NERA
ECONOMIC CONSULTING

U.S. LNG Exports – Prospects and Implications

Sugandha D. Tuladhar

NERA Economic Consulting

EPRI Annual Energy and Climate Seminar
Washington, DC

May 21 - 22, 2013

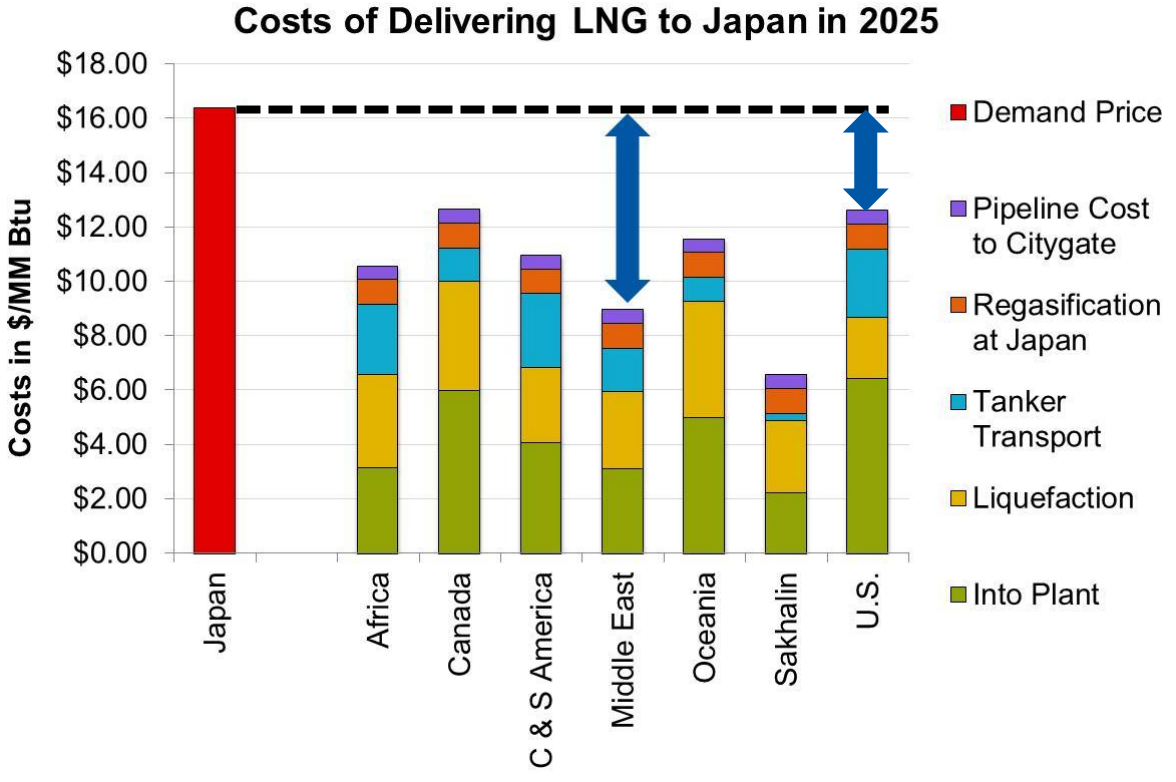
Insight in Economics™

Agenda

NERA
ECONOMIC CONSULTING

- Why such interest in LNG exports?
- Overview of the NERA Study.
- How did we conduct the NERA Study?
- Discussion of results.

LNG Interests driven by Potential Profits



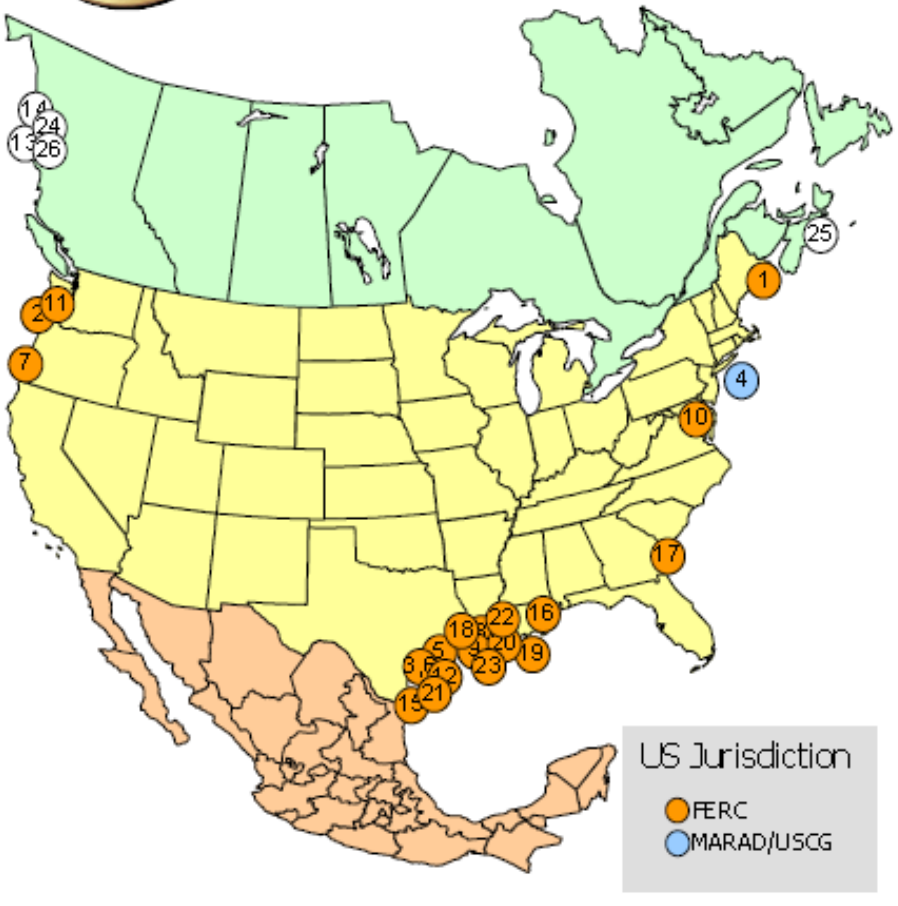
- The difference between the cumulative costs and the landed price is the profit that is motivating exporters
- How long is it sustainable with all these competitors?
- An important issue today is who keeps the profit?
- An important question for tomorrow is will profits continue to exist? or will it be bid away?

Proposed LNG Projects in North America

NERA ECONOMIC CONSULTING

North American LNG Import/Export Terminals

Proposed/Potential



Import Terminal

PROPOSED TO FERC

1. **Robbinston, ME:** 0.5 Bcfd (Kestrel Energy - Downeast LNG)
2. **Astoria, OR:** 1.5 Bcfd (Oregon LNG)
3. **Corpus Christi, TX:** 0.4 Bcfd (Cheniere – Corpus Christi LNG)

POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS

4. **Offshore New York:** 0.4 Bcfd (Liberty Natural Gas)

Export Terminal

PROPOSED TO FERC

5. **Freeport, TX:** 1.8 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction)
6. **Corpus Christi, TX:** 2.1 Bcfd (Cheniere – Corpus Christi LNG)
7. **Coos Bay, OR:** 0.9 Bcfd (Jordan Cove Energy Project)
8. **Lake Charles, LA:** 2.4 Bcfd (Southern Union - Trunkline LNG)
9. **Hackberry, LA:** 1.7 Bcfd (Sempra – Cameron LNG)
10. **Cove Point, MD:** 0.75 Bcfd (Dominion – Cove Point LNG)
11. **Astoria, OR:** 1.30 Bcfd (Oregon LNG)
12. **Lavaca Bay, TX:** 1.38 Bcfd (Excelerate Liquefaction)

PROPOSED CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

13. **Kitimat, BC:** 0.7 Bcfd (Apache Canada Ltd.)
14. **Douglas Island, BC:** 0.25 Bcfd (BC LNG Export Cooperative)

POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS

15. **Brownsville, TX:** 2.8 Bcfd (Gulf Coast LNG Export)
16. **Pascagoula, MS:** 1.5 Bcfd (Gulf LNG Liquefaction)
17. **Elba Island, GA:** 0.5 Bcfd (Southern LNG Company)
18. **Sabine Pass, TX:** 2.6 Bcfd (ExxonMobil – Golden Pass)
19. **Plaquemines Parish, LA:** 1.07 Bcfd (CE FLNG)
20. **Cameron Parish, LA:** 0.16 Bcfd (Waller LNG Services)
21. **Ingleside, TX:** 1.09 Bcfd (Pangea LNG (North America))
22. **Lake Charles, LA:** 0.54 Bcfd (Magnolia LNG)
23. **Cameron Parish, LA:** 0.20 Bcfd (Gasfin Development)

POTENTIAL CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS

24. **Prince Rupert Island, BC:** 1.0 Bcfd (Shell Canada)
25. **Goldboro, NS:** 0.67 Bcfd (Pieridae Energy Canada)
26. **Kitimat, BC:** 2.0 Bcfd (LNG Canada)

As of February 21, 2013

Office of Energy Projects

Problem Statement

NERA
ECONOMIC CONSULTING

- Under NGA section 3(c), the import and export of natural gas, including LNG, from and to a nation with which there is in effect an FTA requiring national treatment for trade in natural gas and the import of LNG from other international sources are deemed to be consistent with the public interest and must be granted without modification or delay.
- Exports of LNG to non-FTA countries require a DOE/FE review.

