Evaluation of the May 2013 API Report:

U.S. LNG Exports: Impacts on Energy Markets and the Economy

CRA Charles River Associates

Prepared for:

America's Energy Advantage

July 19, 2013

Lead Author

Ken Ditzel

Special thanks to Pang Laohapairoj and Jonathan Painley

Disclaimer

The conclusions set forth herein are based on independent research and publicly available material. The views expressed herein are the views and opinions of the authors and do not reflect or represent the views of Charles River Associates or any of the organizations with which the authors are affiliated. Any opinion expressed herein shall not amount to any form of guarantee that the authors or Charles River Associates has determined or predicted future events or circumstances and no such reliance may be inferred or implied. The authors and Charles River Associates accept no duty of care or liability of any kind whatsoever to any party, and no responsibility for damages, if any, suffered by any party as a result of decisions made, or not made, or actions taken, or not taken, based on this paper. Detailed information about Charles River Associates, a registered trade name of CRA International, Inc., is available at www.crai.com.

Scope of Work and Executive Summary

Task #	Task Description	Our Findings
1	Explain how the base case North American and U.S. supply curves in the API report compare to other published supply curves.	• The supply curve used in the API report is one of the most optimistic supply curves published. It is at least twice as optimistic as MIT's median and EIA's reference cases. • While API report's North American supply curve is similar to EIA's high EUR case, it is at least 450-1000 Tcf (15 – 33 years) larger than MIT's high resource case at equivalent prices.

2	Review the list of 39.2 Bcf/d of planned international LNG exports under construction or planned. Determine the likelihood of these projects being built.	• Of the 39.2 Bcf/d of international projects listed as planned, 26.5 are unlikely to be built:
		  • 10.9 Bcf/d are highly unlikely because they are shelved, projects already under construction, or have had their capacity de-rated.
		  • 15.6 Bcf/d are post-2020 or in regions where additional capacity is unlikely to be built for the foreseeable future (e.g., Australia).

3	Evaluate the merits of using a supply curve for projecting prices in the LNG market.	• Using a single supply curve to support a position that future LNG market prices will fall 20% from current levels is problematic for three reasons:
		  • Supply curves are static and are not representative of the changing regional supply/demand dynamics over time. As such, they should be appropriately caveated and presented with sensitivities.
		  • Many of the projects in the API report's LNG supply curve (see Finding #2) are unlikely to be built, making it inaccurate.
		  • The API report attempts to bolster its supply curve analysis by linking it to $95/bbl oil through 2035. This is an extreme scenario given current prices are above $105/bbl and real annual price inflation for oil has averaged almost 6% over the last 25 years.

4	Review the U.S. demand response in the base case and scenario cases presented in the API report given the low gas prices projected.	• While the forecasted gas demand growth in the API report is more realistic than EIA's reference case demand forecast, we believe it could be higher given historical precedent during periods of low prices, the number of proposed regulations affecting coal power plants, and the potential for NGV market penetration.

5	Assess the validity of the API report's long-term NGL production and disposition forecast.	• The implication that LNG exports will increase NGLs and thus will be a boon to petrochemicals is far from certain. There are two factors that could disrupt this notion:
		  • NGL additions to LNG exports: To meet Asian pipeline specifications, LNG from the U.S. must be at a higher heating value, thus NGL additions are required. The amount can be significant – 9% of existing NGL demand for 10 Bcf/d of exports.
		  • NGL exports: There are a number of proposed NGL export projects that could consume up to 18% of existing NGL demand.

Table of Contents

Sources and Major Assumptions Documentation

- The ICF North American supply curve can be found on page 67 of the May 2013 API Report.
- The ICF U.S. and Canadian supply curves can be found on pages 24 and 25 of the testimony given by Harry Vidas of ICF Resources before the Subcommittee of Energy & Power of the U.S. House of Representatives Committee on Energy and Commerce on February 5, 2013.
- The U.S. Energy Information Administration's (EIA) implied U.S. supply curve was derived by cumulatively adding the annual U.S. production from 2012 through 2040 from the EIA's 2013 Annual Energy Outlook (AEO) and then plotting the cumulative production against AEO's forecasted prices.
- The Canadian National Energy Board (NEB) implied Canadian supply curve was derived by cumulatively adding the annual Canadian production from 2012 through 2040 from the NEB's November 2011 "Canada's Energy Future" study and then plotting the cumulative production against NEB's forecasted prices.
- The EIA-NEB implied North American supply curve was derived by adding the NEB's Canadian supply curve on top of the EIA's U.S. implied supply curve.
- We compared the ICF technically recoverable resource base to resource base estimated by other studies since 2008, including previous resource assessments conducted by ICF.

Analysis Conducted and Our Findings

Analysis Conducted

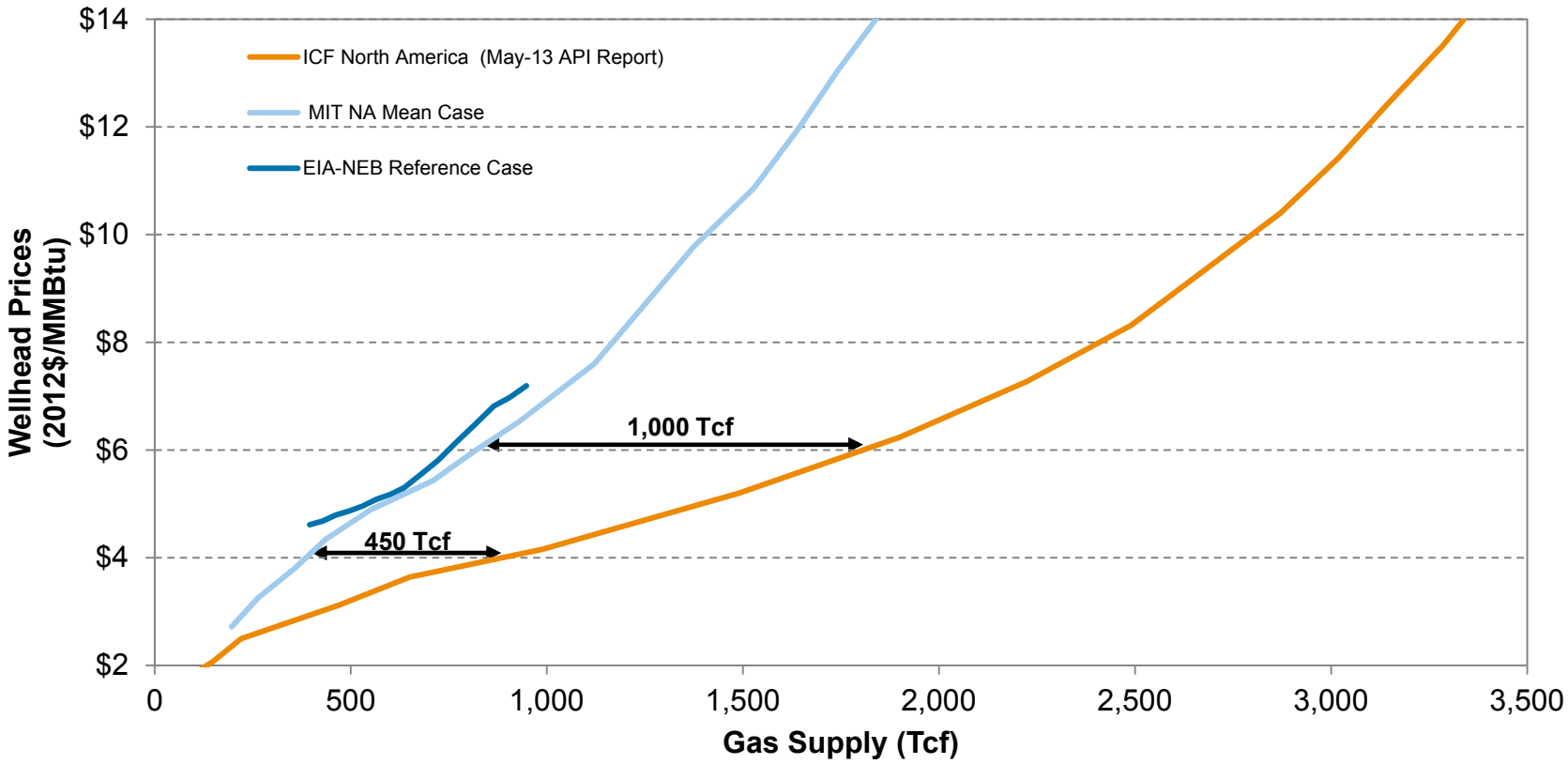
- Compared ICF's supply curve projections as published in API Report and ICF's February congressional testimony to supply curves published by MIT and supply curves implied by EIA's Annual Energy Outlook and Canada's National Energy Board (NEB).
- Examined total resource estimates over the past six years to show how the estimates in the API report compare relative to other published estimates.

Our Findings

- The North American gas supply curve in the API report is highly optimistic relative to other published supply curves. For example, the supply curve used forecasts about 450-1,000 Tcf more gas resources available at prices ranging from $4 to $6/MMBtu. That is equivalent to 15 to 33 years of current North American demand.
- The API report's estimated U.S. technically recoverable gas resources are highly optimistic compared to others published, such as MIT, EIA, Potential Gas Committee (PGC), and Advanced Resources International (ARI).

The North American (NA) supply curve in the API report is highly optimistic compared to reference case forecasts from published sources such as MIT, EIA, and Canada's NEB.

