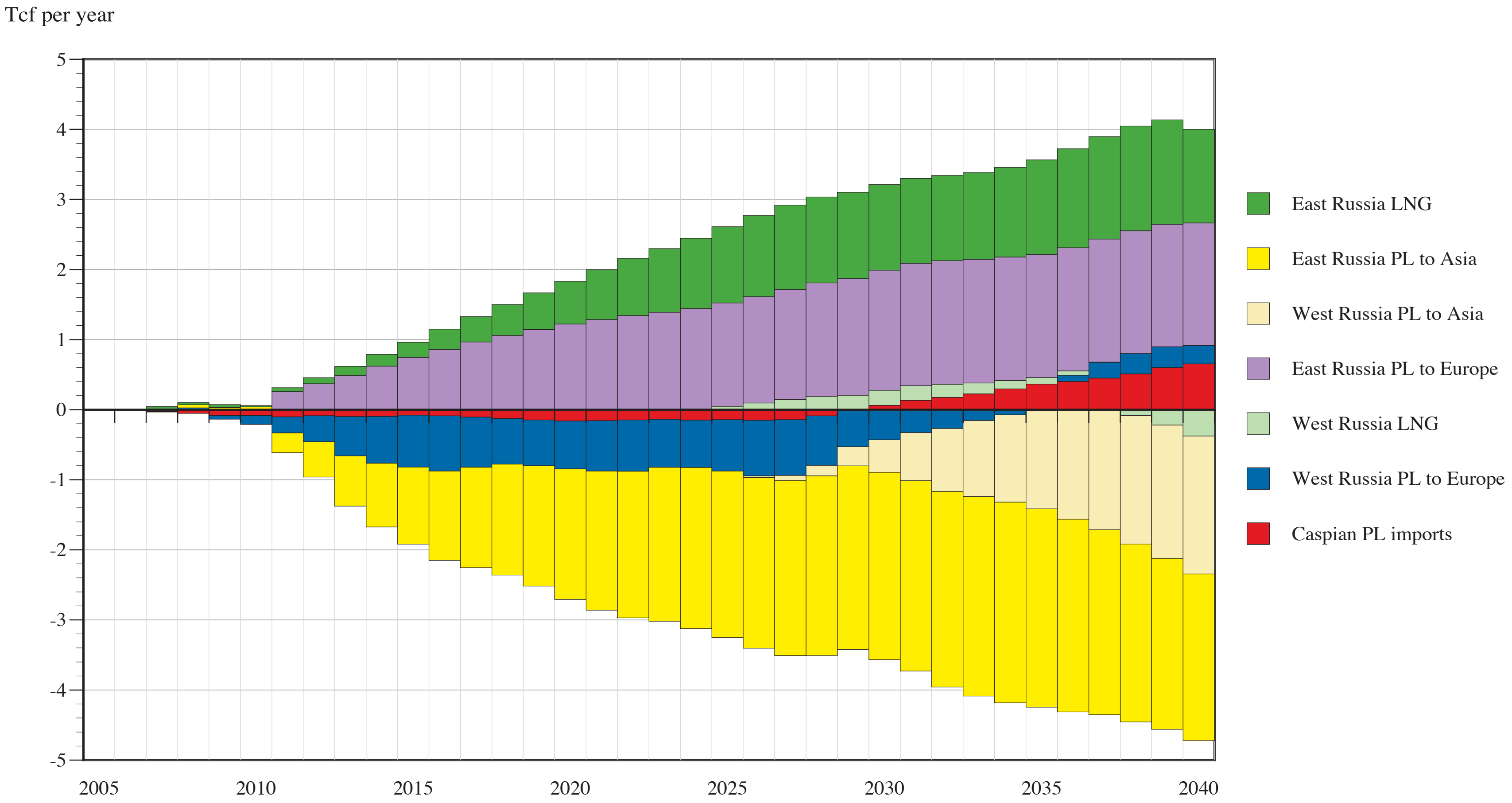
Scenario 3: No Asia Pipes

- Pipeline developments are focused to the West.
- LNG from Sakhalin expands relative to the Reference Case.



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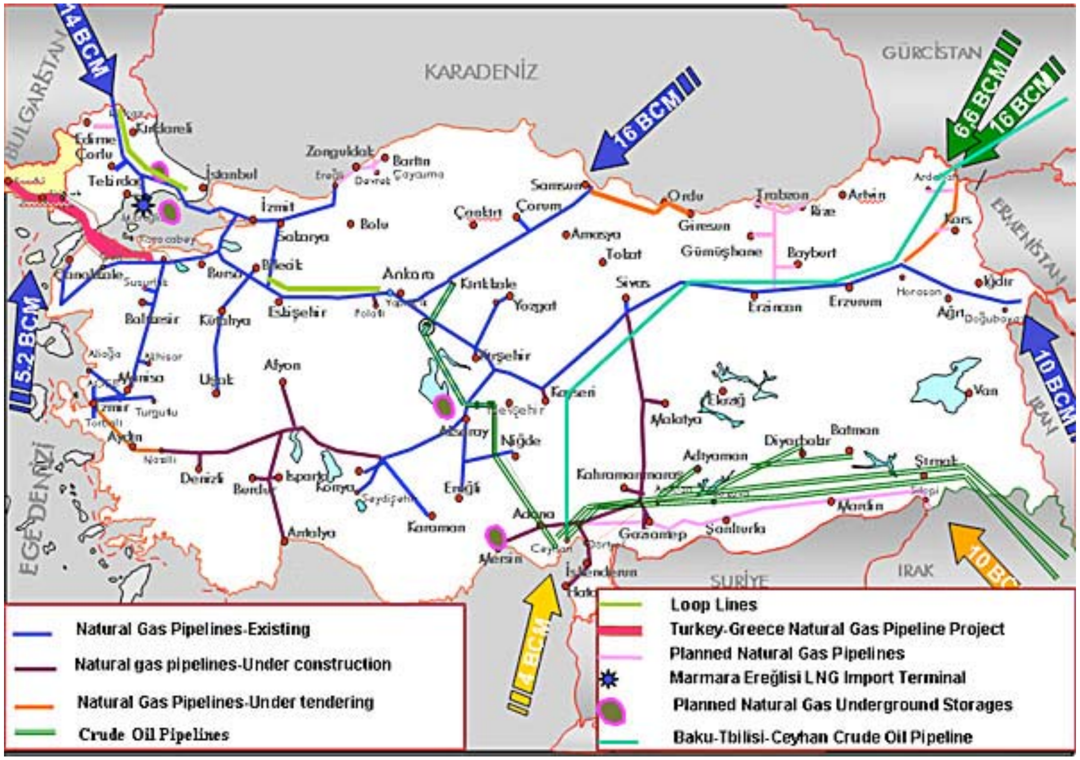
Scenarios 4 and 5: Turkey in the Middle

- A natural gas market hub provides a focal point and location for spot market transactions and gas trading, thus allowing for greater price discovery opportunities. In effect, the hub provides a liquid pricing point for both suppliers and demanders to base current and future decisions.
- Geography makes Turkey a likely candidate to emerge as a natural gas market hub at some point in time in the future. Existing and potential sources of supply are diverse. Europe is a major consuming market that seeks to import natural gas from a variety of sources.

