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Analysis of U.S. Natural Gas Market Price Impacts from Increasing Natural Gas Supply Accessibility for Different Natural Gas Demand Outlooks

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ABBREVIATIONS

AEO	Annual Energy Outlook
Bcf/d	Billion cubic feet per day
Bcm	Billion cubic meters
DOE	Department of Energy
EIA	Energy Information Administration
EU	European Union
FID	Final investment decision
HOGR	High oil and gas resource case
IEA	International Energy Agency
IGU	International Gas Union
LNG	Liquefied natural gas
MTPA	Million tonnes per year
MMBtu	Million British Thermal Units
NGMM	Natural Gas Market Module
NERA	NERA Economic Consulting
ROW	Rest of World
Tcf	Trillion cubic feet
TETCO	Texas Eastern Transmission pipeline
TRR	Technically recoverable reserves
TTF	Title Transfer Facility

EXECUTIVE SUMMARY

Some policy makers have expressed concerns related to domestic natural gas prices impacts arising from U.S natural gas exports and whether there is adequate natural gas supply available to satisfy domestic gas demand; concerns which are unsupported. This study concludes that the U.S. will continue to have sufficient natural gas resources to meet growing market needs (to satisfy both domestic consumption and exports demand) at relatively low prices, and that the lack of new pipeline infrastructure is a material impediment to the natural gas industry bringing the lowest cost gas resources to the market.[1] Further, the study demonstrates that natural gas price impacts from increasing accessibility of supply would actually reduce natural gas prices, even with higher levels of U.S. LNG exports. Thus, lower domestic gas prices can be achieved by addressing the underlying constraints to accessibility (e.g., permitting and other issues for midstream natural gas infrastructure) to enable low cost natural gas resources to reach the market.

This study focuses on examining the inadequacies of the U.S.'s current pipeline infrastructure and how alleviating the infrastructure limitations through pipeline expansions can reduce natural gas prices by providing improved access to large volumes of natural gas supply. The analysis is conducted across various potential U.S. liquefied natural gas (LNG) export levels and different domestic and global market demand conditions. This study analyzes eight different scenarios that combine two natural gas supply cases (with different infrastructure accessibility assumptions), with four different natural gas demand cases, see Table 1.

The supply cases represent varying amounts of natural gas supply that are available for domestic consumption and exports, based on assumptions of existing and planned pipeline capacity. In the first supply case, hereafter referenced as "*Restrictive Accessible Supply,*" it is assumed that natural gas supply for the domestic and export markets are restricted to current and under construction pipeline capacity operating at recent historic maximum capacity utilization levels. The second supply case represents increased access to large volumes of natural gas supply, hereafter referenced as "*Expanded Accessible Supply.*" It includes planned pipeline capacity (as well as current and under construction pipeline capacity), which are assumed to operate at higher capacity utilization levels commensurate with higher market determined levels of natural gas export demand from the U.S.

Table 1: Supply and Demand Scenarios Analyzed

Supply Case	Demand Case
Restrictive Accessible Supply	Reference
	High U.S. Domestic Demand
	NERA Most Likely U.S. LNG Exports
	European Supply Diversification
Expanded Accessible Supply	Reference
	High U.S. Domestic Demand
	NERA Most Likely U.S. LNG Exports
	European Supply Diversification

[1] Unless other specified, the term "market" refers to the total U.S. natural gas market comprising of natural gas supply both for domestic consumption and exports demand.

The demand cases represent a range of domestic and export demand levels for natural gas. The default demand outlook, referenced as "*Reference,*" assumes EIA's AEO 2022 Reference case projections. A higher than expected domestic demand for natural gas case, referenced as "*High U.S. Domestic Demand,*" was considered to represent an increase in the economy-wide demand for natural gas. The third demand case based on prior NERA analysis is referenced as "*NERA Most Likely U.S. LNG Exports*" and assumes a market determined level of U.S. LNG exports that is expected to occur with a high degree of probability. The current global natural gas market, and in particular the European gas market, has experienced unprecedented disruption as a result of the Russian invasion of Ukraine. Europe seeks new gas sources to relieve the current shortage of natural gas supply due to curtailed flows of Russian pipeline gas into Europe and to also diversify its energy supply sources. The U.S. is in a position to support its European allies to help partially replace the reduction in Russian pipeline natural gas in the short run and to diversify its energy supply with improved energy security in the long run by supplying them with LNG. Thus, the fourth demand case, referenced as *"European Supply Diversification,"* assumes higher U.S. LNG export levels to meet the deficit in natural gas supplies to Europe brought on by the curtailment of Russian natural gas pipeline imports.

The results of this study reinforce the conclusions regarding U.S. natural gas price impact from LNG exports from prior studies, including NERA 2012 and 2018 studies conducted for the U.S. Department of Energy (DOE). In addition, the study also shows the impacts of increasing natural gas supply accessibility. More specifically:

- **The U.S. continues to have sufficient natural gas resources to meet growing market needs at relatively low prices.** An analysis of the U.S. EIA's estimates of technically recoverable resources of dry natural gas and prices from U.S. supply regions shows that there are sufficient natural gas supply resources to support both domestic and export demand within a reasonably low-price range of $3 to $4/MMBtu (assuming no regional pipeline constraints).[2]

- **Lack of new natural gas pipeline infrastructure is a material impediment to bringing the lowest cost gas resources to the market**. The lack of new pipeline infrastructure has likely contributed to sub-optimal current natural gas market conditions and price formation. As a result, the U.S. is unable to utilize the lowest cost natural gas resources from the Northeast region (and particularly from the Marcellus and Utica shale gas basins). Several pipeline projects in the Northeast have been cancelled since 2020 largely as a consequence of regulatory and permitting challenges. In the absence of these infrastructure pipeline cancellations, natural gas consumers would likely face less upward price pressure and have access to lower cost natural gas supplies which in turn would ultimately lead to lower domestic natural gas prices.

- **Natural gas price impacts from expanding pipeline infrastructure are expected to reduce natural gas prices, even with higher levels of U.S. LNG exports.** The natural gas price reductions from an expansion in pipeline infrastructure accessibility are estimated to be between $0.25 and $0.30/MMBtu in 2025 and between $0.25 and $0.40/MMBtu in 2035 across the numerous scenarios analyzed, see Table 2.

[2] All prices are expressed in 2021$, unless otherwise stated.

- **Addressing the underlying permitting and other issues for midstream natural gas infrastructure is a critical priority for energy policy to enable low cost natural gas resources to reach the market**. Additional pipeline infrastructure build-outs, from the Eastern low cost supply region (and particularly from the Marcellus and Utica shale gas basins), has the potential to provide inframarginal gas supplies which could support higher domestic and export demand and reduce the impacts on natural gas commodity prices.

Table 2: Natural Gas Price Impacts from Increasing Supply Accessibility ($2021/MMBtu)

		Supply Cases		
Year	**Demand Cases**	**Restrictive Accessible Supply**	**Expanded Accessible Supply**	**Change in Prices**
2025	Reference	$2.90	$2.65	-$0.25
	High U.S. Domestic Demand	$2.90	$2.65	-$0.25
	NERA-Most Likely U.S. LNG Exports	$2.95	$2.70	-$0.25
	European Supply Diversification	$3.00	$2.75	-$0.30
2035	Reference	$3.60	$3.35	-$0.25
	High U.S. Domestic Demand	$3.65[3]	$3.35	-$0.30
	NERA-Most Likely U.S. LNG Exports	$3.80[2]	$3.40	-$0.40
	European Supply Diversification	$3.70[2]	$3.35	-$0.35

Constraints within the existing permitting regimes have contributed to delays and cancelations of multiple pipelines, which illustrates high project specific risks and uncertainty. In contrast, the analysis shows that the expeditious build-out of planned or additional pipeline infrastructure without permitting delay is important to alleviate short terms price impacts and provide for more efficient development of low cost resources.

[3] The equilibrium market prices for these scenarios (where the total accessible supply is insufficient to meet total demand) is the adjusted marginal price on the export market supply curve. A description of the methodology employed to calculate the adjusted prices are provided in Appendix I.

1. INTRODUCTION

This study examines how alleviating the current limitations in U.S. pipeline infrastructure through pipeline expansions can reduce natural gas prices by providing improved access to large volumes of gas supply. The study examines different levels of U.S. natural gas exports, both pipeline and LNG, under varying supply and demand conditions and natural gas pipeline infrastructure outlooks. The natural gas price impacts in this study are measured as the difference between the market equilibrium natural gas supply prices in the restrictive and expanded accessible supply cases. For this study, we constructed eight different scenarios taking into account two natural gas supply and four natural gas demand outlooks.[4] This study assesses whether current and planned natural gas pipeline infrastructure have the ability to support different levels of natural gas exports using supply and demand curves that were developed based on data from the EIA.[5]

1.1 Background

Fifteen years ago, the prevailing wisdom was that the U.S. would continue to be an importer of natural gas to satisfy domestic demand with increasing prices over time for the foreseeable future. However, with estimates of proven resources increasing year-over-year, U.S. natural gas production has observed tremendous growth. The continued optimism towards shale gas potential and accelerated recovery due to advancements in hydraulic fracturing and horizontal drilling techniques resulted in a low and sustained natural gas price environment for more than a decade. However, natural gas prices have become more volatile and increasing since mid-2022 as a result of pent up demand coming out of COVID-19, imbalance in the storage levels, and global natural gas market disruptions arising from geo-political events.[6]

With the decreasing full-cycle[7] cost of shale gas production, the U.S. became a net exporter of natural gas in 2017 buoyed by the exports of LNG. Natural gas production has increased by an annual average growth rate of about 3% in the past decade.[8] In 2021, the U.S. exported a record high of about 9.8 Bcf/day of LNG.[9] The global natural gas market, in particular the European markets, witnessed unprecedented changes in 2022 due to the Russian invasion of Ukraine. As of mid-2022, the U.S. had the highest LNG export capacity in the world and averaged 11.2 Bcf/day of LNG exports in the first-half of

[4] Additional natural gas demand sensitivity cases are described and evaluated, see Appendix II.

[5] The modeling approach for this study does not rely on a global gas market model analysis with interaction effects.

[6] Contraction of natural gas demand during the COVID-19 pandemic resulted in a decline in prices; while weather events such as a colder than average 2020-2021 winter season and winter storms in February 2021 resulted in higher than average prices in 2021 compared to 2020.

[7] Full-cycle costs includes the actual cost associated with exploration, appraisal, development of gas fields up to the point of production.

