

Outlook for North American Trade in LNG and Oil

LSI Energy Exports in the
Northwest Conference

Steve Levine
Paul R. Carpenter
Anul Thapa

October 24, 2013

THE **Brattle** GROUP

Agenda

Natural Gas

- Past to Present: market developments, shale gas, LNG
- Future: LNG demand uncertainty and supply competition

Oil

- U.S. and Canadian production growth
- Reduced U.S. imports from overseas sources

Shale Gas Recap

Substantial increase in shale gas production in past 5-7 years

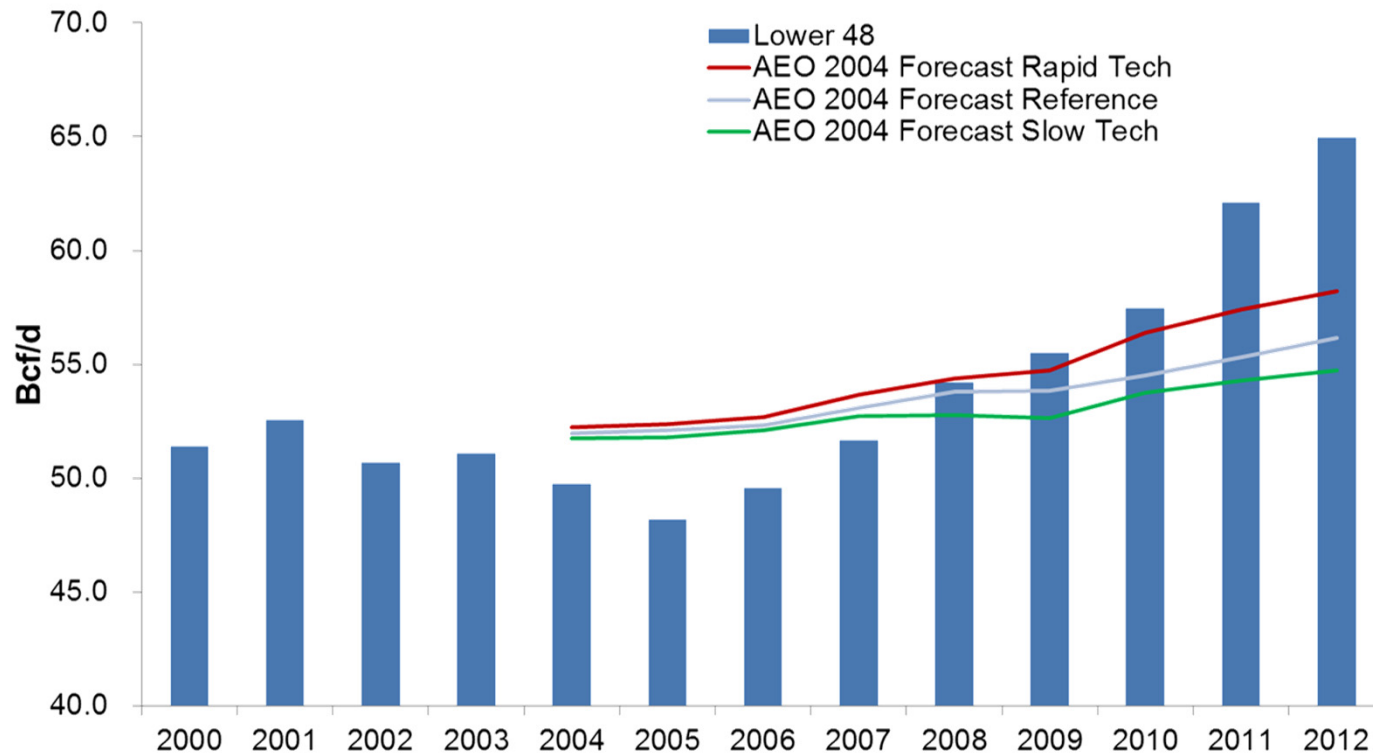
- Changed the economics of North American natural gas markets
- Stranding (even recent) investments in pipeline and LNG regas infrastructure
- 20 Bcf/d of LNG import capacity unutilized (LNG imports <1 Bcf/d)
- Leading to the development of LNG export terminals
- Spawning a resurgence in petrochemicals and on-shore manufacturing

Is it permanent, or the next temporary boom in a series of boom-bust cycles?

- It is technology-driven, so one would think it is permanent
- But, depends on the long-run shape of the North American supply curve for natural gas

Substantial Growth in U.S. Gas Production Driven by Shale Gas Development

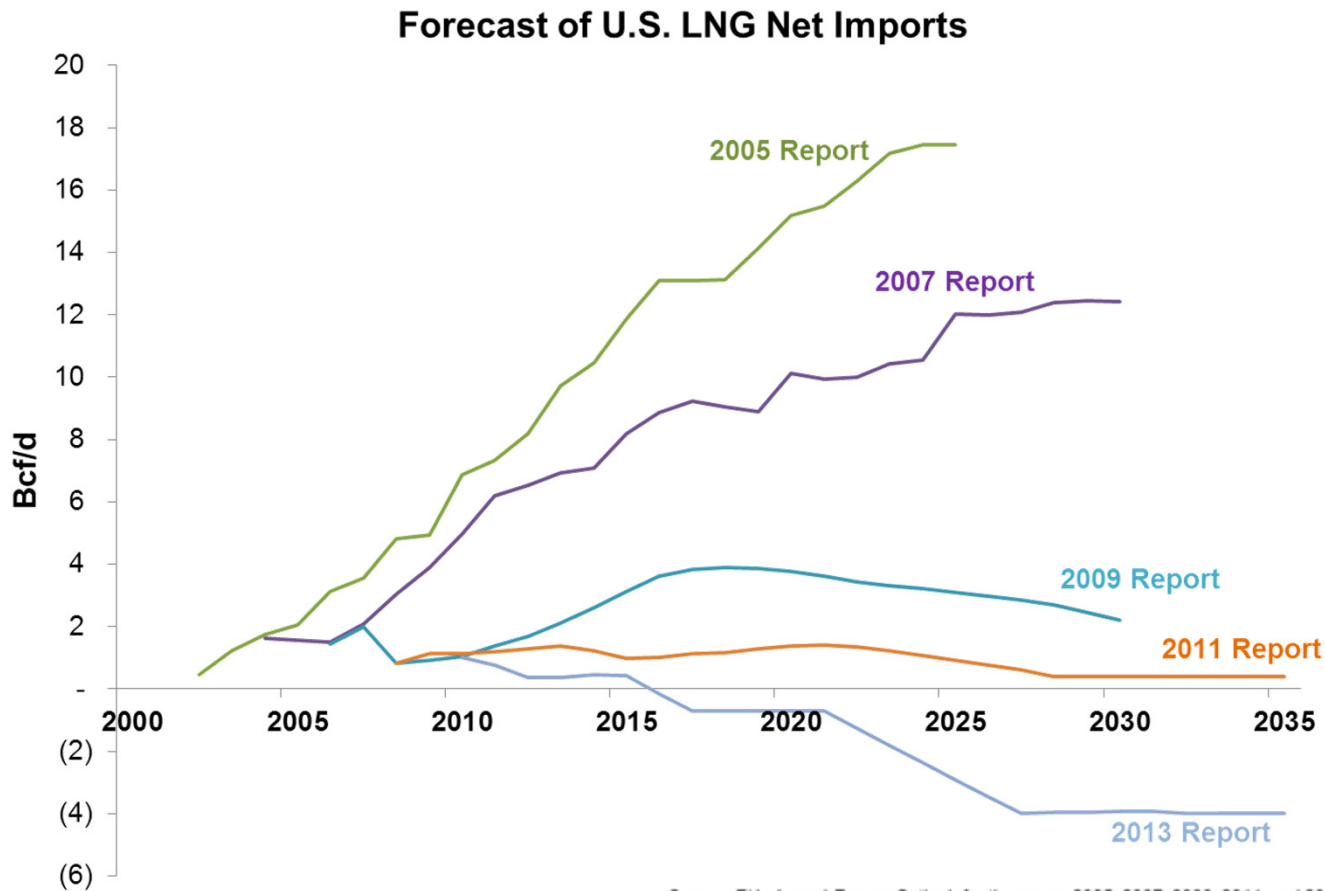
Lower 48 dry natural gas production has grown by over 15 Bcf/d since 2005 – driven by shale gas development



Source: EIA, historical gas production 2000 - 2012, forecasts are from AEO 2004.
Note: Lower 48 dry production is calculated as total US dry natural gas production less Alaskan natural gas production. 2012 dry Alaskan production is calculated as the average of 2010 and 2011.

Shale Changes U.S. Outlook in World Gas Markets

Pre-shale EIA outlook of 12-18 Bcf/d of imports by 2025;
Current outlook of 4 Bcf/d of exports by 2030



Source: EIA, Annual Energy Outlook for the years 2005, 2007, 2009, 2011, and 2013.

LNG Trade – 2003 vs. 2012

LNG trade doubled in past decade, led by demand growth in Asian-Pacific markets and supply increases in the Middle East

**Total LNG Exports for 2003 vs 2012
(Bcf/d)**

Country/Region [1]		2003 [2]	2012 [3]
North America	[a]	0.2	0.1
South & Central America	[b]	1.2	2.4
Europe/Eurasia	[c]	-	2.2
Middle East	[d]	3.4	12.7
Africa	[e]	3.9	5.2
Asia Pacific	[f]	7.7	9.1
TOTAL	[g]	16.3	31.7

Sources:

[2]: BP Statistical Review of World Energy June 2004

[3]: BP Statistical Review of World Energy June 2013

**Total LNG Imports for 2003 vs 2012
(Bcf/d)**

Country/Region [1]		2003 [2]	2012 [3]
North America	[a]	1.4	1.1
South & Central America	[b]	0.1	1.5
France	[c]	1.0	1.0
Spain	[d]	1.5	2.1
United Kingdom	[e]	-	1.3
Other Europe/Eurasia	[f]	1.5	2.3
Sub-Total for Europe/Euras	[g]	3.9	6.7
Middle East	[h]	-	0.4
China	[i]	-	1.9
India	[j]	-	2.0
Japan	[k]	7.7	11.5
South Korea	[l]	2.5	4.8
Taiwan	[m]	0.7	1.6
Thailand	[n]	-	0.1
Sub-Total for Asia Pacific	[o]	11.0	22.0
TOTAL	[p]	16.3	31.7