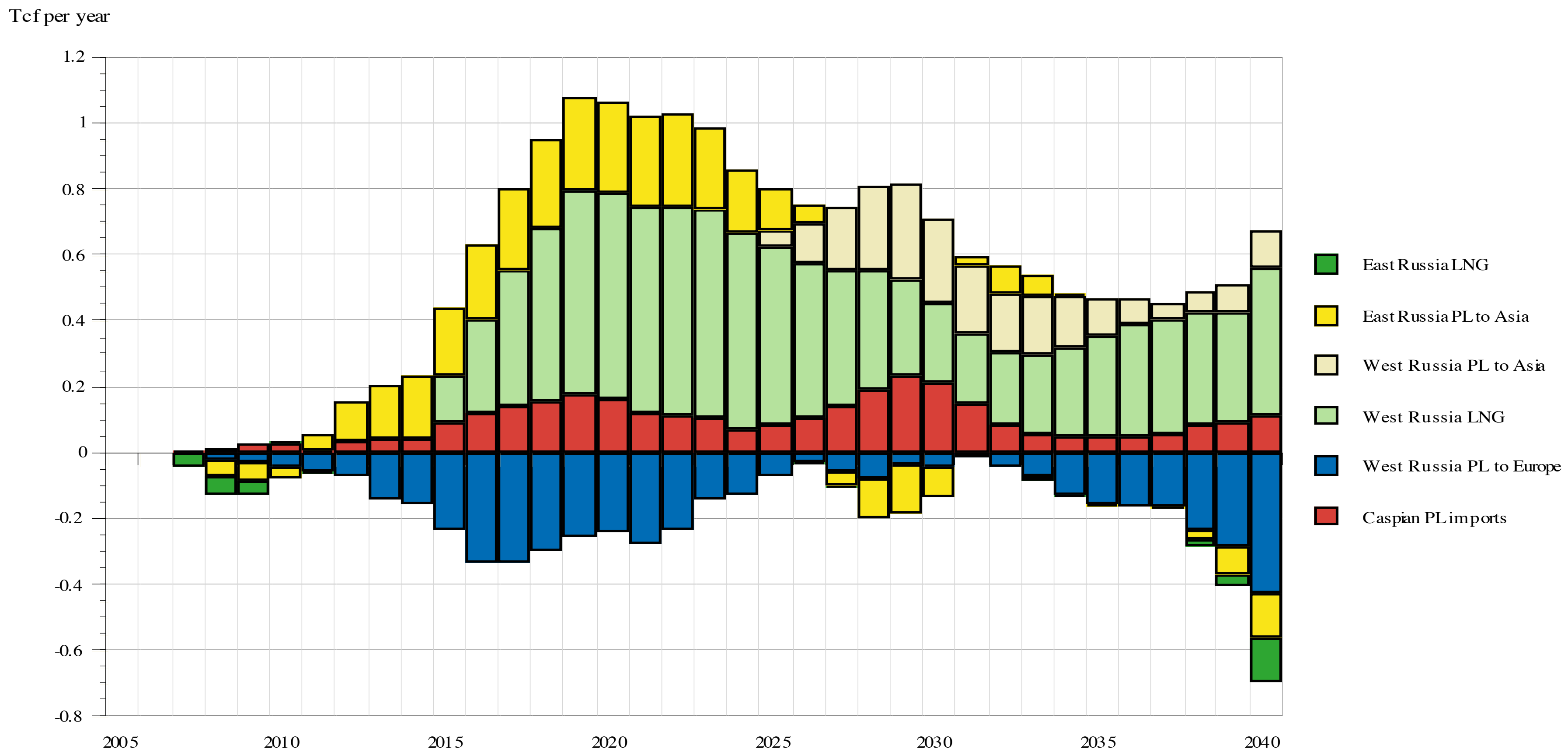
- Existing and potential sources of supply
  - Bluestream pipeline (Russia)
  - Iran-Turkey pipeline (Iran, Turkmenistan)
  - LNG (Algeria, Nigeria)
  - South Caucases pipeline (Azerbaijan)
  - Nabucco pipeline (Azerbaijan, Turkmenistan)
  - Syria-Turkey pipeline (Egypt, Iraq, Saudi Arabia)
  - Iraq-Turkey pipeline (Iraq)



Source: BOTAS

Scenario 4: Russia Accelerates

- Murmansk LNG is accelerated.
- Asian developments are accelerated. Caspian imports increase as there is more infrastructure available to move product to Europe. This enables some lower cost Caspian resources to displace some production in Yamal.