[8] U.S. Natural Gas Marketed Production, U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/hist/n9050us2A.htm).

[9] "EIA Forecasts Rising U.S. Natural Gas Exports," Natural Gas Intelligence, January 19, 2022 (available at https://www.naturalgasintel.com/eia-forecasts-rising-u-s-natural-gas-exports/).

2022.[10] U.S. natural gas demand globally is expected to increase to support the energy needs and security of U.S. allies, in particular Europe in the absence of Russian gas. This will require the necessary infrastructure in the form of pipeline and liquefaction capacity. With cancellations of major natural gas pipeline projects in recent years, policy makers are concerned about hindering the flow of low cost natural gas supplies and the associated pressure this can have on the domestic natural gas market. However, with Europe's policy shift toward LNG to replace Russian pipeline gas and the availability of abundant natural gas resources domestically, the outlook for natural gas demand and production are more optimistic now than ever before.

1.2 Objectives of This Study

The objective of this study is to examine how alleviating the infrastructure limitations associated with current natural gas pipeline infrastructure and expanding pipeline accessibility will help reduce natural gas prices. The study assesses the impacts on U.S. natural gas market prices under different levels of U.S. LNG exports and domestic demand, different natural gas pipeline infrastructure outlooks and using aggregate regional supply curves. Different levels of supply potential are assessed for domestic and global markets based on existing and planned pipeline capacities for nine natural gas supply regions in the U.S. The study conclusions are also used to re-assess the conclusions reached by past studies that have analyzed the impacts on the U.S. natural gas market from U.S. LNG exports.

1.3 Outline of the Report

The remainder of the report is organized as follows. Section 2 provides an overview of the U.S. and global natural gas markets. Section 3 describes the high level conclusions from past studies evaluating the impacts on the U.S. natural gas market from LNG exports. Section 4 provides a brief overview of the recent developments in the U.S. and global natural gas markets. Section 5 explains the assessment approach used for the study. Section 6 describes the primary scenarios that we modeled while a discussion of some key results from the analyses are presented in Section 7. Appendix I provides a description of the assumptions employed in the construction of the supply and demand cases for this study. Appendix II provides a description of the three demand sensitivity cases that are analyzed for this study and some of the key results from the analysis. Appendix III provides a detailed description of the historical and current trends in the U.S. and global natural gas markets.

[10] Natural Gas Weekly Update, for week ending July 27, 2022, U.S. Energy Information Administration, July 28, 2022 (available at https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/07_28/).

2. OVERVIEW OF HISTORICAL AND CURRENT TRENDS IN THE U.S. AND GLOBAL NATURAL GAS MARKETS

2.1 U.S. Natural Gas Production, Consumption, Prices and Trade

U.S. natural gas production has undergone a significant paradigm shift since the late 2000s with production from unconventional gas formations (such as from shale gas and coalbed seams) having significantly increased. Natural gas withdrawals from shale gas formations have increased by about ten-fold from 2008 to 2020.[11] Total U.S. natural gas withdrawals grew by about 58% during this period with the ten-fold increase in shale gas production more than offsetting the 55% decline in withdrawals in conventional sources.[12] U.S. natural gas reserves have also grown significantly from 2008 to 2020, increasing by nearly eight-fold with the commercialization of shale gas production from natural gas formations significantly contributing to this increase.[13]

Shale gas production in the U.S. has also become more locationally diverse over time. The total shale gas production in 2021 amounted to about 27 Tcf. The Marcellus Play produced the most shale gas accounting for about one-third of total production (or about 9.1 Tcf) followed by the Permian and the Haynesville plays which accounted for about 17% (4.6 Tcf) and 15% (4.1 Tcf) of total production in 2021 respectively.[14] The proven reserve estimates of shale gas have also been increasing over time with the Marcellus play estimated to have the greatest reserves amounting to about 129 Tcf in 2020 followed by the Permian play where reserves are estimated to be about 53 Tcf.[15] Further, robust improvements in rig efficiency has been achieved, brought about by innovations in horizontal drilling. The greatest increase has been noted in the Appalachia region where rig productivity has increased by nearly fifty-fold since 2008.[16]

U.S. natural gas consumption has also shown continued growth since 2008 increasing by 28% from about 21.5 Tcf in 2008 to 27.4 Tcf in 2021.[17] The increase has largely been driven by the electric power sector where natural gas demand was about 69% higher in 2021 compared to 2008.[18] This increase is largely the consequence of a greater reliance on natural gas owing to environmental regulations which have motivated the retirement of coal-fired generators and their replacement with natural gas-fired generators.

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[11] "Natural Gas Gross Withdrawals and Production," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm).

[12] Ibid.

[13] "Proved reserves, reserves changes, and production," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#exploration).

[14] "Dry shale gas production estimates by play," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#production).

[15] "U.S. shale plays: natural gas production and proved reserves." U.S. Crude Oil and Natural Gas Proved Reserves, year-end 2020 (available at https://www.eia.gov/naturalgas/crudeoilreserves/).

[16] Drilling Productivity Report, U.S. Energy Information Administration (available at https://www.eia.gov/petroleum/drilling/).

[17] "Total consumption," U.S. Energy Information Administration, as of July 2022 (available at https://www.eia.gov/naturalgas/data.php#consumption).

[18] Ibid.

Further, lower natural gas prices in the U.S. compared to other regions in the world have also provided the industrial sector in the U.S. with a competitive advantage with the industrial sector demand for natural gas increasing by about 23% in 2021 compared to 2008.[19]

The development of shale gas resources in the U.S. have historically contributed to lowering natural gas prices. Prior to 2008, higher natural gas prices in the U.S. were the result of the continued depletion of conventional natural gas resources combined with an increase demand brought on by the growth in natural gas use by electric generators. In 2009, there was a precipitous drop in natural gas prices brought on by lowered natural gas demand as a result of a decline in economic activity and industrial output from the ongoing economic recession. Further, developments relating to drilling and production technologies enabled natural gas producers to increase natural gas production from shale gas formation. Thus, this resulted in increasing quantities of natural gas being produced at lower prices despite lower natural gas demand. Natural gas prices spiked in 2014, a consequence of the polar-vortex conditions experienced across large parts of the U.S., which drove up the demand for natural gas and depleted storage inventories. More recently in 2021, U.S. natural gas prices increased largely driven by a colder-than-average 2020-2021 winter season, which drove up the demand for heating in several parts of the U.S. Strong demand for natural gas in the electric sector continued into a warmer-than-average summer, which kept demand for natural gas from electric generators elevated, and lower levels of coal-fired generation on account of plant retirements and higher coal prices. The price spikes observed in U.S. natural gas prices during the first half of 2022 were a consequence of tightness in the domestic market from constraints around natural gas accessibility. In recent years growing congestion in the production takeaway pipelines[20], particularly in the Appalachian region, have also contributed to supply tightening thereby limiting the ability to transport natural gas to demand centers.

Natural gas trade and flow patterns have also changed over time as the U.S. has emerged as a major source of gas supply. Pipeline imports from Canada have been declining over time and were about 22% lower in 2021 compared to 2008 levels.[21] On the other hand, pipeline exports to Mexico have increased by about five-fold since 2008.[22] Pipeline exports to Canada increased from 2008 to 2012 but have since remained relatively flat.[23] Pipeline exports to Canada in 2021 were about 68% higher than 2008 levels. LNG imports into the U.S. have steadily declined with 2021 import level about 94% lower than in 2008.[24] LNG exports from the U.S. have significantly increased since 2008 by about ninety-fold from about 0.04 Tcf (or 0.13 Bcf/day) in 2008 to about 3.6 Tcf (or 9.8 Bcf/day) in 2021.[25] Until 2015, all LNG exports

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[19] Ibid.

[20] "Gas production growth, pipeline constraints leave Appalachian cash basis lagging,", S&P Global Commodity Insights, March 30, 2021. (available at https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/033021-gas-production-growth-pipeline-constraints-leave-appalachian-cash-basis-lagging).

[21] "U.S. imports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_impc_s1_m.htm); "U.S. exports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_m.htm).

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

from the U.S. were to Japan.[26] However, since then, there has been significant diversification of destinations for U.S. LNG exports. In 2021, about 47% of LNG exports (or about 4.6 Bcf/day) were to Asia followed by exports to Europe (about 3.3 Bcf/day or 34% of LNG exports) while in 2022, there was a significant rise in U.S. LNG exports to Europe.[27] During the first four months of 2022, the U.S. exported 74% of its LNG to Europe, with the U.S. becoming the world's largest LNG exported in the first half of 2022.[28,29] In Asia, the two countries that constituted the largest share of U.S. LNG exports were South Korea and Japan (each comprising about 19% of total U.S. LNG exports) while in Europe, they were Spain and the United Kingdom (comprising about 9% and 8% of total U.S. LNG exports).[30]

2.2 U.S. Natural Gas Infrastructure – Liquefaction Capacity and Pipelines

Sabine Pass, the first LNG export terminal to be constructed in the lower-48 states, shipped its first cargo of domestically sourced natural gas in February 2016. Since then, U.S. LNG export capacity has grown rapidly with the U.S. becoming the world's largest LNG exporter in the first half of 2022 with new liquefaction trains at Sabine Pass and Calcasieu Pass beginning operations in 2022. According to the EIA, total LNG export terminal liquefaction capacity in operation in the U.S. amounts to 13.6 Bcf/day(or 102.1 MTPA)[31] while the total export terminal capacity currently under construction or in the commissioning phase is 6.93 Bcf/day (or 49.1 MTPA) (See Table 16 in Appendix III).[32] The total liquefaction capacity for LNG export terminals which have been approved but have not yet begun construction amounts to 22.7 Bcf/day (or 160.7 MTPA) (See Table 17 in Appendix III).[33]

The U.S. natural gas pipeline system has also grown rapidly in response to growth in regional demand and new natural gas production. The shale gas boom has also contributed to modifications to existing pipeline systems to allow for bidirectional flow (called reversal projects). Historical peaks in terms of pipeline capacity additions occurred in 2008 when LNG import projects in the U.S. were being actively developed and in 2018 when LNG export capacity in the U.S. was growing.[34] In 2021, about 7.4 Bcf/day or 2.7 Tcf of interstate natural gas capacity was added, the lowest addition of interstate pipeline capacity

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[26] US exported LNG to Japan from Alaska for more than 40 years before the Kenai terminal was closed in 2015.

[27] U.S. Natural Gas Exports and Re-Exports by Country, U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm).

