

Quantitative Analysis of Scenarios for Chinese Unconventional Natural Gas Resources and Their Role in Global LNG Markets

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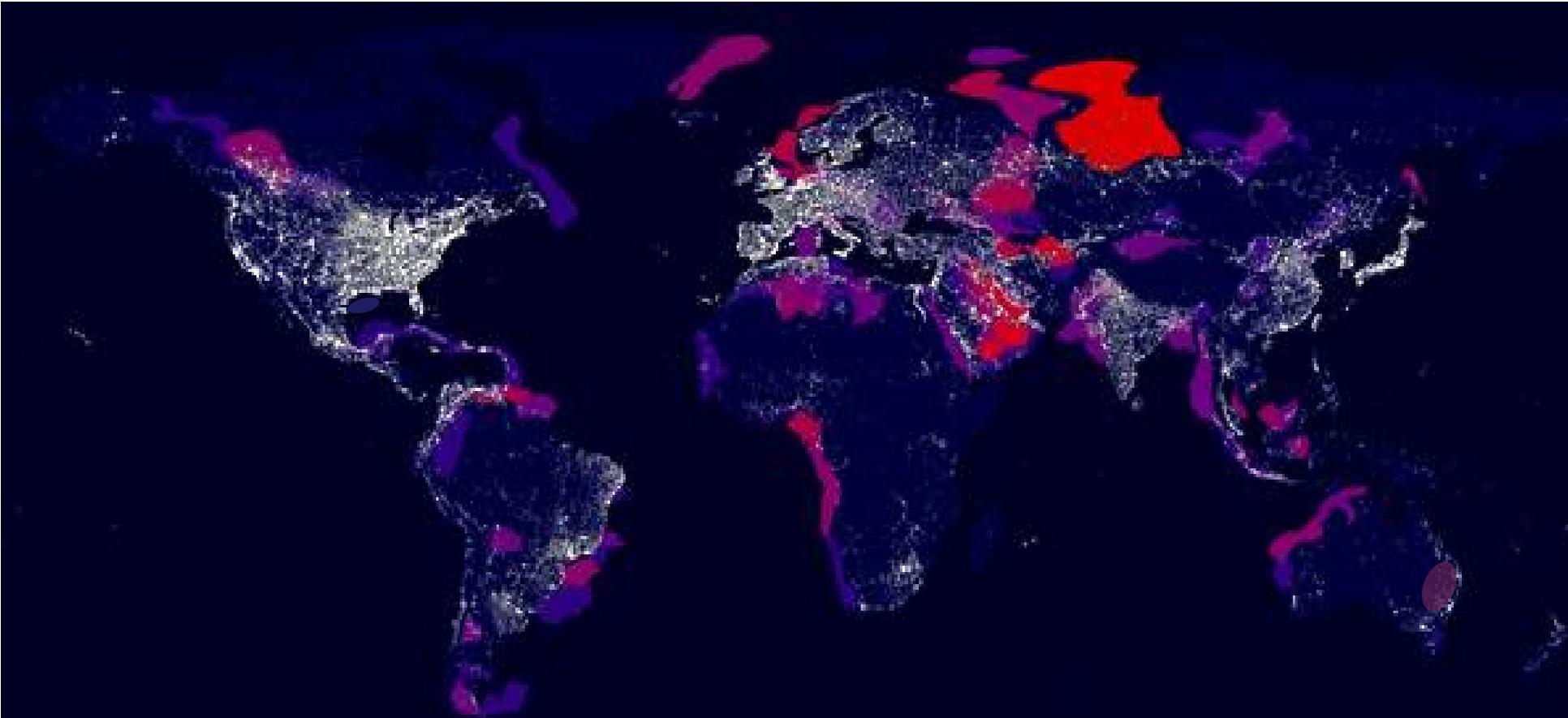
December 2, 2011

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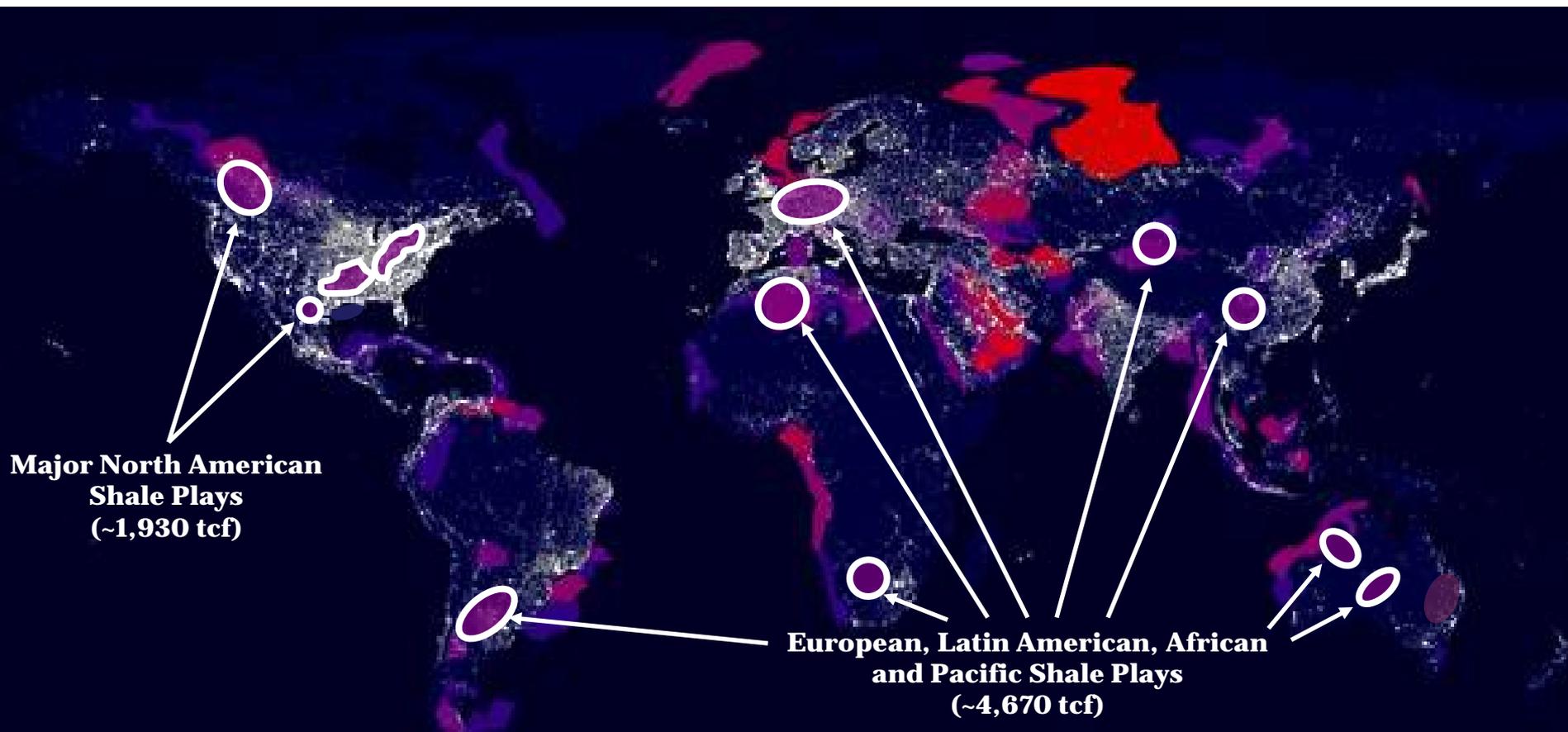
Analysis