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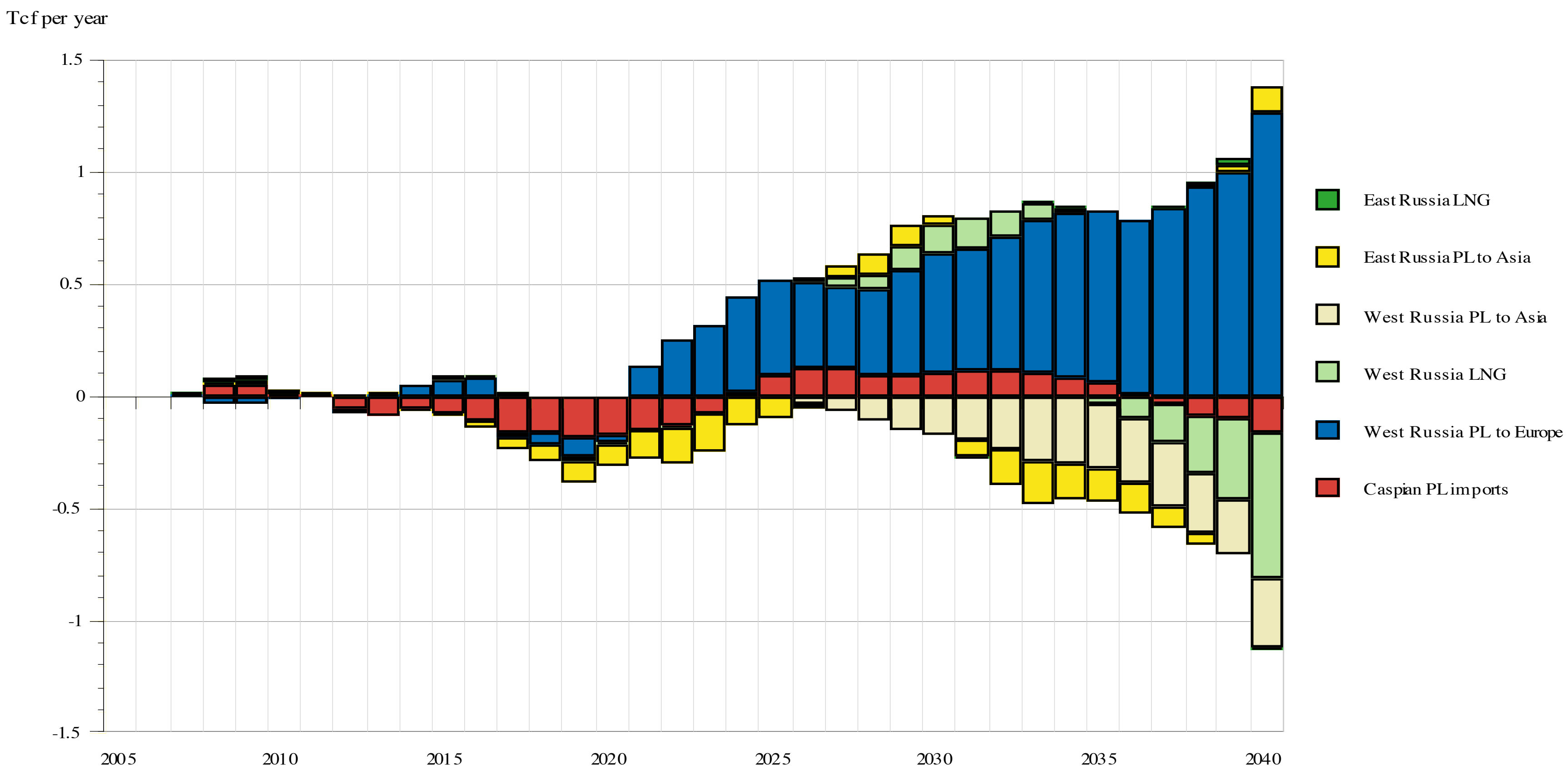
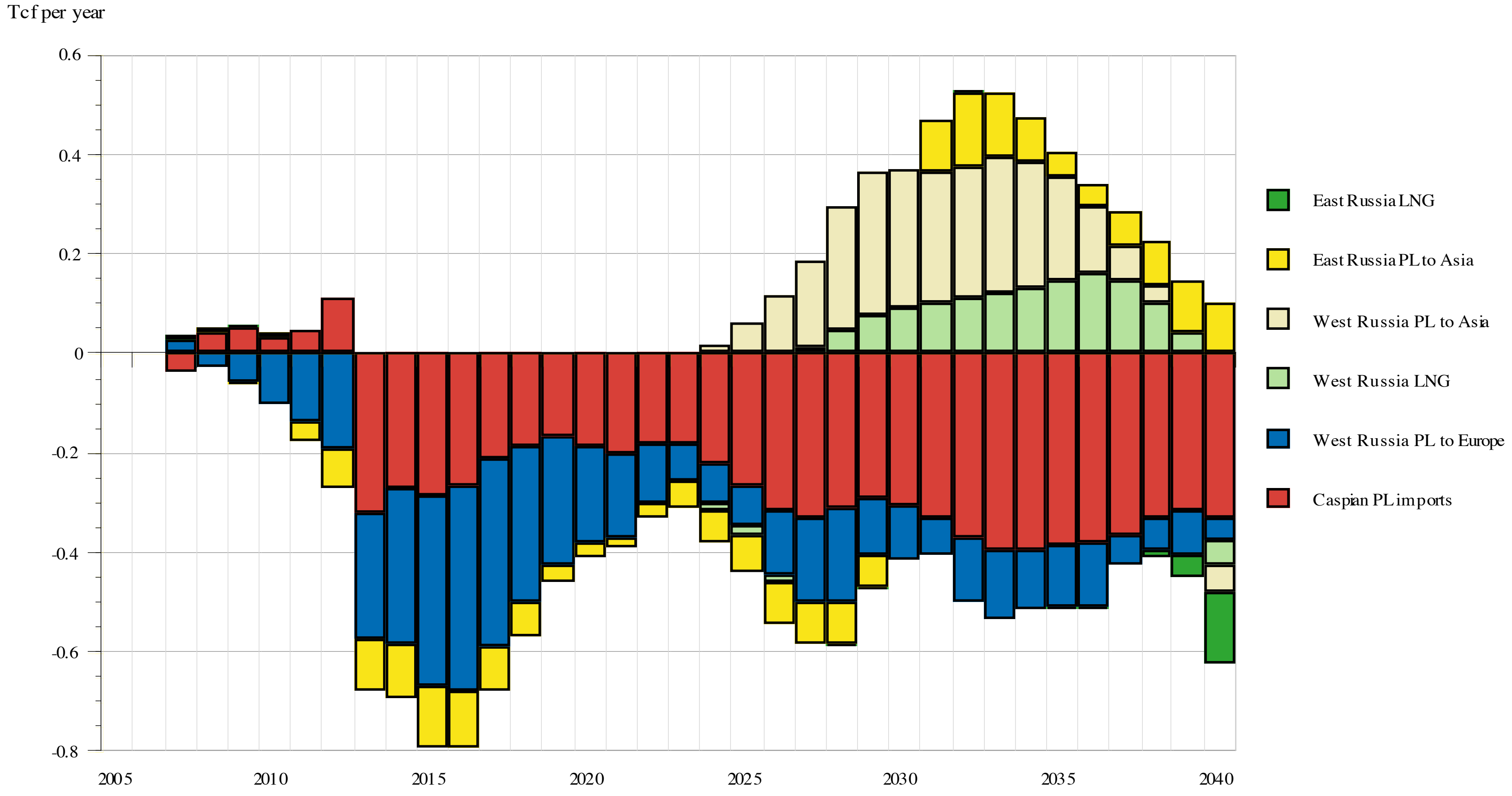
Scenario 4b: Russia Accelerates & Iraq Constrained

- When Iraqi developments are disallowed, we see a significant expansion of Russian exports to Europe.