[28] "U.S. liquefied natural gas exports to Europe increased during the first 4 months of 2022, " U.S. Energy Information Administration, June 7, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=52659).

[29] Natural Gas Weekly Update, U.S. Energy Information Administration, July 28, 2022 (available at https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2022/07_28/).

[30] Ibid.

[31] 1 MTPA of LNG approximately equals 48.7 Bcf.

[32] "U.S. liquefaction capacity," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#imports).

[33] Ibid.

[34] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

since 2016 when LNG exports from the U.S. began to grow.[35] About 5 Bcf/day (or 1.8 Tcf) of these additions were in the Texas and Gulf Coast markets with the additions intended to serve LNG export demand by connecting other pipelines with LNG export terminals.[36]

The natural gas pipeline network in the U.S. is also expected to expand into the future. However, pipeline developers in the U.S. have faced an increasingly challenging regulatory environment to complete projects with hurdles also expected for future projects.[37] Pipeline projects that will be constructed between 2022 through 2026 are expected to add about 3.4 Tcf (or 9.3 Bcf/day) of capacity while projects that have either been announced, approved or where an application has been submitted have the potential to add about 17.3 Tcf (or 47.4 Bcf/day) of capacity.[38] About half of the pipeline capacity currently under construction and about 80% of the planned pipeline capacity are designated to serve LNG export demand.[39] About 8.5 Tcf (or 23.3 Bcf/day) of pipeline capacity are associated with pipeline projects that have either been cancelled or placed on hold since 2020 (See Table 19 in Appendix III).[40] The majority of the projects which have been cancelled or placed on hold are intra-regional pipeline projects originating in either Texas or Louisiana. However, there have also been several large projects cancelled in the Appalachian region such as the Atlantic Coast Pipeline (1.5 Bcf/day), the PennEast Pipeline (1.1 Bcf/day) and the Constitution Pipeline (650 MMCf/day).[41]

2.3 Rest of World Natural Gas Production, Consumption, and Trade

In 2021, natural gas production in regions of the world (other than the U.S.) was about 25% higher than production levels in 2008 with the largest increases in production seen in the Asia Pacific and Middle East.[42] On the other hand, natural gas consumption has grown at a faster rate than production with

[35] Interstate pipelines are those that cross state borders and those that serve export demand, both at pipeline border crossings and at terminals exporting LNG. *See* "Natural gas interstate pipeline capacity additions decrease in 2021," U.S. Energy Information Administration, February 24, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=51398).

[36] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

[37] "US pipeline developers face increasing hurdles as sector difficulties intensify,"S&P Global Market Intelligence, August 7, 2020. (available at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/us-pipeline-developers-face-increasing-hurdles-as-sector-difficulties-intensify-59826372).

[38] Ibid.

[39] Ibid.

[40] Ibid.

[41] "Atlantic Coast Pipeline Cancelled as Delays and Costs Mount," The New York Times, July 5, 2020 (available at https://www.nytimes.com/2020/07/05/business/atlantic-coast-pipeline-cancel-dominion-energy-berkshire-hathaway.html); "PennEast becomes the latest to scuttle a natural gas pipeline project," Reuters, September 27, 2021 (available at https://www.reuters.com/business/energy/penneast-end-development-pennsylvania-new-jersey-natgas-pipe-2021-09-27/); "Williams, Partners Abandon Constitution Pipeline Project, North American Energy Pipelines," February 25, 2020 (available at https://www.napipelines.com/williams-partners-abandon-constitution-pipeline-project/).

[42] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

consumption levels in 2021 about 36% higher than consumption levels in 2008.[43] As with production, the largest increases in consumption were in the Asia Pacific and Middle East regions. With respect to natural gas trade, Europe and Asia Pacific have historically been net importers of natural gas while Africa, the Middle East and the CIS region[44] have all been net exporters of natural gas. Both North America (excluding the U.S.) as well as South and Central America has evolved from being a net exporter of natural gas in 2008 to a net importer of natural gas in 2021. For three of the world regions (South and Central America, Asia Pacific and Europe), the share of which U.S. LNG imports comprise the region's total natural gas imports has been increasing since 2016 with LNG exports from the U.S. comprising of half of the region's natural gas imports for South and Central America and about 20% of the region's natural gas imports for the Asia Pacific region in 2021.[45] For the same three regions, U.S. LNG exports' share of the region's natural gas consumption has also been increasing since 2015. U.S. LNG exports comprised of about 10% of the region's consumption for South and Central America and about 5% for the Asia Pacific region.[46] From 2018 through 2021, Asia imported the largest share of U.S. LNG exports driven by long-term supply agreements and high spot prices. However, U.S. LNG exports to Europe have significantly increased in 2022 as a consequence of the Russia-Ukraine conflict.

2.4 Rest of World Natural Gas Infrastructure

At the end of 2021, there existed about 897.6 MTPA (or 120 Bcf/day) of global regasification capacity with about 95% of this capacity in regions that are outside the U.S.[47] About 49.8 MTPA (or 6.64 Bcf/day) of regasification capacity was added in 2021, with floating regasification units (or FSRUs) comprising 69% of the additions.[48] In the first four months of 2022, about 12.5 MTPA (or 1.7 Bcf/day) of liquefaction capacity was brought online, bringing the total online global liquefaction capacity to 472 MTPA (or 62.9 Bcf/day) as of April 2022.[49] About 80% of this capacity is in regions that are outside the U.S. By 2026, planned liquefaction capacity amounts to 119 MTPA (or 15.9 Bcf/day) with the large majority of this capacity located in the CIS region and the Middle East.[50] By 2024, planned regasification capacity amounts to 162 MTPA (or 21.6 Bcf/day) with most of this planned capacity located in the Asia Pacific region and particularly in China (nearly 70% of the total).[51]

[43] Ibid.

[44] The CIS region refers to the Commonwealth of Independent States and includes Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.

[45] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

[46] Ibid.

[47] Ibid.

[48] Ibid.

[49] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/).

[50] Ibid.

[51] Ibid.

LNG import capacity in the European Union (EU) and the United Kingdom (UK) will expand by 34%, or 6.8 Bcf/d, by 2024 compared with 2021. According to EIA, since the Russian invasion of Ukraine, European countries have

3. SUMMARY OF PRIOR U.S. LNG EXPORT STUDIES

Several prior studies have shown that increases in U.S. LNG exports led to greater U.S. natural gas production, supporting the economic demonstration of the substantial potential U.S. natural gas resources that can be tapped into with pipeline expansions necessary to ensure adequate natural gas pipeline infrastructure. The studies have also concluded that increases in U.S. LNG export levels are associated with modest increases to domestic natural gas prices.

Since 2012, the Department of Energy's Office of Fossil Energy (DOE/FE) has commissioned five studies to examine the effects of U.S. LNG exports on the U.S. economy and domestic energy markets. The first study was carried out by the EIA and published in January 2012 (2012 EIA study).[52] The second study was carried out by NERA and published in December 2012 (2012 NERA Study).[53] The third study was carried out by the EIA and published in October 2014 (2014 EIA Study).[54] The fourth study was carried out jointly by the Center for Energy Studies at Rice University's Baker Institute and Oxford Economics and published in October 2015 (2015 Rice Study).[55] The fifth study was carried out by NERA and published in June 2018 (2018 NERA Study).[56]

- The 2012 EIA Study assessed how four different DOE/FE prescribed levels of natural gas exports under EIA's different Annual Energy Outlook (AEO 2011) projections could affect domestic energy markets. The study was confined to analyzing the impacts of the specified levels of exports on U.S. natural gas prices and not on the broader economy. The study found that increased natural gas production accounted for about 60 to 70% of natural gas export volumes, with some minor additional contribution from increased exports across Canada.[57]

- The 2012 NERA Study estimated the macroeconomic impacts of natural gas exports as well as their impacts on U.S. natural gas prices. It analyzed the impacts of prescribed levels of exports on the U.S. economy by comparing results for each of the alternative export level cases to the results from the corresponding EIA baseline export cases. The study found that in the long-run, natural gas producers could overcome drilling constraints and other limitations and that by 2035,

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reactivated development of previously dormant regasification projects and have started development of new projects. https://www.eia.gov/todayinenergy/detail.php?id=54780

[52] "Effect of Increased Natural Gas Exports on Domestic Energy Markets," U.S. Energy Information Administration, January 2012 (available at https://www.energy.gov/sites/prod/files/2013/04/f0/fe_eia_lng.pdf).

[53] "Macroeconomic Impacts of LNG Exports from the United States," NERA Economic Consulting, December 3, 2012 (available at https://www.energy.gov/sites/prod/files/2013/04/f0/nera_lng_report.pdf).

[54] "Effect of Increased Levels of Liquefied Natural Gas Exports on U.S. Energy Markets," U.S. Energy Information Administration, October 2014 (available at https://www.eia.gov/analysis/requests/fe/pdf/lng.pdf).

[55] "The Macroeconomic Impact of Increasing U.S. LNG Exports," Oxford Economics and Rice University, October 29, 2015 (available at https://www.energy.gov/sites/prod/files/2015/12/f27/20151113_macro_impact_of_lng_exports_0.pdf).