- Shale gas developments of the past decade in the North American gas market have been nothing short of transformative. In fact, expectations have been significantly altered and the way we view our energy future is now dramatically different. Moreover, the effects extend beyond the North American market, as highlighted by Medlock, Jaffe and Hartley (2011) in the recent DOE funded Baker Institute study, “Shale Gas and US National Security.”
- Recent assessments of recoverable shale resource have been very high. ARI published an assessment of up to 1275 tcf of technically recoverable shale gas. So, we ask the basic questions:
 - What if the Chinese shale resource base is both large and commercially attractive? Will it too be transformative?
- We also test the thesis that Chinese economic growth will remain strong for the next 30 years. This is an equally important scenario given most expectations.
- To do this, we consider three scenarios for comparison using the Rice World Gas Trade Model:
 - (1) Reference Case, (2) High Shale Case, (3) Low Demand Case

**Some context:
Consensus was that LNG is coming to North America...**



**... shale changed that. LNG to Asia is the new consensus.
Might shale also change this?**



Paradigm Shifts: The New Norm?

Fewer than 10 years ago, most predictions were for a dramatic increase in LNG imports to North America, as demand for natural gas was set to outstrip domestic production. However, shale gas development in North America has completely altered this view. As a result, growth opportunities for LNG developers are now seen as being primarily in Asia.

However, if shale gas developments they prove to be significant in China – could dramatically diminish the long term prospect for LNG markets, and be every bit as “game-changing” as developments in North America have proven to be.

The Global Shale Gas Resource (cont.)

- A comparison of estimates of recoverable shale.
 - RWGTM estimates are not directly comparable. See table footnote.

	Rogner (1997)*	ARI (2011)	RWGTM
North America	1537	1931	686
Latin America	847	1225	---
Europe	220	639	220
FSU	251	---	---
China	1411	1275	75
India		63	---
Australasia	925	396	50
Middle East	1019	---	---
North Africa		558	---
Other	235	538	---
Total	6445	6625	1031

*- applies a 40% recovery factor to the estimated gas in place.

** - The assessments in the RWGTM incorporate an assessment of economic viability as well as a discount factor applied to reflect other constraints.

Global Shale: Little Data and Lots of Uncertainty

- There is uncertainty about shale resources outside of North America.
- The estimates of resource in-place are very large, and location is a premium in many instances.
- However, accessibility is critical. Not only do cost and technology matter, but market structure and government policy is equally as important.
 - Arguably, if the current market structure in the United States did not exist, the shale gas boom would not have occurred. This is due to the fact that the small producers who initiated the proof of concept had little to no risk of accessing markets from very small production projects. A market in which capacity rights are not unbundled from facility ownership does not foster entry by small producers.

Recoverable Shale Resource in China for this Exercise

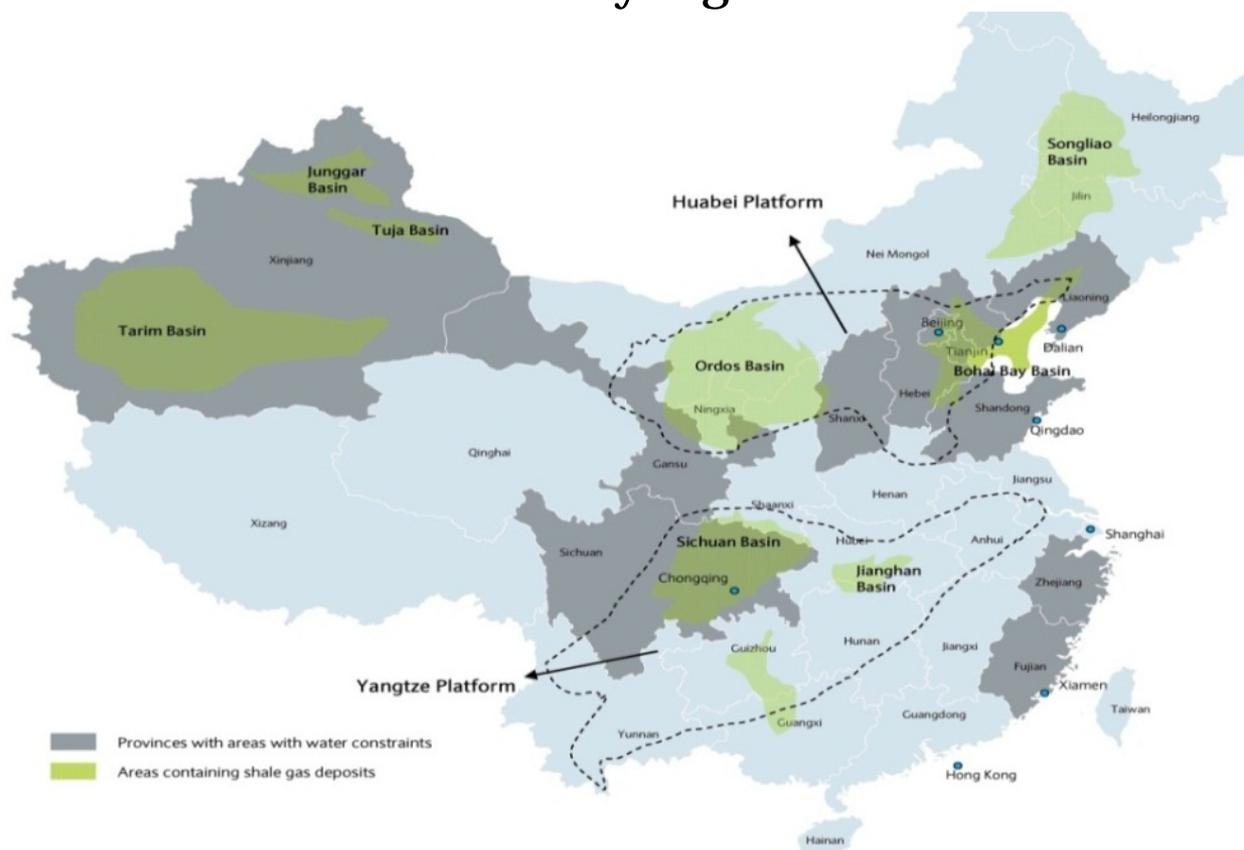
- The Reference Case in this paper contains only 75 tcf of *recoverable* shale resource. We stress this assessment considerably in the High Shale Case.

Units: trillion cubic feet

		Reference	High China Shale
West	Tarim Basin	---	250
	Junggar Basin		
	Tuja Basin		
Central	Sichuan Basin	45	120
	Jiangnan Basin		
North Central	Ordos Basin	30	150
Northeast	Songliao Basin	---	80
	Bohai Bay Basin		
	Total	75	600

A Potential Problem? Water Availability in China

- Water could play a major role in Chinese shale gas production endeavors, as indicated by the fact that known shale plays are highly coincident with regions where water stress is already high.