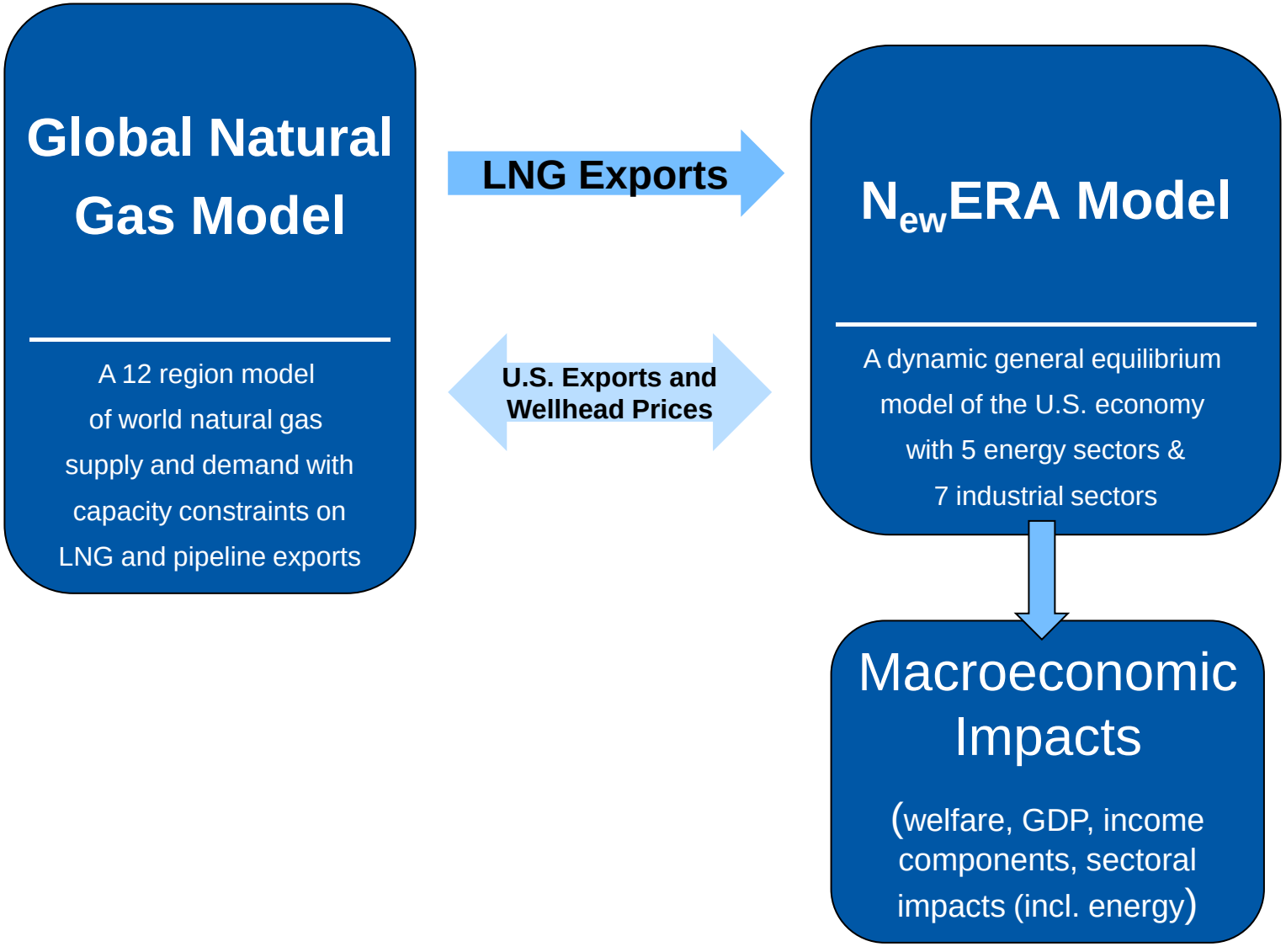
Overview of the NERA Study

NERA
ECONOMIC CONSULTING

- Commissioned by DOE/FE to build on an earlier EIA study.
- Started with the EIA Study:
  - LNG export levels were specified by DOE/FE
  - Used the *AEO 2011* National Energy Modeling System ("NEMS").
  - Determined change in U.S. natural gas:
    - Prices
    - Supply/Demand
- NERA study added:
  - International natural gas market factors that influence export volumes and the prices at which they can be sold
  - Macroeconomic impacts on the U.S. economy from LNG export expansion

NERA's Suite of Models Represents Dynamics of International and Domestic Natural Gas Markets

NERA
ECONOMIC CONSULTING



Key Assumptions about Liquefaction Plant

NERA ECONOMIC CONSULTING

- Liquefaction plants are owned and operated by a domestic firm.
  - Investment in liquefaction plant is domestically financed so that there is some crowding out of capital and some reduction in consumption.
  - Assumed investment cost of $4.5 billion for each billion cubic feet (Bcf) a day of incremental capacity.
  - 10% of the natural gas feedstock to the liquefaction plant is consumed internally.
- Liquefaction capacity is built for the maximum level of exports.
  - If the export level drops, the plant is underutilized but still collects tolling charges.
- U.S. gas producers receive wealth transfer from foreign sources to cover:
  - “pay-or-take” tolling charges of $2.50 per Million Btu of the exported volumes net of natural gas loss in liquefaction process.
  - 15% of the Henry Hub price for exported volumes.
- U.S. does not capture additional quota rents in the core scenarios.

Dimensions of the Natural Gas Market Dynamics in the Modeling Framework

NERA ECONOMIC CONSULTING

- 3 U.S. Resource Outlooks:
  - AEO 2011 Reference case (**REF**)
  - AEO 2011 High shale EUR (**HEUR**)
  - AEO 2011 Low shale EUR (**LEUR**)
- 3 International Natural Gas Market Outlooks:
  - International Reference case defined by IEO 2011 (**REF**)
  - Demand Shock (**D**): Far East retires nuclear capacity and is replaced by natural gas fired generation
  - Supply-Demand Shock (**SD**): Assumes that there no new builds of Liquefaction or export capacity in Southeast Asia, Oceania, Africa and Demand (**D**) shock
- 7 LNG export limits
  - No quota (no exports), low/slow (**LS**), low/rapid (**LR**), high/slow (**HS**), high/rapid (**HR**), low/slowest (**LSS**), and unconstrained.

13 Export Levels Were Chosen From 63 Possible Scenarios

NERA ECONOMIC CONSULTING

63 GNGM Scenarios

13 Macroeconomic Scenarios

U.S.	REF		HEUR	LEUR
International	Demand (D)	Supply/Demand (SD)	Supply/Demand (SD)	Supply/Demand (SD)
Export Volume/pace				
Low/Slow	**USREF_D_LS**	*USREF_SD_LS*	*HEUR_SD_LS*	
Low/Rapid	**USREF_D_LR**	*USREF_SD_LR*	*HEUR_SD_LR*	
High/Slow		**USREF_SD_HS**	*HEUR_SD_HS*	
High/Rapid		**USREF_SD_HR**	*HEUR_SD_HR*	
Slowest	**USREF_D_LSS**		*HEUR_SD_LSS*	*LEUR_SD_LSS*

scenarios in *italics* are at DOE/FE defined export volumes
scenarios in **bold** are NERA determined export volumes

Key Findings From the NERA Study

NERA
ECONOMIC CONSULTING

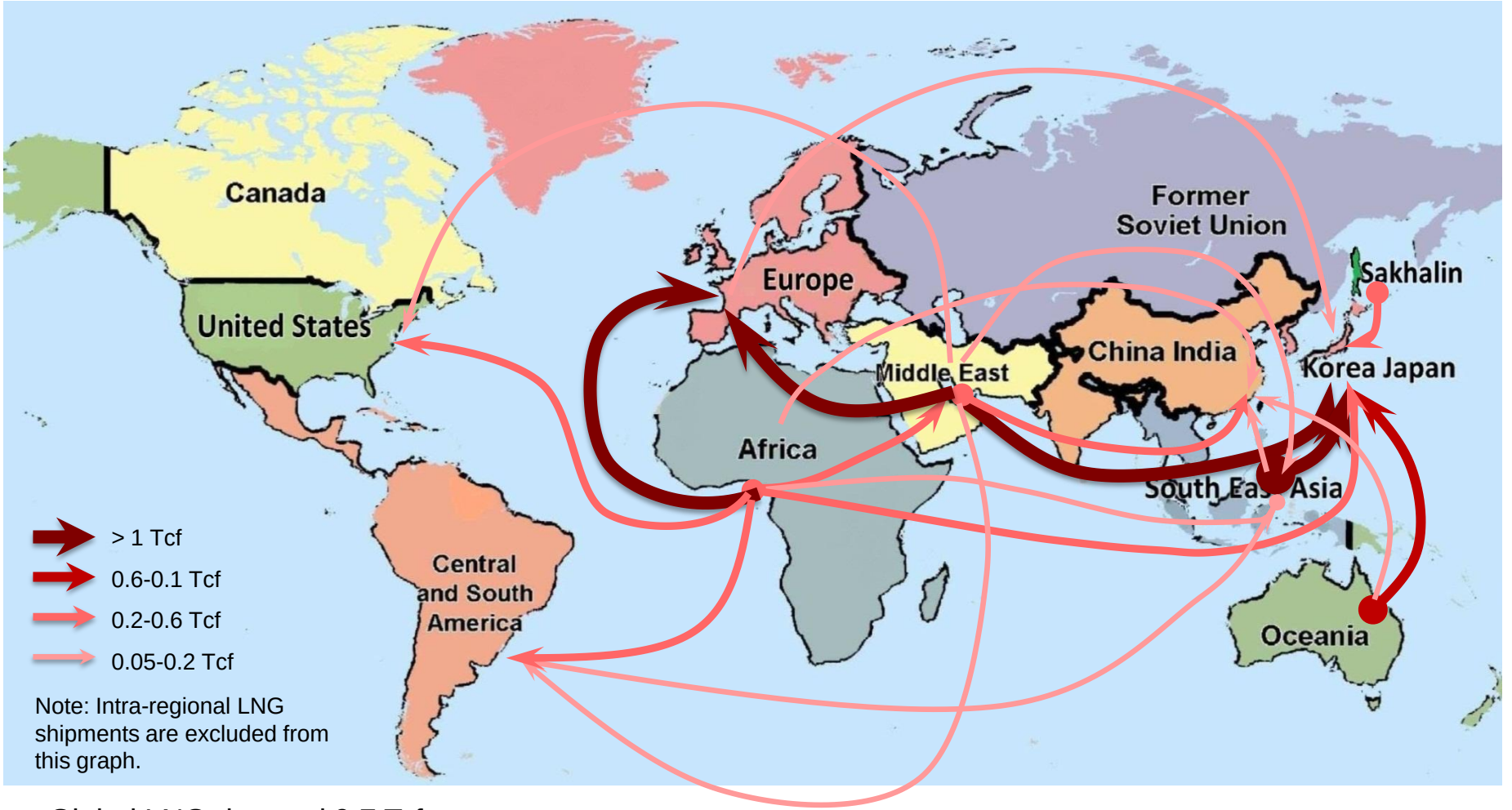
- LNG export levels depend upon natural gas market dynamics.
- LNG exports would provide a small but positive net economic benefit
- Net benefit is positive in all scenarios.
- Net economic benefits increase as the level of LNG exports increased.
- Increases in natural gas price attributable to LNG exports remain in a relatively narrow range across the entire range of scenarios.
- LNG exports are likely to have relatively small impact on the manufacturing sector.
- LNG exports are supported by a combination of increased production and economy wide demand reduction.