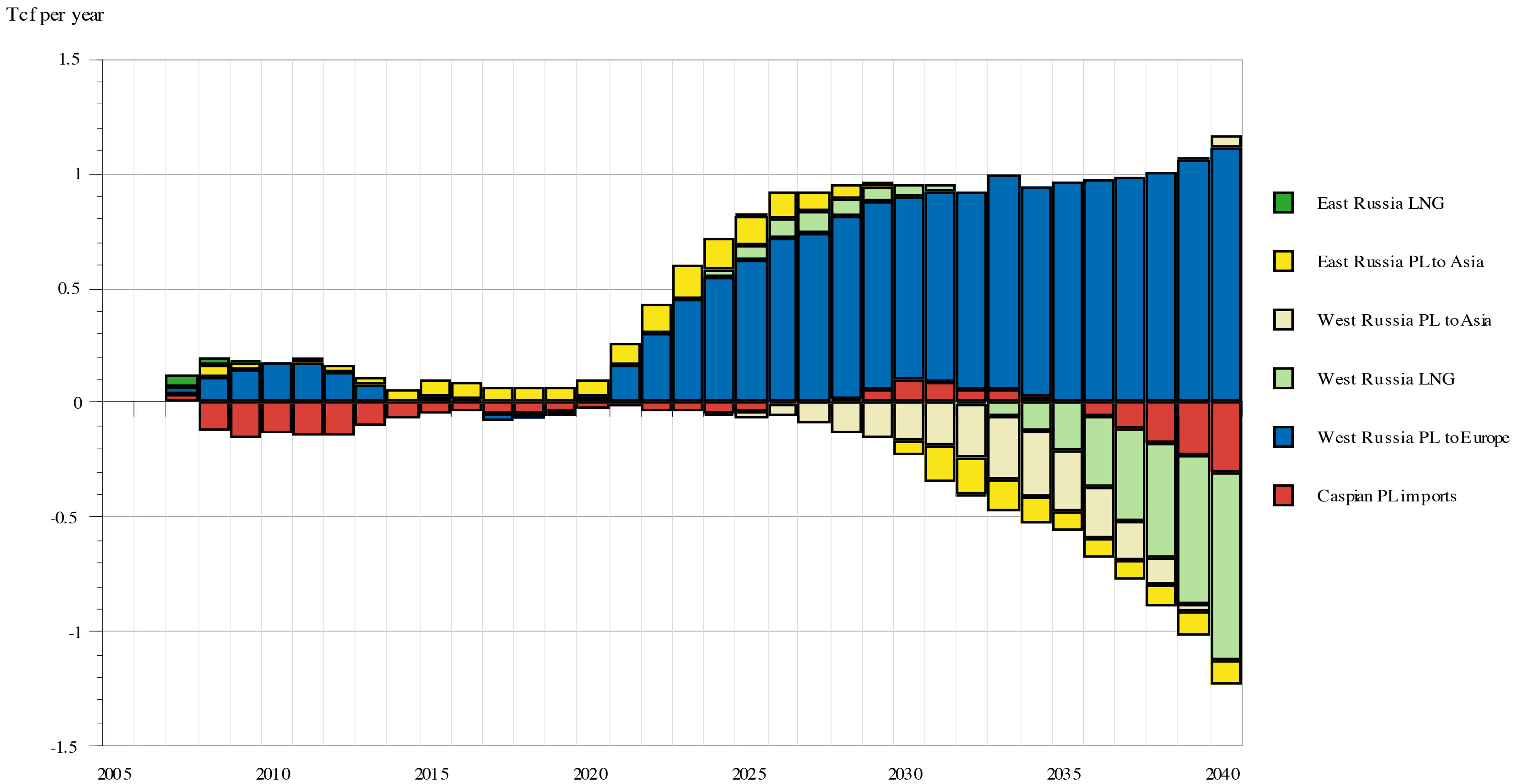
Scenario 5: Russia By-pass

- Caspian gas is diverted into alternative infrastructure, thus by-passing Russia. This has the effect of reducing Russian exports to Europe as Caspian gas takes market due to subsidized infrastructure.
- The loss of market in Europe encourages Russian expansion to the East.



Scenario 5b: Russia By-pass and Iraq Constrained

- No Iraqi gas to Europe allows Russian gas to retake much of the European market it loses when Iraq is allowed.