[56] "Macroeconomic Outcomes of Market Determined Levels of U.S. LNG Exports," NERA Economic Consulting, June 7, 2018 (available at https://www.energy.gov/sites/prod/files/2018/06/f52/Macroeconomic%20LNG%20Export%20Study%202018.pdf)

[57] 2012 NERA Study, p. 6.

the increase in natural gas production accounted for about 60% of the LNG export volumes compared to about 30 to 40% in 2015.[58] The study also projected that LNG exports would not drive the price of domestic natural gas to levels observed in countries around the world that were willing to pay oil parity-based prices for LNG imports.[59]

- The 2014 EIA Study is an update of EIA's January 2012 study of LNG export scenarios. The study assesses domestic energy market and economic impacts of scenarios that limited LNG exports to 12 Bcf/day, 16 Bcf/day, and 20 Bcf/day in 2015, with these export limits increasing at a rate of 2 Bcf/day each year, as prescribed by the DOE/FE. The study analyzed the impacts of the LNG export levels in the scenarios on the U.S. economy by comparing these impacts to those in the corresponding baseline cases. The study found that across the different export scenarios and baselines, higher natural gas production satisfies about 61% to 84% of the increase in natural gas demand from LNG exports, with a minor additional contribution from increased imports from Canada.[60] The study also projected the average natural gas prices in the lower-48 states to be 4% to 11% higher over the 2015-2040 period in the 12 Bcf/day and 20 Bcf/day export cases respectively, relative to the reference case baseline.[61]

- The 2015 Rice Study was a scenario-based economic assessment of U.S. LNG export levels of 12 Bcf/day and 20 Bcf/day under different U.S. natural gas supply conditions and international natural gas market conditions. The study analyzed the impacts of LNG exports on the U.S. economy by comparing scenarios that constrain the U.S. LNG exports to 12 Bcf/day and 20 Bcf/day under various domestic natural gas supply and demand conditions while holding international conditions constant to alternative scenarios that support demand pull of significantly higher-level exports. The study found that greater volumes of LNG exports support the long-term expansion of U.S. production with domestic production continuing to increase throughout the time horizon when LNG export volumes increase to 20 Bcf/day from 12 Bcf/day. The majority of the increase in LNG exports are accommodated by expanded domestic production rather than reductions in domestic demand.[62] The study also projected Henry Hub natural gas prices to average between 2.6% to 7.5% higher compared to when the U.S. LNG exports are 12 Bcf/day (the reference case for this study).[63]

- The 2018 NERA Study developed and examined a wide range of scenarios for future U.S. LNG exports; assessed the likelihood of different levels of unconstrained LNG exports; and analyzed the outcomes of the different LNG export levels on the U.S. natural gas markets and the U.S. economy as a whole over the 2020 to 2040 time period. The study also analyzed the macroeconomic performance of the U.S. economy for several of these scenarios within the Most Likely range of LNG exports. The study found that, to support higher LNG exports, natural gas

[58] 2012 NERA Study, p. 51.

[59] 2012 NERA Study, p. 76.

[60] 2014 EIA Study, p. 12.

[61] 2014 EIA Study, p. 12.

[62] 2015 Rice Study, p. 11-12.

[63] 2015 Rice Study, p. 83.

production grows more rapidly in all scenarios than in the scenarios with lower exports.[64] The study projected the range of Henry Hub prices across the Most Likely range of LNG exports to be between \$3.9 to \$6.7/MMBtu.[65]

Aside from the studies commissioned by the DOE/FE that are summarized above, two other studies, and an update of one of the studies, have examined the effect of increases in LNG exports from the U.S. on the U.S. economy and on natural gas prices. A summary of these studies is presented below.

- The Deloitte Center for Energy Solutions and Deloitte MarketPoint LLC carried out an assessment of the potential economic impacts of LNG exports from the U.S. on the U.S. natural gas market prices and natural gas production and flows over a 30-year time horizon.[66] The study, which was published in 2011 (2011 Deloitte Study), includes a reference case which represented existing assumptions relating to LNG export levels and a modelled scenario in which included an incremental 6 Bcf/day of LNG exports.[67] The study projected the weighted-average price impact to be \$0.12/MMBtu on U.S. prices from 2016 to 2035 as a result of an incremental 6 Bcf/day of LNG exports, with the \$0.12/MMBtu representing a 1.7% increase in the projected average U.S. city gate price of \$7.09/MMBtu during this period.[68]

- The American Petroleum Institute (API) commissioned ICF International to undertake a study of the domestic energy market and economic impacts of LNG exports which was published in May 2013 (2013 API Study).[69] The study examined the impacts of LNG exports in the U.S. economy and international trade through the year 2035 for several scenarios with LNG export levels ranging from no exports to a high of 20 Bcf/day by 2035. In each of the three export cases analyzed, the study found that the majority of the incremental LNG exports (79% to 88%) are offset by increased domestic natural gas production with only about 21% to 27% stemming from a decrease in domestic natural gas demand.[70] The study also projected the average increase in wholesale natural gas price over the 2016-2035 period to be between \$0.32 and \$1.02/MMBtu and between \$0.10 to \$0.11/MMBtu on a per Bcf/day basis.[71]

- The American Petroleum Institute (API) commissioned ICF International to carry out an update of its 2013 study to review recent changes to the World LNG markets, the U.S. economy and

[64] 2018 NERA Study, p. 69.

[65] 2018 NERA Study, p.55.

[66] The incremental 6 Bcf/day of exports represented the total volume of three export applications at Sabine Bass, Freeport, and Lake Charles LNG terminals.

[67] "Made in America: The economic impact of LNG exports from the United States," Deloitte Center for Energy Solutions, 2011 (available at https://www2.deloitte.com/content/dam/Deloitte/us/Documents/energy-resources/us-er-made-in-america.pdf).

[68] 2011 Deloitte Study, p. 2.

[69] "U.S. LNG Exports: Impacts on Energy Markets and the Economy," ICF International, May 15, 2013 (available at https://www.api.org/-/media/Files/Policy/LNG-Exports/API-LNG-Export-Report-by-ICF.pdf).

[70] 2013 API Study, p. 6.

[71] 2013 API Study, p. 6.

other relevant factors.[72] The study, which was published in 2017 (2017 API Study), did not re-do all the analyses performed for the prior studies but discusses the impact of the changes on the U.S. economy and natural gas market. The study discussed changes to the U.S. natural gas resource base, the potential for U.S. LNG exports and the projected impact of the LNG export levels on domestic natural gas prices. The study found that increases in domestic natural gas production offset about 88% to 90% of the export volumes while reduced domestic consumption only accounted for about 14% to 16% of total export volumes.[73]

[72] "Impact of LNG Exports on the U.S. Economy: A Brief Update," ICF International, September 2017 (available at https://www.api.org/-/media/Files/Policy/LNG-Exports/API-LNG-Update-Report-20171003.pdf).

[73] 2017 API Study, p. 26.

4. FUTURE IMPLICATIONS OF RECENT DEVELOPMENTS IN THE U.S. AND GLOBAL NATURAL GAS MARKETS

4.1 The Effects of the Pandemic on the Natural Gas Markets

In the first half of 2020, global natural gas demand fell by an estimated 4% year-over-year as a result of the COVID-19 pandemic, as well as an exceptionally mild winter in the northern hemisphere.[74] Most of the declines in natural gas consumption were estimated to occur in the mature markets across Europe, North America, and Asia with these markets accounting for about 80% of the forecasted drop in global natural gas demand for 2020.[75] During the second quarter of 2020, natural gas spot prices fell to their lowest levels in at least a decade across all major gas-consuming regions. According to the IEA, an increase in demand in fast growing markets such as Asia, Africa and the Middle East will contribute to the recovery of global gas demand in 2021 while the more mature natural gas markets such as the U.S. will see more gradual recoveries.

As a consequence of the COVID-19 pandemic, U.S. natural gas production and consumption decreased slightly in 2020 (relative to 2019 levels) by about 1.2% and 2.1% respectively.[76] The lower levels of consumption also pushed prices down with the average annual price of natural gas at Henry Hub declining from $2.56/MMBtu in 2019 to $2.03/MMBtu.[77] The low prices contributed to higher natural gas consumption in the electric power sector in 2020 while increased U.S. liquefaction capacity led to an increase in natural gas exports. Natural gas consumption in the electric power sector rose by 3% in 2020, as low natural gas prices made natural gas a more competitive fuel for generation, particularly in comparison to coal.[78] Natural gas consumption in the other sectors of the economy declined between 2019 and 2020. Milder winter months in 2020 compared to the prior years resulted in a 7% decrease in heating demand in the residential sector and a 11% decrease in the commercial sector, compared to the prior two years.[79] Industrial sector demand declined by 3% in 2020 amid a weakening economy.[80] The industrial and commercial sectors also consumed less natural gas on account of COVID-19 closures and the reduced usage of facilities. Total U.S. natural gas net exports rose by 13% in 2020 stemming from an increase in pipeline exports to Mexico and LNG exports at the beginning and end of 2020.[81] The proved natural gas reserves were revised downward by about 4% from 495.4 Tcf in 2019 to 473.3 Tcf in 2020, largely as a consequence of the decline in natural gas prices which did not support operators' projections

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[74] Gas 2020, Analyzing the impact of the Covid-19 pandemic on global natural gas markets, International Energy Agency, June 2020 (available at https://www.iea.org/reports/gas-2020).

[75] Global Gas Security Review 2020, International Energy Agency, October 2020 (available at https://www.iea.org/reports/global-gas-security-review-2020).

[76] Natural Gas Annual, U.S. Energy Information Administration, September 30, 2021 (available at https://www.eia.gov/naturalgas/annual/).

[77] "Proved reserves of natural gas fell 4% in the United States during 2020," U.S. Energy Information Administration, January 26, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=51038).

[78] "U.S. consumption and production of natural gas decreased while exports grew in 2020," U.S. Energy Information Administration (available at https://www.eia.gov/todayinenergy/detail.php?id=50196).

[79] Ibid.

[80] Ibid.

[81] Ibid.

of resource development.[82] Natural gas rig counts in the U.S. had generally been falling through 2019 and at the end of March 2020, 102 natural gas-directed rigs were active.[83] The number of natural gas-directed rigs decreased throughout the first half of 2020 and fell to 69 rigs at the end of July 2020.[84] Since then the rig count has increased, reaching pre-COVID levels in January 2021.

The fall in natural gas demand resulting from the COVID-19 pandemic also had effects on the global LNG market. Feedgas flows declined with no LNG export projects moving to the FID phase and the number of new executed LNG contracts steeply declining. Global LNG contracting activity declined to about 35 bcm[85] (or 3.4 Bcf/day) in 2020 from 74 bcm (or 7.2 Bcf/day) in 2019, a year-on-year decrease of over 50% with the average number of LNG contracts signed declining from an average of 63 (during 2015-2019) to 32 contracts in 2020.[86] In 2020, numerous developers also postponed investments, announced project schedule delays and adjusted milestones. Further, although pipeline natural gas exporters bore the greatest burden of the supply-side adjustment to the demand drop caused by COVID-19, the majority of LNG exporting countries also had to curtail their LNG exports during the first half of 2020 with the U.S. accounting for the biggest share of downward adjustment in global LNG supply.[87]

4.2 Geo-political and Supply Considerations

As a result of the Russia-Ukraine conflict, the EU set a target to reduce its dependence on Russian natural gas by two-thirds within a year and to cut off all remaining purchases by 2027.[88] In 2021, about 44% of Europe's natural gas imports came from Russia with Europe producing only one-fifth of the natural gas that it needs.[89] Since the end of 2021, countries in Europe have increasingly imported more LNG to compensate for lower natural gas pipeline imports from Russia and to fill their natural gas storage inventories. LNG imports into Europe increased by 63% during the first half of 2022, averaging 14.8 Bcf/day.[90] As an example, the U.S. has pledged to increase LNG exports to Europe. In 2022, the U.S. pledged to supply 15 bcm (or 1.5 Bcf/day) of LNG to Europe and ensure that Europe receives about 50

[82] U.S. Crude Oil and Natural Gas Proved Reserves, Year-end 2010, U.S. Energy Information Administration, January 2022 (available at https://www.eia.gov/naturalgas/crudeoilreserves/index.php).