Economic Growth in the Low China Demand Case

- The Reference Case in this paper assumes a real growth rate of 5.6% from 2010 through 2040. So per capita income in PPP terms climbs to about 5 times its 2010 levels by 2040.
- The Low China Demand Case cuts this growth rate to just under 3.0%. . So per capita income in PPP terms climbs to just under 2.5 times its 2010 level by 2040.
- Note that the growth rate is declining through the time horizon, so nearby years are characterized by higher growth.

Scenario Results

Key findings

- Robust development of shale gas in China, which would occur if a significant proportion of its domestic resource can be done profitably, is just as game-changing as shale gas developments in North America have been.
 - Significant reduction in LNG imports... fall from just over a 42% market share to just under a 25% market share in 2030.
 - Significant reduction in pipeline imports... fall from just under a 25% market share to just under a 13% market share in 2030.
 - Development of pipeline exports from Northeast China to the Korean peninsula... rise to just under 1.0 bcf/d by 2040.
 - Price impacts are contingent on development costs of shale. As modeled, Asian LNG price is lowered by almost \$0.50 on an average annual basis by the 2030s. But, some regional impacts in China are larger.

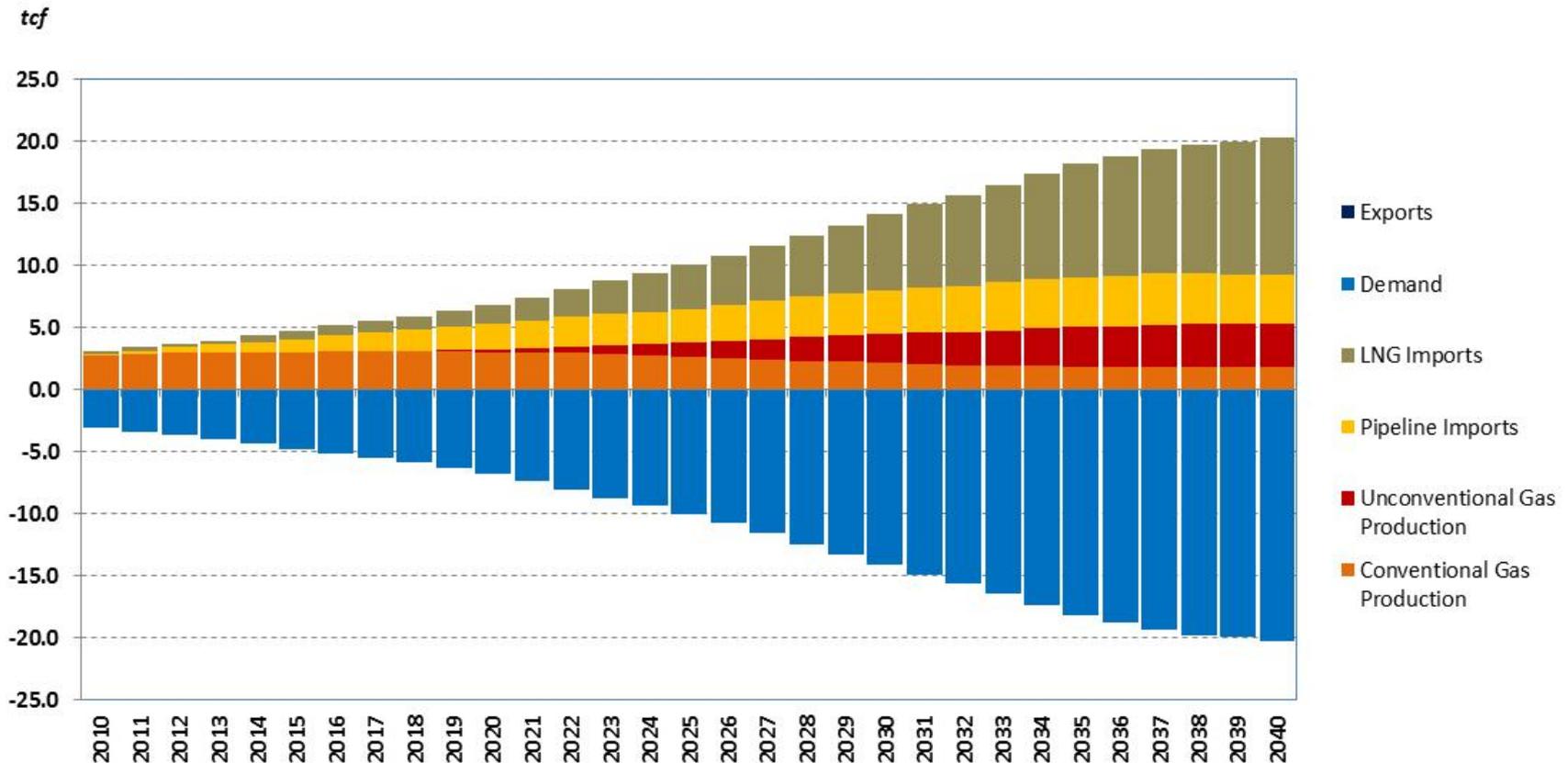
Key findings (cont.)

- Lower than expected demand growth has a significant impact on LNG market development. In fact, lower demand growth negatively effects all supply-directed endeavors toward China.
 - Significant reduction in LNG imports.
 - Significant reduction in pipeline imports.
 - Domestic production is lower.

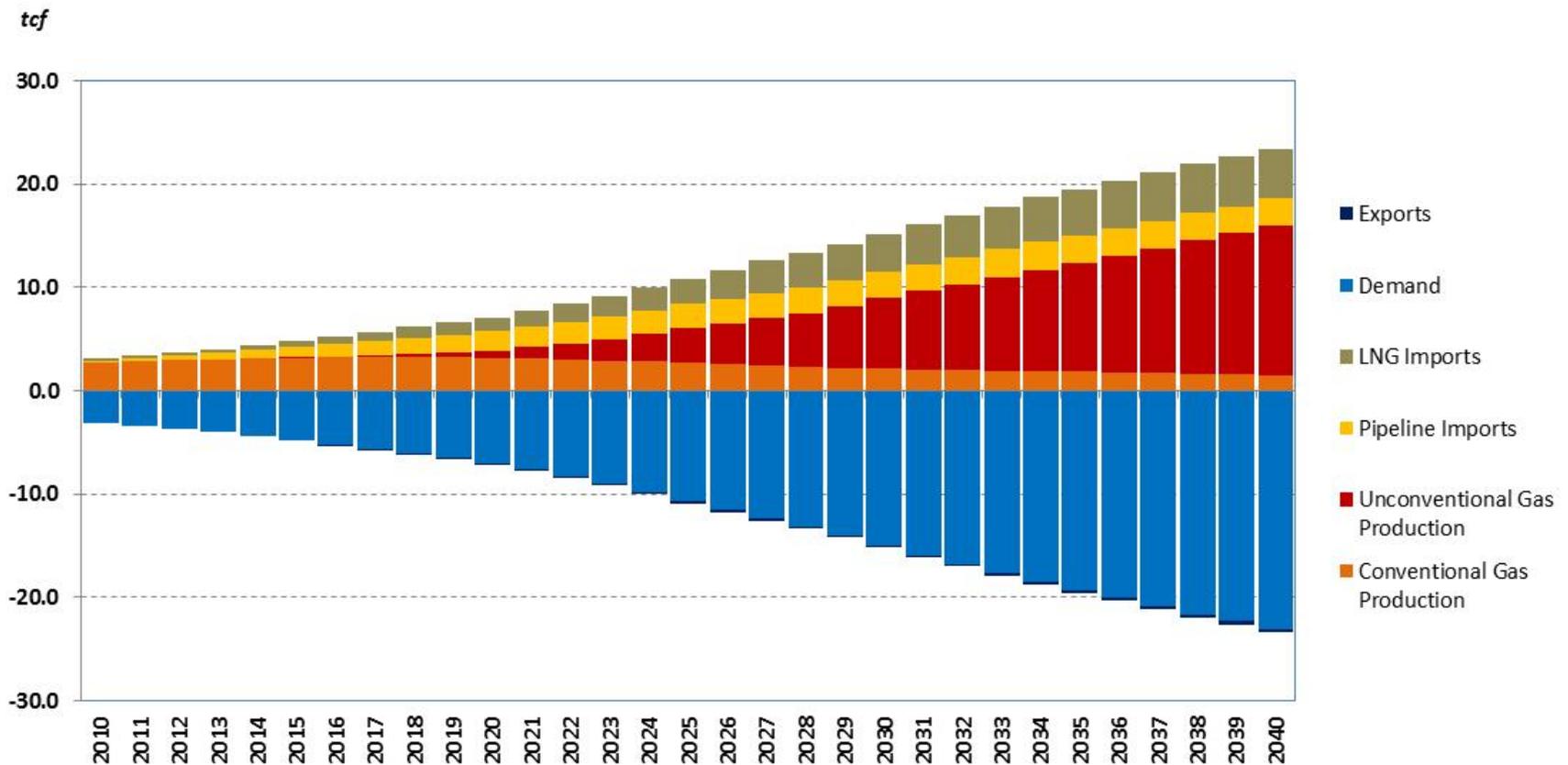
A Key Point: in both cases considered herein, LNG is most impacted. This signals that developments in China will have a lasting commercial and geopolitical impact on global gas market developments.