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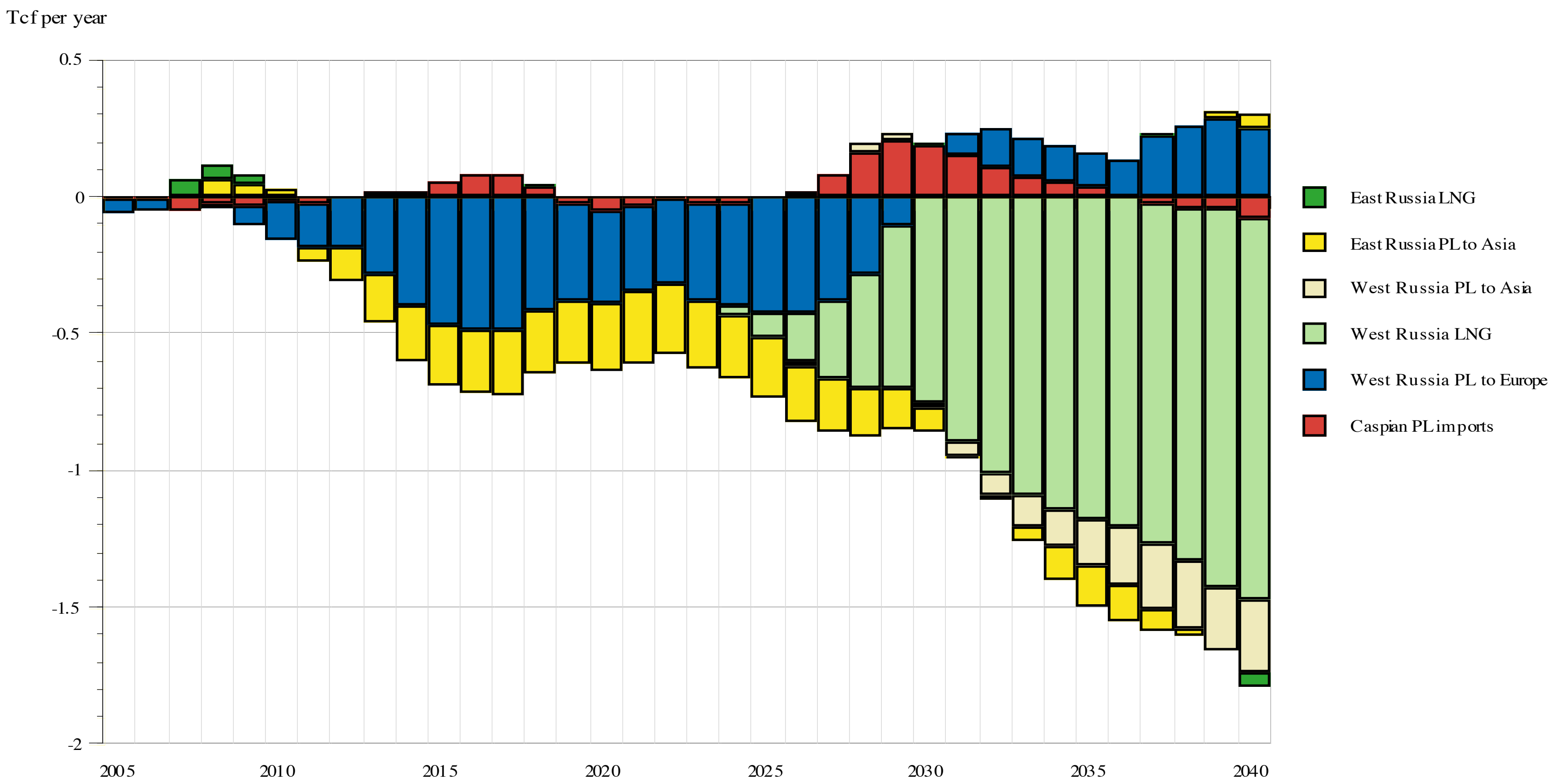
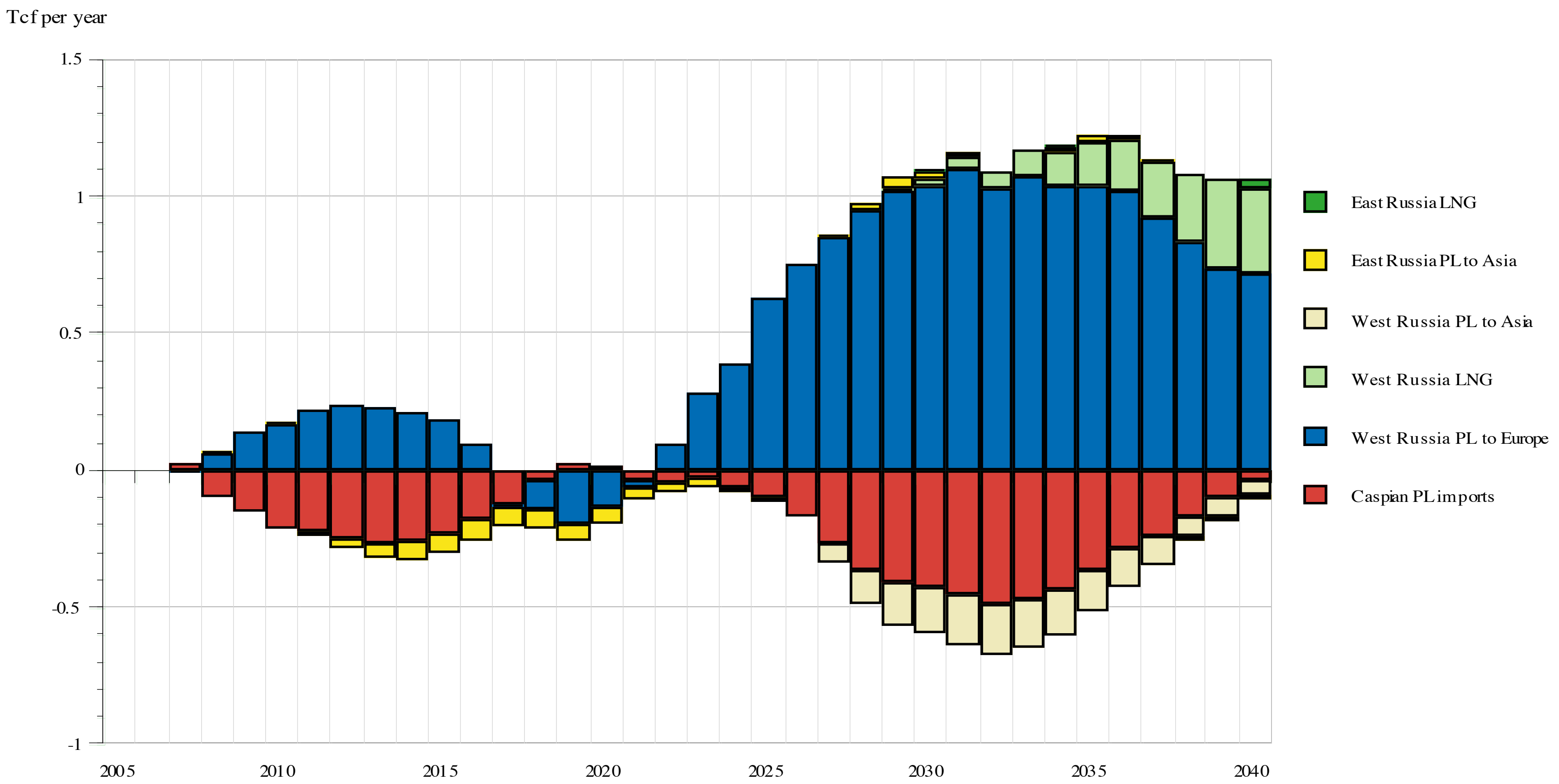
Scenario 6: Gas Troika

- Coordination among Russia, Iran and Qatar results in lower exports via pipeline to Europe, and eliminates Russian LNG.
  - The higher required return renders some investments unattractive. This follows from the fac that price does not respond that greatly due to adequate demand response and supply response from other producers.



Scenario 6: Gas Troika & Iraq Constrained

- No Iraq allows greater Russian volumes to Europe, almost completely regaining the market lost when Iraq is allowed.