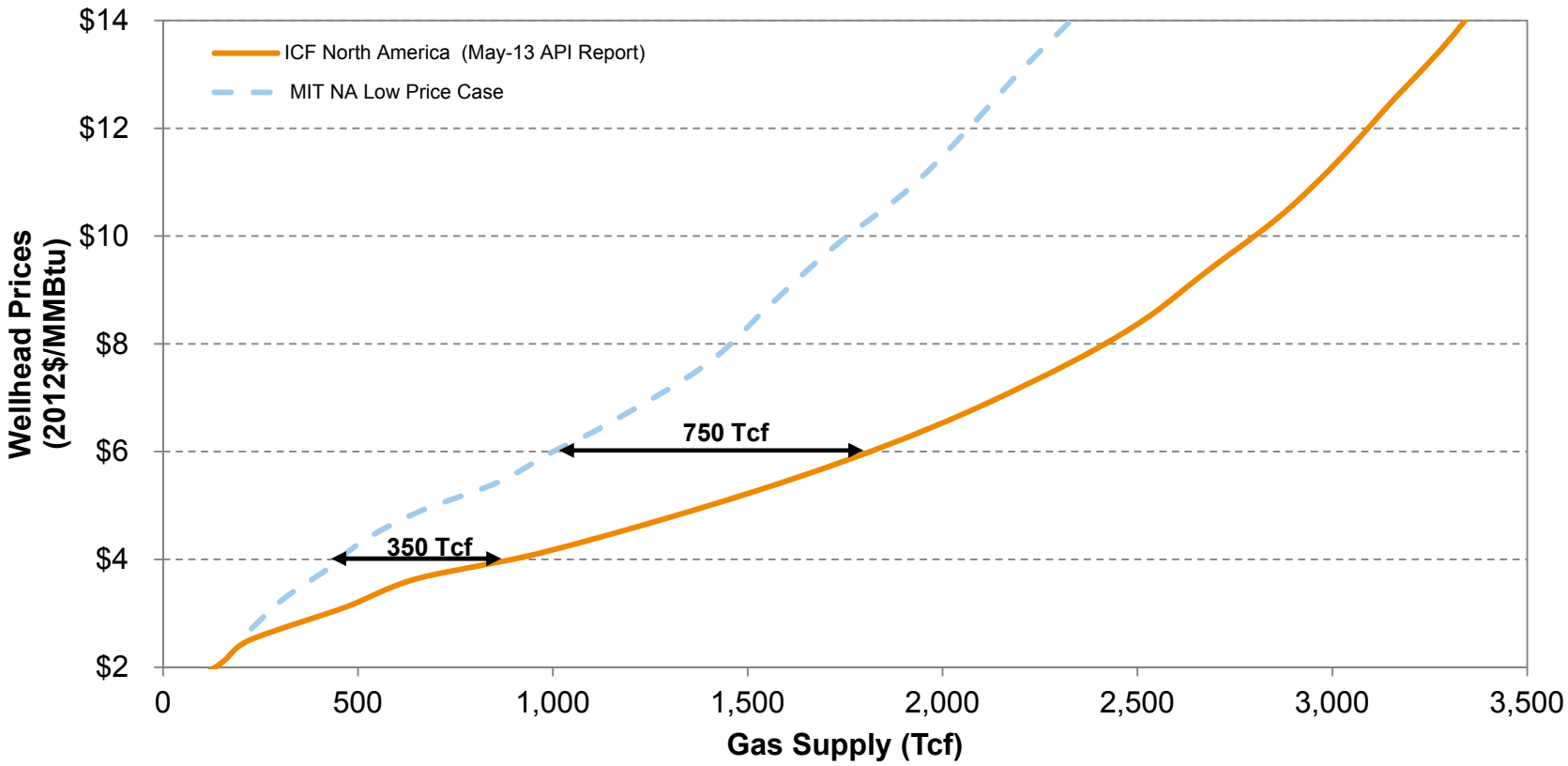
North American Supply Curve Comparison – Base Case



Compared to MIT's and EIA's base cases, ICF forecasts about 450-1,000 Tcf more gas resources available at prices ranging from $4 to $6/MMBtu. That is equivalent to 15 to 33 years of additional resources at current levels of demand.

The API report's NA supply curve also is highly optimistic when compared to MIT's low price case (high estimated ultimate recovery).

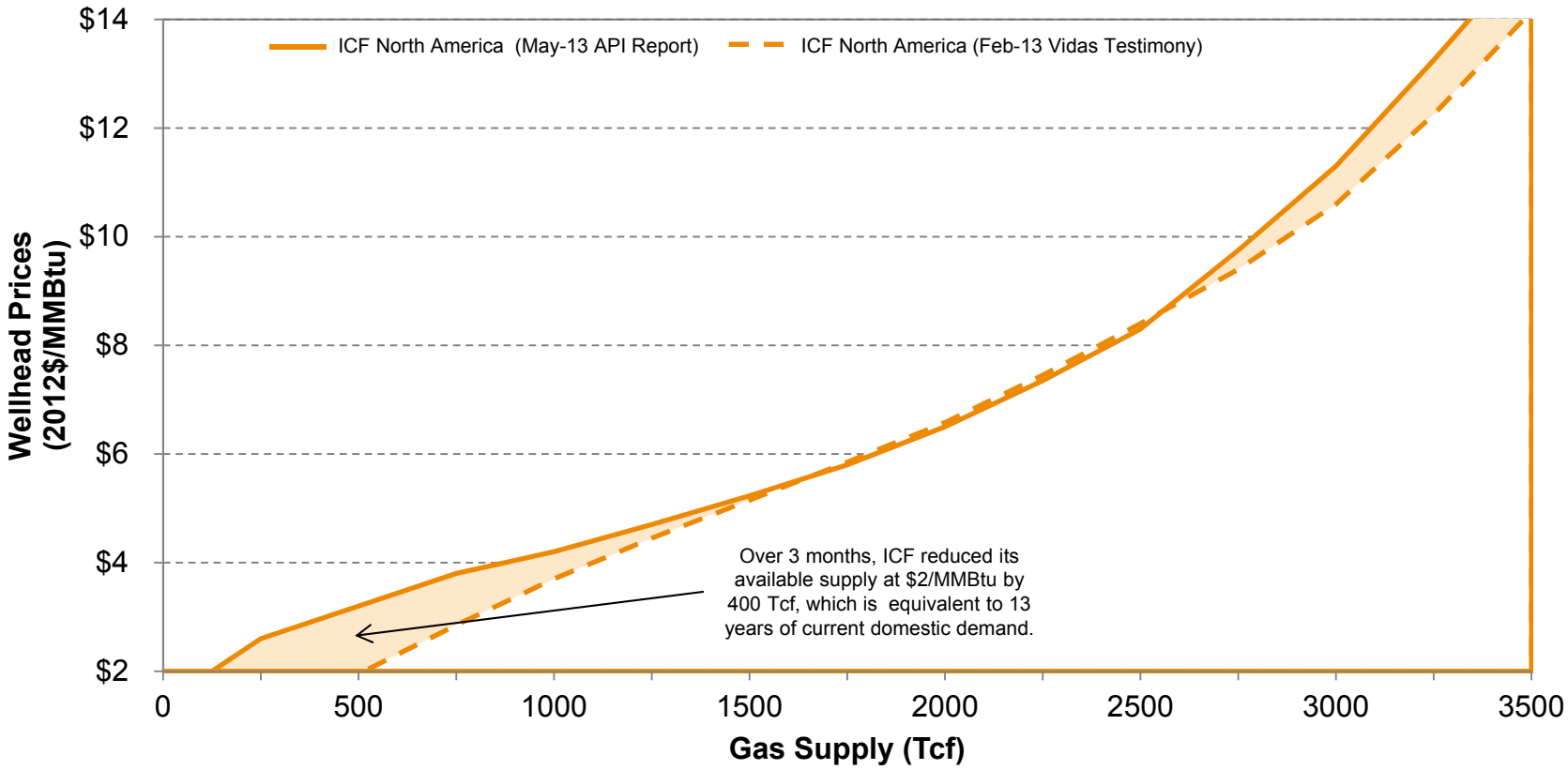
North American Supply Curve Comparison – Low Price Case



Compared to MIT's low price supply curve, ICF forecasts about 350-1,000 Tcf more gas resources available at prices ranging from $4 to $6/MMBtu. That is equivalent to 12 to 33 years of additional resources at current levels of demand.