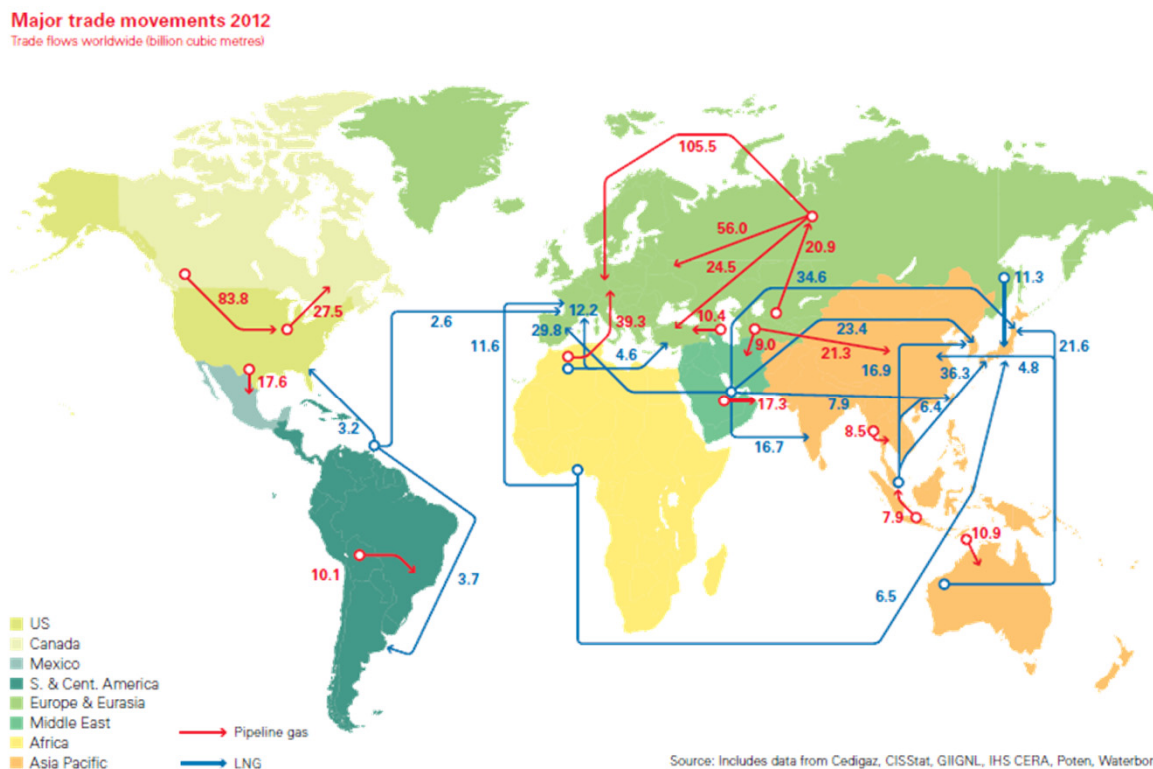
Sources:

[2]: BP Statistical Review of World Energy June 2004

[3]: BP Statistical Review of World Energy June 2013

The Present-Major Natural Gas Trade Flows in 2012

- Three distinct regional markets, Asia (oil-linked contract prices), Europe (mix of oil-linked and spot gas pricing), and North America (Henry Hub + “basis” pricing)
- Some diversions of spot cargoes between regions (limited spot market)

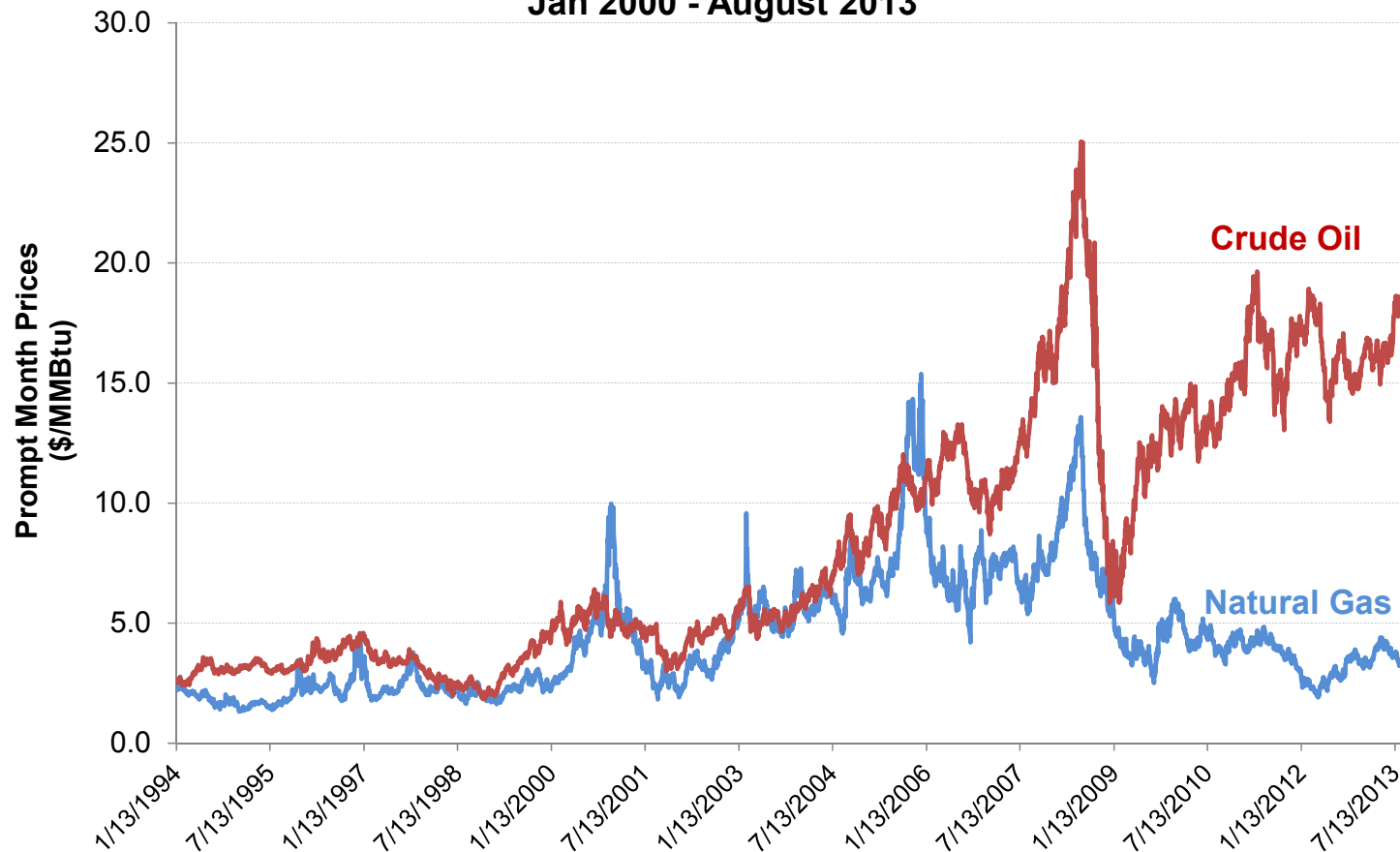


Source: Includes data from Cedigaz, CISStat, GIIGNL, IHS CERA, Poten, Waterborne.

Source: BP Statistical Review of World Energy 2013.

Recent Large Oil/Gas Price Differential Makes Oil Price-linked LNG Exports Look Attractive

**NYMEX Prompt Month Prices
Crude Oil vs. Natural Gas
Jan 2000 - August 2013**



Sources/Notes: NYMEX data downloaded from EIA. The crude oil prices are for WTI Cushing, OK Crude Oil Future Contracts.

IEA Gas Demand Forecast (Golden Rules Case) Shows Largest Demand Growth in Asia

**Natural Gas Demand by Region
in the Golden Rules Case
(Bcf/d)**

Region/Country		2010	2035	2035 Demand less 2010 Demand
[1]		[2]	[3]	[4]
Americas	[a]	81	102	20
<i>United States</i>	[b]	66	76	10
Europe	[c]	56	67	11
Asia Oceania	[d]	17	23	6
<i>Japan</i>	[e]	10	13	3
OECD	[f]	155	192	37
E. Europe/Eurasia	[g]	64	84	20
<i>Russia</i>	[h]	43	54	11
Asia	[i]	39	116	77
<i>China</i>	[j]	11	57	47
<i>India</i>	[k]	6	19	13
Middle East	[l]	35	62	27
Africa	[m]	10	16	6
Latin America	[n]	14	24	10
Non-OECD	[o]	162	303	141
World	[p]	316	495	178

Sources:

[2] - [3]: World Energy Outlook 2012_GoldenRulesReport p78

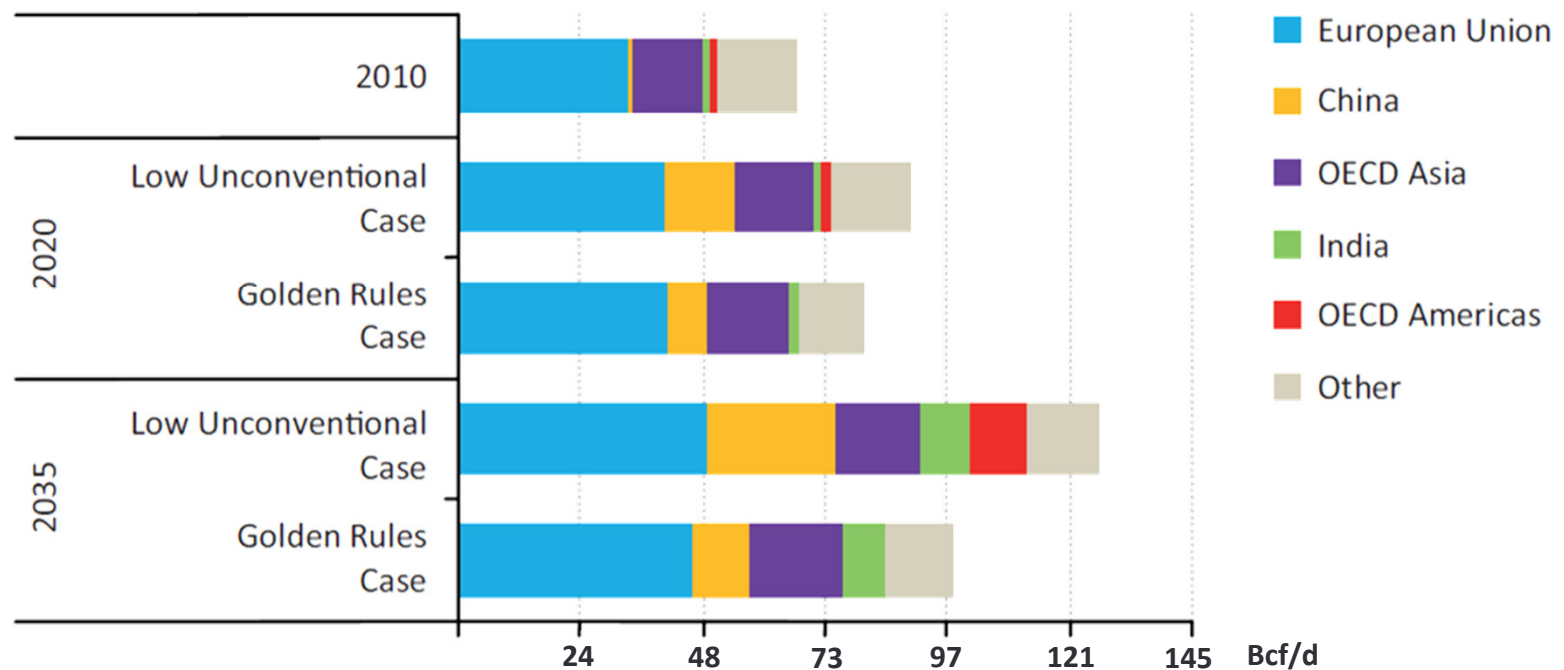
- Gas demand growth to 2035 expected to be particularly strong in China (47 Bcf/d), Middle East (27 Bcf/d), and India (13 Bcf/d)
- But gas demand growth is highly uncertain and can be met by indigenous production, pipeline imports and/or LNG imports
- Part of the uncertainty relates to electric sector gas demand (and the future generation mix of nuclear, coal, gas and renewables)
- LNG market growth likely to depend heavily on China and India demand growth
- Japan and South Korea (currently ~50% of LNG demand) forecasted to grow at much slower pace