Baseline View: World Gas Market in Balance With No LNG Exports From the U.S.

NERA
ECONOMIC CONSULTING

- We started with the IEO 2011 view that there are no lower 48 LNG exports
- With this view of the world, conditions are not favorable for U.S. lower 48 LNG exports to displace other projects
  - LNG from North America would not displace existing or under construction projects in other parts of the world

LNG Flows in 2010

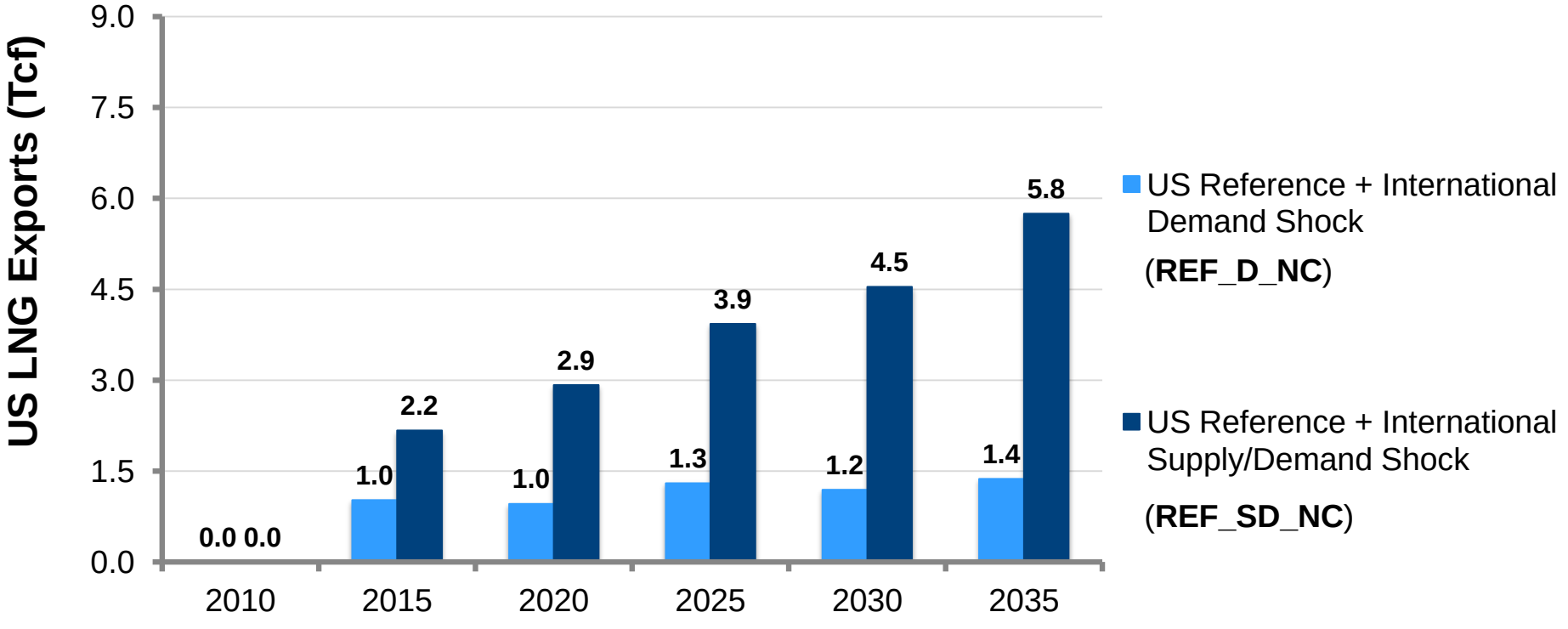


Global LNG demand 9.7 Tcf
Global natural gas demand 113 Tcf

International Shocks Open Opportunity For the U.S.

NERA ECONOMIC CONSULTING

- Either greater world demand (**D**) or/and less world supply (**S**) creates an economic opportunity for U.S. lower 48 to export LNG.
- If LNG exports are unrestricted, U.S. could cost-effectively export 1.4 to 5.8 tcf by 2035.

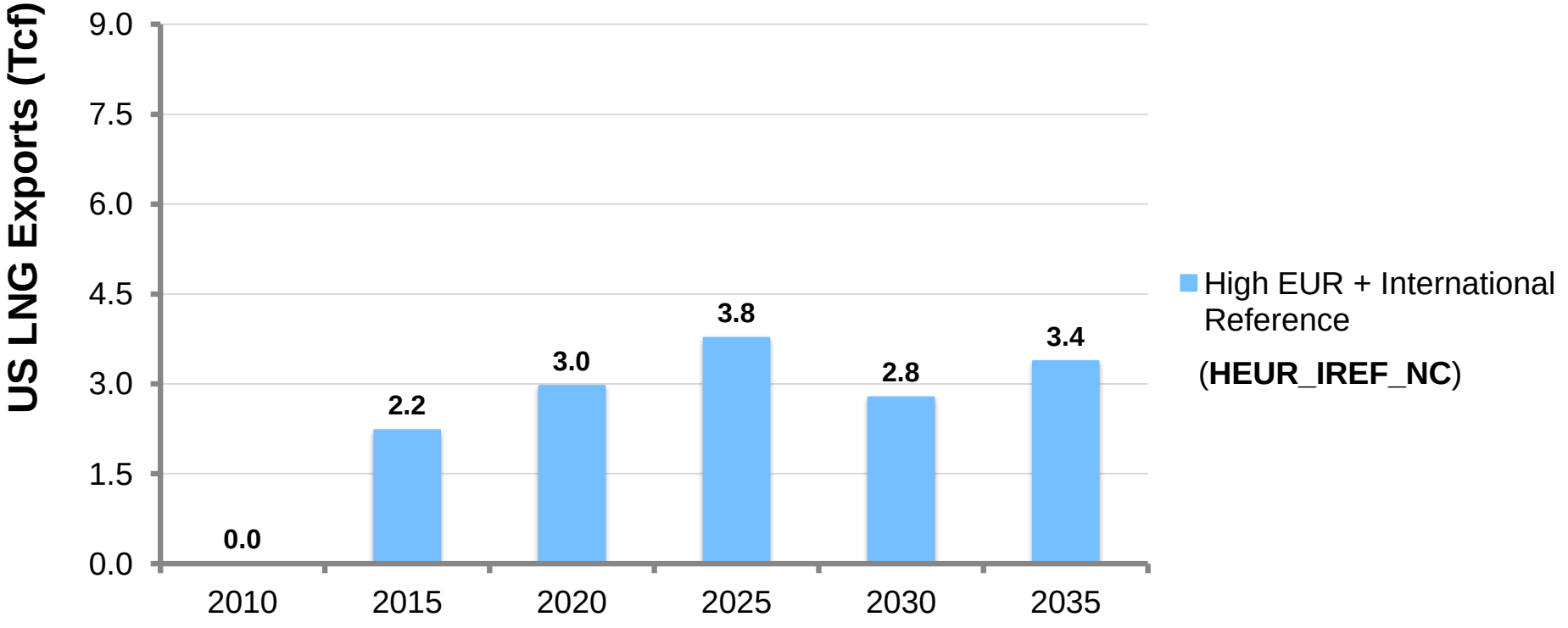


Abundant natural gas leads to more LNG exports

NERA ECONOMIC CONSULTING

- Similarly should U.S. shale gas prove more abundant than in the Reference case, then the U.S. Lower 48 would export LNG.

- If LNG exports are unrestricted and natural gas abundant, U.S. could export 3.4 tcf by 2035 without any supply and demand shocks.

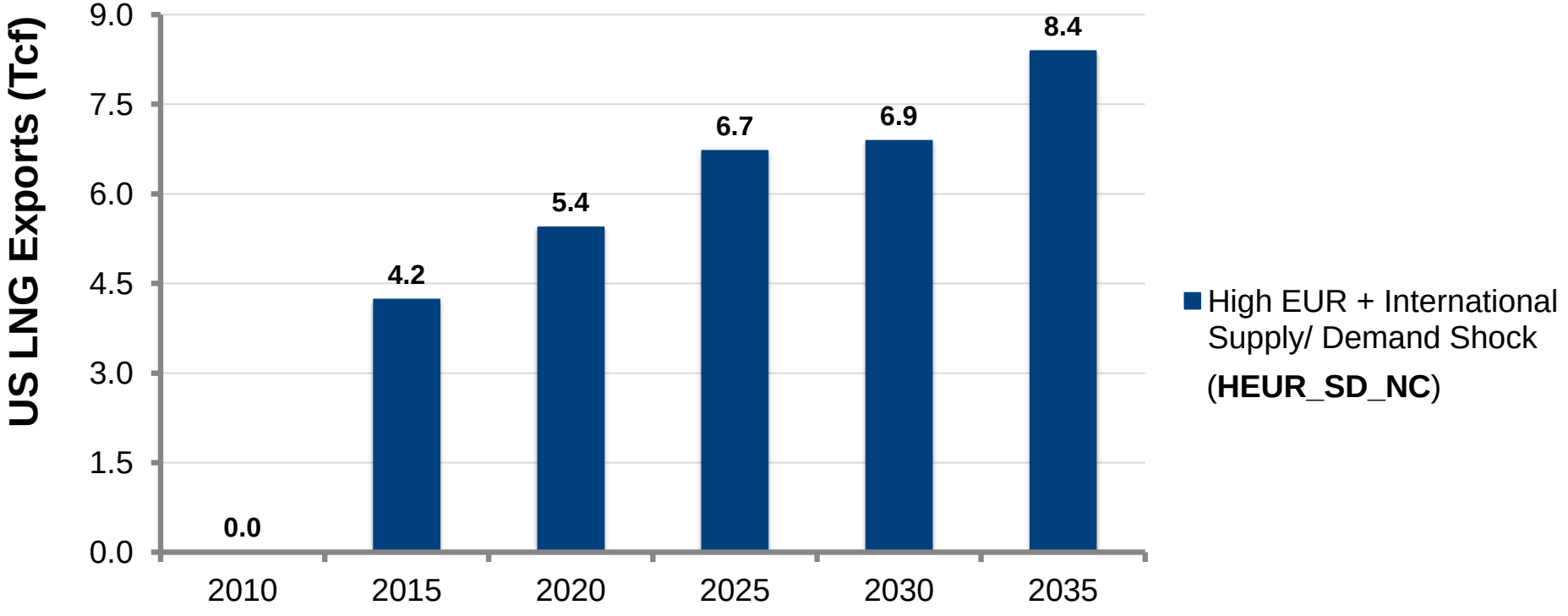


Export Level Rises Even More If There Is International Demand-Push or Supply-Pull