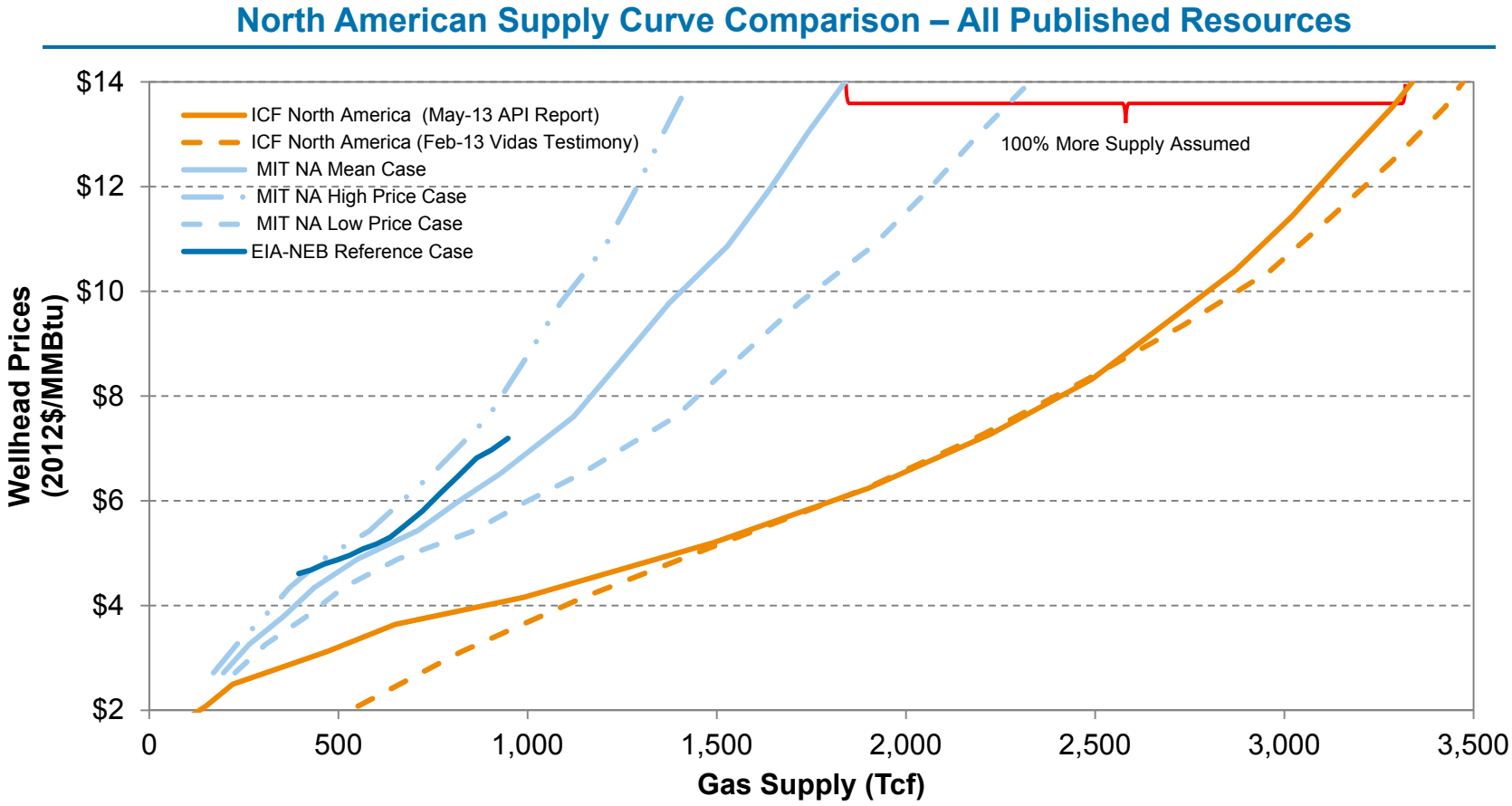
ICF's North American supply curve has changed significantly during 2013, especially at the front of the supply curve.

ICF North American Supply Curve Comparison



Footnote:
(1) U.S. LNG Exports: Impacts on Energy Markets and the Economy, ICF International, May 15, 2013
(2) U.S. Oil and Gas Resources, Harry Vidas, ICF Resources, LLC, February 5, 2013

The North American supply curve in the API report is up to 100% larger than the base cases presented by MIT and EIA-NEB.



CRA Charles River Associates

Table of Contents

Overview of Resources Estimates

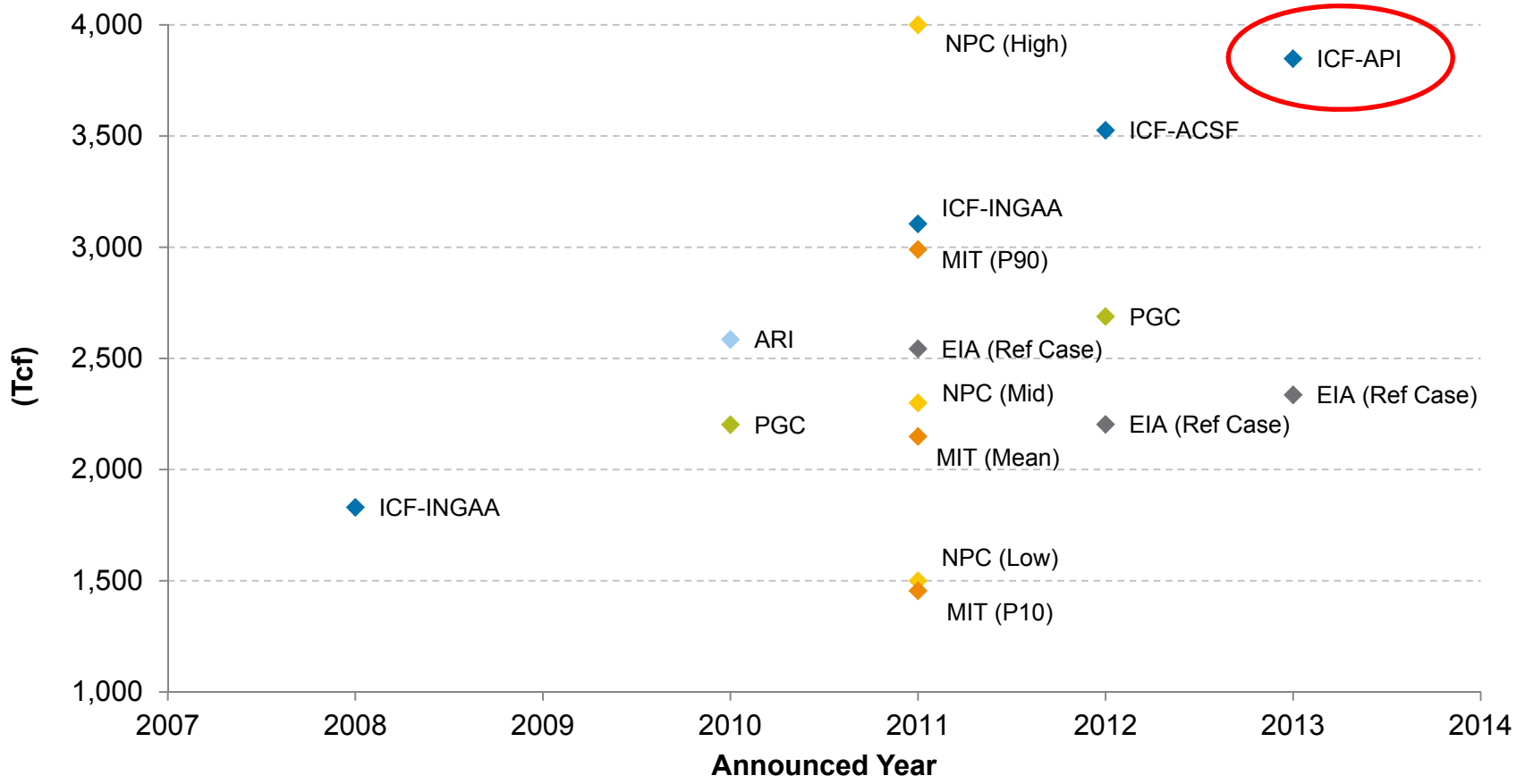
Overview

- Shale gas resource estimates have increased significantly over the past 5 years as technology breakthroughs in horizontal drilling and fracturing have enabled greater access to shale deposits.
- The increases in U.S. resource estimates have been broad-based across entities that estimate resources; however, the degree of increase has been quite varied.
- The following slides present the range of resource estimates from EIA, MIT, PGC, ARI, and ICF.
- The resource estimates used by API clearly lie on the most optimistic end of the spectrum, which mainly has been a result of ICF's view of shale resources.
  - The ICF shale gas resource has increased from 22% of its total resource base in 2008 to 55% of its total resource base in 2013. Over the period, the ICF shale gas resource estimate increased from 516 Tcf to 2,565 Tcf, or by 397%.

Sources

- ICF-INGAA, November 2008; ARI, August 2010; NPC, 2011; MIT, June 2011; ICF-INGAA, June 2011; ICF-ACSF, October 2012; EIA-AEO, August 2012; PGC, December 2012; EIA-AEO, May 2013; ICF, May 2013

The total U.S. resources estimate used in the API report is about 40% and 65% larger than PGC's and EIA's resource estimates, respectively.



ICF forecasts about 1,100 Tcf more U.S. gas resources than PGC and about 1,500 Tcf more U.S. gas resources than EIA's latest reference case.

ICF's North American shale gas resources estimates have grown 397% between 2008 and 2013.

Resource Base Type (Tcf)	ICF-INGAA 2008		ICF-API 2013		2008-2013 Change
Remaining proved	262	*11%*	358	*8%*	37%
Resource appreciation and discovered undeveloped	309	*13%*	273	*6%*	-12%
New conventional fields	856	*37%*	707	*15%*	-17%
Tight gas	240	*10%*	642	*14%*	168%
Coalbed methane	155	*7%*	142	*3%*	-8%
Shale gas	516	*22%*	2,565	*55%*	397%
	2,338	***100%***	**4,687**	***100%***	**100%**

Table of Contents

Overview

API Report Premise

- The API report posits that the international pipeline of liquefaction projects that are under construction and planned exceeds the 2035 demand for LNG, thus placing the U.S. at a disadvantage to compete globally.
  - The API report estimates global LNG demand to be approximately 70 Bcf/d in its low demand scenario and approximately 90 Bcf/d in its high demand scenario by 2035.
  - The API report states that there are 50.5 Bcf/d of international projects under construction or being proposed; adding this to the 42 Bcf/d of current operating capacity, the API report implies that there could be 92.5 Bcf/d of capacity available by 2035, satisfying the global demand for both the low and high demand scenarios.

Our Findings

- The list of planned, international LNG liquefaction projects in the API report is based on outdated information:
  - The data on the status of planned international projects and assumptions regarding their likelihood are questionable, leaving about one-third (or 12.7 Bcf/d of the 39.2 Bcf/d) of their list of planned projects being worthy to consider as higher probability projects.