Concluding remarks

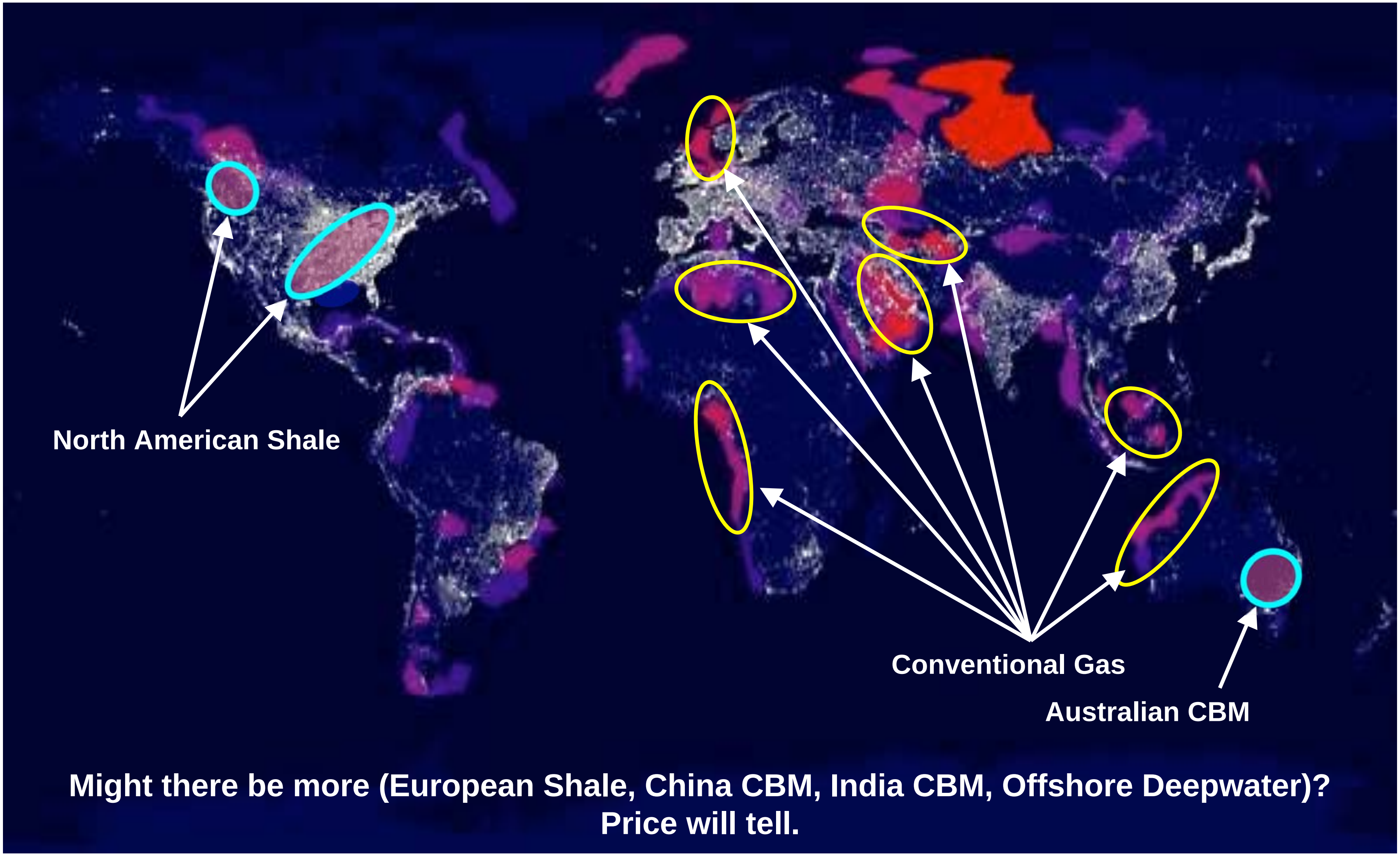
Key Conclusions

- Gas supplies in the Middle East are of critical importance. Iraqi gas developments, in particular, due to the size and location (geology and geography) of the resource, are important to watch, although this is a longer term development.
  - Large Middle East Resources
    - Iraq: 111 tcf (proved) + 112 tcf (GTK) + 65 tcf (YTF) = 288 tcf
    - Iran: 991 tcf (proved) + 140 tcf (GTK) + 298 tcf (YTF) = 1,429 tcf
    - Saudi Arabia: 258 tcf (proved) + 297 tcf (GTK) + 640 tcf (YTF) = 1,195 tcf
  - Varied (but growing) Middle East Demand
    - Iraq: 0.064 tcf/yr
    - Iran: 3.948 tcf/yr
    - Saudi Arabia: 2.680 tcf/yr
  - Iraq resources are geographically advantaged, being located in north and west rather than in the south.
- Developments in North America with shale renders demand for LNG there low. This leaves large quantities of LNG in the Atlantic basin available to Europe.

Key Conclusions (cont.)

- Timing is important. Many of the resources in play will have similar costs at the burner-tip. So, *first-mover advantage* is crucial.
- Opportunity for Russia to Asia, but could erode market share in Europe by lowering LNG demand in the Pacific.
- Europe diversifies sources of supply in almost all cases.
  - Diversification is a natural progression as demand grows and the capacity of soviet era infrastructures to capture that market is eroded.
  - Actions by Russia can accelerate the trend.
- A cartel, if limited to the “Troika” nations, has little ability to earn monopoly rents. Demand is elastic and the supply curve for alternative sources is fairly elastic.
- Given the role of the Middle East as a possible competitor to Russia for European market share, any broad coordinated action among the key producing countries could limit supply options for a security of supply driven EU.
  - However, if prices rise enough alternative technologies could limit market opportunities long term.
- Climate change policies could drive demand up, but who will respond?

Competing Sources of Supply (LR Considerations)



European Market LNG Penetration

- Capacity in 2009 will be 28% of annual demand, and it could be as high as 40% of annual demand by 2011.
- There is an additional 180 bcm of import capacity that has received approval or is in the approval process.
- LNG will be relatively cheap in the short term due to high supply, low demand, and new shale resources in the US.

Existing					
Terminal	**Location**	**Country**	**Current Capacity (Bcm/yr)**	**Current Capacity (bcf/d)**	**Initial Start-up**
Fluxys LNG	Zeebrugge	Belgium	9.1	0.8805	1987
Fos Sur Mer	Fos sur Mer, Marseille	France	4.5	0.4354	1972
Montoir De Bretagne	Montoir-de-Bretagne, Nantes	France	10	0.9675	1982
Revithoussa	Revithoussa, Athens	Greece	4.5	0.4354	2000
GNL Italia	Panigaglia	Italy	3.5	0.3386	1971
Sines LNG	Sines	Portugal	5.2	0.5031	2003
Barcelona	Barcelona	Spain	14.45	1.3981	1969
Bilbao	Bilbao	Spain	8	0.7740	2003
Cartegena	Cartagena	Spain	10.5	1.0159	1989
El Ferrol LNG	Murgados	Spain	3.6	0.3483	2007
Huelva	Huelva	Spain	11.83	1.1446	1988
Saggas	Sagunto, Valencia	Spain	6.57	0.6357	2006
Aliaga	Aliaga	Turkey	6	0.5805	2006
Marmara Ereglesi	Marmara Ereglisi	Turkey	5.2	0.5031	1992
Grain LNG	Isle of Grain, Kent	UK	13	1.2578	2005
Teeside Gasport	Teesside	UK	4.13	0.4000	2006
Total			***120.08***	***11.62***	

Under Construction					
Fos Cavou	Fos Cavaou	France	8.25	0.7982	2009
OLT Offshore LNG Toscana	Offshore Port of Livorno	Italy	4.7	0.4547	2011
Terminale LNG Adriatico	Offshore Rovigo	Italy	8	0.7740	2009
Dutch Gate Terminal	Rotterdam	Netherlands	12	1.1610	2011
Dragon LNG	Waterston, Milford Haven, Wales	UK	6	0.5805	2009
South Hook LNG	South Hook, Milford Haven, Wales	UK	10.5	1.0159	2009
Total			***49.45***	***4.78***	