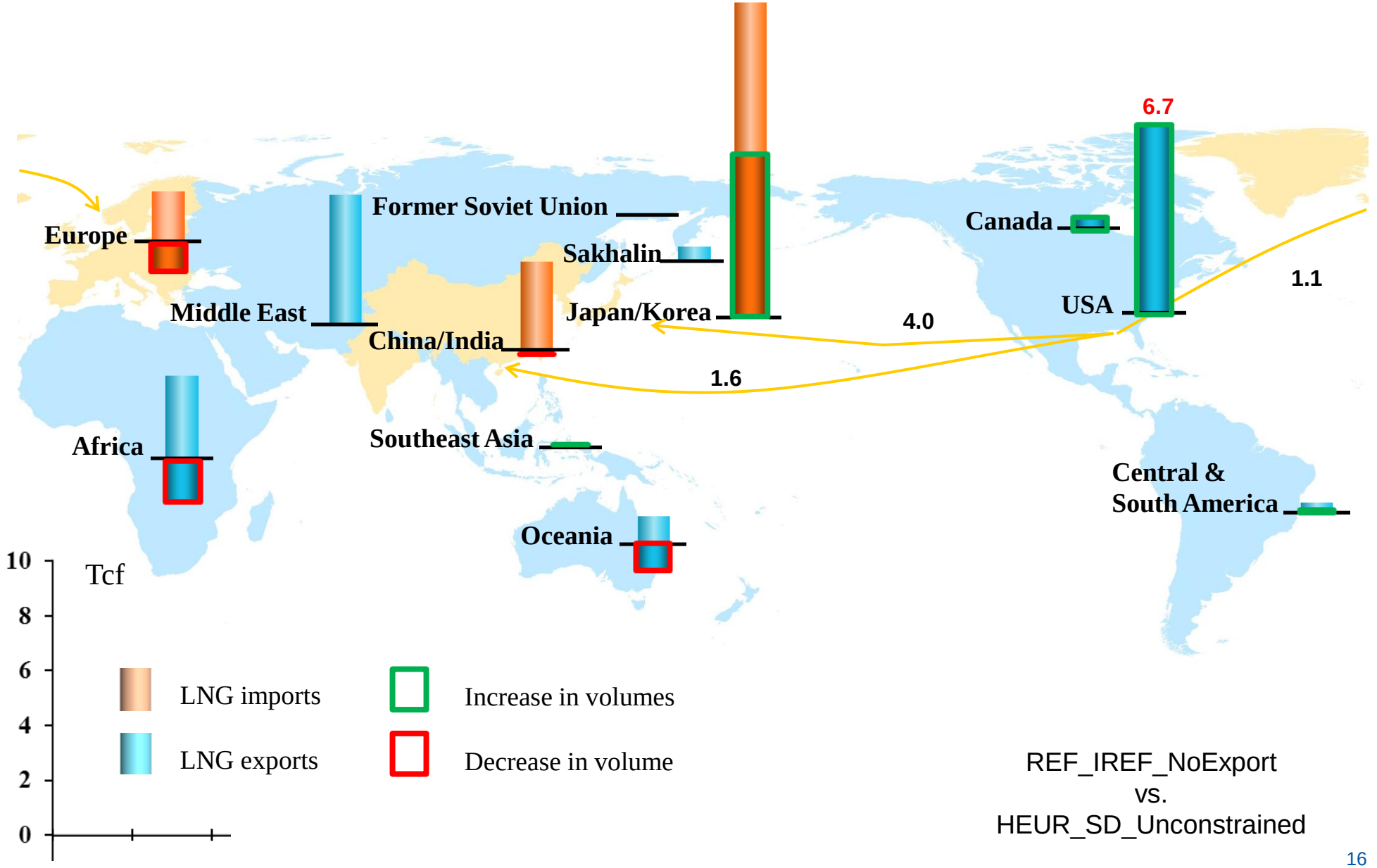
NERA ECONOMIC CONSULTING

- Abundant U.S. shale gas (**HEUR**) and greater world demand with lower international supply (**SD**) would result in even greater U.S. LNG exports

- If LNG exports are unrestricted, U.S. could export 8.4 tcf by 2035 (2.6 tcf more than the U.S. REF case)



Changes in Regional LNG Supply/Demand in 2025 (Tcf)

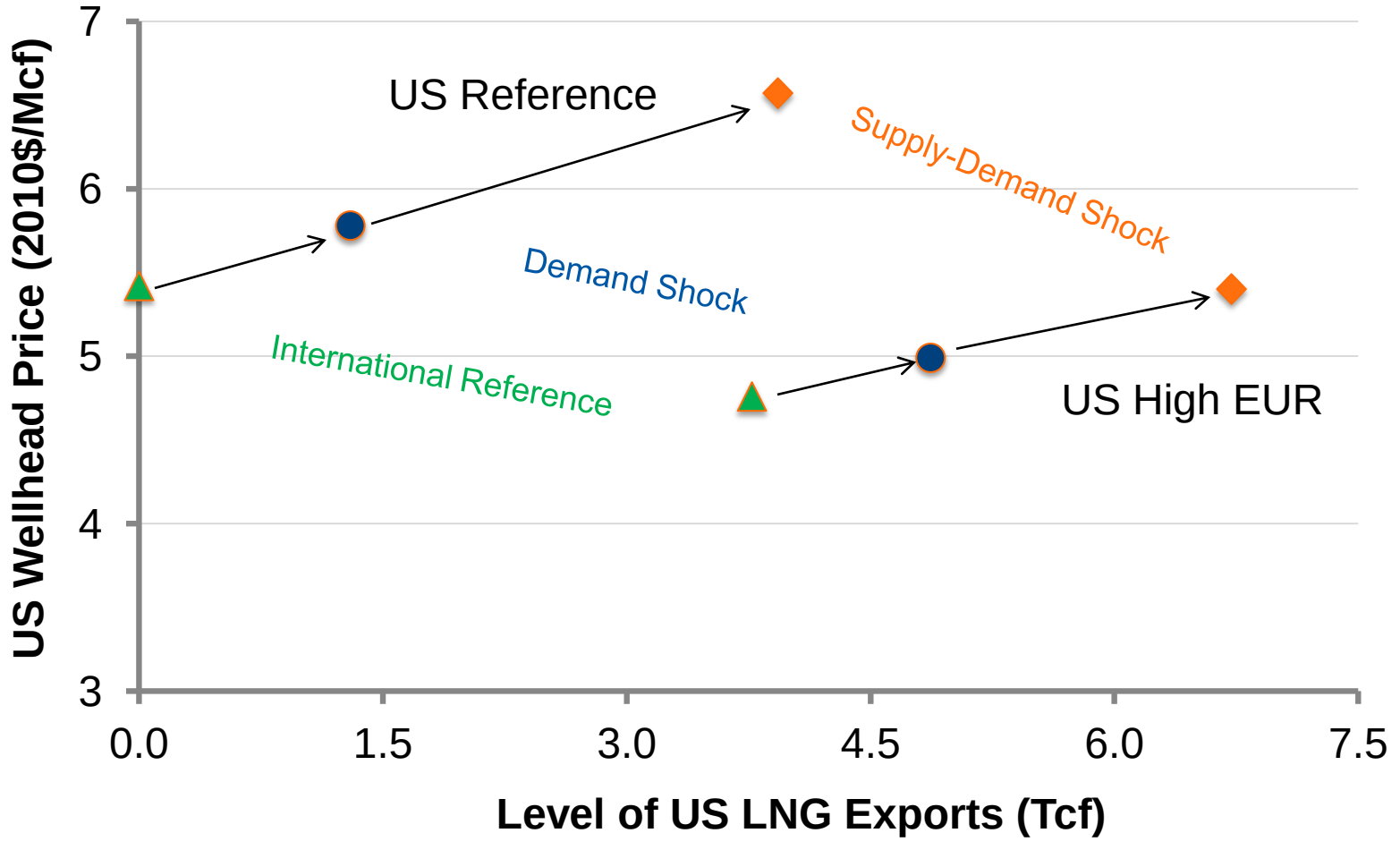


REF_IREF_NoExport
vs.
HEUR_SD_Unconstrained

Natural Gas Prices Rise With Increase in LNG Exports

NERA ECONOMIC CONSULTING

Wellhead Price vs. U.S. Export Levels (2025)



Change in Natural Gas Prices are Modest ($ per MM Btu)