[83] North America Rotary Rig Count (Jan 2000 – Current), Baker Hughes (available at https://rigcount.bakerhughes.com/na-rig-count).

[84] Ibid.

[85] 1 Bcm equals 35.3 Bcf

[86] Global Gas Security Review 2020, International Energy Agency, October 2020 (available at https://www.iea.org/reports/global-gas-security-review-2020).

[87] Ibid.

[88] "U.S., EU strike LNG deal as Europe seeks to cut Russian gas," Reuters, March 25, 2022 (available at https://www.reuters.com/business/energy/us-eu-strike-lng-deal-europe-seeks-cut-russian-gas-2022-03-25/).

[89] "Reducing the EU's dependence on imported fossil fuels," European Commission, April 20, 2022 (available at https://ec.europa.eu/info/news/focus-reducing-eus-dependence-imported-fossil-fuels-2022-apr-20_en); "Europe's Quest to Replace Russian Gas Faces Plenty of Hurdles," The New York Times, May 5, 2022 (available at https://www.nytimes.com/2022/05/05/business/energy-environment/natural-gas-europe-russia-ukraine.html).

[90] "The United States became the world's largest LNG exporter in the first half of 2022," U.S. Energy Information Administration, July 25, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=53159).

bcm (or 4.8 Bcf/day) of additional U.S. LNG until at least 2030.[91] U.S. LNG exports to Europe in 2021 were about 3.34 Bcf/day (or 34% of the total U.S. LNG exports).[92] In comparison, during the first half of 2022, U.S. LNG exports to Europe averaged about 39 bcm or 7.5 Bcf/day, 68% of the 57 bcm or 11 Bcf/day of total U.S. LNG exports.[93] However, these exports to Europe have come at the expense of declining U.S. LNG imports to other countries such as Pakistan which saw its imports in the first half of 2022 decline by about 72%.[94]

The explosion at Freeport's LNG export terminal in June 2022 had a significant impact on the availability of U.S. LNG exports with the blast cutting the country's LNG exports by approximately 2 Bcf/day.[95] In February 2023, approval was granted to restart commercial operations at the facility.[96] Considering that global supply chains are still recovering from the effects of the COVID-19 pandemic, the outage could be much longer if spare parts are required. The export terminal is a critical piece of infrastructure supplying four LNG cargos per week to European markets. The outage prompted month-ahead gas on the European benchmark TTF to spike 12.6% to €88.70/MWh.[97]

Further, the global gas market supply adequacy could also be impacted by LNG capacity outages which in turn could impact the demand for U.S. LNG exports. A high level of global liquefaction capacity outages was noted in 2020 which remained elevated throughout 2021. In 2021, the LNG volume lost to planned or unplanned outages was estimated to be 53 bcm (or 5 Bcf/day), about a 44% increase relative to the 2015-2020 average (about 3.5 Bcf/d).[98] About half of the LNG volumes lost to unplanned outages in 2021 were due to upstream issues that limited feedgas availability, with the most severe incidents occurring in Nigeria, Trinidad and Tobago, and Malaysia. Project delays could further limit supply availability as well. Of the nearly 190 bcm (or 18.4 Bcf/day) of global liquefaction capacity under construction in early 2021, it was estimated that about 20% was ahead of schedule (by an average of 8 months), 35% was on time, and 45% was delayed (by an average of 14 months).[99]

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[91] U.S., EU strike LNG deal as Europe seeks to cut Russian gas," Reuters, March 25, 2022 (available at https://www.reuters.com/business/energy/us-eu-strike-lng-deal-europe-seeks-cut-russian-gas-2022-03-25/).

[92] U.S. Natural Gas Exports and Re-Exports by Country, U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm).

[93] "US LNG exports to Europe on track to surpass Biden promise," Euractiv, July 26, 2022 (available at https://www.euractiv.com/section/energy/news/us-lng-exports-to-europe-on-track-to-surpass-biden-promise/).

[94] Ibid.

[95] "Fire causes shutdown of Freeport liquefied natural gas export terminal," U.S. Energy Information Administration, June 23, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=52859).

[96] "Freeport LNG Cleared to Restart Commercial Operations Eight Months After Explosion," Natural Gas Intelligence, February 21, 2023 (available at https://www.naturalgasintel.com/freeport-lng-cleared-to-restart-commercial-operations-eight-months-after-explosion/).

[97] "US LNG is becoming a zero-sum game," Energy Monitor, June 17, 2022 (available at https://www.energymonitor.ai/analysis/opinion-us-lng-is-becoming-a-zero-sum-game).

[98] Gas Market Report, Q1 2022 (including Gas Market Highlights 2021), International Energy Agency, January 2022 (available at https://www.iea.org/reports/gas-market-report-q1-2022).

[99] Ibid.

Despite these schedule delays and outages, in the longer run U.S. LNG could face challenges from other low-cost producers who are expanding future export capacity. Qatar for example, has plans to increase the liquefaction capacity at their North Field LNG facility by nearly 64%, from 77 MTPA (or 10.1 Bcf/day) to 126 MTPA (or 16.6 Bcf/day) by 2027.[100] Further, Australia's Woodside Energy also recently announced that construction had begun on expanding the Pluto LNG facility in Western Australia with the expansion expected to nearly double capacity to around 10 MTPA (or 1.3 Bcf/day).[101] In the U.S. on the other hand, a wave of recent contracting announcements has kicked off the next cycle of new U.S. LNG export facility builds. Cheniere Energy sanctioned an expansion of its Corpus Christi LNG facility that would add about 10 MTPA (or 1.3 Bcf/day) while Venture Global LNG made a FID to build its second U.S. LNG export facility – the 20 MTPA (or 2.6 Bcf/day) Plaquemines LNG facility in Louisiana.[102] More than 33 MTPA (or 4.3 Bcf/day) of long-term agreements tied to U.S. LNG projects have been signed since Russia's invasion of Ukraine with U.S developers securing another 13 MTPA (or 1.7 Bcf/day) of preliminary deals in 2022.[103] Of the total 46 MTPA (or 6 Bcf/day) of firm contracts and preliminary deals, about 9.9 MTPA (or 1.2 Bcf/day) were with buyers in Europe.[104]

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[100] "Qatar selects four partners for $30bn North Field expansion project," Offshore Technology, June 8, 2022 (available at https://www.offshore-technology.com/news/qatar-partners-field-expansion/).

[101] "Santos, Woodside Advance Australian LNG Expansion," Natural Gas Field Development, Natural Gas Intelligence, September 8, 2022 (available at https://www.naturalgasintel.com/santos-woodside-advance-australian-lng-expansion-natural-gas-field-development/).

[102] "LNG Project Tracker: Contracting surge accelerates next cycle of export projects," S&P Global Market Intelligence, July 14, 2022 (available at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/lng-project-tracker-contracting-surge-accelerates-next-cycle-of-export-projects-70992920).

[103] Ibid.

[104] Ibid.

5. U.S. NATURAL GAS MARKET IMPACT ASSESSMENT APPROACH

A partial equilibrium approach is used to examine natural gas price reductions from increasing accessible supply by expanding availability of pipeline infrastructure in the U.S. under different demand outlooks. The supply regions analyzed in this study are based on the natural gas supply regions in EIA's NGMM which models the transmission, distribution, and pricing of natural gas in their National Energy Modeling System (NEMS) shown in Figure 3 below.[105] Further, the prices that we evaluate in this study are supply prices which represent the marginal price that corresponds to the supply curve for each region. For this study, we analyze 9 natural gas supply regions including: East, West Coast, Rocky Mountain, Midcontinent, Southwest, Gulf Coast, Gulf, Northern Great Plains and Pacific.[106] The natural gas supply for each region analyzed is calculated using inter-state and intra-state pipeline capacity within that region and assumptions relating to historical pipeline capacity utilization.

We analyze natural gas supplies for two markets within the U.S. for our assessment approach– the domestic market, where natural gas is supplied to satisfy regional demand, and the export market, where natural gas is supplied to meet natural gas export demand, both for pipeline exports from the U.S. to Canada and Mexico and for LNG exports. The export supply market is based on pipeline capacity from the different supply regions to Canada and Mexico and pipeline capacity from various supply regions to the states in the U.S. where LNG export terminals are primarily located (Texas, Louisiana). The domestic supply market is based on the rest of the intra-regional and inter-regional pipeline capacity in the U.S.

For each natural gas supply region evaluated, we assume that natural gas supply volumes as high as the EIA's AEO 2022 Reference Case projected production volume levels would be available at the region's supply price (also based on the AEO 2022 Reference Case). Natural gas supply volumes that are in excess of the AEO 2022 Reference Case production volumes are assumed to be available at higher prices consistent with natural gas supply elasticity assumptions. [107,108] Two different supply outlooks are evaluated in this study which differ with respect to the pipeline capacity and capacity utilization

[105] Natural Gas Market Module of the National Energy Modeling System: Model Documentation 2022, U.S. Energy Information Administration, August 2022 (available at https://www.eia.gov/outlooks/aeo/nems/documentation/ngmm/pdf/ngmm(2022).pdf).

[106] For this study, we do not evaluate natural gas market impacts in Alaska.