Growth in Global Net Imports Also Makes LNG Exports Attractive

Demand growth expected in non-OECD countries, particularly China

- China's net gas imports only ~1.4 Bcf/d in 2010
- IEA - China' net imports could reach ~7 Bcf/d to 14 Bcf/d by 2020 and ~ 12 Bcf/d to 25 Bcf/d by 2035

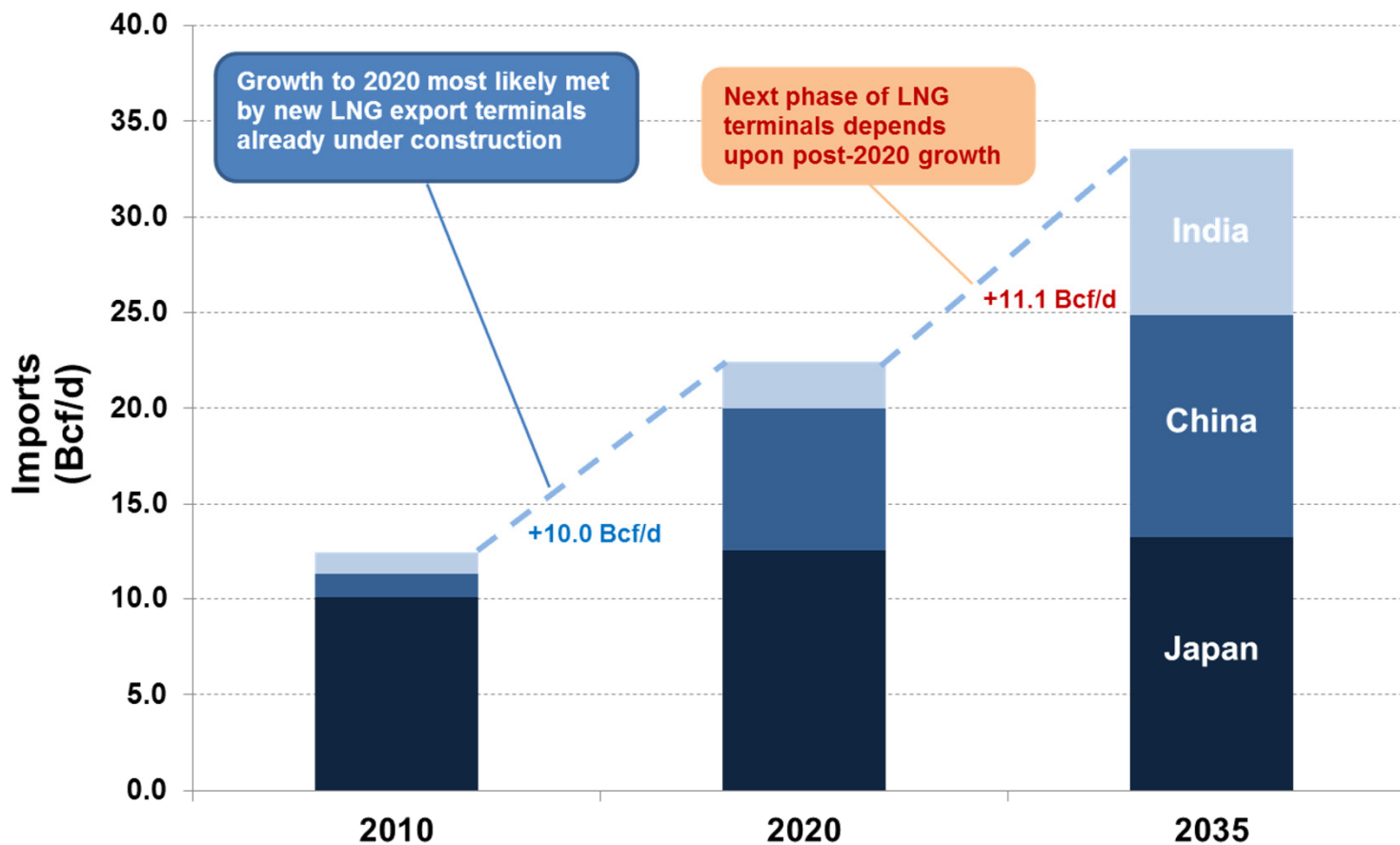
Figure 2.12 ▶ Major natural gas net importers by case



Source: Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, IEA, 2012, p.97

Potential Import Growth in Key Asian Countries

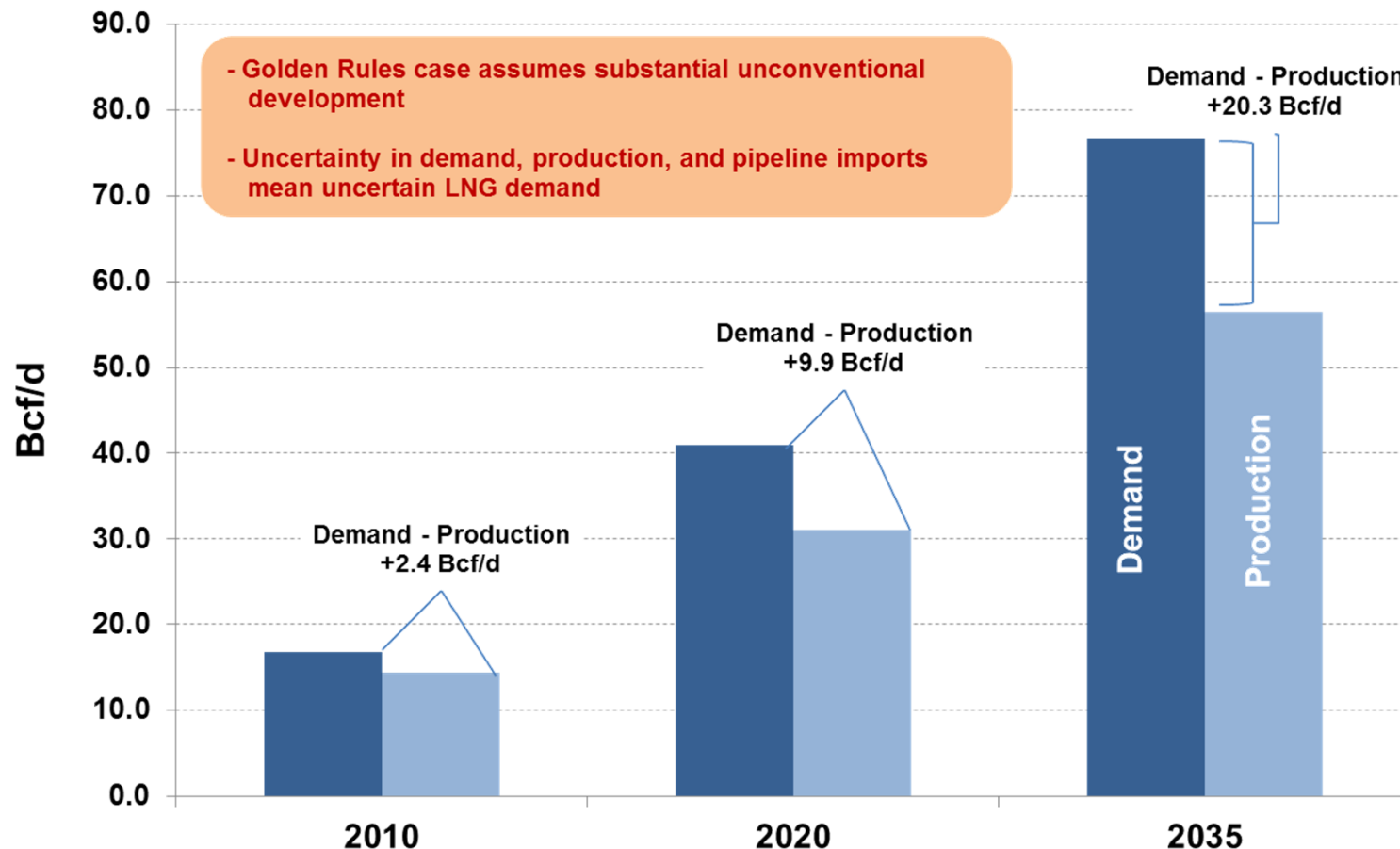
Import Growth in Key Asian Countries World Energy Outlook 2012 - Golden Rules Case