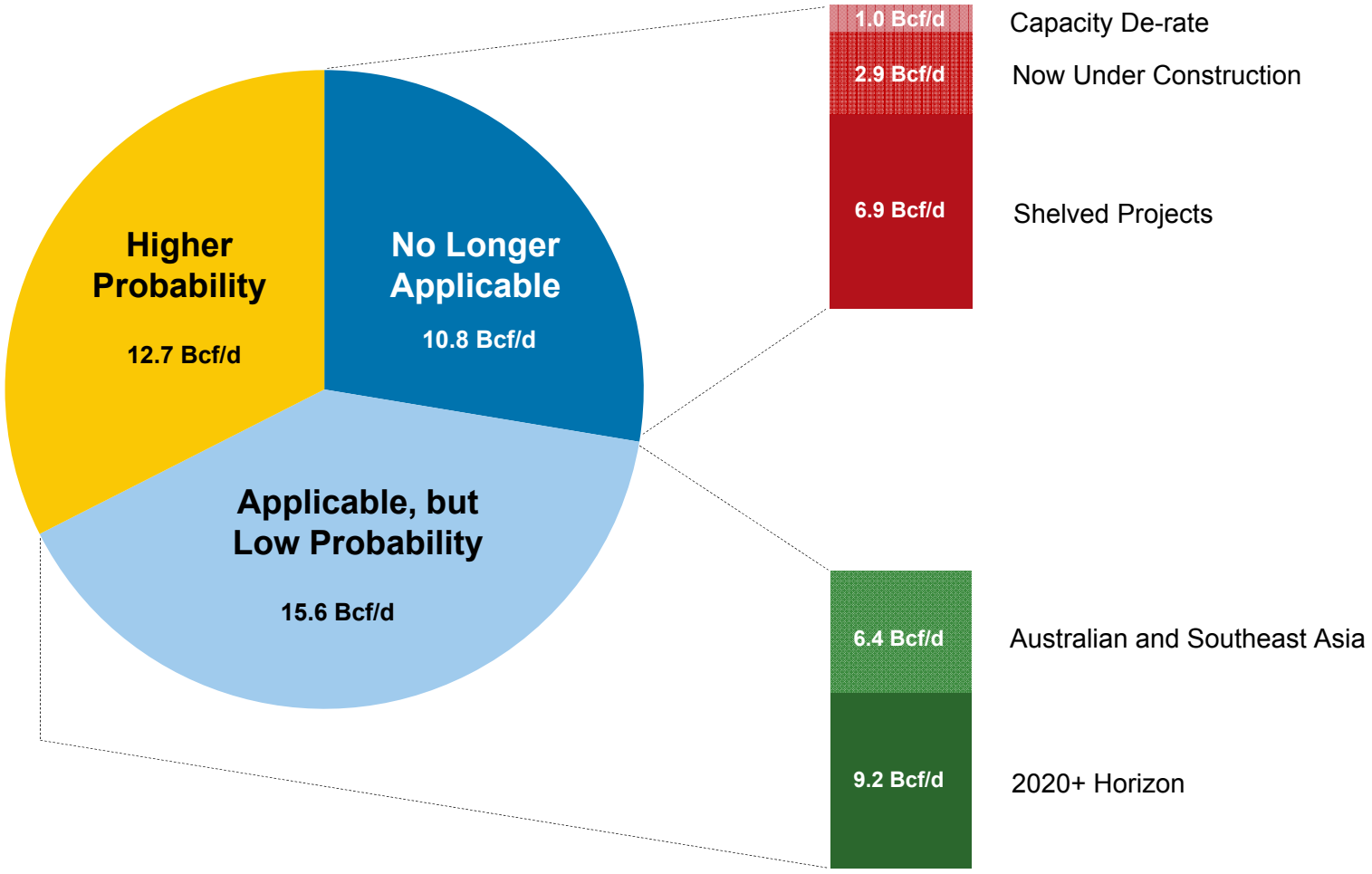
Sources Used

- Zeus Intelligence LNG database; http://member.zeusintel.com/lng/export/index.aspx
- Press releases
- Publicly available reports

Two-thirds or ~26 Bcf/d of planned projects on API report's list no longer are applicable or are "low probability" projects…

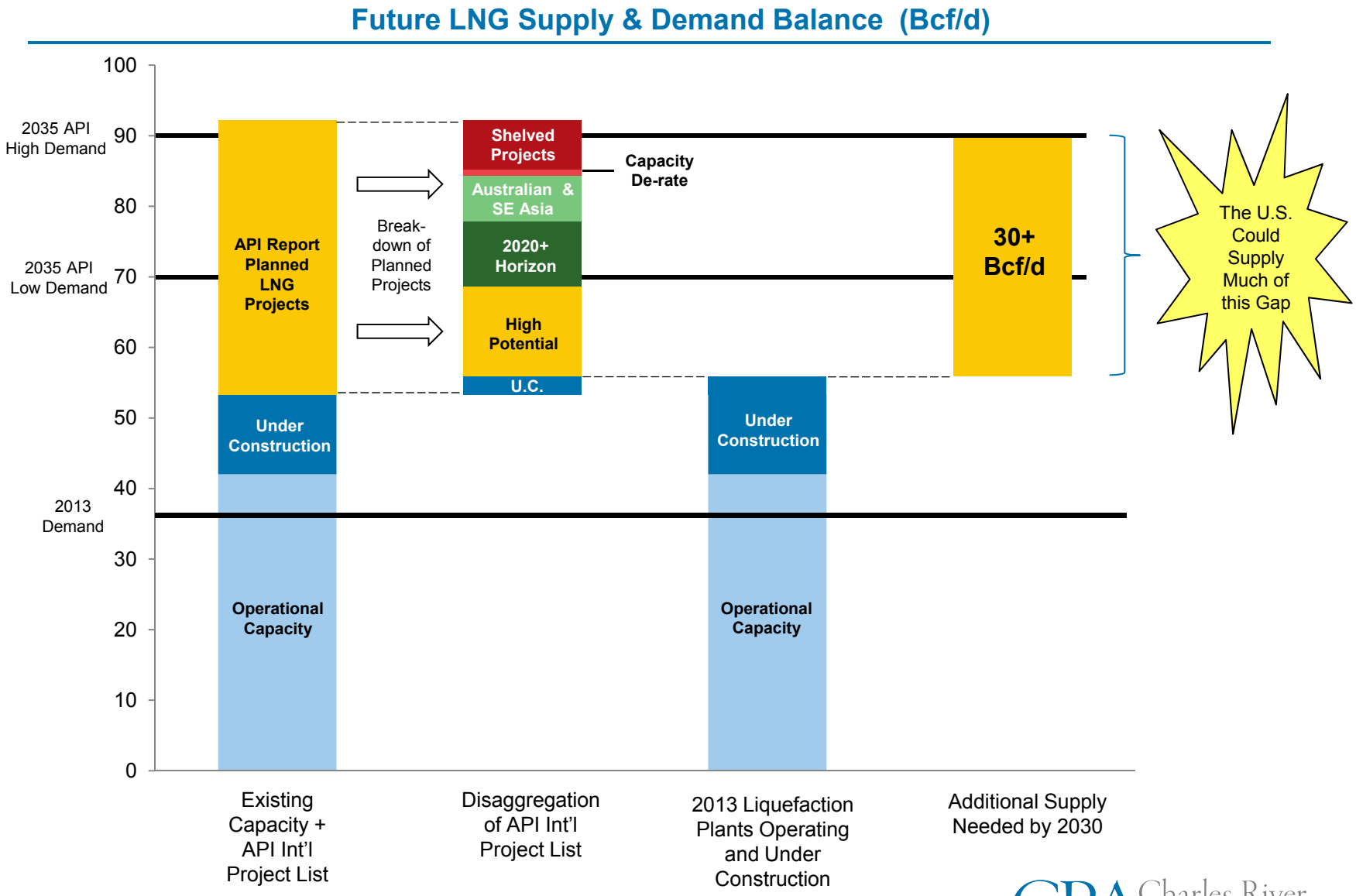
Disaggregation of the API Report's Planned Liquefaction Projects

API Report Planned International Capacity: 39.2 Bcfd



CRA Charles River Associates

…leaving room for the United States to compete for much of the anticipated gap of 30+ Bcf/d of capacity required in the API report's High Demand scenario.



CRA Charles River Associates

Table of Contents

Overview

The API Report Premise

- The API report argues that "given the competition from new sources likely to be available in the next several years from the U.S. and other countries, this pricing level [recent LNG prices of $13.90/MMBtu to $15.00/MMBtu delivered to Asia] is probably not sustainable."(1)
- The API report also states that market prices are well above the actual delivered cost of LNG to Asia and argues that pressure will be placed on lowering the market price.
  - The LNG supply curve presented in the API report suggests that incremental growth of 39-57 Bcf/d by 2035 implies delivered LNG costs of $9-$10/MMBtu from the marginal supplier of current international LNG projects that are under construction and proposed.
  - The API report states that delivered prices to Asia will be $12.49/MMBtu and $12.96/MMBtu or approximately $3/MMBtu to $4/MMBtu higher than the supply curve costs due to oil indexation at 76% to 79% of crude.