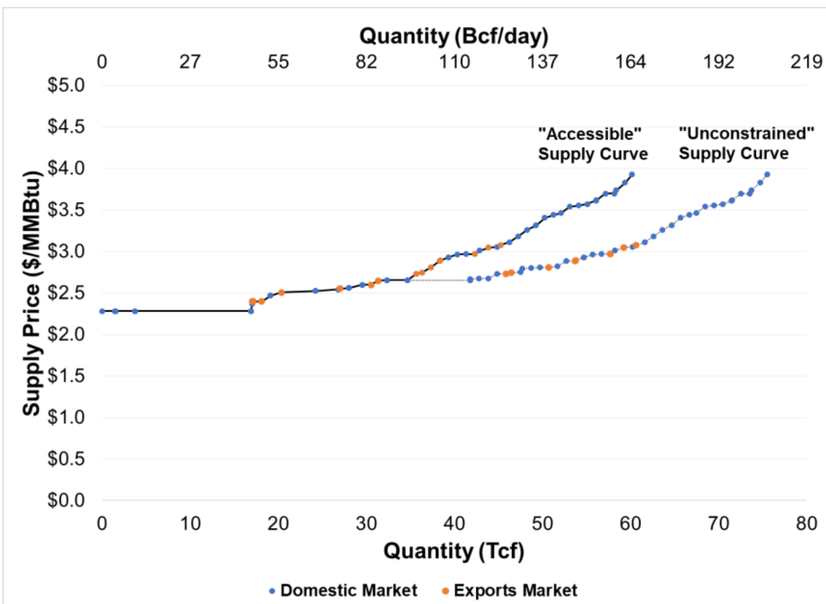
[107] A description of the assumptions and the methodology used to construct the supply curves for the domestic and export supply market for the two supply cases is provided in Appendix I.

[108] We also accounted for associated natural gas (from the Permian region) when constructing the supply curves. To accomplish this, we assumed that 49% of the natural gas supply (based on the share of associated natural gas production to total natural gas production in 2020) from the Southwest region would be available at the lowest price in the supply curve. *See* Drilling Productivity Report, U.S. Energy Information Administration, December 2022 (available at https://www.eia.gov/petroleum/drilling/); "Associated natural gas production declines in 2020, following three years of growth,", U.S. Energy Information Administration, August 23, 2021 (available at https://www.eia.gov/todayinenergy/detail.php?id=49256).

assumptions used to estimate natural gas supply under these two outlooks. The steps involved in estimating the natural gas price impacts are as follows. [109]

- As the first step, the natural gas supplies to the domestic and export supply markets for the various regions are separately ordered (from lowest to highest) by supply price to construct separate supply curves.
- As the second step, the natural gas supplies from the domestic and the export markets for the different supply regions are combined and then ordered (from lowest to highest) by supply price to construct a single supply curve with "unconstrained" volumes.
- As the third step, a supply curve consisting of only "accessible" volumes (resulting from inadequate pipeline infrastructure) is constructed. The accessible supply volumes are developed using the unconstrained supply volumes, which are adjusted to exclude the domestic supply volumes at prices that are above the domestic market equilibrium price but below the export market equilibrium price. These excess domestic supply volumes are unavailable to support the export market owing to accessibility constraints in intra-state and inter-state pipeline infrastructure. After excluding these domestic supply volumes, the remaining domestic and export supply volumes are ordered (from lowest to highest) by supply price to construct the accessible supply curve. Figure 1 illustrates the unconstrained and accessible supply curves.

Figure 1: Illustrative Supply Curves with Unconstrained and Accessible Volumes



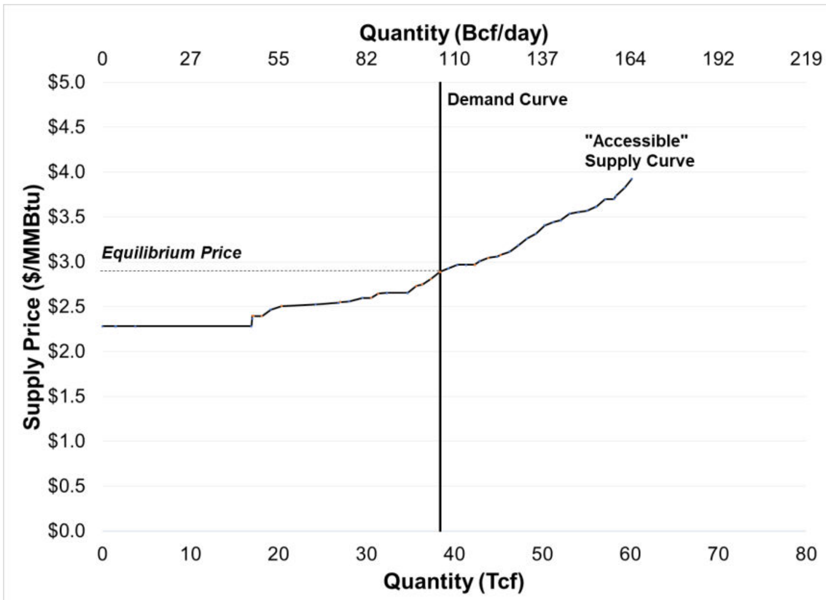
- As the fourth step, the demand curve is constructed.[110] The total demand for natural gas includes domestic consumption, pipeline and LNG exports demand for the U.S. The point of intersection

[109] The supply curve for the exports market can be interpreted as an *excess supply curve* which incorporates constraints relating to natural gas supply. If there were no constraints on the movement of natural gas, then the excess supply curve would be any supplies net of domestic consumption from a single supply curve. In this study, due to constraints in regional connectivity, we assume that not all natural gas supplies are available for the exports market.

[110] The demand curve is assumed to inelastic.

of the demand and supply curves, shown in Figure 2 below, identifies the marginal unit of accessible supply and the market equilibrium price. The market equilibrium price is estimated for both of the supply outlooks and the difference between the equilibrium prices for the accessible and unconstrained scenario yields the natural gas price impact from increasing the accessibility of gas supply through expansion of pipeline infrastructure.[111]

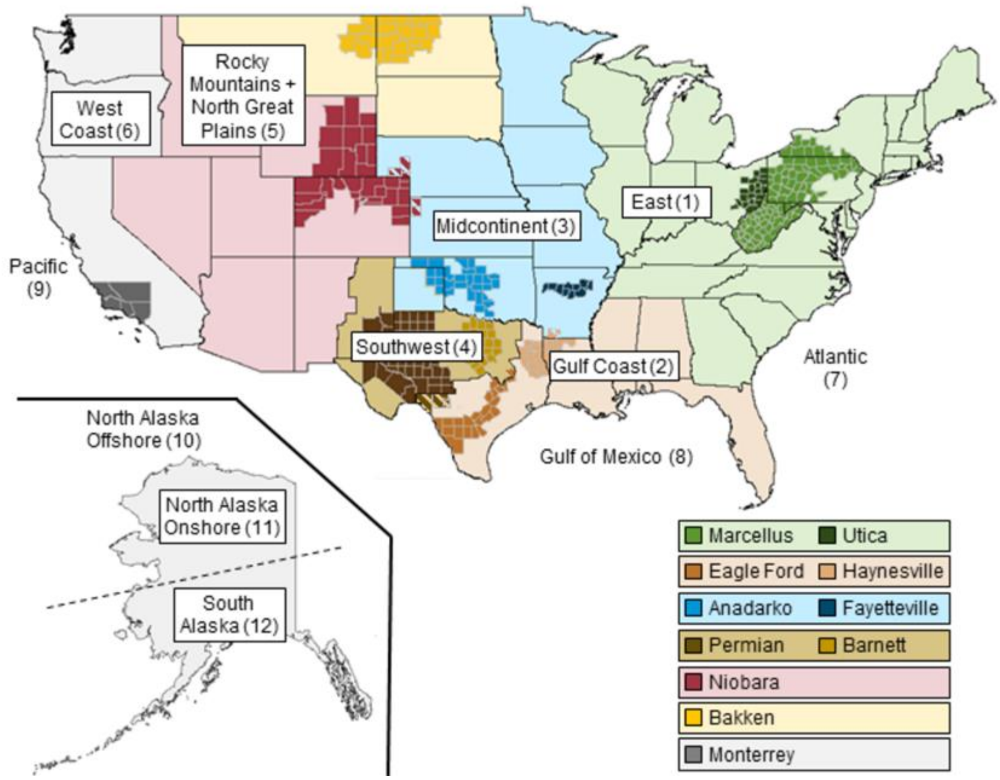
Figure 2: Illustration of Market Equilibrium Price Determination



The above approach is employed to determine the price impacts from demand shifts associated with varying levels of domestic natural gas consumption, pipeline natural gas and LNG exports under the different market outlooks analyzed in this study. For this study, impacts are assessed for two snapshot periods - 2025 and 2035. This approach isolates the natural gas price impacts from expansion of pipeline infrastructure necessary to support different levels of natural gas demand from increases in domestic markets as well as LNG exports.

[111] The price impact evaluated is a difference-in-difference in the natural gas prices with all things being equal with the exception of natural gas supply accessibility between the two supply outlooks.

Figure 3: Natural Gas Supply Regions



For this study, we rely entirely on publicly available data, including the following data sources:

- Regional natural gas supply price, consumption, LNG and pipeline natural gas exports: U.S. EIA's AEO 2022 publication[112]
- Natural gas historical and future pipeline capacity: U.S. EIA's natural gas pipeline tracker, U.S. EIA data on pipeline state-to-state capacity[113]
- Natural gas historical pipeline flows: U.S. EIA data on interstate movement of natural gas by state[114]
- U.S. current and future liquefaction capacity: U.S. EIA and FERC data on current, under construction and planned liquefaction capacity[115]
- ROW current and future liquefaction and regasification capacity, ROW historical pipeline natural gas and LNG flows: IGU World LNG Report 2022, Gas LNG Europe's LNG import terminal

[112] Annual Energy Outlook 2022, U.S. Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/).

[113] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines)

[114] International and Interstate Movements of Natural Gas by State, U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_ist_a2dcu_SAL_a.htm).

[115] U.S. Liquefaction Capacity, U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php); North American LNG Export Terminals, Federal Energy Regulatory Commission (available at https://cms.ferc.gov/media/north-american-lng-export-terminals).

database, IMF report on the potential impact of disruptions to natural gas supply in Europe, BP's Statistical Review of World Energy [116]

- ROW natural gas production, consumption and trade projections: U.S. EIA's IEO 2021 publication[117]

[116] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/); GLE LNG Database (available at https://www.gie.eu/transparency/databases/lng-database/); Natural Gas in Europe, The Potential Impact of Disruptions to Supply, International Monetary Fund, July 2022 (available at https://www.imf.org/en/Publications/WP/Issues/2022/07/18/Natural-Gas-in-Europe-The-Potential-Impact-of-Disruptions-to-Supply-520934); Statistical Review of World Energy, BP (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

[117] International Energy Outlook 2021, U.S. Energy Information Administration, October 2021 (available at https://www.eia.gov/outlooks/ieo/).