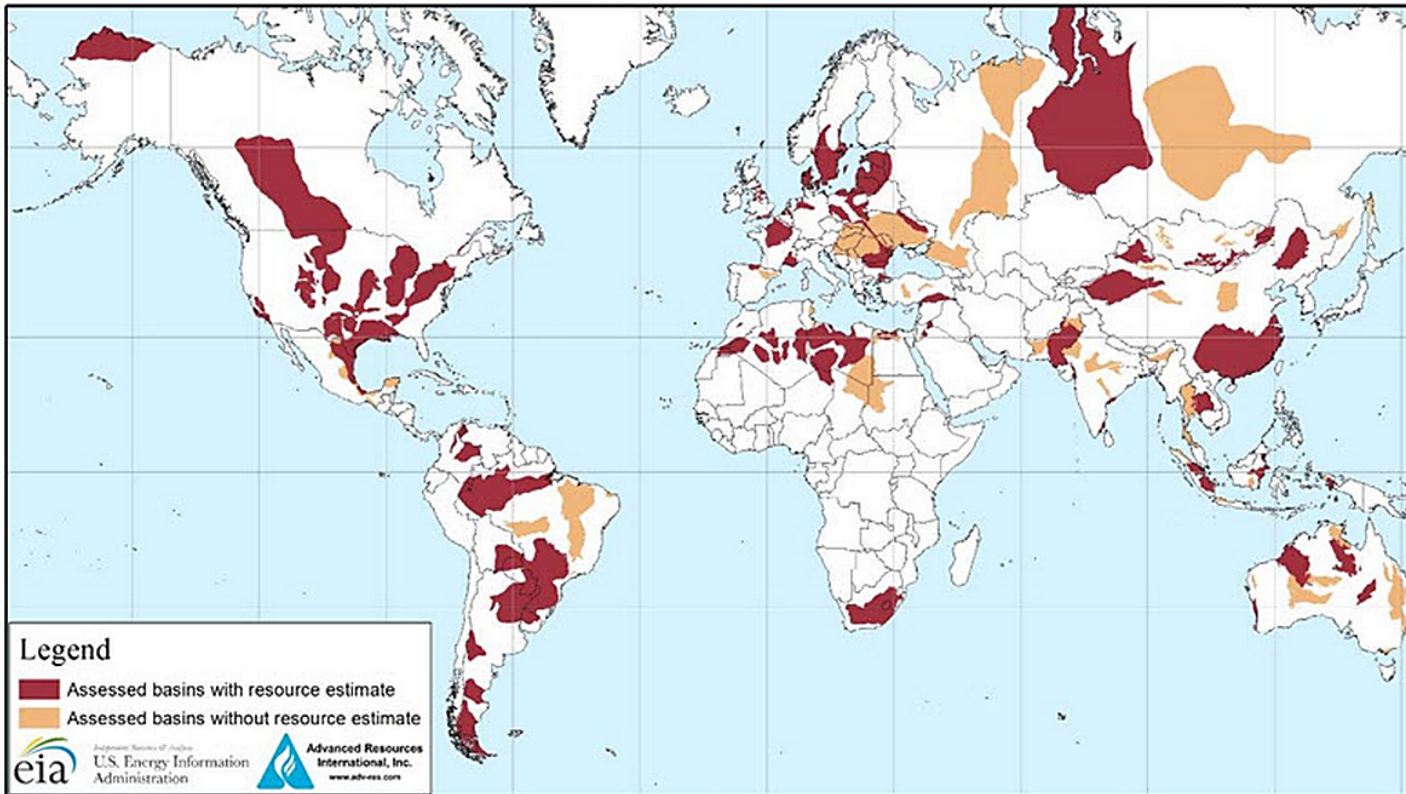
Note: Imports calculated as demand less indigenous production.

Uncertainty in LNG Demand Driven by Uncertainty in Natural Gas Demand and Indigenous Production Growth

Demand and Production Growth in India and China World Energy Outlook 2012 - Golden Rules Case



Global Shale Gas Assessment



Technically Recoverable Shale Gas Resources Tcf	
1. U.S	1,161
2. China	1,115
3. Argentina	802
4. Algeria	707
5. Canada	573
6. Mexico	545
7. Australia	437
8. South Africa	390
9. Russia	285
10. Brazil	245
11. Others	1,535
Grand Total	7,795

Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

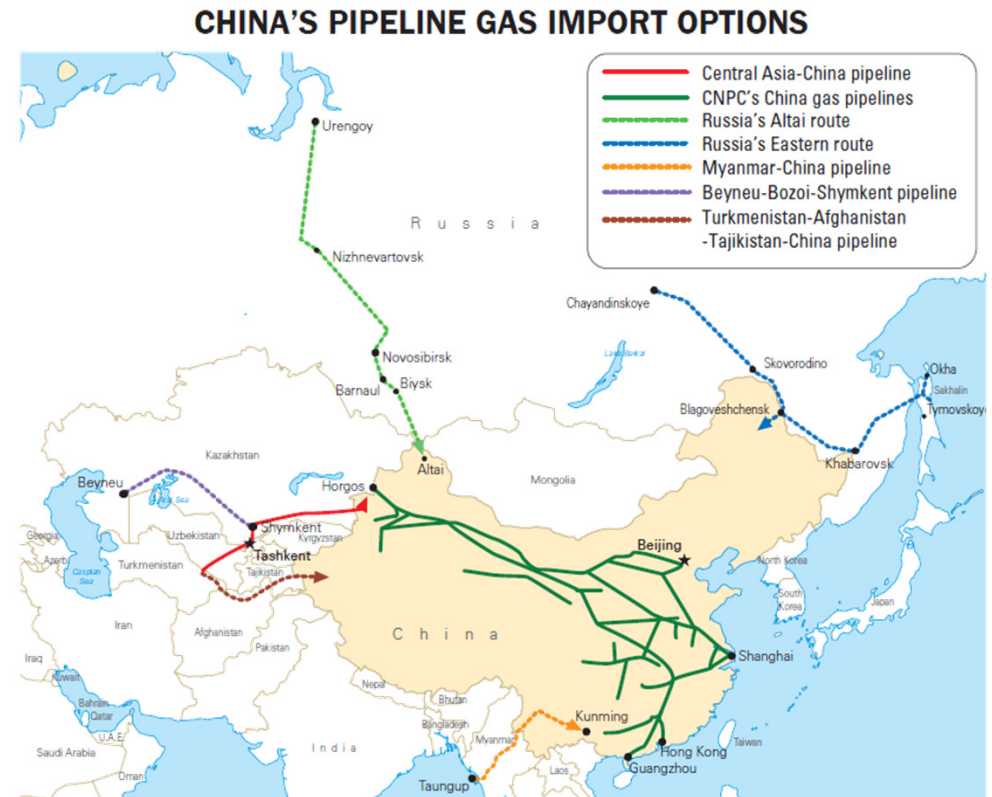
Source: "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States," EIA, June 2013.

Significant Uncertainty in Unmet Gas Demand Post-2020

Brookings: LNG shortfall of ~5 Bcf/d expected by 2020 (i.e., LNG supply < LNG demand)

Global LNG outlook depends in part on supply-demand dynamics in China

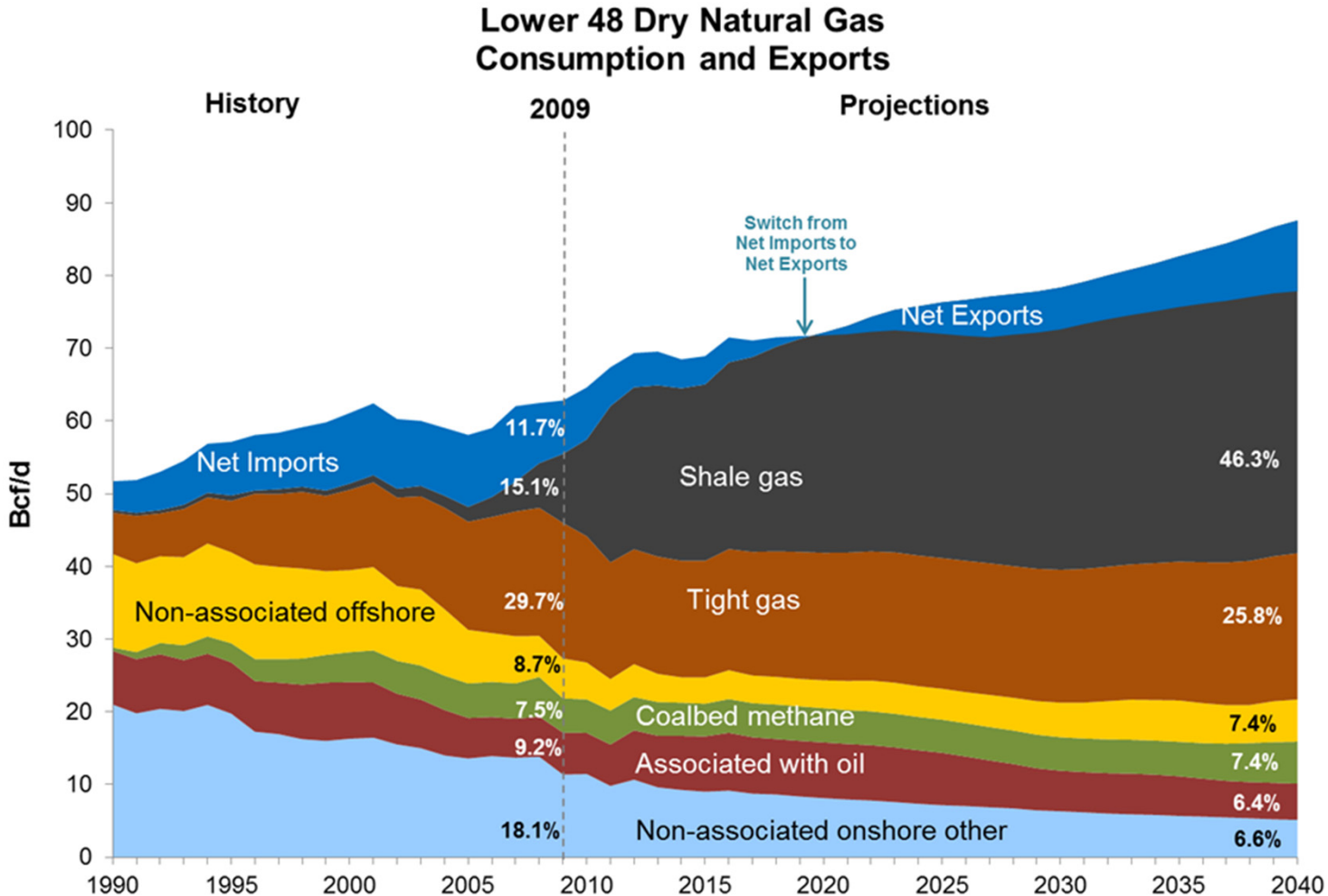
- China potentially has competitive alternatives for gas supply
- Some estimates suggest China has 1,115 Tcf of shale gas reserves (~10x the size of Marcellus)
- China is exploring several import options apart from LNG (e.g., pipeline imports from Russia)
- Gas started flowing on the Myanmar-China pipeline on July 28, 2013 (expected to receive ~0.4 Bcf/d over 30-years).