Reference Case: Shale Gas and Market Balance in China

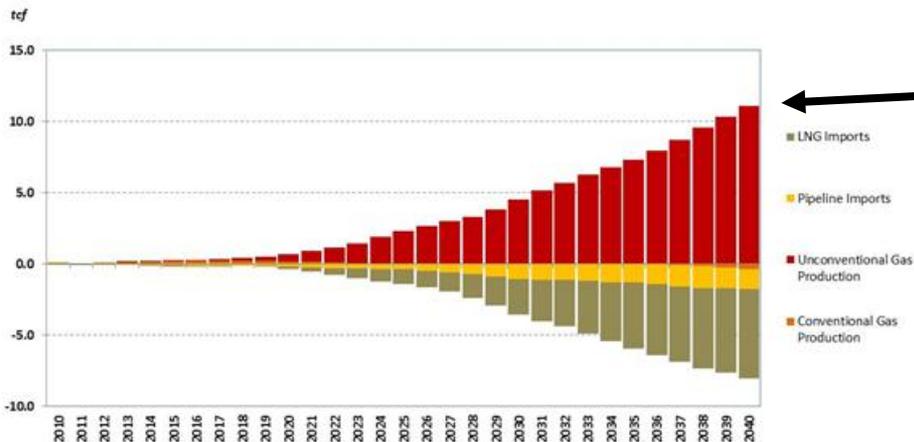
- Shale gas production increases, but LNG imports are by far the largest source of supply in China, reaching over 50% of the market by 2035.



High China Shale Case: Shale Gas and Market Balance in China



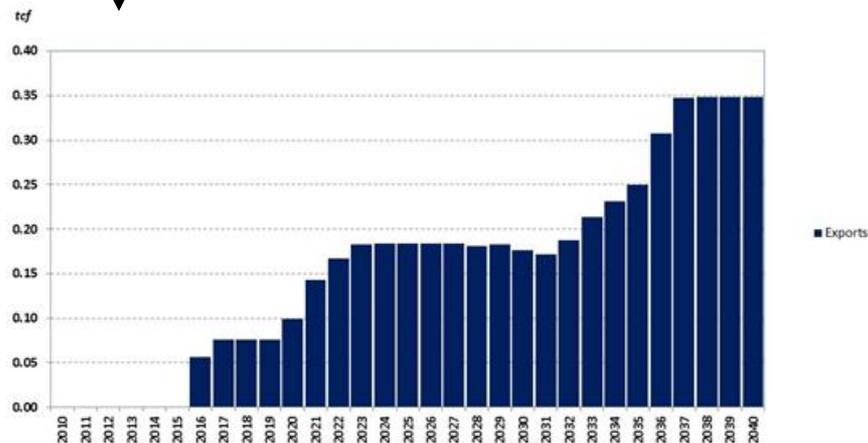
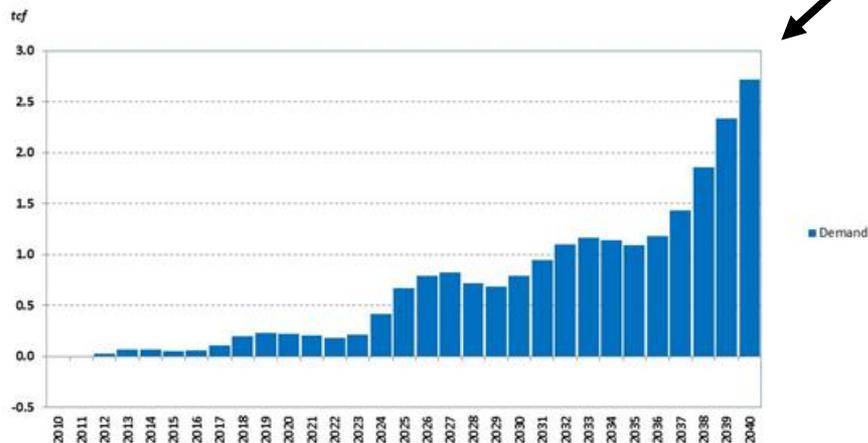
High China Shale Case: Sources of Change in the Supply-Demand Balance