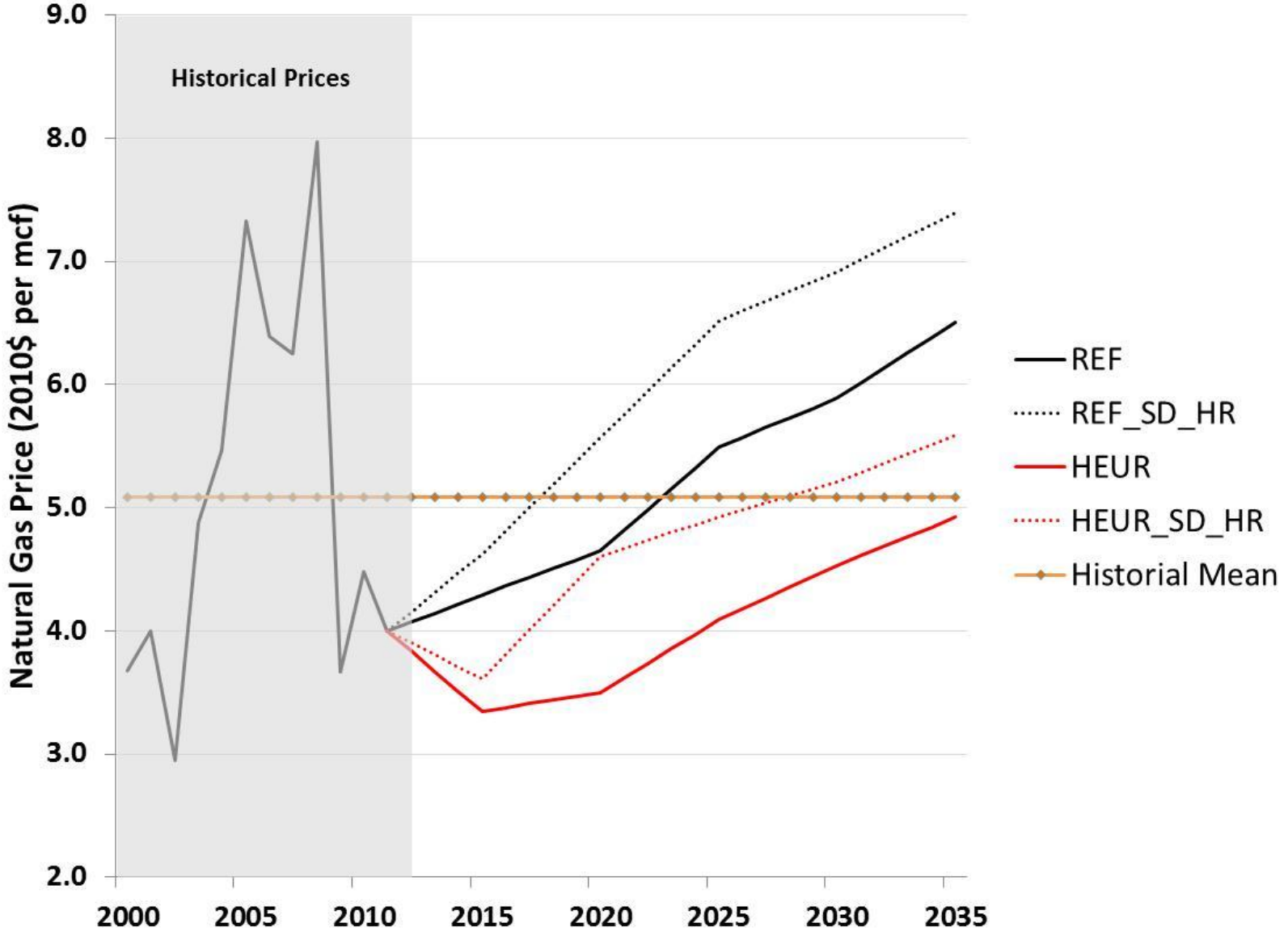
NERA ECONOMIC CONSULTING

	2015	2020	2025	2030	2035
HEUR_SD_HR	0.26	1.07	0.81	0.66	0.65
HEUR_SD_HS	0.08	0.46	0.73	0.66	0.65
HEUR_SD_LR	0.26	0.46	0.36	0.30	0.30
HEUR_SD_LS	0.08	0.46	0.36	0.30	0.30
HEUR_SD_LSS	0.04	0.21	0.33	0.30	0.30
USREF_SD_LR	0.32	0.63	0.50	0.45	0.40
USREF_SD_LS	0.10	0.63	0.50	0.45	0.40
USREF_SD_HR	0.32	0.89	0.99	1.00	0.87
USREF_SD_HS	0.10	0.63	0.99	1.00	0.87
USREF_D_LR	0.30	0.26	0.32	0.24	0.24
USREF_D_LS	0.10	0.26	0.32	0.24	0.24
USREF_D_LSS	0.05	0.26	0.32	0.24	0.24
LEUR_SD_LSS	-	0.36	0.21	-	0.04

Change in natural gas price is less than approximately $1 per MMBtu

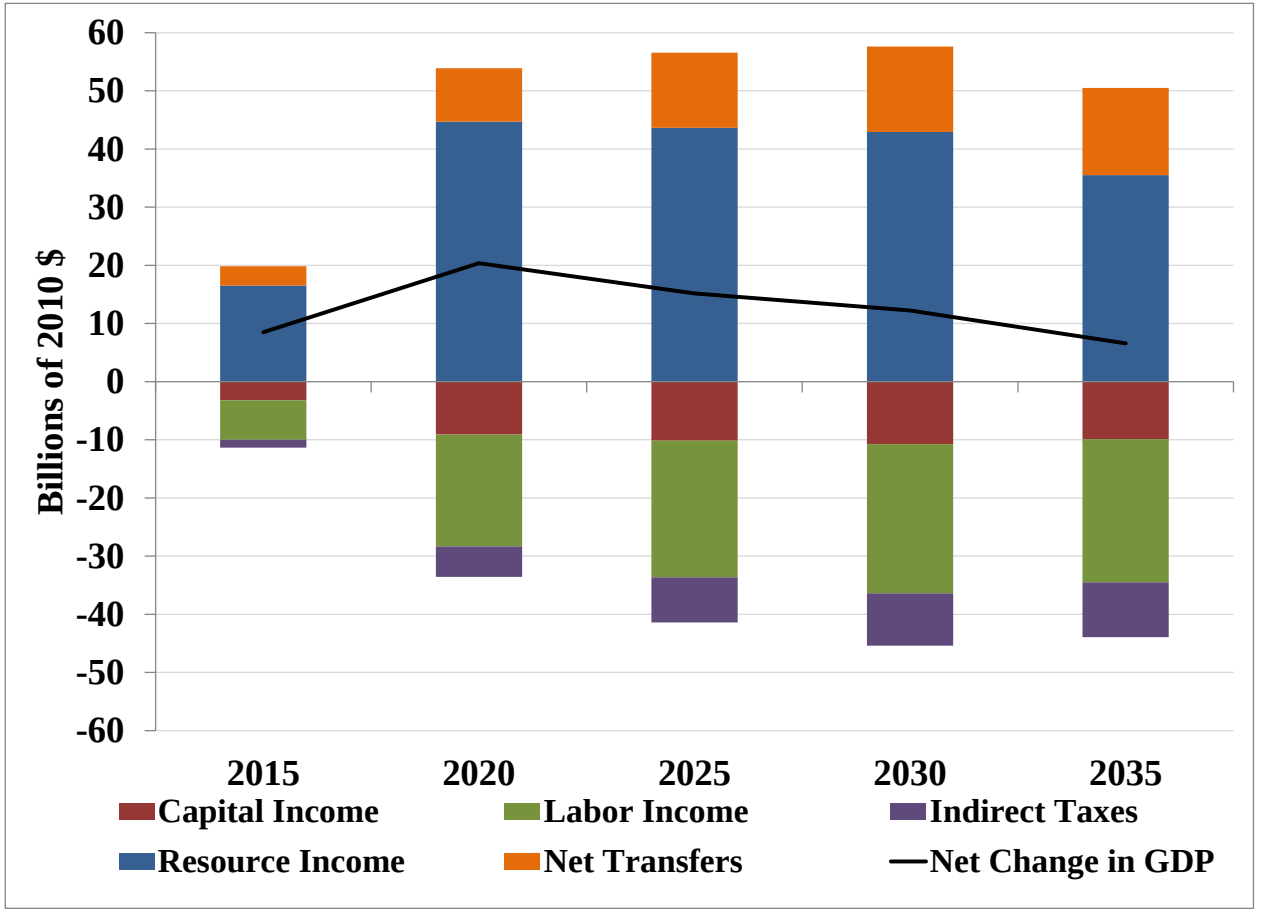
Rise in Natural Gas Prices Are Modest Relative to Historical Volatility