Source: Gazprom, CNPC, Energy Intelligence

Source: "China Keeps Import Options Wide Open," World Gas Intelligence, July 25, 2012

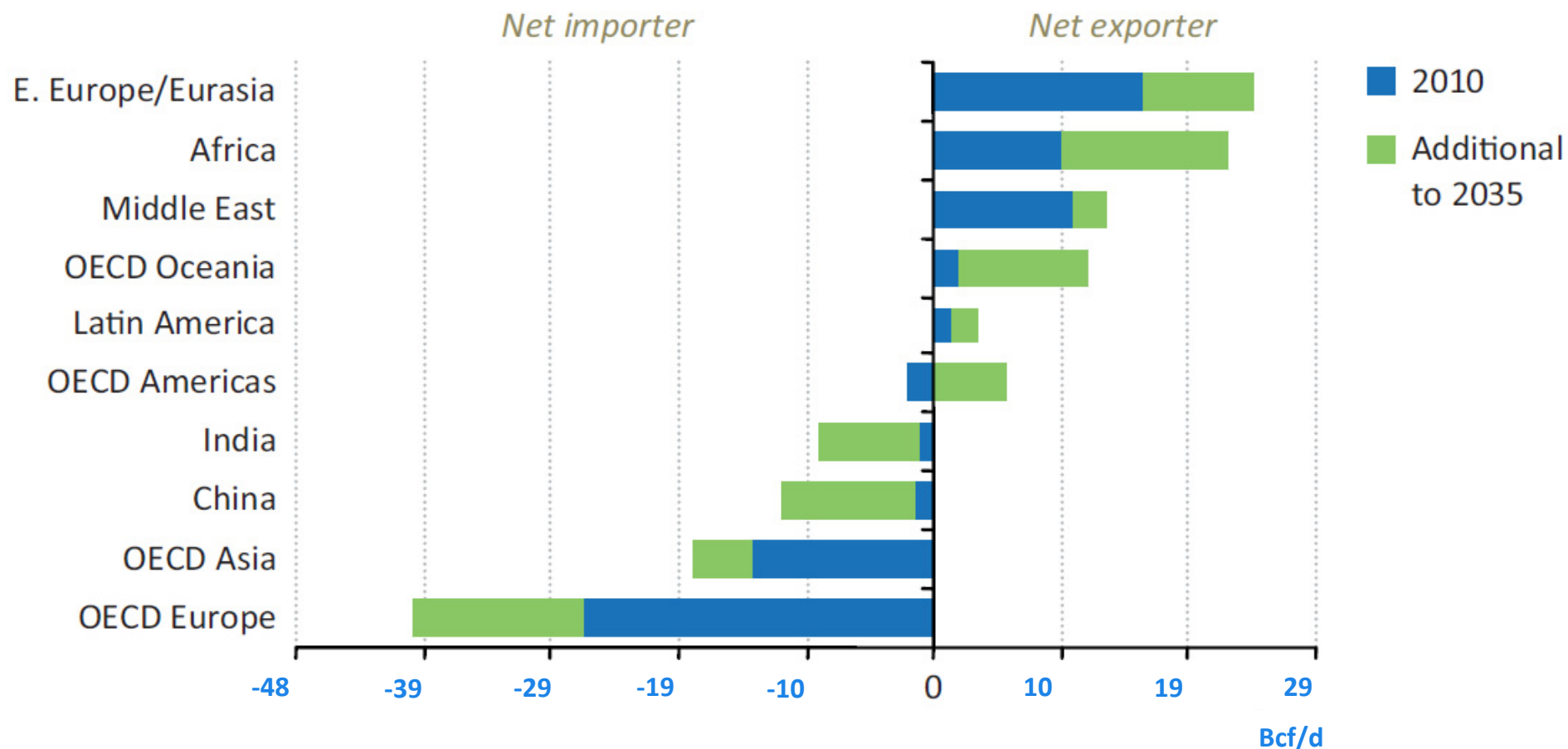
Shale Gas Dominates Forecasted U.S. Supplies



Source: EIA, Annual Energy Outlook 2013 Early Release. Excludes Alaska. The percentages shown above are calculated as percent of total lower 48 natural gas demand. The shale gas percentage for 2040 is calculated as total shale gas production less net exports divided by lower 48 natural gas demand, assuming that shale gas is the source of the net exports.

Natural Gas Net Trade by Major Regions

Golden Rules Case



Source: Golden Rules for a Golden Age of Gas, World Energy Outlook Special Report on Unconventional Gas, IEA, 2012.

~37 Bcf/d of Proposed U.S. LNG Export Capacity

Proposed U.S. LNG Export Terminals (As of September 11, 2013)					
Project		Capacity (Bcf/d)	Status FTA	Status non-FTA	Announced Online Date
[1]		[2]	[3]	[4]	[5]
Lower 48:					
Sabine Pass Liquefaction, LLC	[a]	2.2	Approved	Approved	2016/2018
Sabine Pass Liquefaction, LLC	[b]	0.5	Pending Approval	Under DOE Review	
Freeport LNG Expansion, L.P. and FLNG Liquefaction, LLC	[c]	2.8	Approved	Approved	2018
Lake Charles Exports, LLC	[d]	2.0	Approved	Approved	2016
Dominion Cove Point LNG, LP	[e]	1.0	Approved	Approved	2017
Carib Energy (USA) LLC	[f]	0.0	Approved	Under DOE Review	
Jordan Cove Energy Project, L.P.	[g]	2.0	Approved	Under DOE Review	2017
Cameron LNG, LLC	[h]	1.7	Approved	Under DOE Review	2016/2017
Gulf Coast LNG Export, LLC	[i]	2.8	Approved	Under DOE Review	
Gulf LNG Liquefaction Company, LLC	[j]	1.5	Approved	Under DOE Review	
LNG Development Company, LLC (d/b/a Oregon LNG)	[k]	1.3	Approved	Under DOE Review	2020
SB Power Solutions Inc	[l]	0.1	Approved	n/a	
Southern LNG Company, L.L.C.	[m]	0.5	Approved	Under DOE Review	
Excelerate Liquefaction Solutions I, LLC	[n]	1.4	Approved	Under DOE Review	2017
Golden Pass Products LLC	[o]	2.6	Approved	Under DOE Review	
Cheniere Marketing, LLC	[p]	2.1	Approved	Under DOE Review	2017
Main Pass Energy Hub, LLC	[q]	3.2	Approved	n/a	2017
CE FLNG	[r]	1.1	Approved	Under DOE Review	2017
Waller LNG Services, LLC	[s]	0.2	Approved	n/a	
Pangea LNG (North America) Holdings, LLC	[t]	1.1	Approved	Under DOE Review	2017
Magnolia LNG, LLC	[u]	0.5	Approved	n/a	
Gasfin Development USA, LLC	[v]	0.2	Approved	n/a	
Freeport-McMoRan Energy LLC	[w]	3.2	Approved	Under DOE Review	
Venture Global LNG, LLC	[x]	0.7	Pending Approval	Under DOE Review	
Subtotal (Lower 48)	[y]	34.6			
Alaska	[z]	2.5			2021/2024
Total United States	[aa]	37.1			

Sources/Notes:

[a] - [y]: http://www.doe.gov/sites/prod/files/2013/06/f1/summary_lng_applications.pdf (accessed June 17, 2013)

[z]: Alaska Gas Port Authority Application to Export LNG (Docket No. 12-75-LNG) filed on July 12, 2012 before the Dept. of Energy.

The application was dismissed on March 7, 2013 without prejudice to re-filing at a future time if the deficiencies are corrected. Namely, DOE noted that the application was deficient in demonstrating the availability of a pipeline, source of supply, and location of the LNG facilities.

~7 Bcf/d to 14 Bcf/d of LNG Export Terminals Proposed in British Columbia, Canada

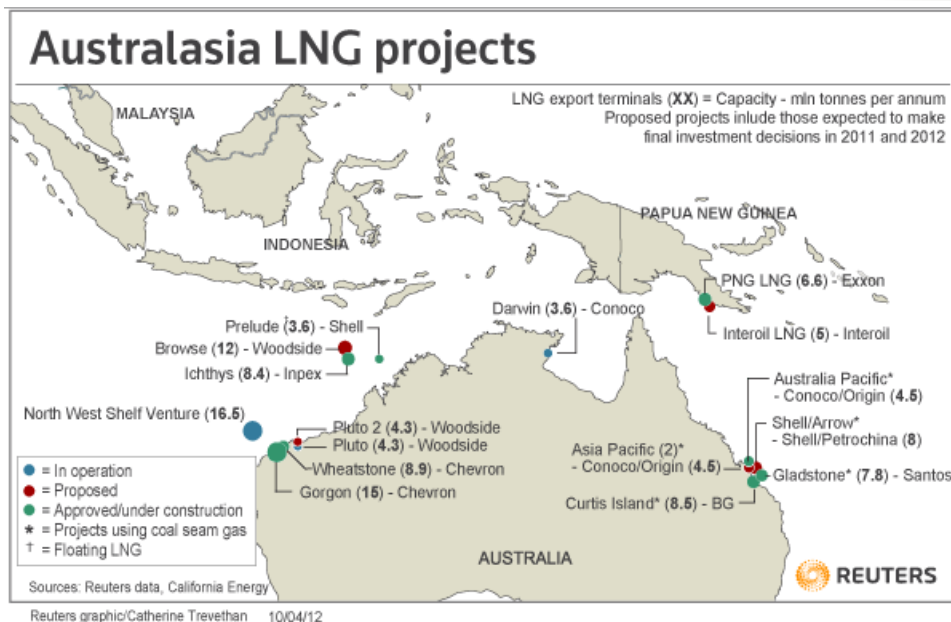
LNG Export Projects Proposed in British Columbia

Project	Ownership	Start Year	LNG Capacity (mmtpa)	LNG Capacity (Bcf/d)	Status/Notes
[1]	[2]	[3]	[4]	[5]	[6]
LNG Canada	[a] Shell / KOGAS / Mitsubishi / PetroChina	2019	12.0 - 24.0	1.6 - 3.1	25 year export license approved
Pacific Northwest LNG	[b] PETRONAS / JAPEX	2018	12.0 - 18.0	1.6 - 2.3	Applied for 25-year export license
Kitimat LNG	[c] Chevron / Apache	2017	5.0 - 10.0	0.6 - 1.3	20 year export license approved
Prince Rupert LNG	[d] BG Group	2020	14.0 - 21.6	1.8 - 2.8	Applied for 25-year export license
Douglas Channel LNG	[e] LNG Partners / Haisla Nation	2015	0.9 - 1.8	0.1 - 0.2	20-year export license approved (for 1.8 mmtpa)
WCC LNG	[f] Exxon Mobil Canada / Imperial Oil Resources	2021	10.0 - 30.0	1.3 - 3.9	Applied for 25-year export license

Sources & Notes:

Company websites, press releases, public documents.