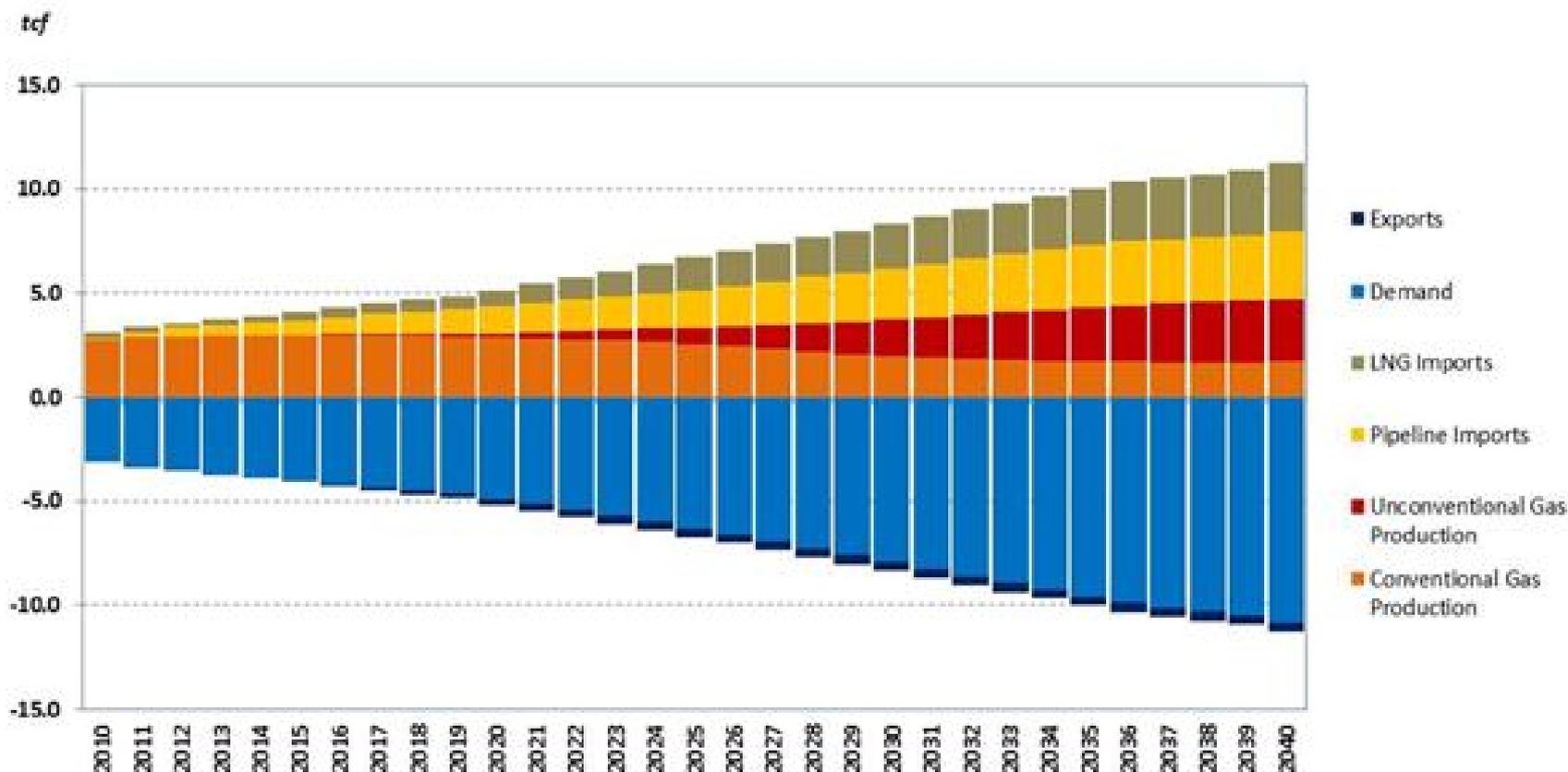
Higher shale gas production displaces both LNG imports and pipeline imports. LNG is affected the most.

Demand is higher

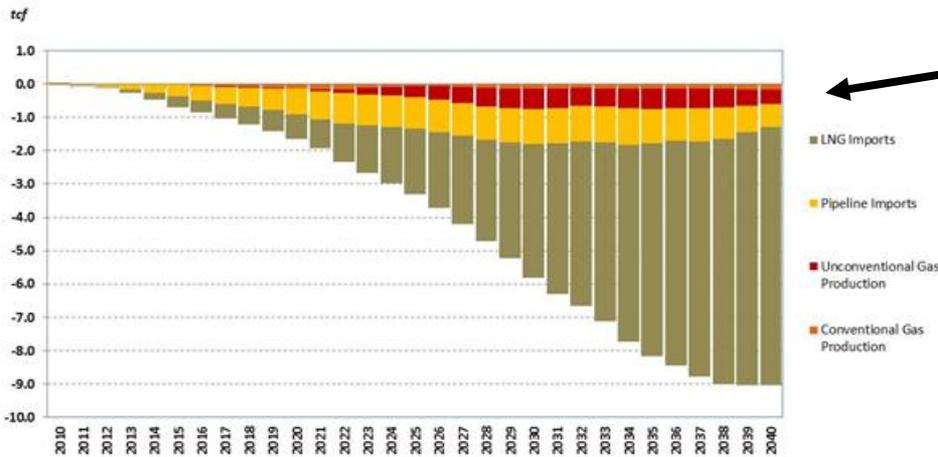
Exports develop to the Korean peninsula



Low China Demand Case: Shale Gas and Market Balance in China



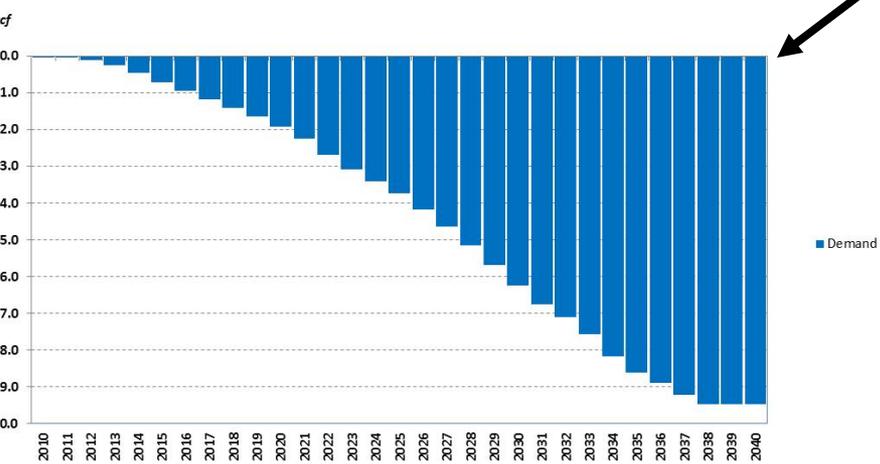
Low China Demand Case: Sources of Change in the Supply-Demand Balance



• Low demand displaces domestic production, LNG imports and pipeline imports. But, LNG is affected most.