Our Findings

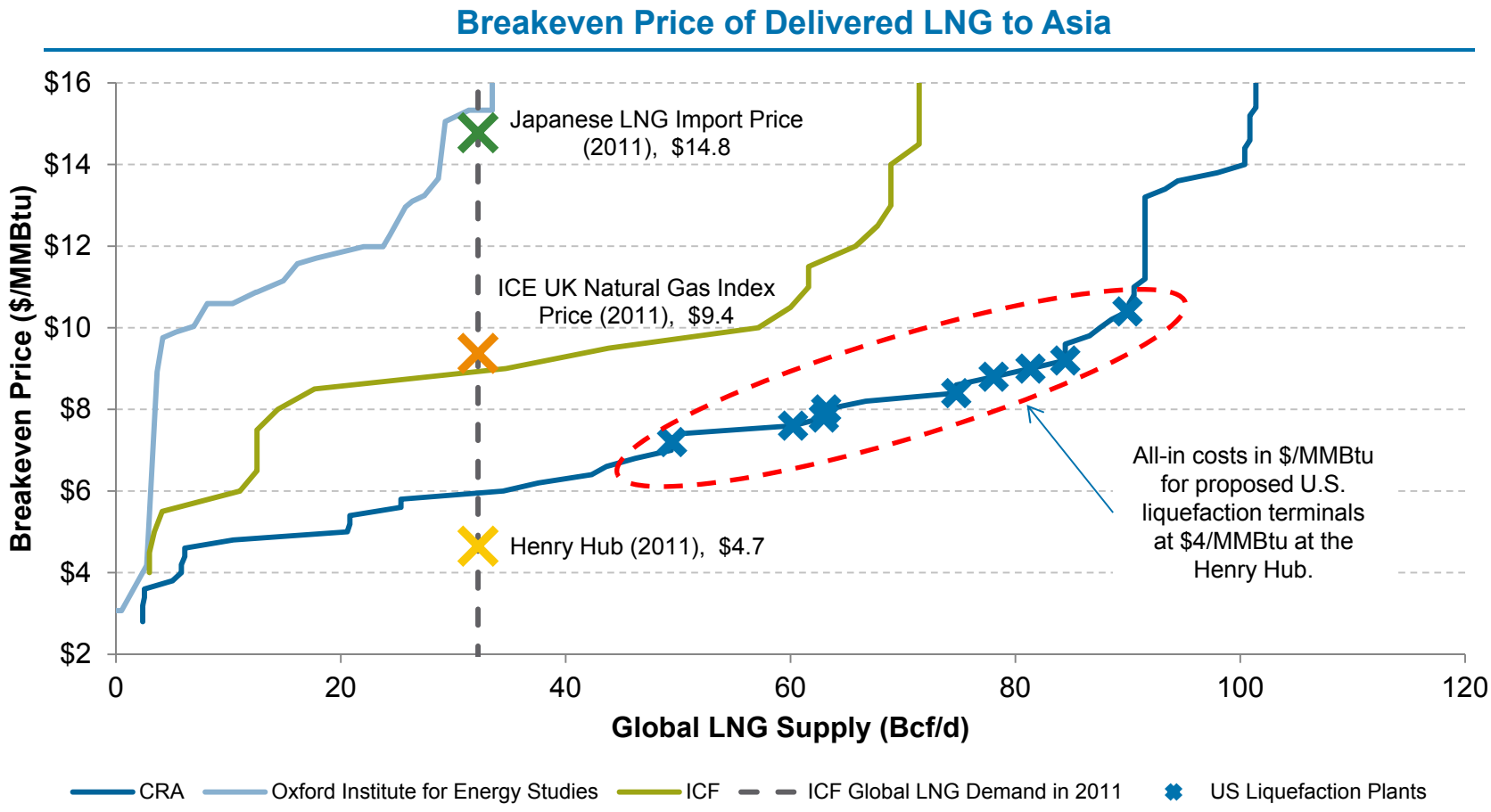
- We agree with the API report's statement that "pricing of international LNG is a complex matter and there is no clear, widely held view of how LNG pricing will evolve in the future – with or without U.S. exports."(2)
- It is worth noting that oil indexation helps secure future supply as it creates a high enough spread between oil and domestic gas prices to incentivize new investment, especially when the investments are multi-billion dollar bets.
- Supply curves are not always equivalent to price curves.
  - Supply curves are helpful in understanding the marginal cost of supply; however, they are not always good indicators of the market clearing price, especially in markets that are dictated by non-transparent, long-term contracts such as LNG.
- The LNG supply curve presented in the API report is a snapshot of supply costs and does not reflect how regional supply and demand changes can influence costs, for example:
  - Increased exports of LNG from the U.S. will increase domestic prices all else equal.
  - Changes in equipment costs due to factors such as steel, concrete, and labor costs will impact the cost structure.

Sources Used

- Zeus Intelligence LNG database; http://member.zeusintel.com/lng/export/index.aspx

(1) API Report, pg. 67.
(2) API Report, pg. 67.

Our LNG supply curve 'snapshot' analysis confirms that many of the proposed U.S. liquefaction projects are competitive at today's prices.



Notes

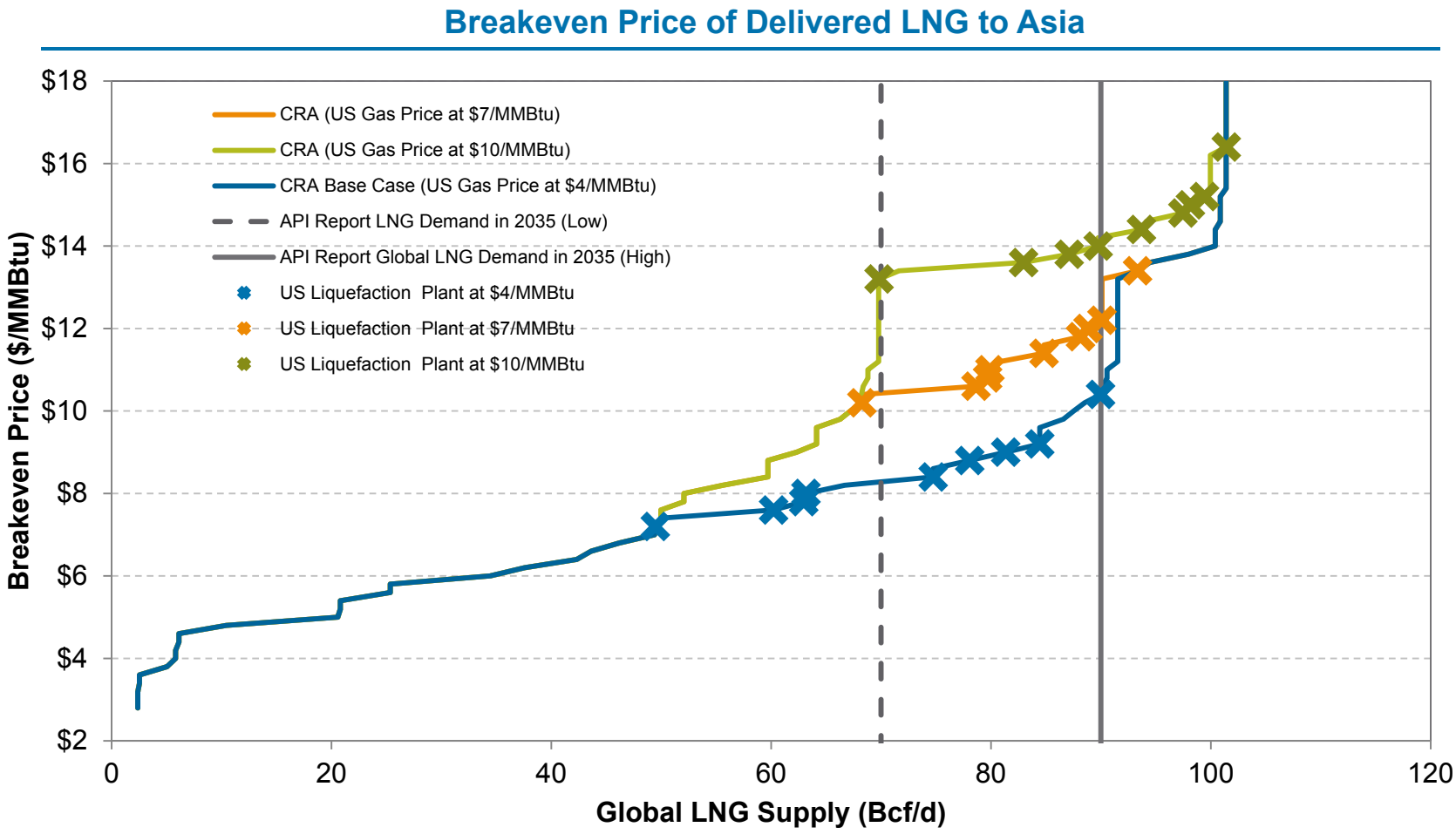
The CRA curve includes existing, under construction, and proposed plants

The Oxford Institute for Energy Studies includes sample projects

The supply curve used in the API report includes only under construction and proposed

CRA Charles River Associates

We project that the U.S. will be a part of the LNG supply mix regardless of whether Henry Hub prices rise to $10/MMBtu.



Note: the above chart is a snapshot of existing and proposed projects. The sensitivities shown are for changes in the Henry Hub price only. The curves do not reflect the changing supply/demand dynamics in other countries.

Table of Contents

Overview: The forecasted gas demand growth in the API report is more realistic than EIA's; however, it could be higher given historical precedent, the number of proposed regulations affecting coal power plants, and the potential for NGVs.