6. DESIGN OF MARKET OUTLOOK SCENARIOS

This section discusses our approach to examine the potential natural gas price reductions from pipeline infrastructure expansion that improve access to large volumes of gas supply. Specifically, the natural gas price impacts were analyzed under different supply and demand conditions - two natural gas supply cases and four primary natural gas demand cases. The two supply cases are paired with the four demand cases to create eight different market outlook scenarios. A brief description of the different supply and primary demand cases that make up the eight market outlook scenarios are provided below. Additionally, three demand sensitivity cases that evaluated higher levels of demand for LNG exports from the U.S. are described in Appendix II. [118]

6.1 Supply Cases

To construct the supply cases for this study, we rely on U.S. EIA state-level data on inter-state and intra-state current and future pipeline capacity as well as historical interstate and intrastate natural gas flows. Two supply cases, which we denote as "Restrictive Accessible Supply" and "Expanded Accessible Supply" have been evaluated for this study. These supply cases are based on varying pipeline capacity availability to supply to the two separate markets for which natural gas supply is defined – the domestic supply market and the export supply market. These cases use a range of assumptions for natural gas pipeline capacity and capacity utilization.

6.1.1 Restrictive Accessible Supply

Under the Restrictive Accessible Supply case, natural gas supply to the domestic and export supply markets is based on *current and under construction pipeline capacity* in the U.S and historical maximum capacity utilization assumptions.[119] Figure 4 shows the supply curves representing unconstrained and accessible supply volumes for the Restrictive Accessible Supply case for 2025 (in the left panel) and 2035 (in the right panel) respectively. The unconstrained supply curve, which is relatively flatter than accessible supply curve, includes volumes that not restricted by regional connectivity limitations. Not all volumes along the unconstrained supply curve that are available for the domestic market (blue dots) are available for the export market (orange dots). When these unavailable volumes are removed due to pipeline constraints, the curve shifts towards the left yielding the accessible supply curve. These supply curves have been constructed by following the first three steps outlined for supply curve construction in Section 5 above.

6.1.2 Expanded Accessible Supply

Under the Expanded Accessible Supply case, natural gas supply to the domestic and export supply markets is based on *current, under construction and planned pipeline capacity* in the U.S. with capacity

[118] The LNG export levels evaluated in these scenarios are based on current, under construction and approved projects which are currently in the pipeline based on EIA and FERC publications, total LNG export applications received by the DOE and on an optimistic natural gas demand outlook for Asia.

[119] A description of the assumptions and the methodology used to construct the supply curves for the domestic and export supply market for the Restrictive Accessible Supply case are provided in Appendix I.

utilization assumed to be equal to 80% for all inter-state and intra-state pipeline legs.[120] This case assumes that the pipeline operators will not be bound by the historical pipeline capacity utilization levels and will increase capacity utilization on the pipelines to support high levels of export demand.

Figure 5 shows the supply curves representing unconstrained and accessible supply volumes for the Expanded Accessible Supply case for 2025 and 2035 respectively. Similar to the restrictive case, the accessible supply curve is relatively steeper than the unconstrained supply curve that includes all the volumes. These supply curves have been constructed by following the first three steps outlined for supply curve construction in Section 5 above.

Figure 4: Unconstrained and Accessible Volumes Supply Curves, Restrictive Accessible Supply (2025 and 2035)

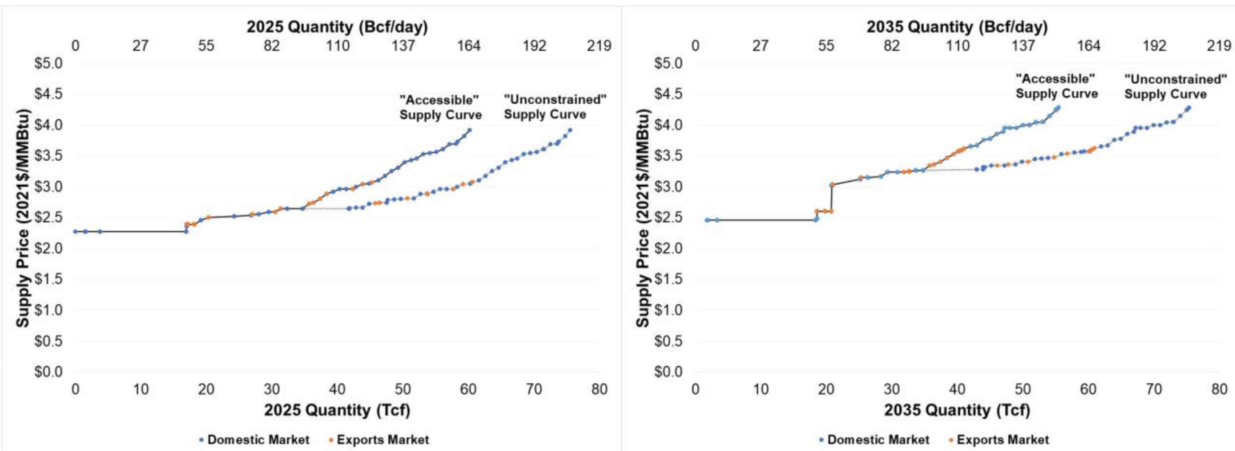
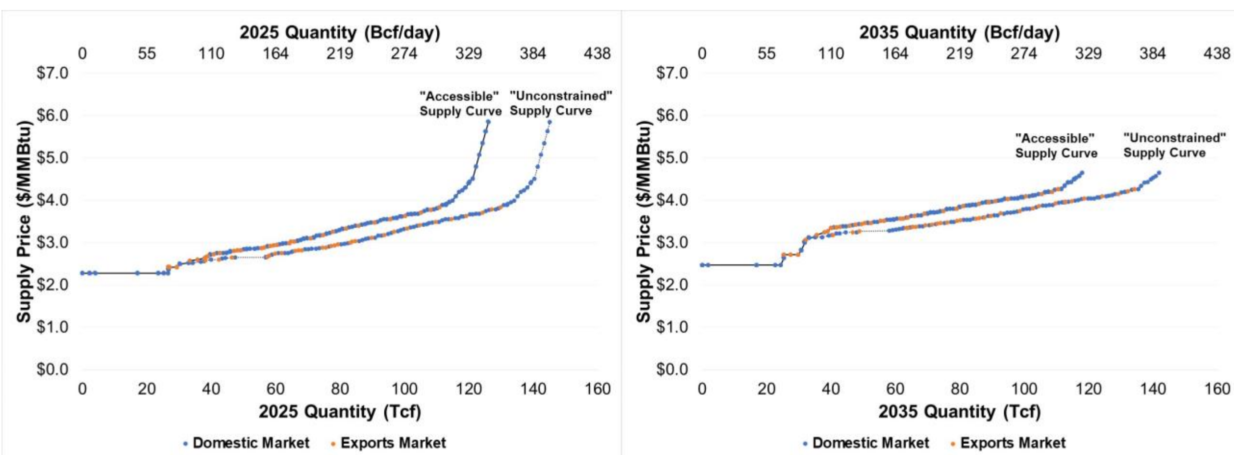


Figure 5: Unconstrained and Accessible Volumes Supply Curves, Expanded Accessible Supply (2025 and 2035)



[120] A description of the assumptions and the methodology used to construct the supply curves for the domestic and export supply market for the Expanded Accessible Supply case are provided in Appendix I.

6.2 Demand Cases

The demand cases evaluated represent varying levels of projected domestic natural gas consumption, pipeline natural gas exports and LNG exports and represent shifts to the U.S. demand curve from changes in U.S. LNG exports and domestic demand.[121]

6.2.1 Reference

The domestic natural gas consumption, pipeline transportation infrastructure, natural gas exports and LNG exports for this scenario are drawn from the EIA's AEO 2022 Reference Case.[122] This case incorporates current laws and regulations enacted as of November 2021.[123] The projections in the case assume known improvements in energy production, delivery, and consumption technologies.

6.2.2 High U.S. Domestic Gas Demand

Domestic natural gas demand could increase as a result of energy transition policies, expansion of manufacturing base that uses natural gas as feedstock and fuel, higher economic growth, lower natural gas price regime, among other factors. To estimate the natural gas demand for this case, the study considered the side case from the AEO 2022 that has the highest projected domestic natural gas consumption. This corresponds to the EIA's AEO 2022 High Oil and Gas Supply case (HOGR).[124] This case assumes more accessible resources and lower extraction technology costs than the AEO 2022 Reference Case and thereby projects higher levels of domestic natural gas consumption, pipeline natural gas exports and U.S. LNG exports. Figure 6 shows the projected natural gas consumption and LNG exports under this case compared to the Reference case.

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[121] For this study, we do not consider natural gas volumes which are used by LNG export terminals to operate the liquefaction equipment. The U.S. EIA estimates that about 8-10% of the natural gas volumes that are delivered to LNG export facilities are used for liquefaction. *See* "Natural gas explained: Liquefied natural gas," U.S. Energy Information Administration (available at https://www.eia.gov/energyexplained/natural-gas/liquefied-natural-gas.php).

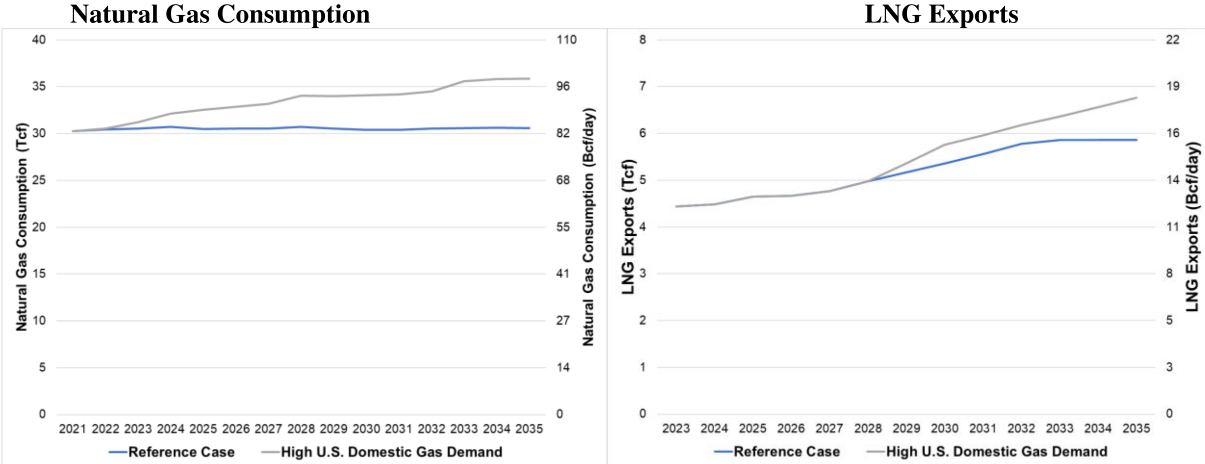
[122] Annual Energy Outlook 2022, U.S. Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/).