• Demand is lower

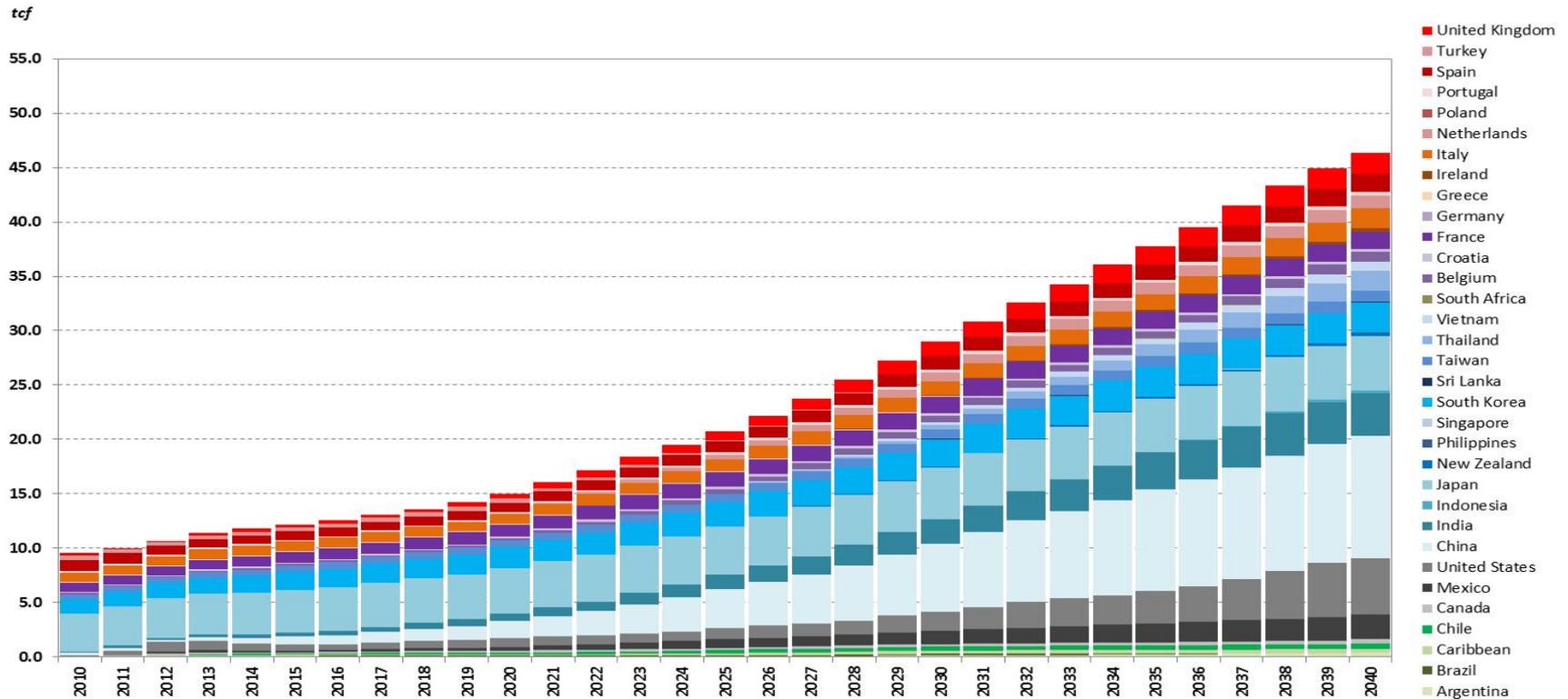
• No exports develop to the Korean peninsula



LNG Market Impacts

Reference Case: LNG Imports by Country, 2010-2040

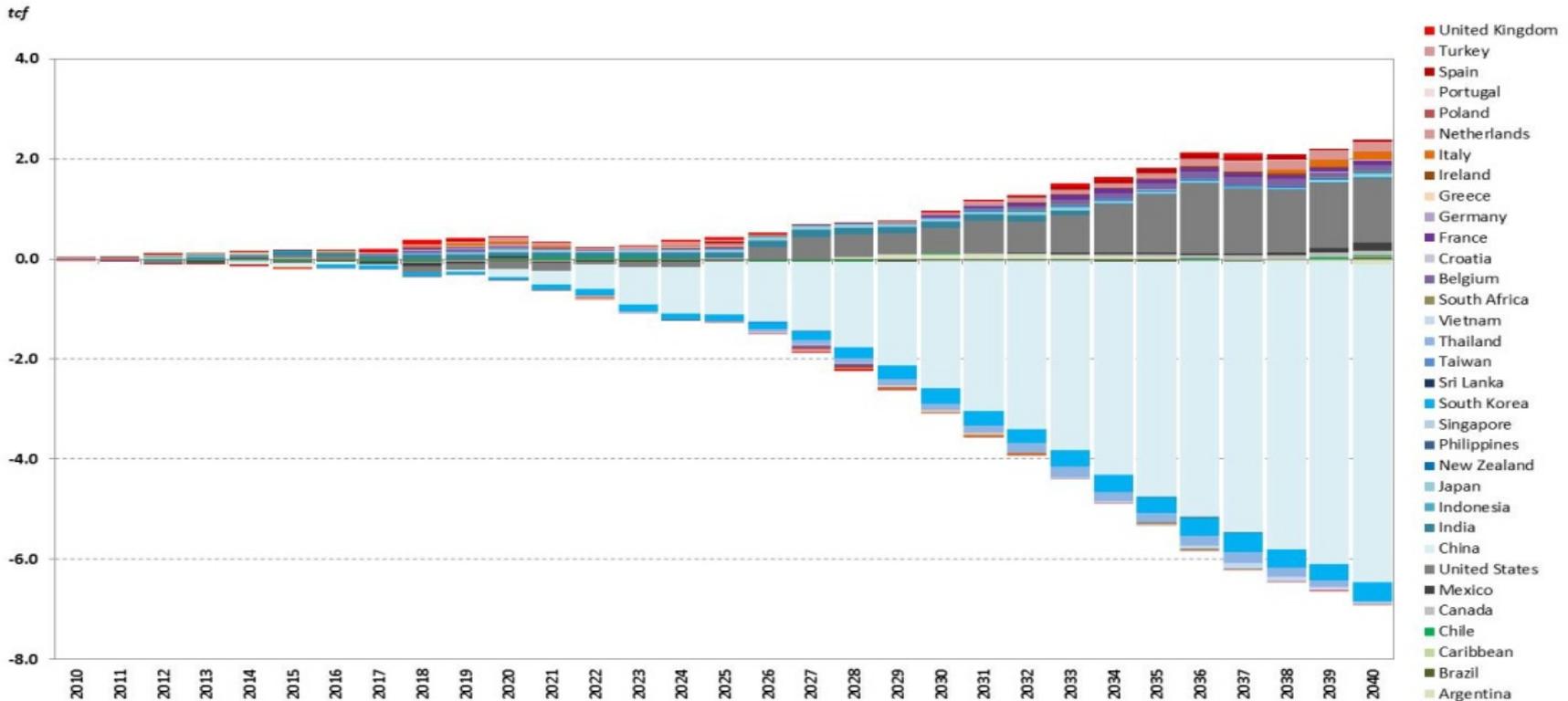
- Developments in China drive LNG market growth



High China Shale Case: LNG Imports by Country, 2010-2040

- The reduction in LNG imports to China is partially offset by a rise in imports in other countries.