API Report's Assumptions and Findings

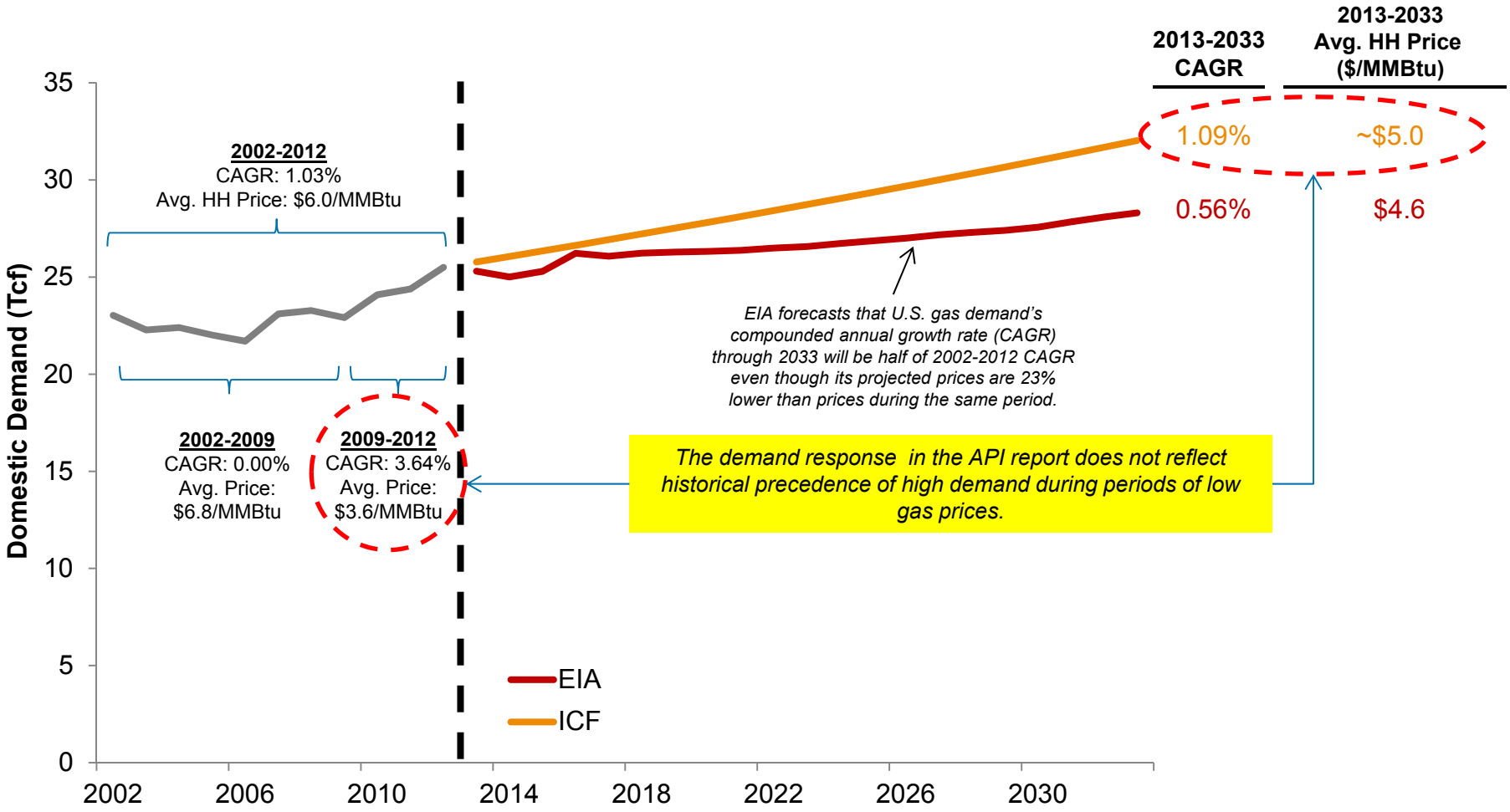
- The API report indicates that its Base Case U.S. domestic gas demand growth is significantly higher than EIA's reference case (1.1% vs. 0.5%) from 2012 to 2035; the higher growth rate is primarily due to higher forecasted demand in the power generation and industrial sectors:
  - Power Generation: the growth rate forecasted in the API report is more than1700% higher than EIA's (1.48% vs. 0.08%).
  - Industrial: the growth rate forecasted in the API report is 33% higher than EIA's (1.19% vs. 0.89%).

Our Findings

- While the API report's U.S. consumption outlook is more grounded than EIA's, we believe it should be higher given historical demand response to low gas prices:
  - The API report projects1.1% per annum growth in domestic consumption (excluding LNG exports) through 2035 at average Henry Hub prices of approximately $5/MMBtu (in 2010$).
  - From 2009 to 2012, however, demand grew 3.6% per annum when gas prices ranged from $2/MMBtu to $6/MMBtu and averaged $3.6/MMBtu in 2010$.
- The API report's forecasted Base Case gas demand is too low for the following reasons:
  - Increasingly stringent emissions will further coal retirements, forcing gas to make up the difference in lost coal generation; while the API report does address the likelihood of increased regulations on coal plants, it does not provide its forecast of coal retirements that can be compared to other studies.
  - It appears that the API report does not forecast a sizable penetration of NGVs, which we believe will be the highest gas growth sector, and would add approximately 3.2 Bcf/d by 2030/2035. This would increase U.S. consumption by 1.2 Tcf and increase the compounded annual consumption growth rate to 1.2% from 1.1%.

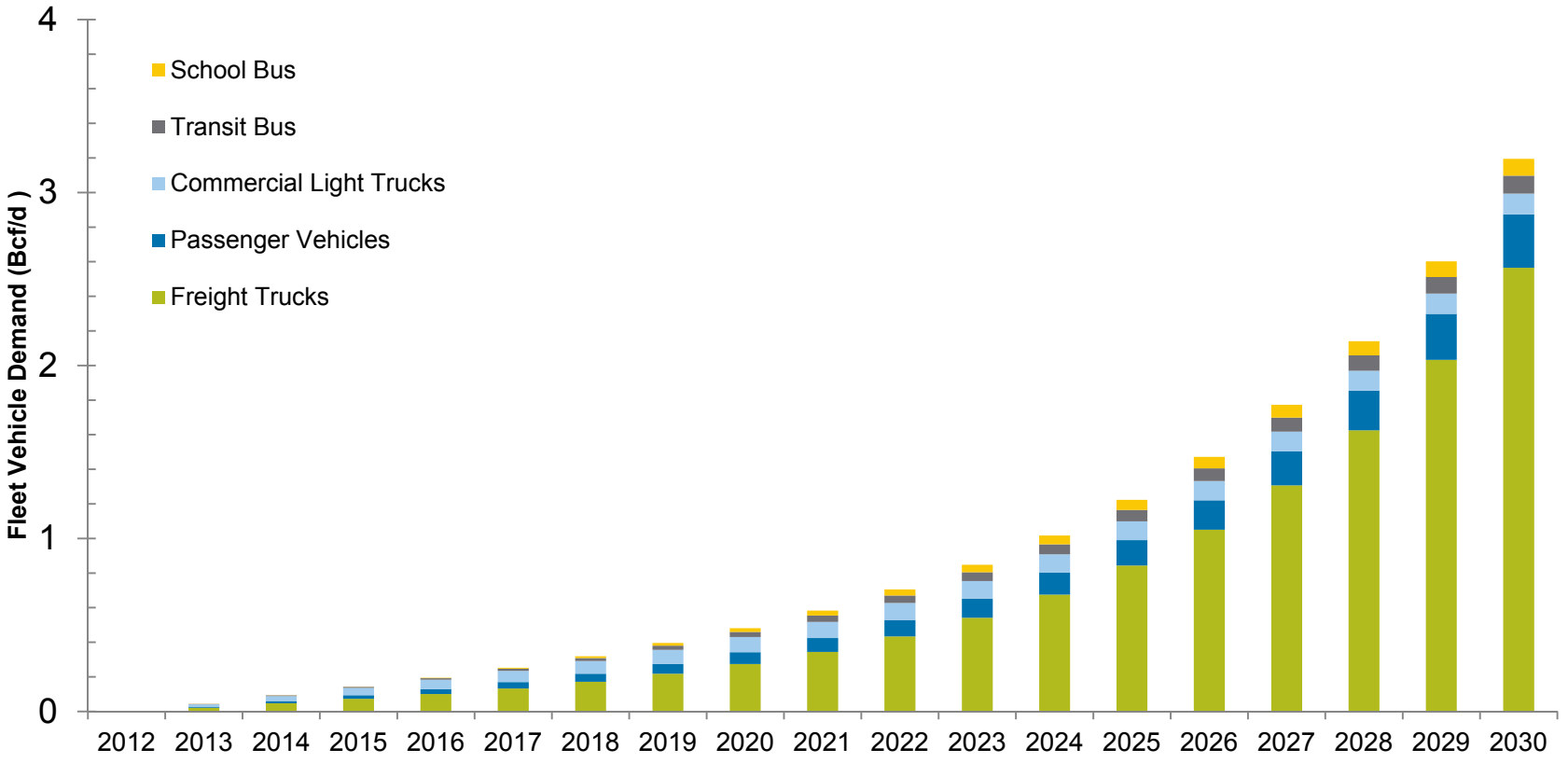
While the API report appropriately points out that EIA's base case demand is too low, the base case in the API report should be slightly higher given historical precedence in times of low prices.

All prices shown in 2010$



CRA Charles River Associates

Natural Gas Vehicles represent an area of demand that the API report may not have fully considered (no specific discussion of NGVs in the API report); CRA forecasts the NGV market to grow to 3.2 Bcf/d by 2030 or 4.6% of current demand.



Source: CRA Analysis

Table of Contents

Overview: The API report's NGL forecast relies heavily on its optimistic supply curve to support exports without incurring much demand destruction; the API report does not consider demand drivers that could counterbalance higher supply.