NERA
ECONOMIC CONSULTING



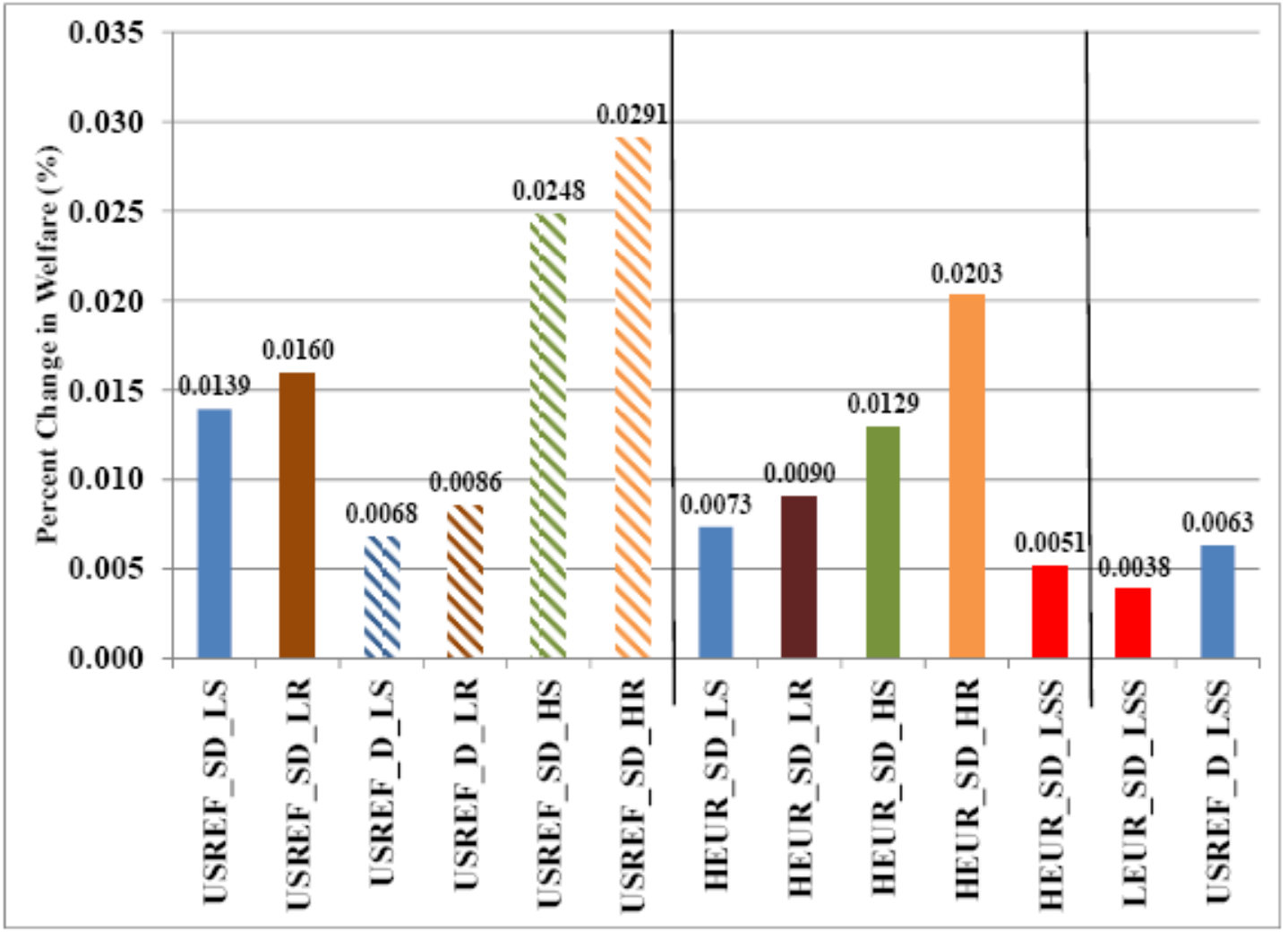
LNG Exports Cause Shift in Resource, Capital, and Wage Income

NERA ECONOMIC CONSULTING



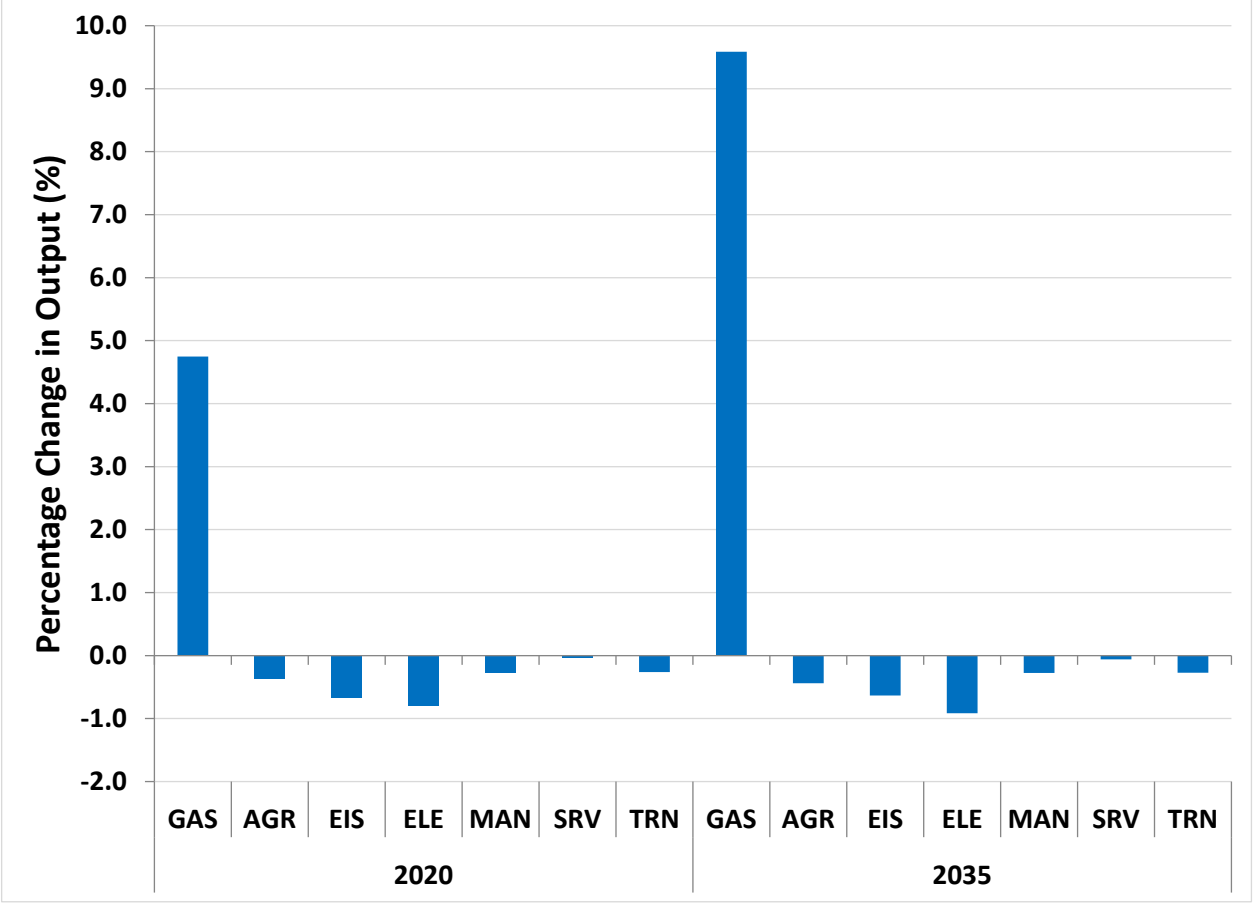
- USREF_SD_HR
- GDP increases in all years.
- Labor and investment income decline
- Increase in resource income to natural gas producers and property owners and net transfers that represent that improvement in the U.S. trade balance due to exporting a more valuable product (natural gas).
- The net effects are positive but, on the scale of the entire economy, they are very small

Consumer Well-being Improves in All Scenarios



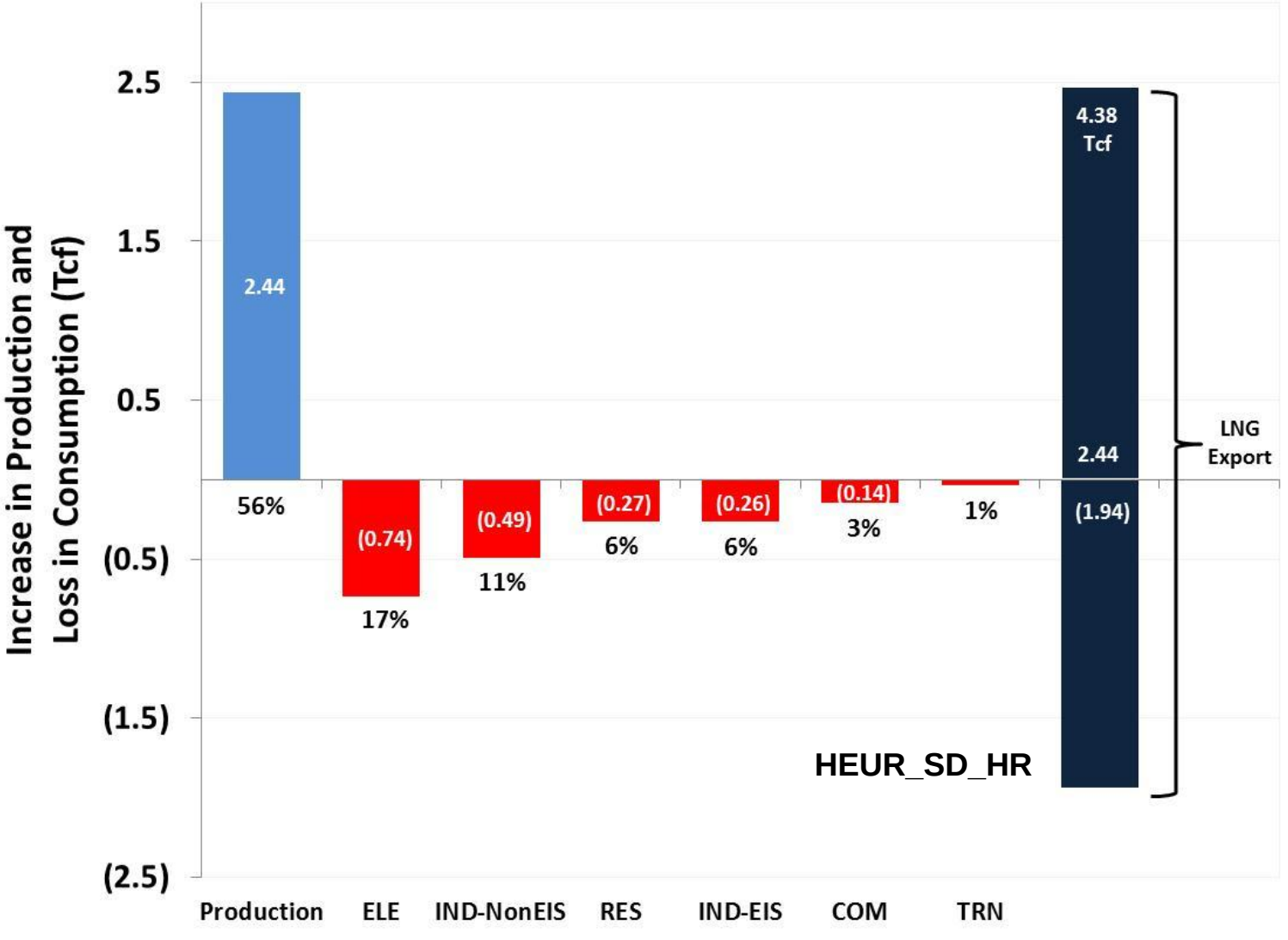
Cross-hatch indicates that exports are below maximum permitted levels

Industrial Impacts are relatively small



- USREF_SD_HR
- Higher natural gas prices can have negative effects on industrial output and employment, particularly in sectors that use natural gas intensively.
- Even in the year of peak natural gas price impacts, the largest change in wage income by industry is no more than 1%.
- Assuming this decline were attributable to lower employment relative to the baseline, no sector analyzed in this study experiences reductions in employment more rapidly than normal turnover

Makeup of LNG Exports in 2035



Comments on NERA's Study: DOE Website Activity

NERA
ECONOMIC CONSULTING

- "The data cover the timeframe of Wednesday, December 5th through Sunday, December 9th. The report had **351,593 hits**. It was the most frequented link on our site for that time period."