Australia Ahead of the Pack with ~8 Bcf/d Under Construction



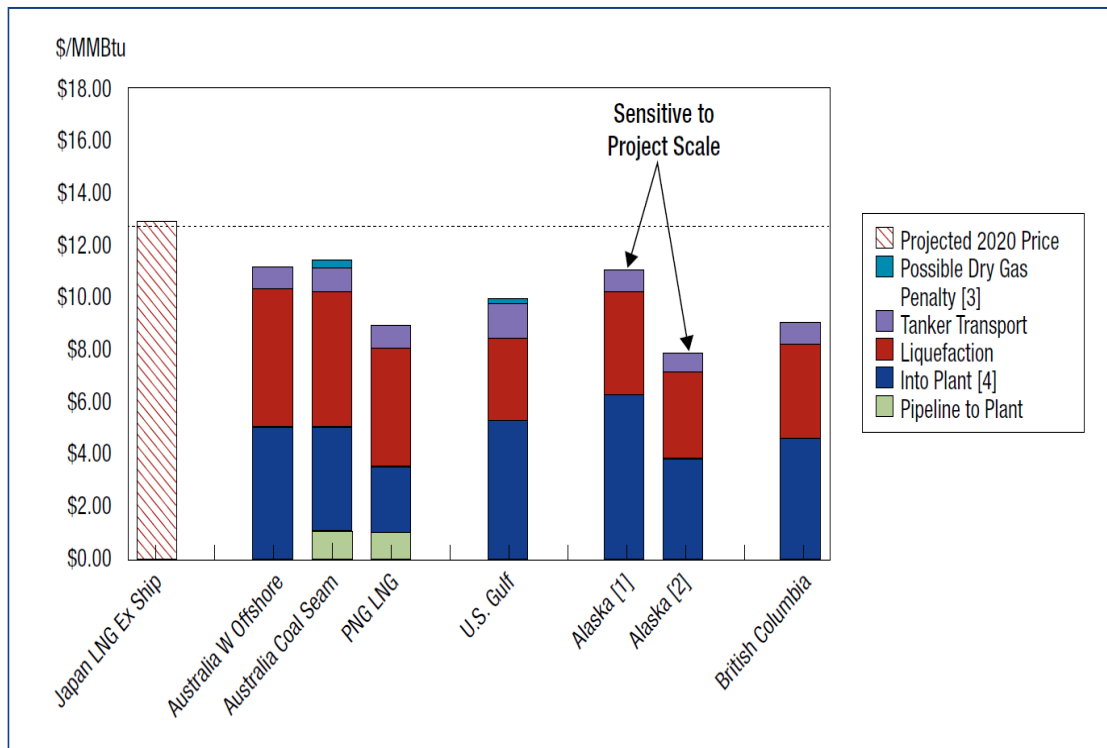
Australian LNG Projects					
Project	Status	Owner	Capacity (Bcf/day)	Cost	Online
[1]	[2]	[3]	[4]	[5]	[6]
North West Shelf Venture	[a] Operational		2.20		1989
Darwin	[b] Operational	Conoco	0.48		Early 2006
Pluto	[c] Operational	Woodside	0.57	\$15 Billion	2013
Subtotal	[d]		3.26		
Gorgon	[e] Approved/Under Construction	Chevron	2.00	\$57 Billion	2014
Wheatstone	[f] Approved/Under Construction	Chevron	1.19	\$35 Billion	2016
Curtis Island	[g] Approved/Under Construction	BG	1.13	\$34 Billion	2014
Ichthys	[h] Approved/Under Construction	Inpex	1.12	\$43 Billion	Q4 2016
Gladstone	[i] Approved/Under Construction	Santos	1.04	\$30 Billion	2015
PNG LNG	[j] Approved/Under Construction	Exxon	0.88		2014
Australia Pacific	[k] Approved/Under Construction	Conoco/Origin	0.60	\$37 Billion	2015
Prelude	[l] Approved/Under Construction	Shell	0.48		
Subtotal	[m]		8.45		
Browse	[n] Proposed	Woodside	1.60		
Shell/Arrow	[o] Proposed	Shell/Petrochina	1.07		
Interoil LNG	[p] Proposed	Interoil	0.67		2015
Asia Pacific	[q] Proposed	Conoco/Origin	0.60		
Pluto 2	[r] Proposed	Woodside	0.57		
Subtotal	[s]		4.51		
Grand Total	[t]		16.21		

Sources:
 Reuters, CNN Money, Bloomberg.

- Australian LNG projects facing substantial cost overruns and competitive pressures
- Korea Gas has reportedly walked away from a non-binding agreement to purchase 1.5 mmtpa (~200 MMcf/d) from Gorgon LNG
- Only 65% of Chevron's share of Gorgon LNG is committed under long-term contracts
- Asian buyers looking for cheaper source of supply (e.g., North America)

Competition to serve LNG demand

Competition to Serve Asian LNG Markets



Note: Gulf exports to Asia assume tankers travel through an expanded Panama Canal

[1]: Assumes 1 bcf/day from Valdez, Alaska

[2]: Assumes 3.1 bcf/day from Valdez, Alaska

[3]: Dry gas penalty is assumed at 2 percent

[4]: For Alaska and British Columbia, "Into Plant" refers to the opportunity cost relative to projections of Henry Hub price

Source: From a client presentation by James Jensen, Jensen Associates

Source: "Liquid Markets: Assessing the Case for U.S. Exports of Liquefied Natural Gas," Brookings Energy Security Initiative, May 2012

- Competition between Lower 48, British Columbia, Alaska and Australia
- Infrastructure challenges for Alaska and BC relative to Gulf Coast (government policies may come into play)
- Brookings & Wood Mackenzie: Alaskan LNG competitive with other LNG suppliers
- But, significant uncertainty in Alaska project costs and timing
 - Wood Mackenzie 2011 estimate ~\$45 - \$50 Billion project costs (21 million ton capacity) or \$8.50/MMBtu
 - But, updated costs ~\$45 - \$65+ Billion (15-18 million ton capacity)
 - Hence, delivered price might be higher than \$8.50/MMBtu due to updated project cost and scope

The Future(s) – 2013-2020 and post-2020?

These two time periods present very different possible futures, as significant new liquefaction capacity will come on line in the first period, at the same time as unconventional (shale) gas technology may spread worldwide in time for the second period (if not before)

What makes the evaluation of these markets (and consequently LNG and infrastructure projects) very difficult is that these two future periods could look very different, and the payoffs and probabilities are very hard to assess. But the long capital recovery period for these projects necessitates that we do so.

LNG and associated infrastructure projects some of the riskiest investments in the world today

- Pre-2020 projects with contracts – the risks involve project cost pressures and pressure on contract pricing arrangements
- Post-2020 projects face significant development, market and competitive risks (significant supply/demand balance uncertainties, LNG imports vs. indigenous production vs. pipeline imports, demand growth uncertainty in China and India)

Summary of Uncertainties Facing LNG Export Projects

Demand Uncertainty

- Need for LNG post-2020 is very uncertain (*e.g.*, China's needs will depend upon its natural gas demand growth as well as growth in its indigenous production)

Competition Uncertainty

- Competition between Australia, British Columbia, Gulf Coast, Alaska and other LNG projects
- Competition from indigenous production and pipeline import options

Pricing/ Project Economics Uncertainty

- Oil-linked or gas-linked
- Panama Canal toll uncertainty
- Project cost uncertainty (*e.g.*, Australian cost overruns)

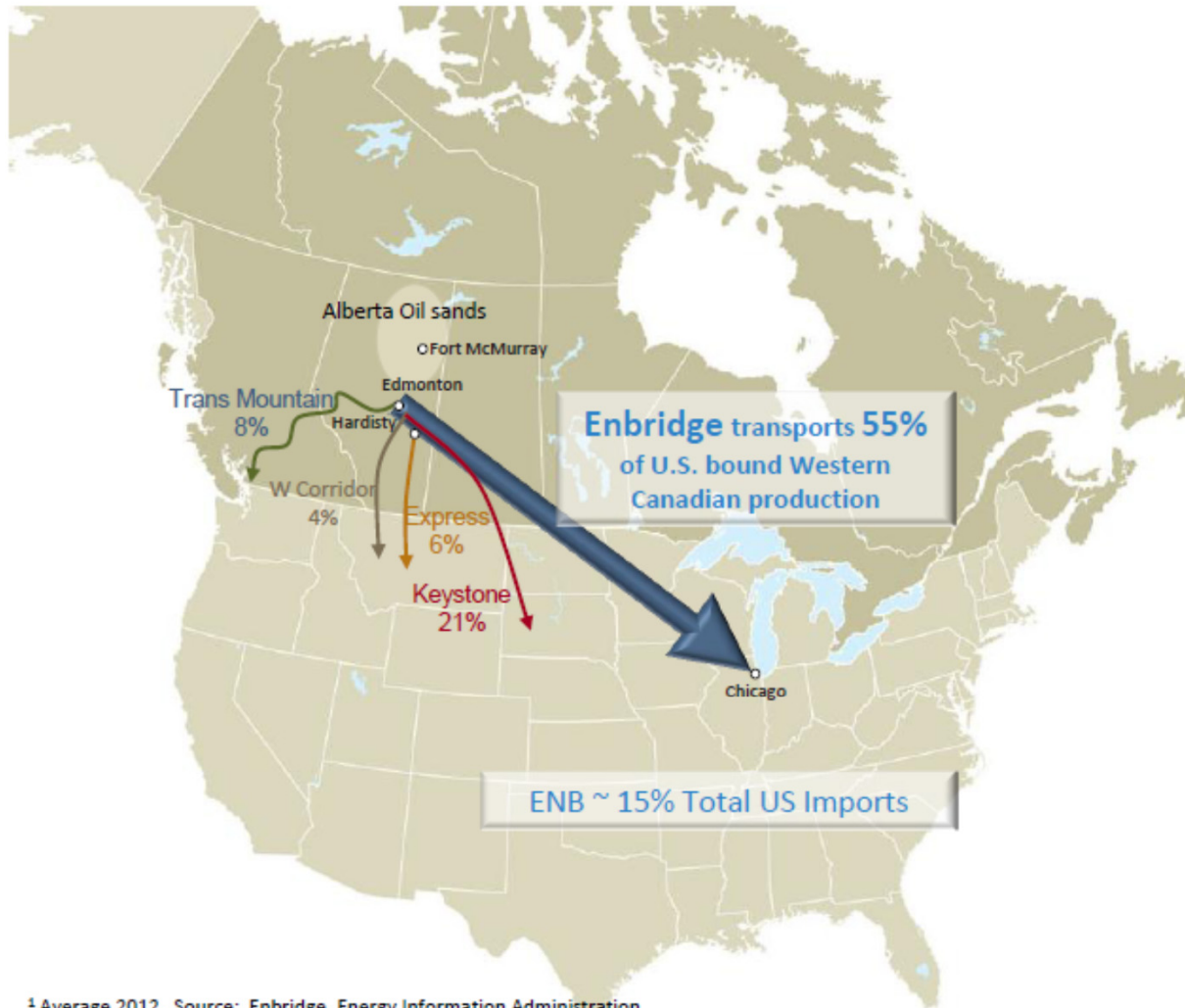
Upstream Infrastructure Development Uncertainty