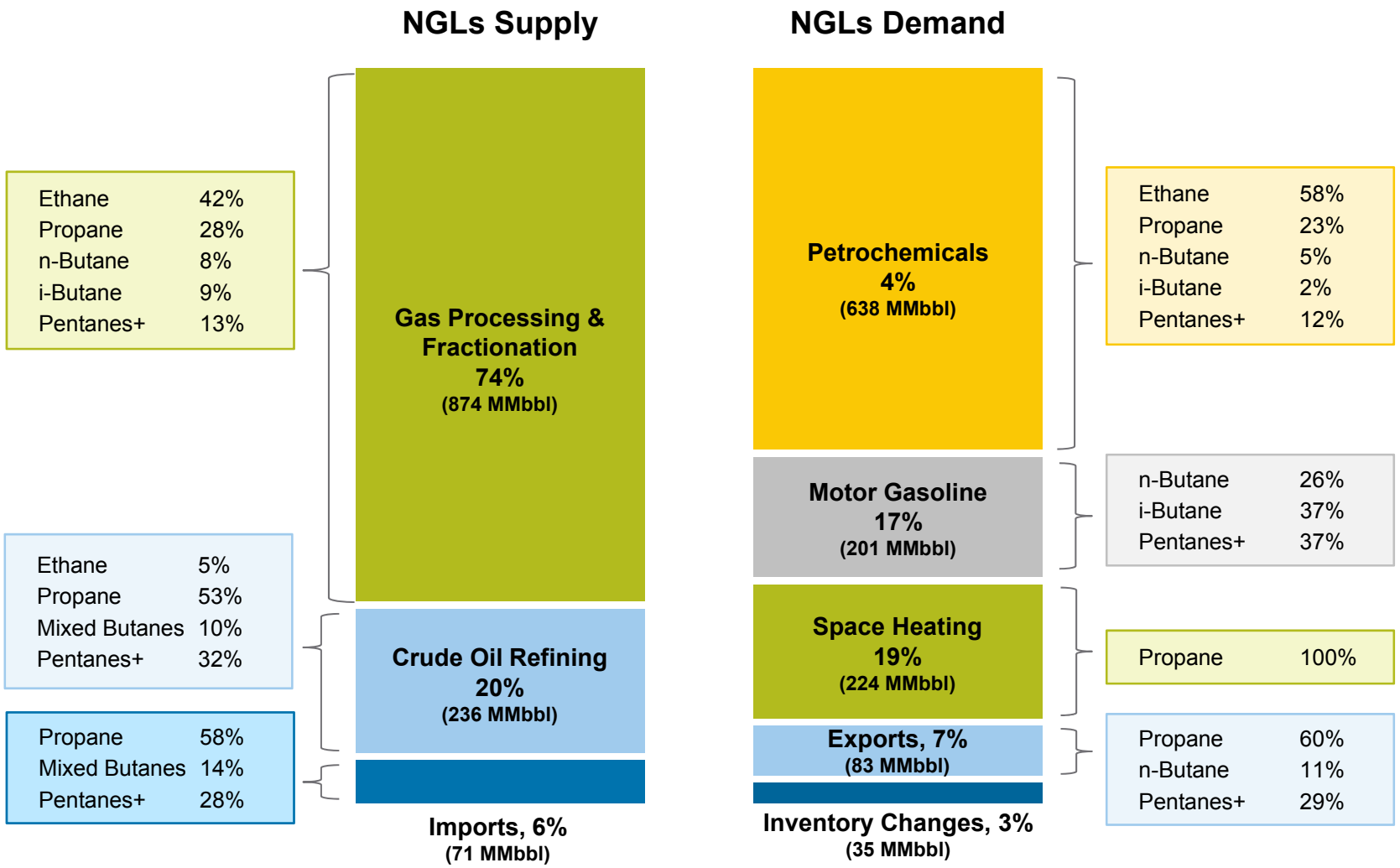
API Report's Assumptions and Findings

- The API report asserts that the additional gas production required to support LNG exports will increase natural gas liquids (NGLs) production, particularly ethane and propane (we agree with this assessment).
- The API report then contends that the higher ethane and propane production will increase ethylene, polyethylene, propylene, and polypropylene capacity above a non-export scenario. This is based on the following assumptions:
  - Exports will induce little demand destruction as the supply curve used in the API report is low and flat.
  - 100% of the incremental ethane production will be directed towards ethylene/polyethylene production; 25% of the incremental propane production will be directed towards propylene/polypropylene production.
- The API report concludes that increased supply of ethane and propane due to LNG exports will add $1.8 to $7.4 billion in GDP relative to a non-export case.

Our Findings

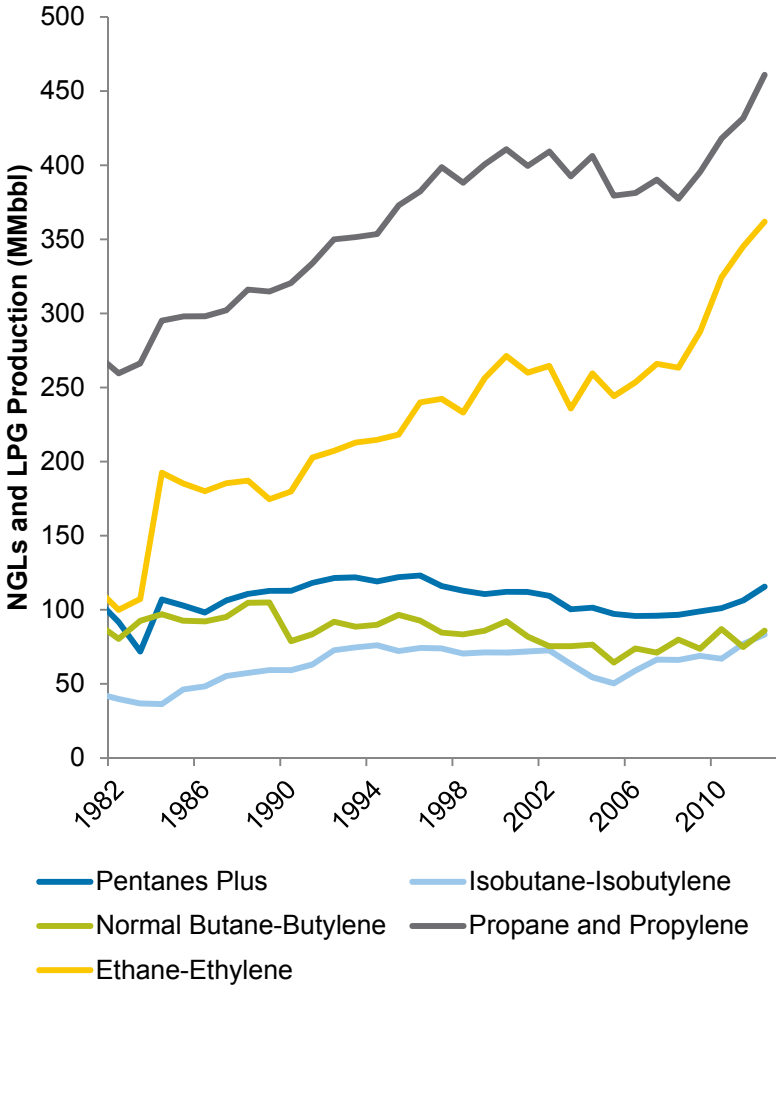
- The API report's conclusion relies primarily on its optimistic supply curve, which allows for natural gas exports with much consequential demand destruction from other sectors (the optimism of the ICF supply curve is addressed in Section 1).
- Under the API report export scenarios, the API report projects that there will be more supply of NGLs due to higher natural gas production levels and that higher supply equates to a favorable environment for petrochemical manufacturers to make investments in capacity.
- This logic is not complete as it does not factor in the demand drivers that could impact NGL prices and thus petrochemical investment:
  - Natural gas specs of importing countries that require ethane additions to meet heat content requirements.
  - Due to the recent oversupply of gas and NGLs, there are plans to increase NGL exports by 18% of existing NGL demand.

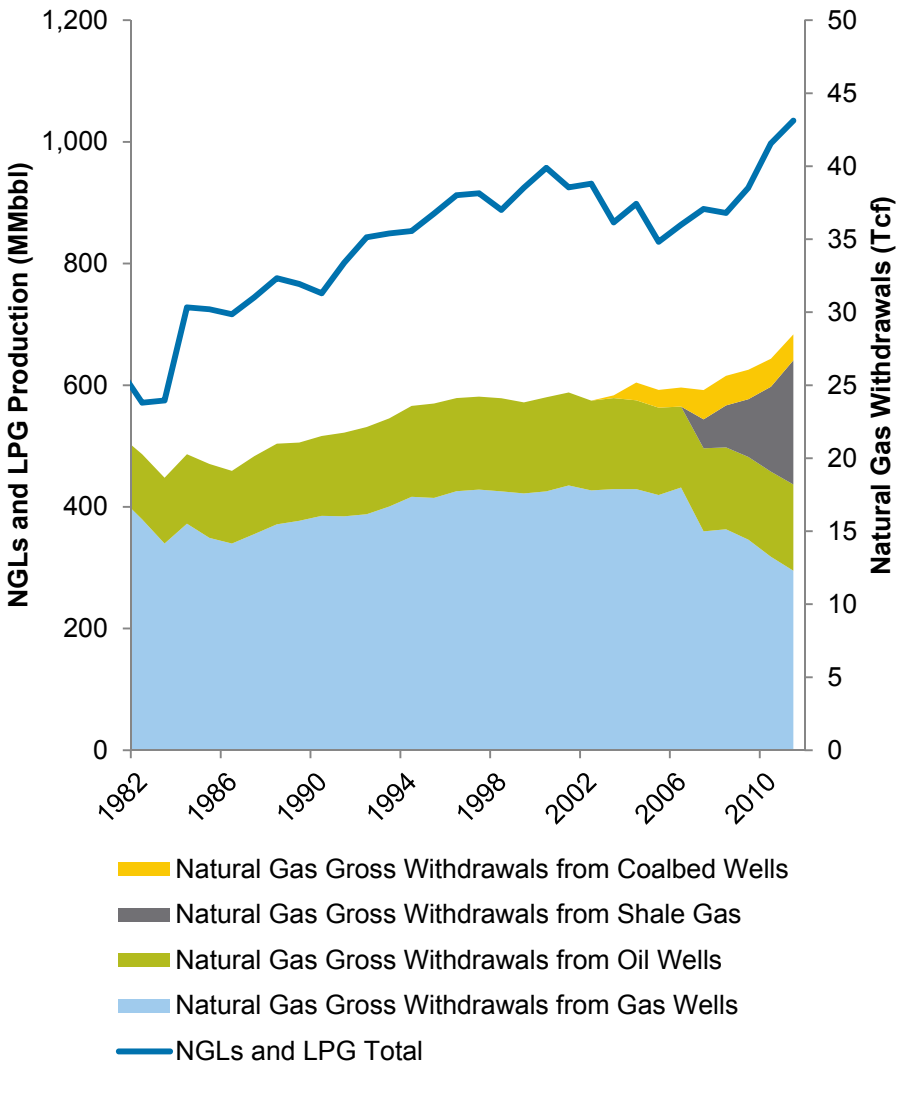
U.S. NGL Supply and Demand Balance in 2012: 1,181 million bbl market