- DOE/FE received over 188,000 initial comments and over 2,700 reply comments.

- Of these, approximately 800 were unique comments.

DOE Granted Freeport LNG Export License on May 17, 2013 – DOE/FE Order 3882

NERA ECONOMIC CONSULTING

- DOE/FE issue a conditional order approving export authorization pending satisfactory completion of the environmental review.
  - '*We have reviewed the evidence in the record and have not found adequate basis to conclude that the export of LNG by FLEX will be inconsistent with the public interest. To the contrary, the best available evidence supports the conclusion that FLEX's proposed exports will benefit the U.S. economy overall and are consistent with the public interest.*'"
- Freeport will supply mainly Japanese customers under tolling agreement
  - Accepted NERA findings on net benefits, lack of demonstrated harm to manufacturing, likely reduction of price volatility, and magnitude of price impacts
- Affirmed policy positions on market choice, preference for free trade, agency for exporters, and that net benefits matter.
- Made no general policy statement on approvals, will re-examine public interest based on future market conditions and cumulative exports

Why Is Any of This Controversial?

NERA ECONOMIC CONSULTING

- Conclusions about net benefits of trade
  - Do not depend on the energy intensity or growth rate of manufacturing
  - Do not depend on the natural gas baseline forecast
  - Do not depend on the level of industry detail
  - Do not even depend on the level of exports that comes out of letting supply and demand work
- They do depend on
  - Understanding comparative advantage
  - Understanding how a dynamic economy grows
  - Understanding the difference between cost and value

In Conclusion

NERA
ECONOMIC CONSULTING

- With unrestricted exports, markets will determine whether
  - natural gas contributes more as an export item or
  - as a domestic raw material.
- It will remain both.
- But, export restrictions will destroy gains to the U.S. economy.

NERA
ECONOMIC CONSULTING

Thank you!

Sugandha D. Tuladhar

Senior Consultant
NERA—Washington D.C.
Work: 202 466 9206
Sugandha.Tuladhar@nera.com

Additional Slides

NERA
ECONOMIC CONSULTING

NERA's N$_{ew}$ERA Model

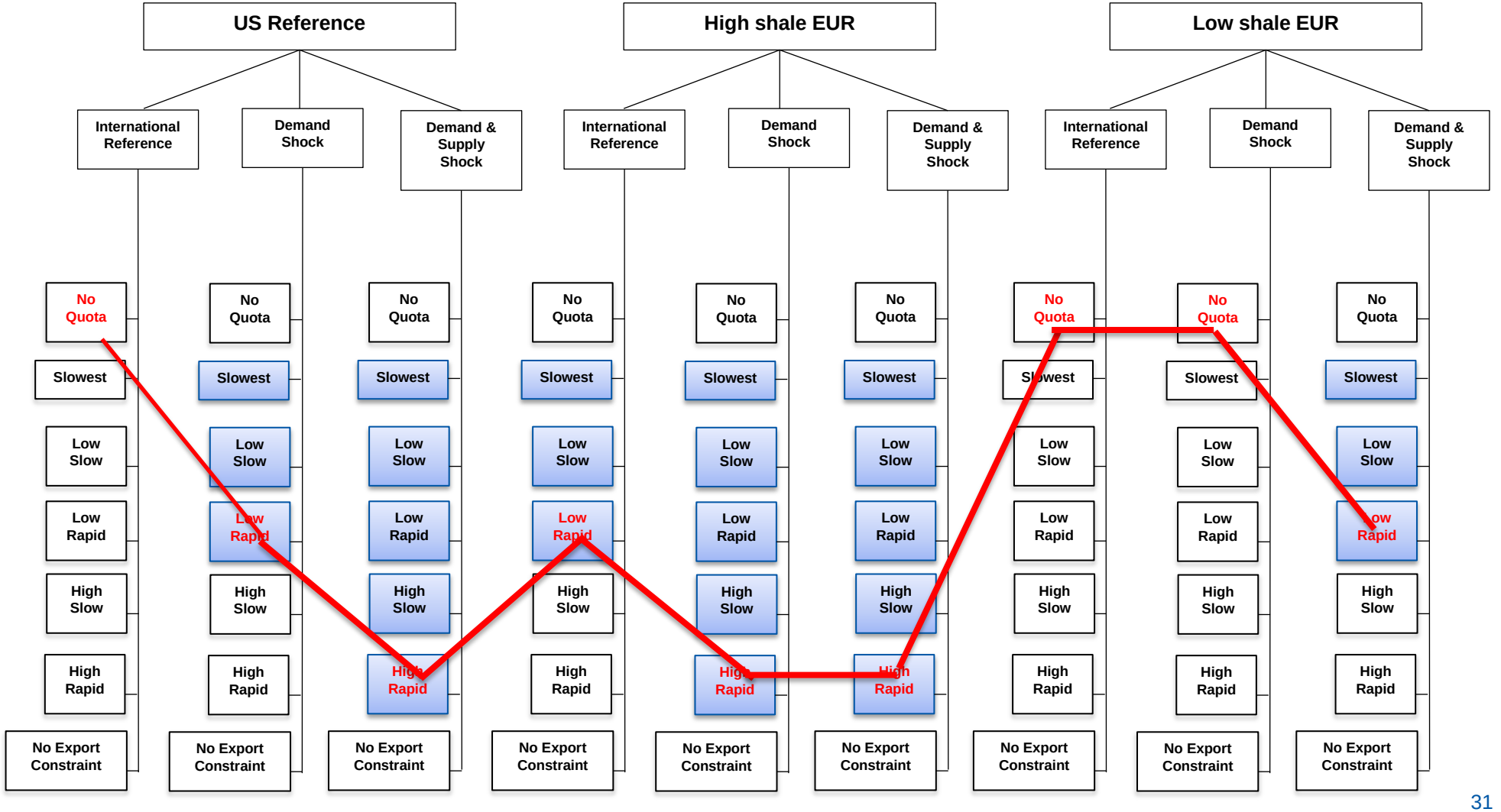
NERA ECONOMIC CONSULTING

- Computable general equilibrium model of the U.S. economy
- The model includes three different types of interacting agents
  - 12 economic sectors including an electricity sector
  - a representative household, and
  - a government (state and federal)
- Agents and markets in the economy interact with perfect foresight till all markets clear (supply equals demand), producers earn no excess profits, and income equals expenditures.
- Government maintains a balanced budget over the model horizon.

All Combinations of U.S. Resource Outlook, International Gas Outlook, and Export Quota were Initially Considered

NERA ECONOMIC CONSULTING

RED indicates maximum export level is achieved in the highlighted scenario and exports do not increase further when additional licenses are issued



13 Feasible Scenarios Were Developed for the Macro Model

NERA ECONOMIC CONSULTING

U.S. Market Outlook	Reference		High Shale EUR		Low Shale EUR	
Int'l Market Outlook	Demand Shock	Supply/ Demand Shock	Demand Shock	Supply/ Demand Shock	Demand Shock	Supply/ Demand Shock
Export Volume/ Pace	Scenario Name					
Low/Slow	**USREF_D_LS**	*USREF_SD_LS*		*HEUR_SD_LS*		
Low/Rapid	**USREF_D_LR**	*USREF_SD_LR*		*HEUR_SD_LR*		
High/Slow		**USREF_SD_HS**		*HEUR_SD_HS*		
High/Rapid		**USREF_SD_HR**		*HEUR_SD_HR*		
Low/ Slowest	**USREF_D_LSS**			*HEUR_SD_LSS*		**LEUR_SD_LSS**

Scenarios in *italics* use DOE/FE defined export volumes.

Scenarios in **bold** use NERA determined export volumes.

Rent-Seeking Behavior Does Not Promote the Common Good

NERA ECONOMIC CONSULTING

- **According to the American Chemistry Council, if the oil to gas price ratio remains above 7, US chemicals remain competitive**

Ratio of oil prices to natural gas prices

(oil price in $/Barrel and gas price in $ per MMBtu)

	2010	2015	2020	2025	2030	2035
EIA_HEUR1_HR	30.1	33.4	29.2	29.4	29.1	27.6
EIA_HEUR1_HS	30.1	35.2	33.8	29.9	29.1	27.6
EIA_HEUR1_LR	30.1	33.4	33.8	32.5	31.3	29.4
EIA_HEUR1_LS	30.1	35.2	33.8	32.5	31.3	29.4
EIA_HEUR1_LSS	30.1	35.6	36.1	32.7	31.3	29.4
EIA_LEUR_LSS	23.9	21.1	19.6	17.6	17.4	16.6
EIA_REF_LR	26.5	26.3	25.5	24.3	24.0	22.4
EIA_REF_LS	26.5	27.7	25.5	24.3	24.0	22.4
NERA_REF_HR	26.5	26.3	24.3	22.4	22.1	21.0
NERA_REF_HS	26.5	27.7	25.5	22.4	22.1	21.0
NERA_REF_LR	26.5	26.5	27.5	25.1	24.9	23.0
NERA_REF_LS	26.5	27.7	27.5	25.1	24.9	23.0
NERA_REF_LSS	26.5	28.0	27.5	25.1	24.9	23.0