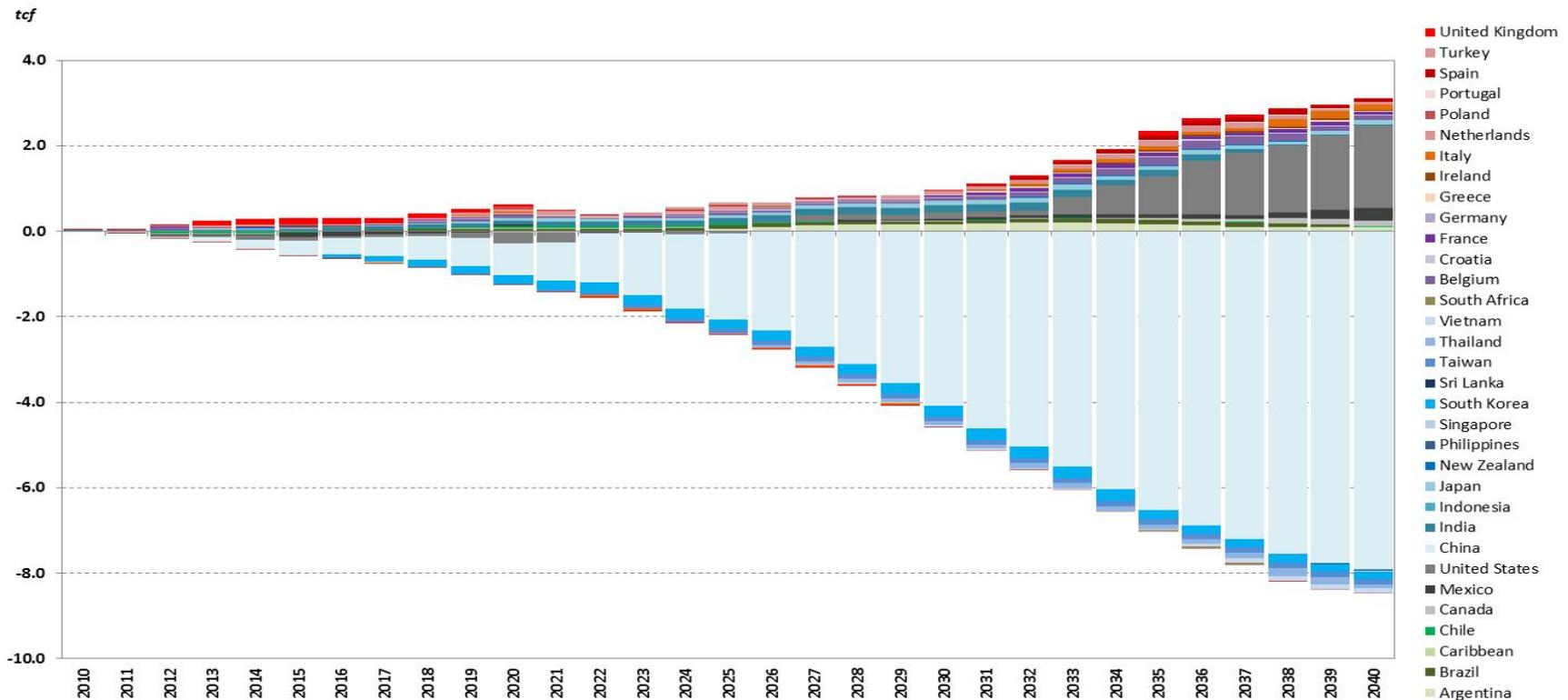
Delta to Reference Case



Low China Demand Case: LNG Imports by Country, 2010-2040

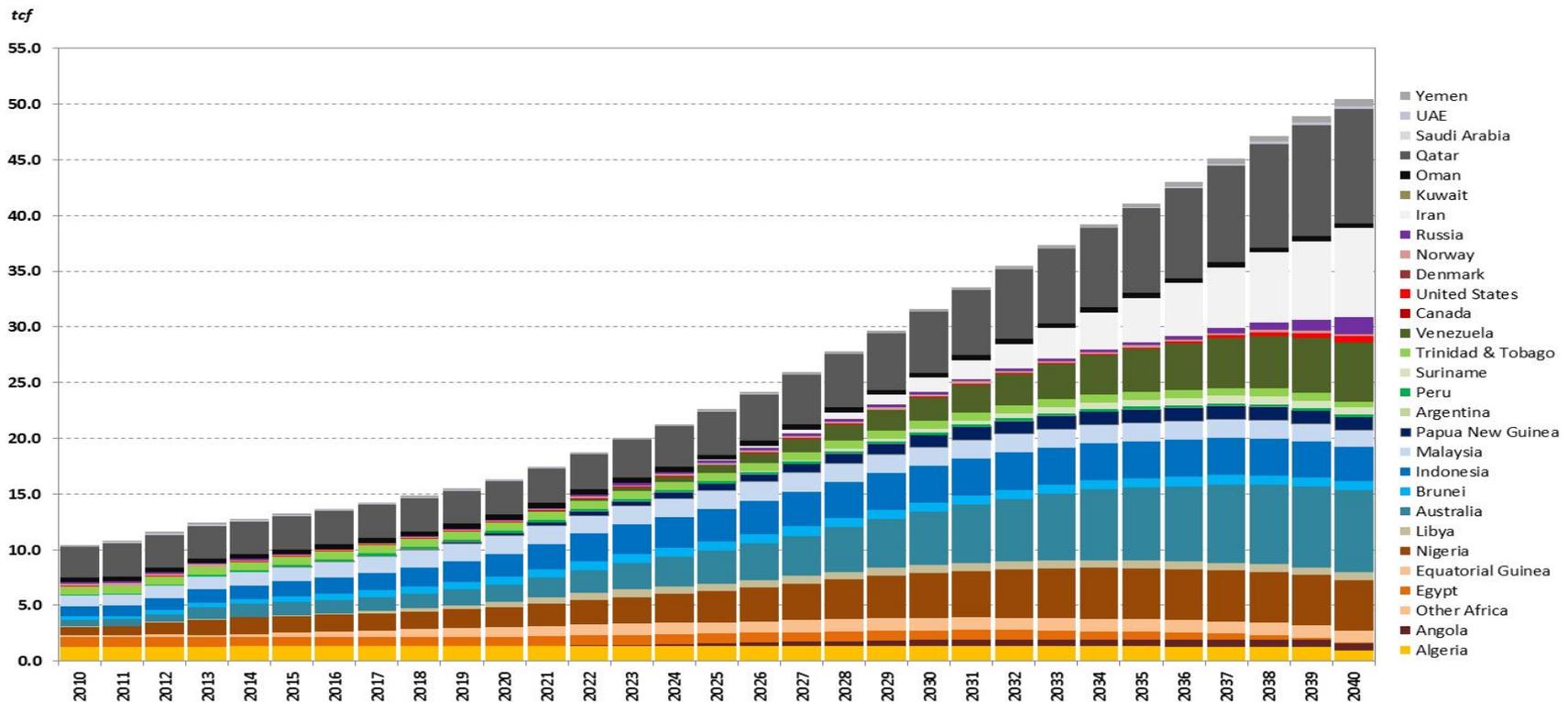
- The reduction in LNG imports to China is partially offset by a rise in imports in other countries... sound familiar?