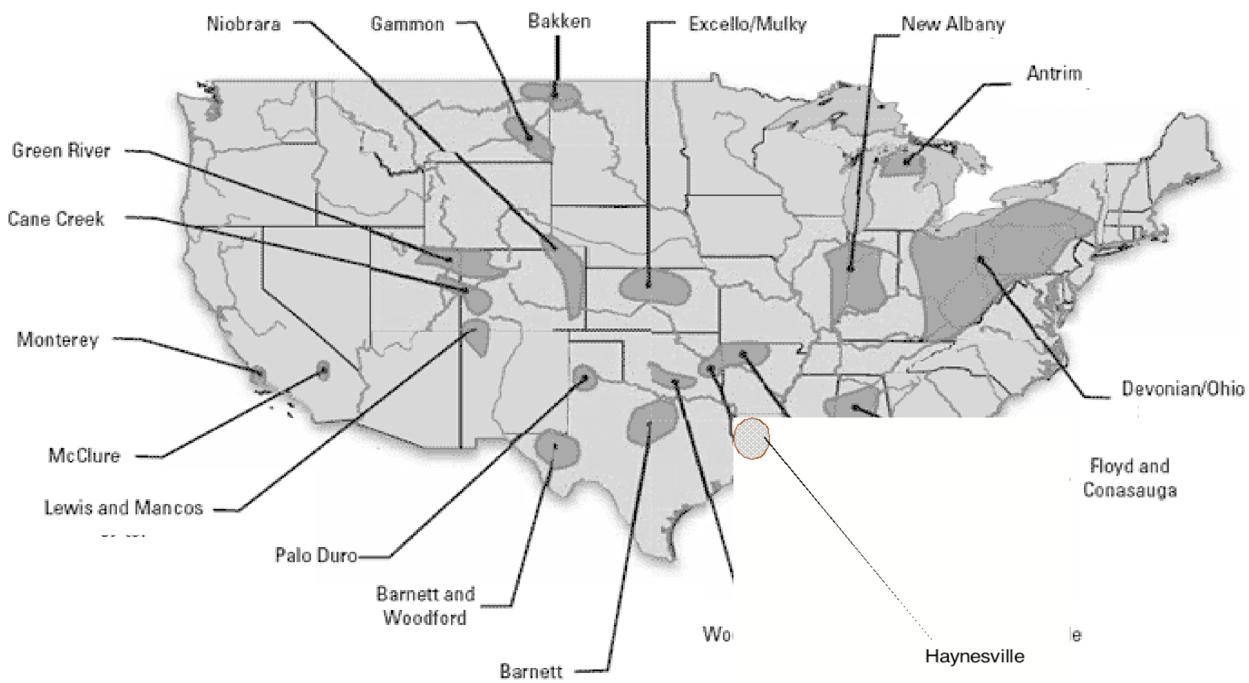
Comments/Questions

Issues in North America that will Impact Russian Influence

1. Recent Shale gas developments leave US an LNG market of “last resort” - at least for a while.
2. Potential resource in OCS could further mitigate role of LNG in North American balance

Developments in North American Shale Gas

- Very active area of exploration and development
  - NCI assessment indicates 275-840 tcf of technically recoverable shale gas
    - Differences driven primarily by producer reports for the Haynesville and Marcellus.
    - Even low end is higher than EIA's 125 tcf (AEO2008) or the 131 tcf cited by PGC (2006)
    - *Do not* include Canada (Montney, Horn River).
    - These are *technically* recoverable estimates. Costs may be an impediment.
      - Breakeven estimated at roughly $7/mcf in most plays. Favors Appalachian developments.
  - Other studies are ongoing.



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Developments in North American Shale Gas (cont.)

- Shale plays in Canada are also being developed.
- Most active areas are in the Horn River and Montney plays in BC and Alberta.
- Supply potential in BC, in particular, has pushed the idea of LNG exports targeting the Asian market
  - Asia is a premium market.
  - Competing projects include pipelines from Russia and the Caspian States, as well as LNG from other locales.
- BC is a basis disadvantaged market, but selling to Asia could provide much more value to developers.
- Utica Shale in Quebec has been compared to the Barnett in Texas, and price is even more favorable.