Source: EIA Petroleum & Other Liquids Supply and Disposition, 2012; NGL101-The Basics, Midstream Energy Group, 2012

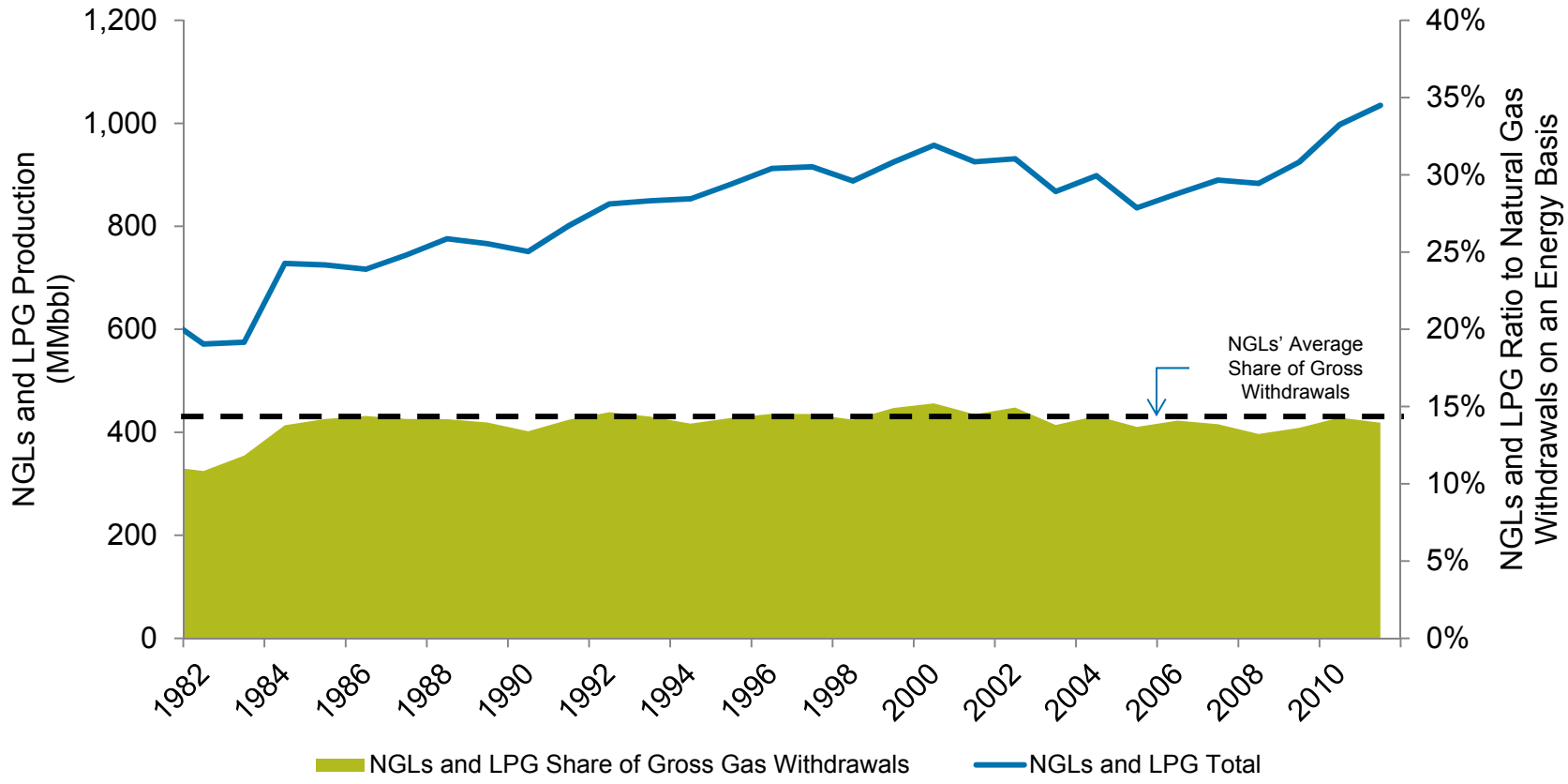
While U.S. NGL production has increased along with overall gas production…





CRA Charles River Associates

…NGLs have remained practically unchanged at 14% of gross natural gas withdrawals on an energy basis.

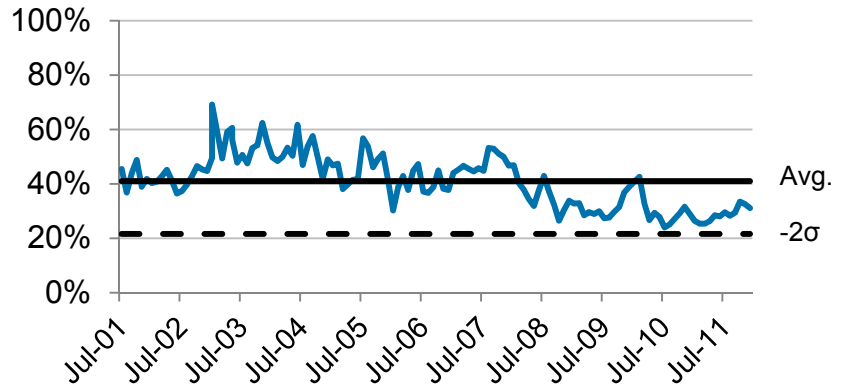


Note: NGLs/LPG total is converted to Mcfe at 3.84:1 based on propane heating value.

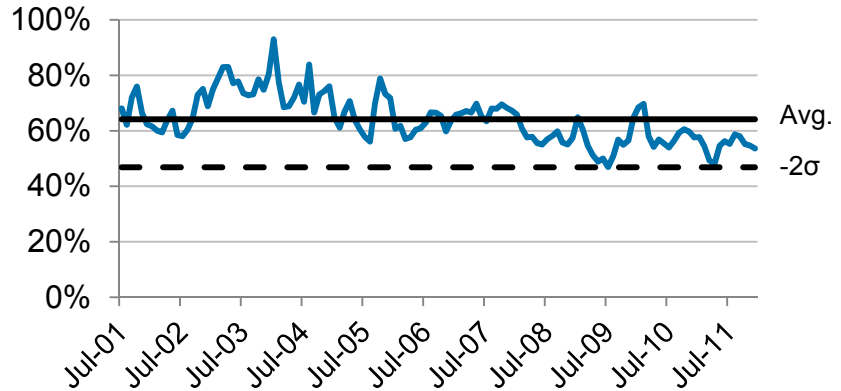
Conclusion: The degree of shale production is not expected to alter the balance of NGL and LPG production relative to total gross withdrawals.

Economic factors will make it unlikely that ethane and propane prices will remain depressed as export markets will lift prices back to historical averages.

Ethane as a % of Louisiana Light Sweet



Propane as a % of Louisiana Light Sweet



Proposed Export Projects

- New and expansion NGLs export projects on the Gulf Coast and the East Coast have already been planned to export oversupply of NGLs.
- More than 600 kbpd (219 MMbbl/y or 18% of current demand) additional export capacity is expected to be operational by 2015.(1)

Owner	Location	Product	Capacity (kbpd)	In-Service
Vitol	TX	Propane	100-200	2013
Targa Resources	TX	Propane	84	2013
Phillips66, Occidental	TX	Propane / Butane	420	2014
Sunoco	PA	Ethane / Propane	N/A	2014
Range Resources	PA	Ethane / Propane	40	2015

Footnote:
(1) The North American Gas Value Chain Development and Opportunities, Platts Special Report, September 2012; New Owners' Big Plans for Marcus Hook Refinery Site, Philly News, May 11, 2013; NGLs to be Exported to Europe from the U.S. Before LNG, Breaking Energy, April 22, 2013.

Additionally, higher heat content requirements for imported natural gas will increase ethane demand.

LNG Composition of Japanese LNG Imports

Plant	Location	C1 Methane	C2 Ethane	C3 Propane	C4 Butane	N2 Nitrogen	Wobbe (MJ/m^3)
GL4Z	Algeria	87.2	8.8	2.1	0.7	1.3	52.3
GL1Z	Algeria	87.4	8.2	1.9	0.7	1.8	51.76
GL2Z	Algeria	91.0	7.6	0.5	0.0	0.8	51.6
GL1K	Algeria	91.0	6.7	0.6	0.2	1.5	51.1
Marsa El Brega	Libya	83.7	11.7	3.5	0.3	0.8	53.3
Nigeria LNG	Nigeria	87.9	5.5	4.0	2.5	0.1	53.9
NW Shelf	Australia	89.0	7.3	2.5	1.0	0.2	53.0
Brunei LNG	Brunei	89.4	6.3	2.8	1.3	0.2	53.1
PT Badak LNG	Indonesia	91.2	5.5	2.4	0.9	0.0	52.7
Arun LNG	Indonesia	88.5	8.4	1.6	1.6	0.0	53.2
MLNG	Malaysia	91.4	4.3	3.0	1.4	0.0	53.0
Atlantic LNG	Trinidad	95.0	4.6	0.4	0.0	0.0	51.6
Oman LNG	Oman	90.0	6.4	0.2	2.5	1.0	52.3
RASGAS	Qatar	89.6	6.3	2.2	1.1	0.8	52.6
ADGAS	U.A.E.	84.0	14.0	1.0	0.9	0.1	53.5
Kenai LNG	Alaska	99.8	0.1	0	0	0.1	51.7

Source: Public data, CRA Analysis
Note: Totals do not equal 100 due to rounding

- For U.S. pipeline quality gas to conform with Japanese heat content standards, ethane and possibly some propane will need to be added to the LNG at the U.S. terminal or at the regasification facility in Japan.
- If NGLs are to be added at the U.S. terminal, the requirements would translate to ~100 MMbbl annually in additional NGL demand (9% of current NGL demand), assuming 10 Bcf/d of exports.