- Infrastructure challenges seen for British Columbia and Alaskan LNG exports since contingent upon large pipeline build-out
- Possible siting advantage in U.S. Gulf Coast due to existing infrastructure

Level of Government Support

- Large “stranded gas” advantage in British Columbia and Alaska, but pipeline infrastructure disadvantage
- Uncertainty in U.S. export permit process

U.S. Crude Oil Imports

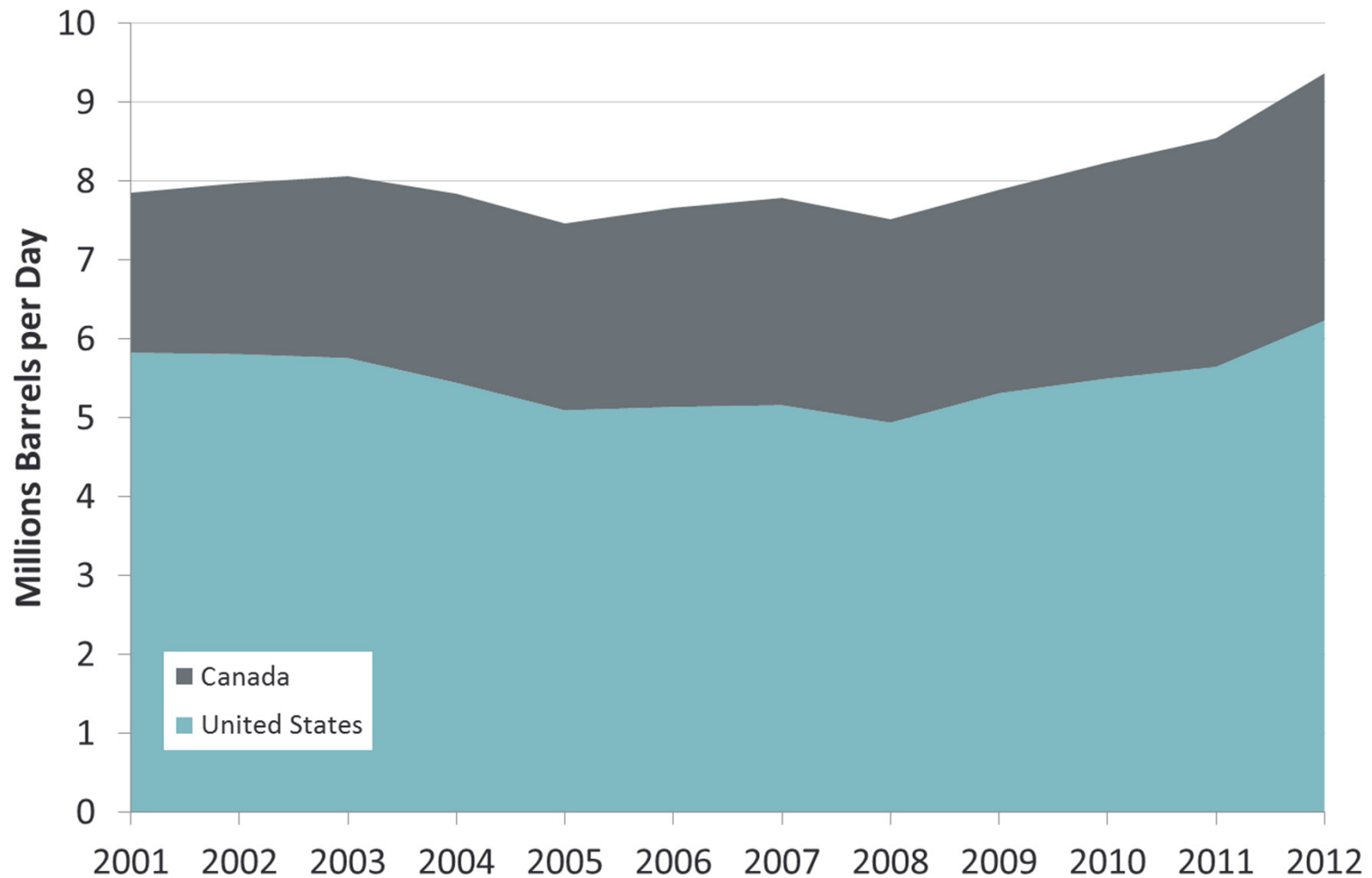


US Imports 2012 ¹	MMbpd	
Western Canada	2.4	
Enbridge		1.3
Others		1.1
Saudi Arabia	1.4	
Mexico	1.0	
Venezuela	0.9	
Iraq	0.5	
Nigeria	0.4	
Colombia	0.4	
Kuwait	0.3	
Angola	0.2	
Brazil	0.2	
Other ²	1.0	
Total	8.7	

2012 Capacity	MMbpd
Enbridge	2.50
Keystone	0.59
Trans Mountain	0.30
Express	0.28
West Corridor	0.15

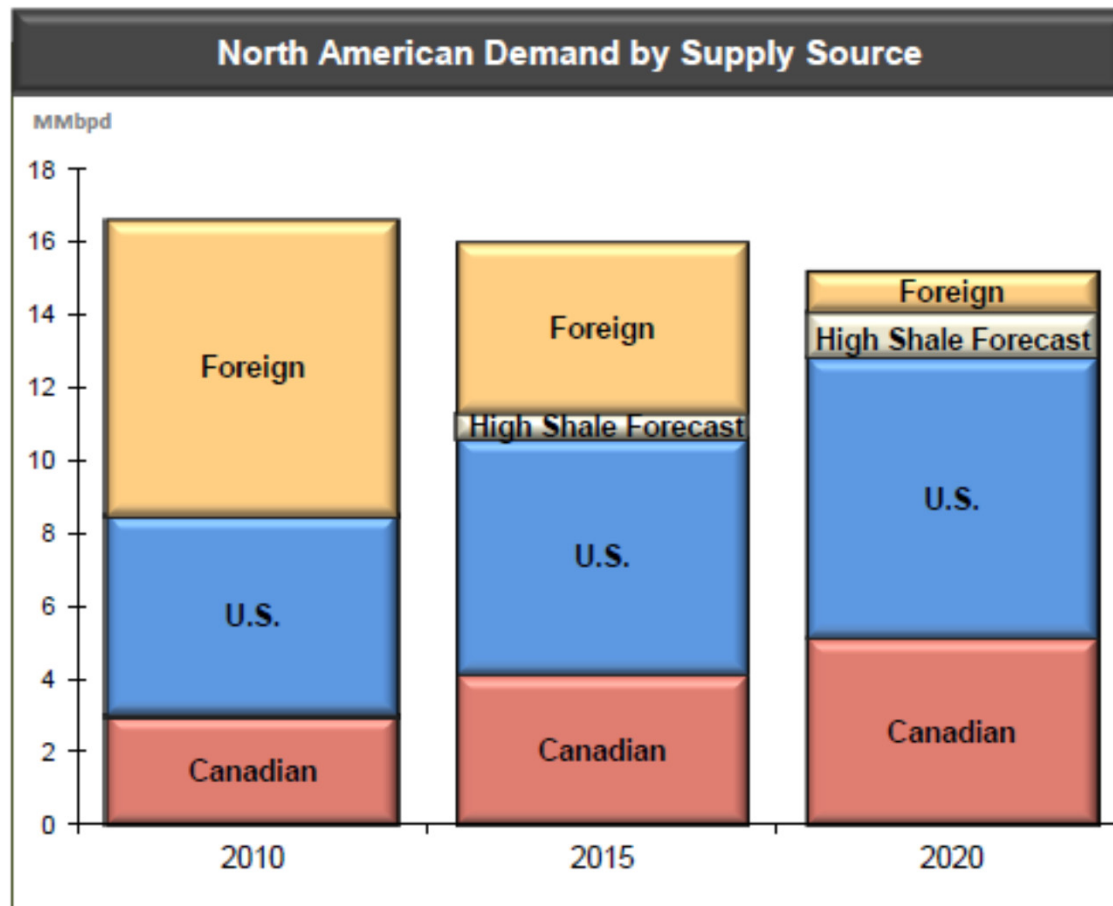
¹ Average 2012. Source: Enbridge, Energy Information Administration
Source: Enbridge Energy Partners Investment Community Presentation, August 2013.

U.S. and Canadian Crude Oil Production



Source: EIA. Historical U.S. data is the average of U.S. Weekly Supply Estimates. Canadian crude oil figures are annual averages.