Delta to Reference Case



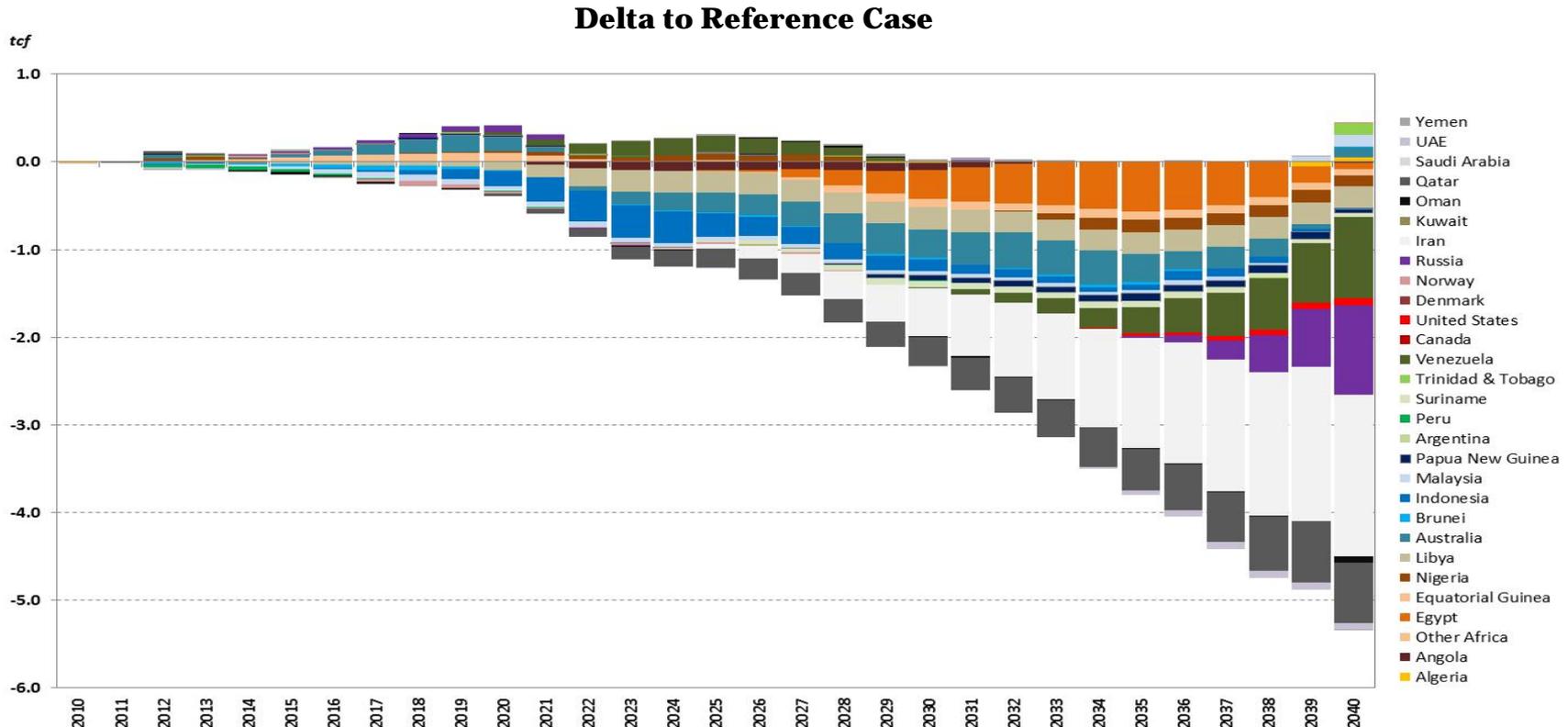
Reference Case: LNG Exports by Country, 2010-2040

- Developments in China drive LNG market growth. Market balance ultimately results in market entry by Iran and Venezuela.



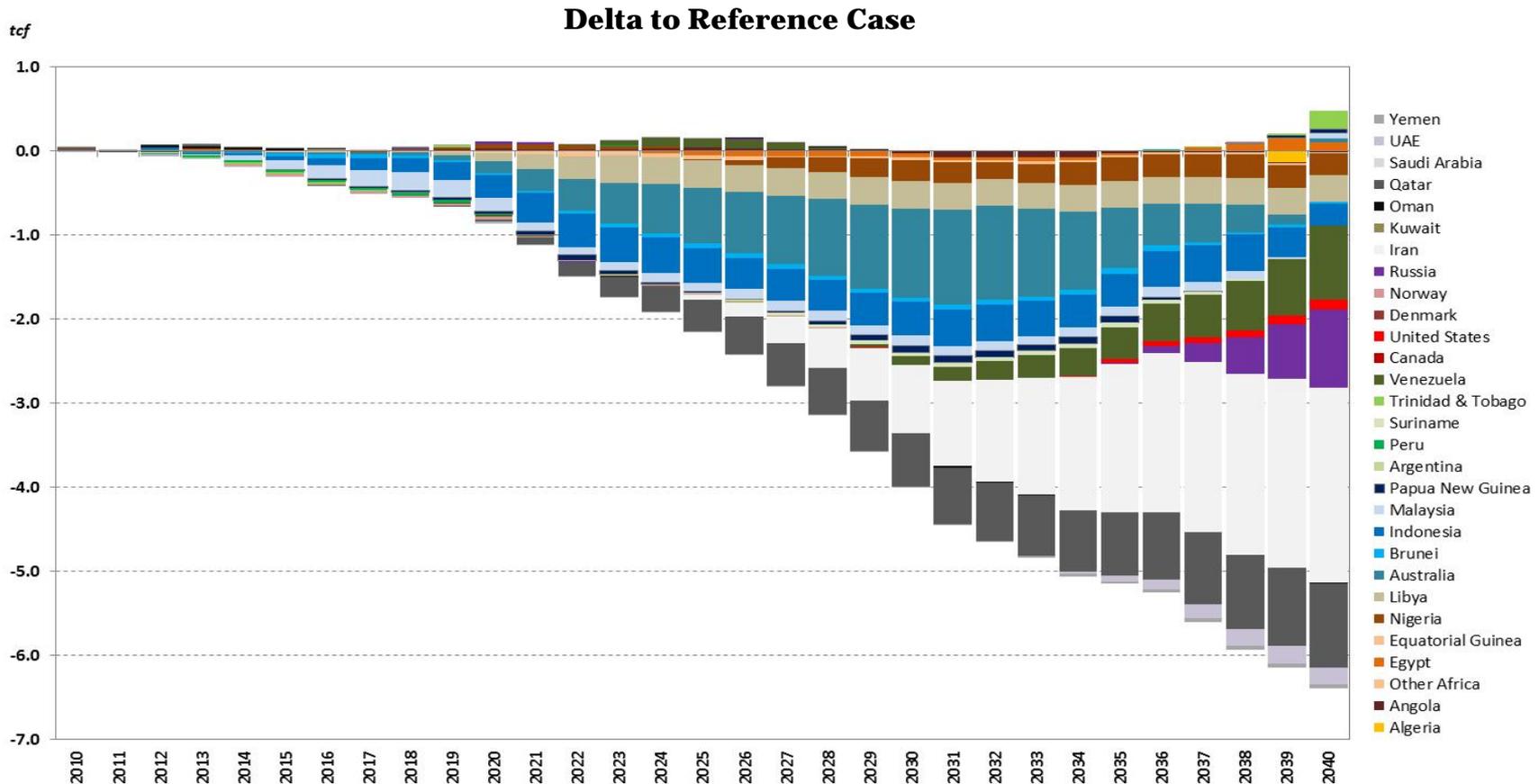
High China Shale Case: LNG Exports by Country, 2010-2040

- The brunt of the impact falls to Iran, Russia, Venezuela, and Qatar. Australian volumes also are lower.



Low China Demand Case: LNG Exports by Country, 2010-2040

- Again, the brunt of the impact falls to Iran, Russia, Venezuela, and Qatar. Australia sees a significant reduction in volume as well, and is the most negatively affected source of LNG supply in the short-to-medium term.



Far-reaching implications of shale gas

- Expansion of production from shale plays has rendered the utilization of LNG import capacity in the US very low, and aggregate average annual capacity utilization may not approach 15% until after 2040.
- China could follow suit!
- **A lot hinges on outcomes in China. Lower demand and/or higher domestic production dramatically alters the outlook for LNG markets.**
- Current and potential future expansion of shale gas in the US, Europe and Asia effectively makes the *global* natural gas supply curve more elastic.
 - This mitigates the potential for sustained increases in price.
 - **Greater supply elasticity also puts pressure on traditional pricing paradigms.**