Lowest ratio = 16.6

Exports Will Raise US Prices and Lower Rivals – But IT DOESN'T MATTER

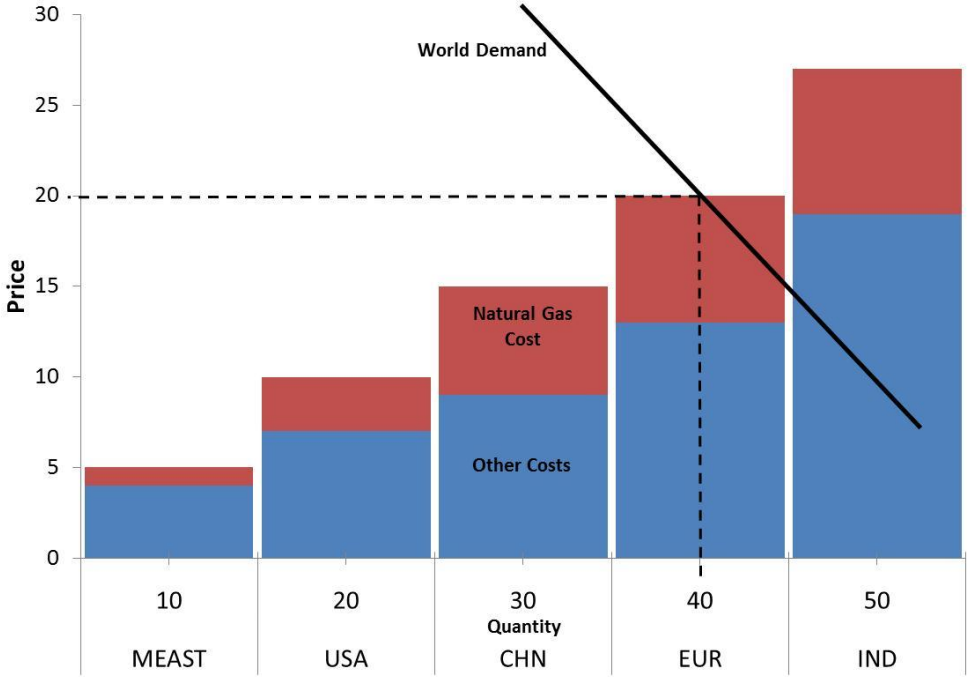
NERA ECONOMIC CONSULTING

- U.S. manufacturing will retain an immense gas cost advantage
  - 2 – 1 cost advantage even with MAXIMUM MARKET-DETERMINED EXPORTS
  - $6/Mmbtu in US + $6/Mmbtu cost of moving to rival = $12 landed at rival
- Comparative advantage:
  - Either the U.S. industry sector will retain its comparative advantage and only a few marginal firms or subsectors will be replaced by imports

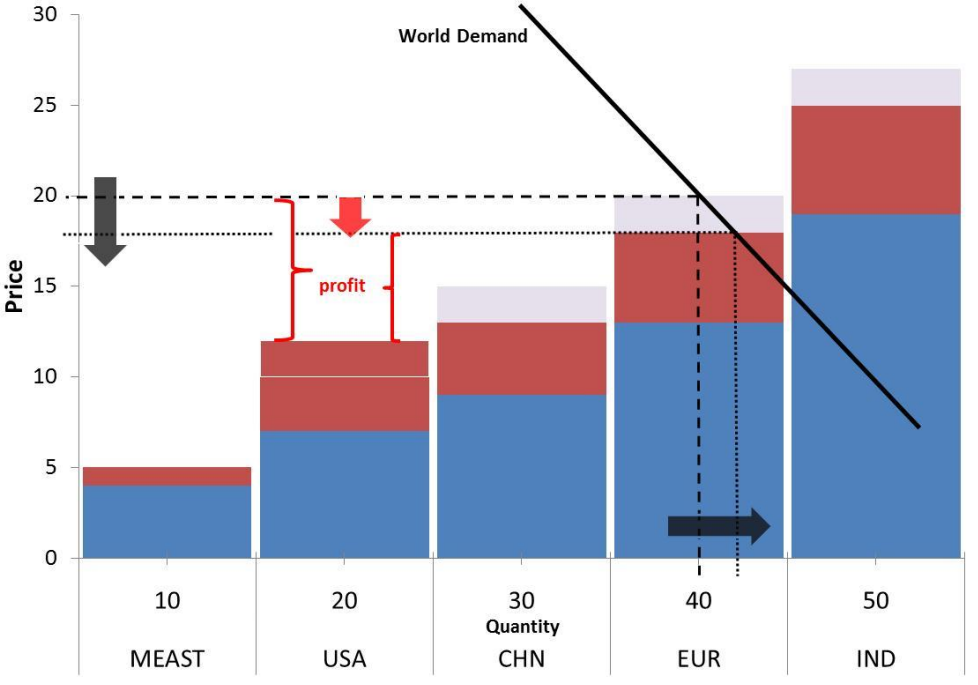
    or
  - If a U.S. manufacturing sector is so inefficient relative to all its rivals that it cannot continue to thrive with a 2 – 1 cost advantage, then comparative advantage says that the U.S. should import chemicals and export goods we produce more efficiently
- No unforeseen shock
  - These are future, predictable changes and allowing such change has been a key factor in U.S. economic success for 200 years

Illustration: Competitiveness of U.S. Manufacturing not harmed

NERA
ECONOMIC CONSULTING

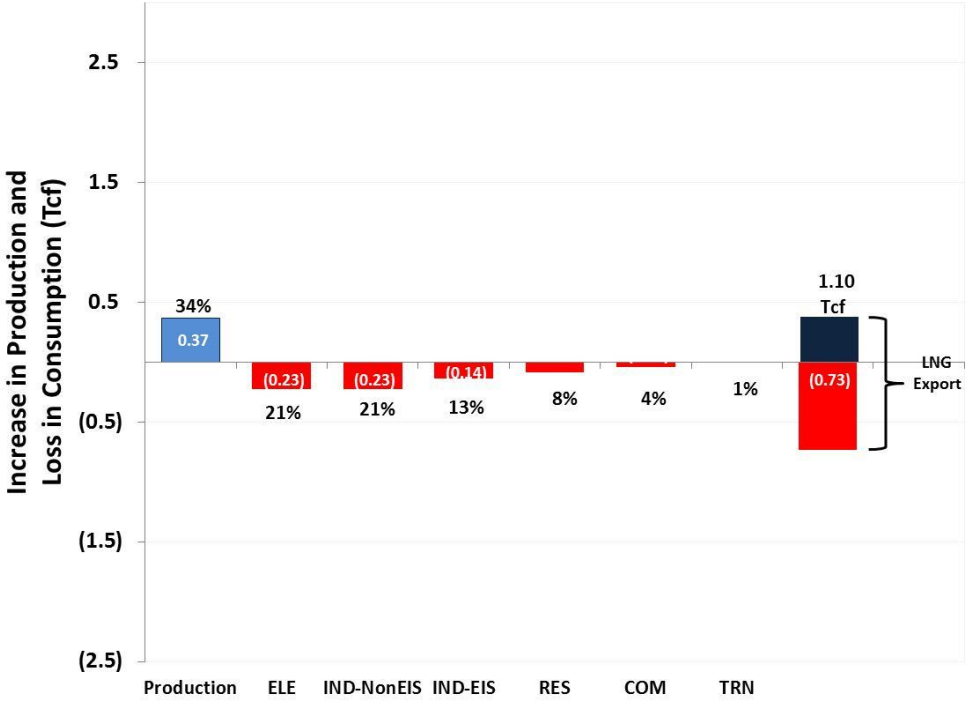


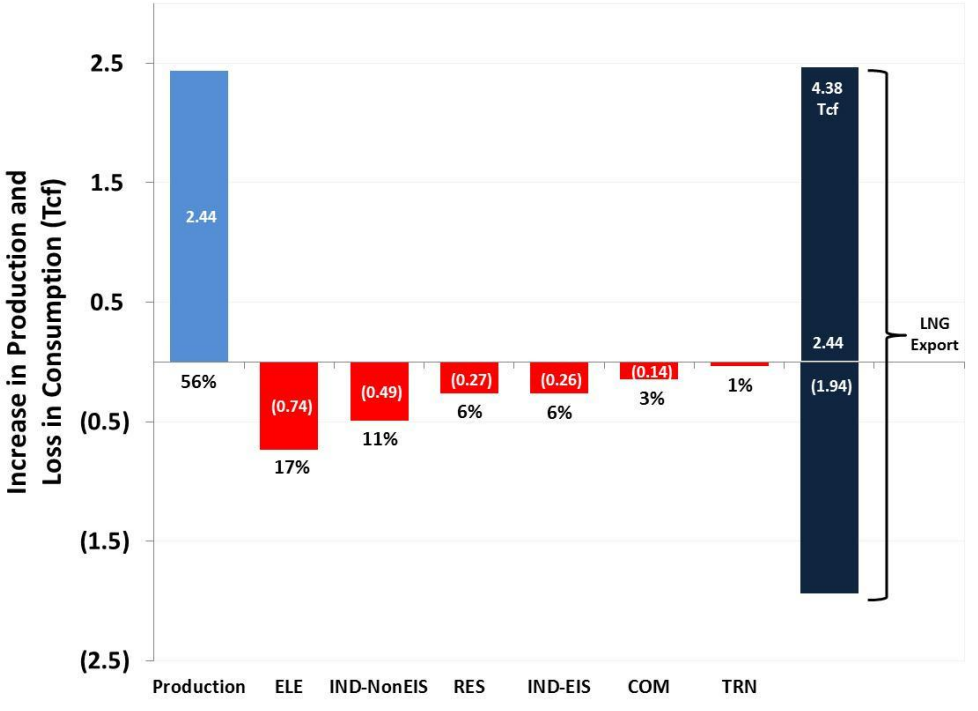
Baseline



LNG Export Case

Makeup of LNG Exports in 2015 and 2035





Future Research

- How will overbuilding of export capacity affect the market?
- How would engineering or infrastructure limits affect how fast U.S. liquefaction capacity could be built?
- How would the location of production or export terminals affect market dynamics? Where are the best locations?
- What are the regional economic impacts and effects on different socioeconomic groups?
- What would be the implications of FDI in facilities and gas production
- Competition between Canada and the United States
  - What happens if U.S. delays or bans LNG to non-FTA countries? Will Canada pick up the additional capacity?
- How might excess worldwide LNG capacity affect the market?
  - Market Price collapse in Asia
  - Competitive Response of LNG suppliers
  - Who wins, who is backed out