North American Crude Oil Forecast

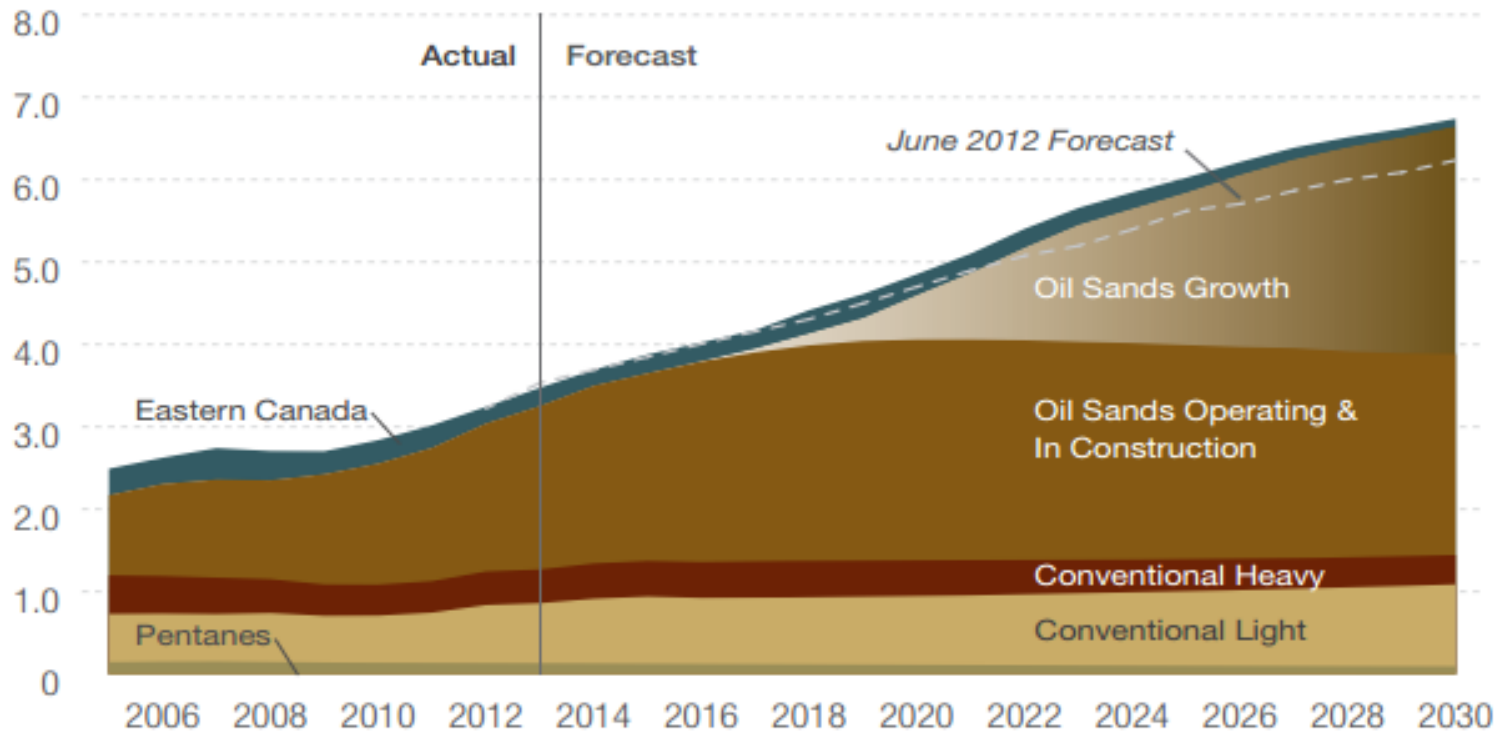


Source: Enbridge Internal Forecast

Source: Enbridge Energy Partners Investment Community Presentation, August 2013.

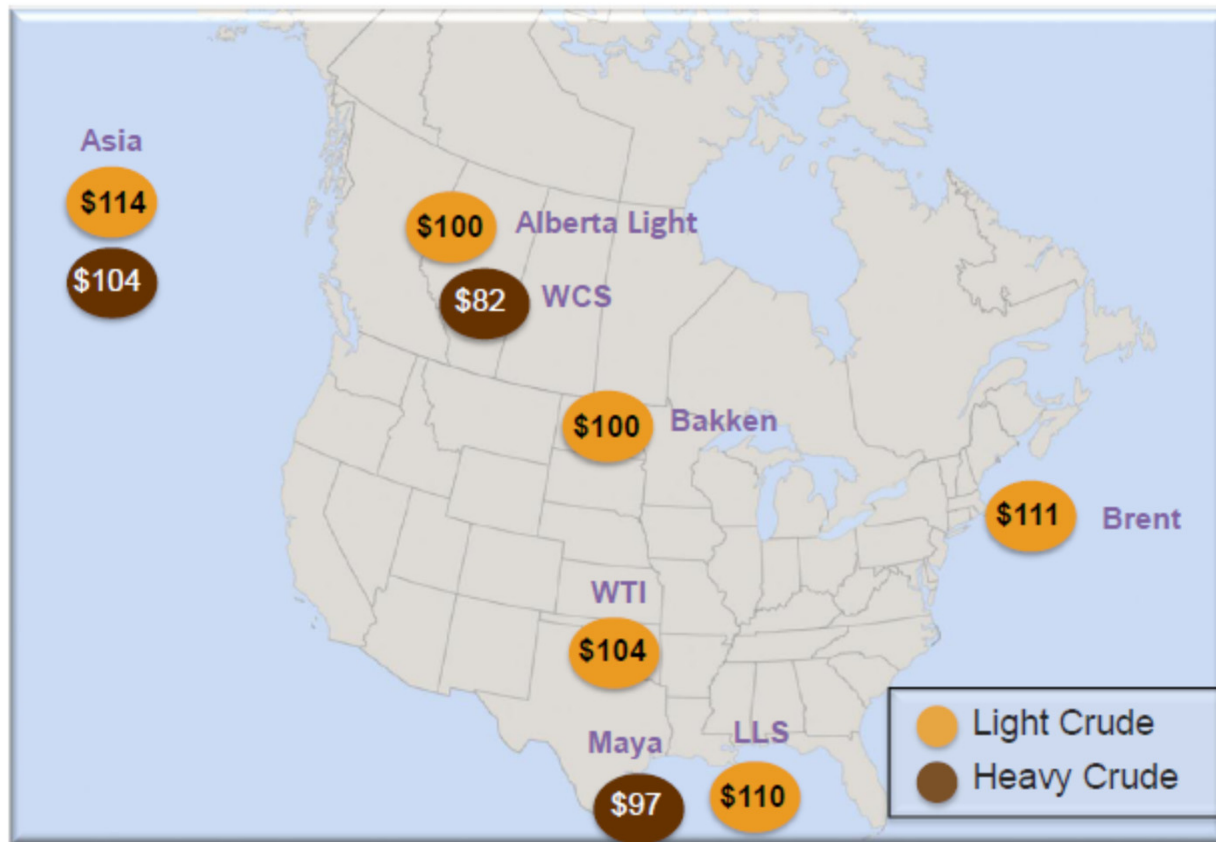
Canadian Oil Production Forecast

Canadian Oil Sands & Conventional Production
million barrels per day



Source: "Crude Oil Forecast, Markets & Transportation," CAAP, June 2013.

Canadian Crude Discounts Drive Infrastructure Development

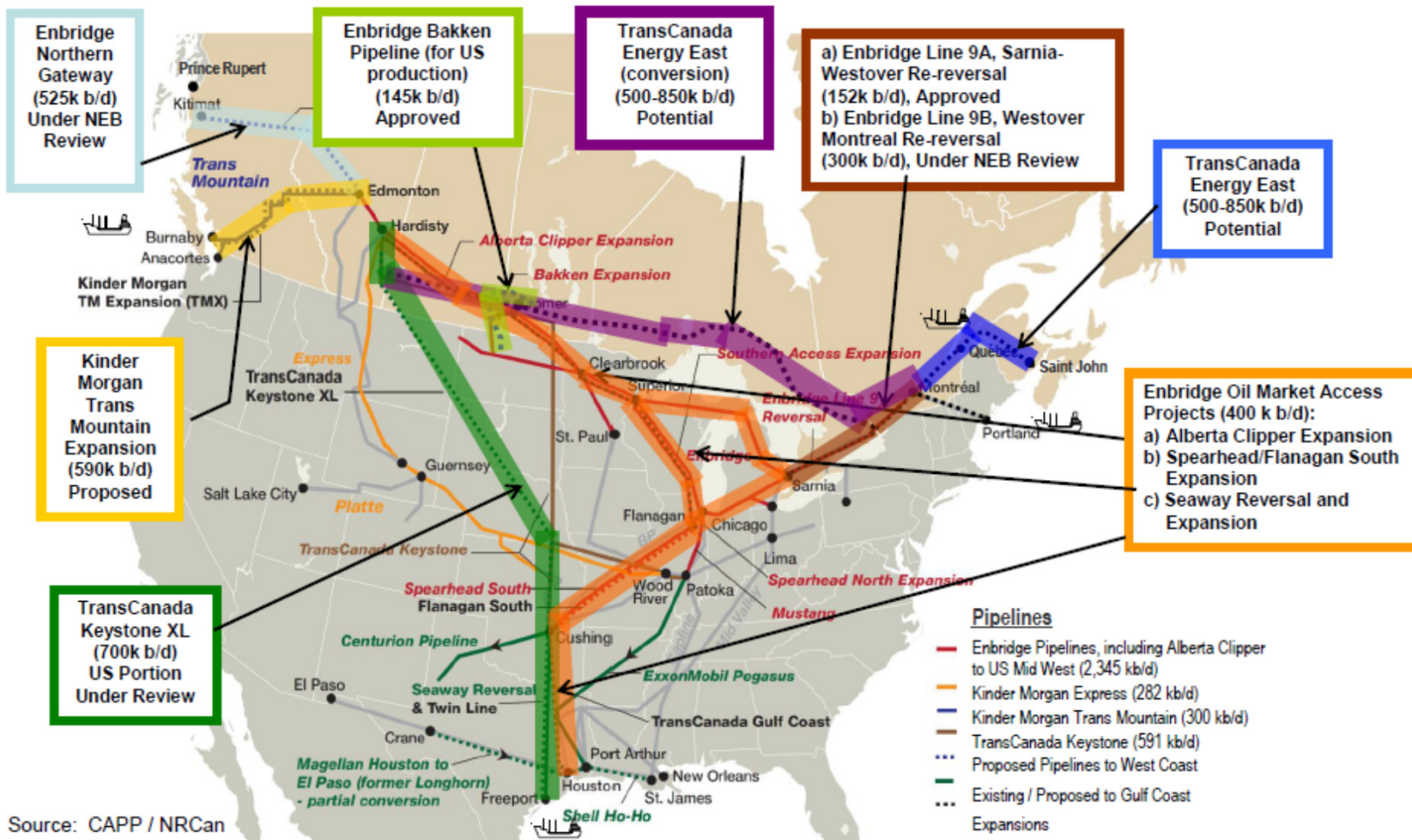


Light Differentials	
Brent – WTI	\$7
LLS – WTI	\$6
Asia – WTI	\$10
WTI – Bakken	\$4
WTI - Alberta Light	\$4

Heavy Differentials	
Maya – WCS	\$15
Asia – WCS	\$22

Source: Enbridge Energy Partners Investment Community Presentation, August 2013.

Proposed Pipelines



Source: CAPP / NRCan

Source: "Market Diversification for Canadian Oil and Gas," John Foran, Natural Resources Canada, June 17, 2013.

The Brattle Group

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world.

Many of our engagements are related to energy and utility regulation in such areas as:

Climate Change Policy and Planning

Cost of Capital

Energy Asset Valuation

Fuel and Power Procurement

Regulatory Strategy and Litigation Support

Renewables

Risk Management

Market Design and Competitive Analysis

Steven Levine is a Principal of The Brattle Group who specializes in energy and regulatory economics, with a particular focus on the natural gas and petroleum industries. He received a B.A. in economics from Brandeis University and an M.B.A. with a concentration in finance from Columbia Business School.

Paul Carpenter specializes in the economics of the natural gas, oil and electric utility industries. He holds a PhD in Applied Economics and an MS in Management from the Massachusetts Institute of Technology, and a BA in economics from Stanford University. He is a Principal and past-Chairman of The Brattle Group.

Anul Thapa is an Associate of The Brattle Group with expertise in the regulation and economics of the natural gas and electricity markets. He received an MBA with a concentration in finance from MIT Sloan School of Management and a B.A. *magna cum laude* in Mathematics and Computer Science from DePauw University.