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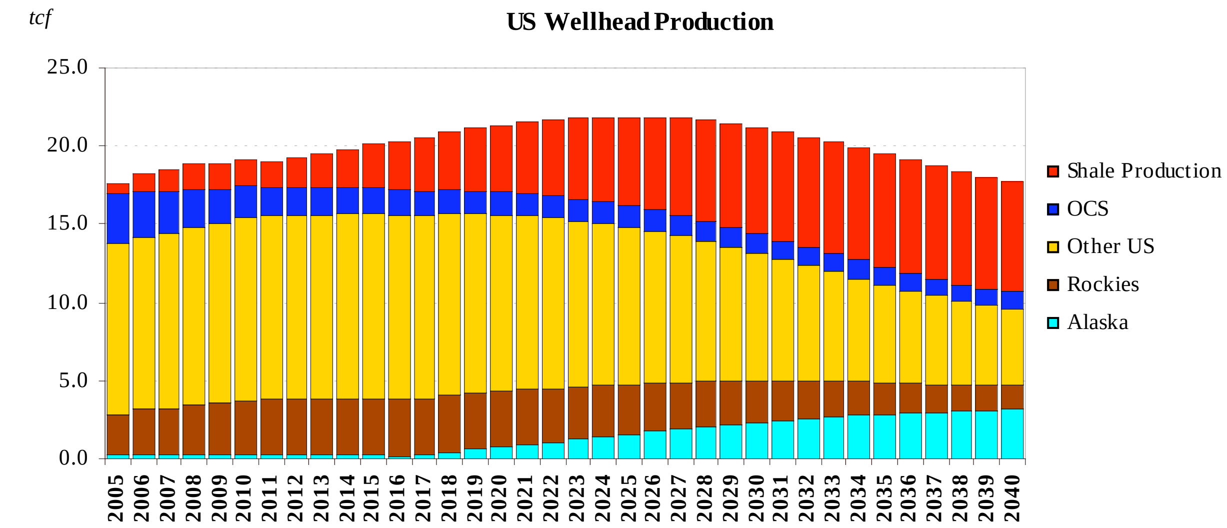
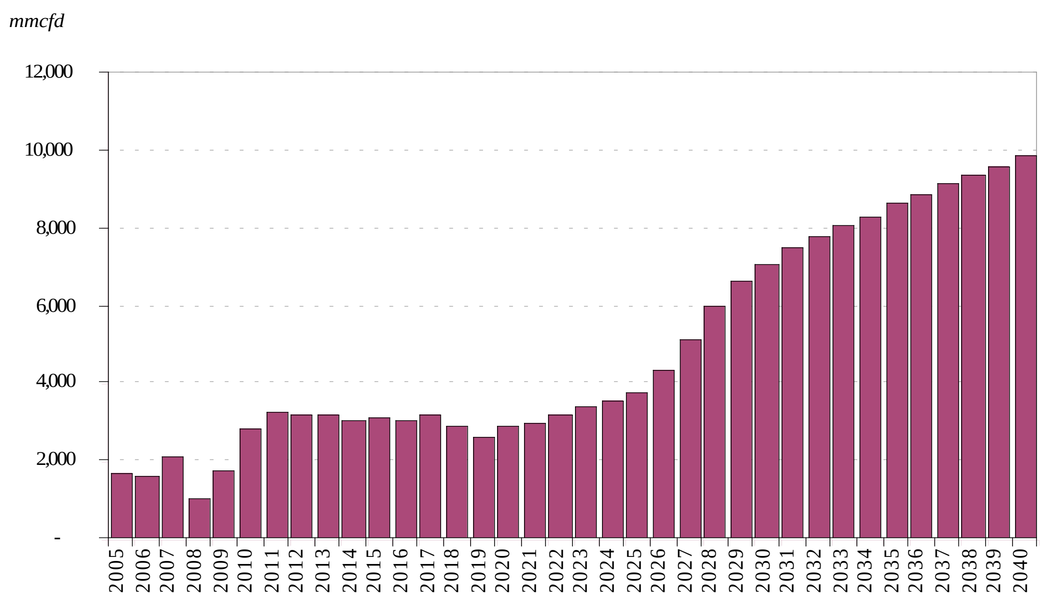
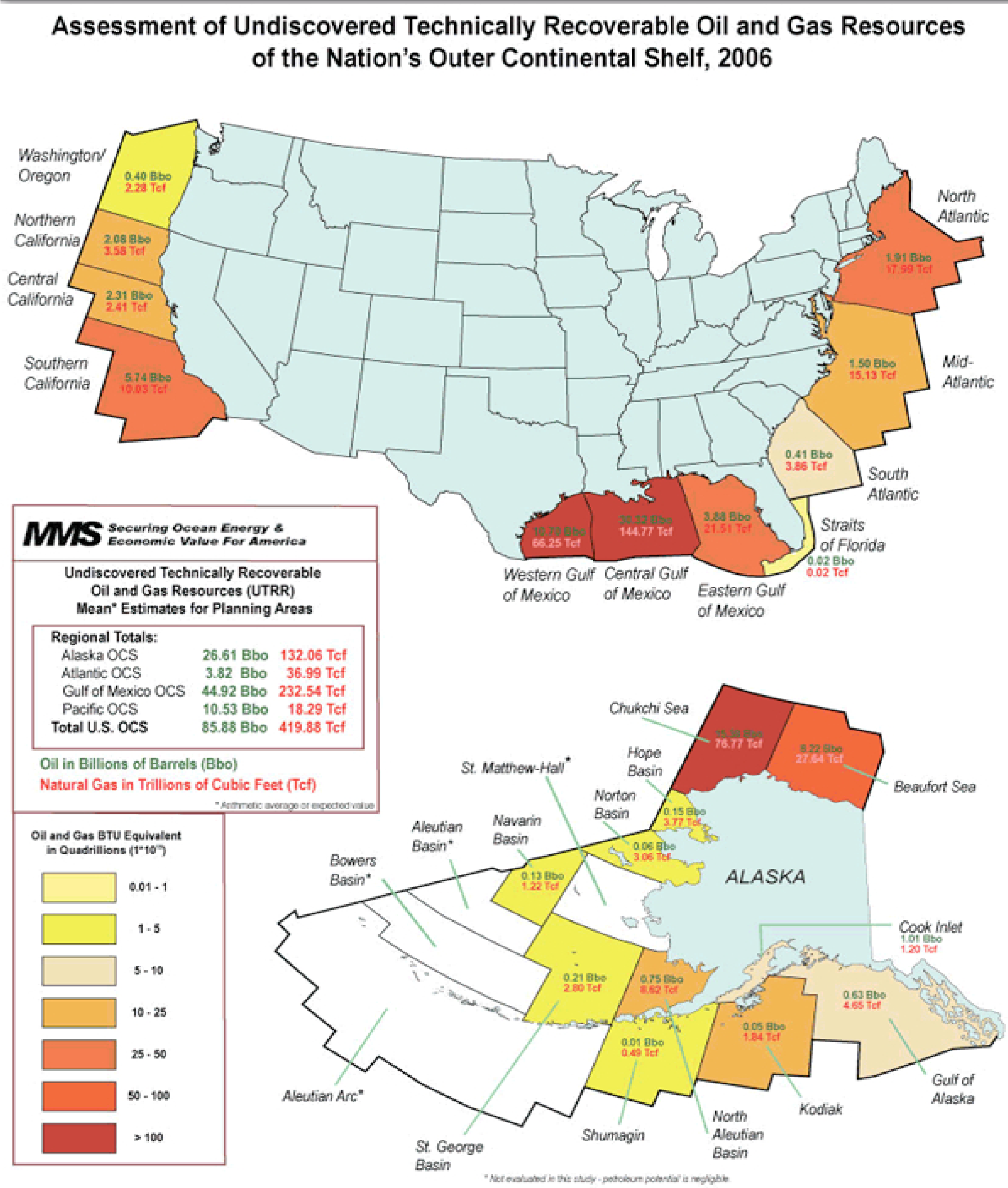
The Effect of Shale in the US



- Shale production increases dramatically.



- This contributes to low LNG terminal utilization in the US through the early 2020s.



Access restrictions: A new call or greater awareness?

- Access restrictions have been lamented in NPC literature for well over a decade
- Lower48 OCS effected resource (mean est.)
  - 18 billion bbl oil
  - 76 tcf natural gas

Natural Gas impacted by restrictions

Planning Region/Basin		Resource Off-limits (Tcf)
Rocky Mountains	Montana	9.4
	Wyoming Thrust Belt	0.8
	Green River	39.5
	Powder River	6.0
	Uinta-Piceance	8.4
	San Juan	5.3
Total Lower 48 (incl. OCS)		**146.8**
Alaska	ANWR	8.6
	North Aleutian Basin	8.6
Total		**164.0**

Data Sources: NPC2003 Supply Task Group Report, MMS, Hartley and Medlock (2007)

Selected Regional Prices

- Markets become increasingly connected, so developments in one region influence other regions.
- Increases in trade leads to price differentials that reflect transport differentials