[123] Summary of Legislation and Regulations Included in the Annual Energy Outlook 2022, U.S. Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/assumptions/pdf/summary.pdf).

[124] Annual Energy Outlook 2022, Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/).

Figure 6: Projected Natural Gas Consumption and LNG Exports (High U.S. Domestic Gas Demand)

Natural Gas Consumption **LNG Exports**

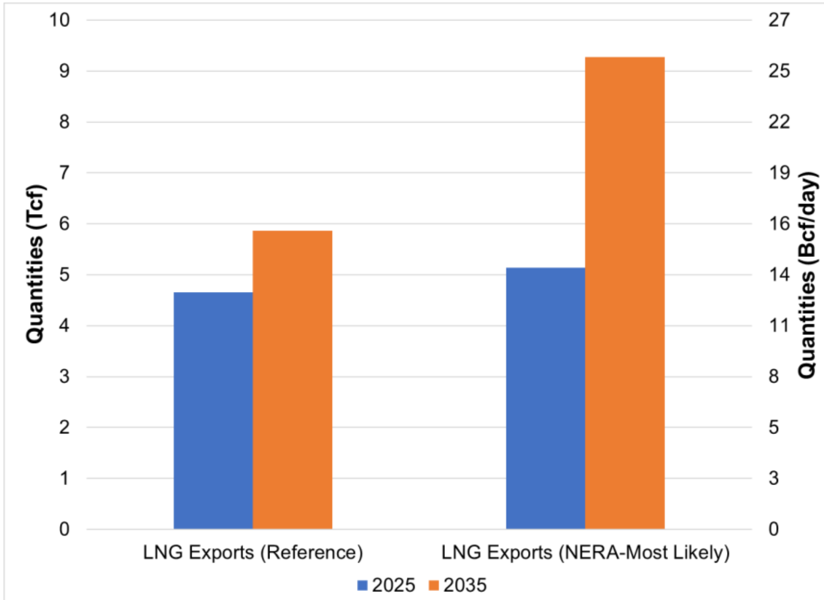


6.2.3 NERA-Most Likely U.S. LNG Exports

The domestic natural gas consumption, pipeline natural gas exports and LNG exports from the U.S. for this case are drawn from the scenarios that comprise the upper end of the "More Likely" range of LNG export scenarios from NERA's 2018 LNG export study in 2025 and 2035.[125] This range consists of scenarios that fall within one standard deviation of the mean level of exports with probabilities assigned to the scenarios ranging from 16% (at the low end) and 84% (at the high end). Figure 7 shows the projected LNG exports under this scenario compared to the Reference case in 2025 and 2035.

[125] The case represents exports volume that has a probability mass of 68% or one standard deviation. *See* Macroeconomic Outcomes of Market Determined Levels of U.S. LNG Exports, NERA Economic Consulting, June 2018 (available at https://www.energy.gov/sites/prod/files/2018/06/f52/Macroeconomic%20LNG%20Export%20Study%202018.pdf)

Figure 7: Projected LNG Exports (NERA-Most Likely)



6.2.4 European Supply Diversification

Russia is the largest supplier of fossil-based energy to Europe and is also the largest exporter of natural gas to the continent from four corridors (Nord Stream, Yamal (via Poland), Ukraine, and Turkstream (via Turkey).[126] In 2021, the EU imported 155 bcm of natural gas pipeline and LNG from Russia, about 44% of total imports.[127] A significant amount of natural gas to Europe is supplied through pipelines. On February 24, 2022, Russia invaded Ukraine and has since been reducing gas supplies from all routes including Nord Stream 1.[128] Russia has progressively cut Nord Stream 1 supplies from 170 million cubic meters of gas per day to completely shutting off gas supplies in late August .[129] The reduction of Russian gas to Europe created unprecedented disruption to the European gas market leading to historical gas price increases. Ever since the invasion, Europe has had to shore up alternate gas supplies, including LNG imports, reduce demand, and fill up its storage for the coming winter season. Although Europe has an annual gas import capacity of 187 bcm, the regasification plants are running at relatively low capacity utilization levels because LNG deliveries bound for Europe have to compete with relatively cheap Russian pipeline gas. Moreover, 37% of the total import capacity is located in Spain that is not well

[126] European natural gas imports, Bruegel, November 2022. (available at https://www.bruegel.org/dataset/european-natural-gas-imports).

[127] Ibid

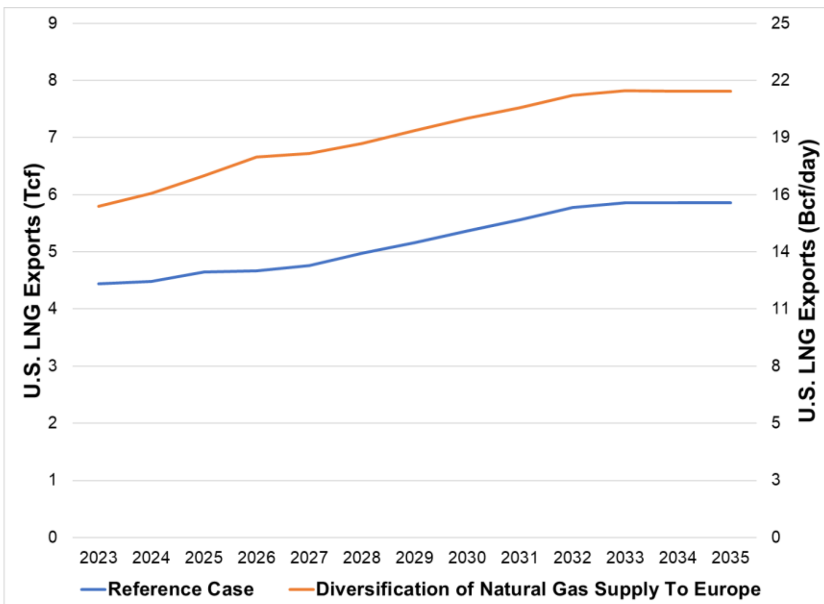
[128] All eyes turn to Russia's share of EU's gas imports, Anadolu Agency, July 2022. (available at https://www.aa.com.tr/en/economy/all-eyes-turn- to-russias-share-of-eus-gas-imports/2647905).

[129] "The Ukraine War in data: 170 million cubic meters of Russian gas gone," Grid, September 8, 2022 (available at https://www.grid.news/story/global/2022/09/08/the-ukraine-war-in-data-170-million-cubic-meters-of-russian-gas-gone/).

connected by pipeline to western Europe.[130] While global cargos have been delivered to Europe to take advantage of high gas prices in 2022, Europe has mainly looked for incremental supplies of LNG from the U.S. with the U.S. share of LNG imports into Europe increasing from 27% in 2021 to 44% during the first 8 months of 2022.[131] The U.S. has supplied an additional 29 bcm of LNG during the first 8 months of 2022, more than what President Biden promised in March 2022 as prices have incentivized higher U.S. exports to Europe.[132]

Under this case, it is assumed that the deficit in natural gas supplies to Europe brought on by the curtailment in Russian natural gas pipeline imports is partially made up by LNG exports from the U.S. to Europe. The projected level of U.S. LNG exports to Europe are determined using projected regasification capacity, the historical maximum capacity utilization of regasification facilities in Europe and the historical share of U.S. LNG exports into Europe compared to total European LNG imports.[133] In this scenario, it is assumed that the domestic natural gas consumption and pipeline natural gas exports from the U.S. are the same as that in the AEO 2022 Reference case. Figure 8 shows the projected LNG exports under this scenario compared to the Reference case.

Figure 8: Projected LNG Reports (Diversification of Natural Gas Supply to Europe)



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130 Natural Gas in Europe: The Potential Impact of Disruptions to Supply, International Monetary Fund, July 2022. (available at https://www.imf.org/en/Publications/WP/Issues/2022/07/18/Natural-Gas-in-Europe-The-Potential-Impact-of-Disruptions-to-Supply-520934).

131 Net European LNG imports by source (Jan-Aug), GIIGNL, September 2022.

132 U.S. promises to deliver 15 bcm more of LNG to Europe in 2022, Reuters, March 2022. (available at https://www.reuters.com/business/energy/us-promises-deliver-15-bcm-more-lng-europe-2022-sources-2022-03-24/).

133 For a description of the assumptions and methodology used to construct this scenario, see Appendix I.

Table 3 outlines the eight primary market outlook scenarios that are analyzed in this study obtained by pairing the two supply and four primary demand case described above. Table 3 also outlines the various scenario levers that relate to domestic consumption, pipeline natural gas exports and LNG exports for each of the eight market outlook scenarios.

Table 3: Primary Market Outlook Scenarios

Scenario	Demand Case	Supply Case	Consumption	Pipeline Natural Gas Exports	LNG Exports
Scenario 1	Reference Case	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	AEO 2022 Reference
Scenario 2	High U.S. Domestic Gas Demand	Restrictive Accessible Supply	High U.S. Demand	High U.S. Demand	High U.S. Demand
Scenario 3	NERA-Most Likely U.S. LNG Exports	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	NERA "Most Likely" Exports
Scenario 4	European Supply Diversification	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	European Supply Diversification
Scenario 5	Reference Case	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	AEO 2022 Reference
Scenario 6	High U.S. Domestic Gas Demand	Expanded Accessible Supply	High U.S. Demand	High U.S. Demand	High U.S. Demand
Scenario 7	NERA-Most Likely U.S. LNG Exports	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	NERA "Most Likely" Exports
Scenario 8	European Supply Diversification	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	European Supply Diversification

Table 4 and Table 5 present the projected domestic consumption, pipeline natural gas exports and LNG exports for the Reference Case and the differences in each of these demand variables relative to the Reference Case for the three other primary demand cases for 2025 and 2035 respectively.

Table 4: Projected Reference Case Demand and Scenario Demand Shifts Relative to Reference Case (2025) (Primary Demand Cases)

2025			
Demand Case	**Consumption**	**Pipeline Natural Gas Exports**	**LNG Exports**
Reference	30.4 Tcf	3.4 Tcf	4.7 Tcf (12.9 Bcf/day)
	Consumption Shift (Relative to Reference Case)	**Pipeline Natural Gas Exports Shift (Relative to Reference Case)**	**LNG Exports Shift (Relative to Reference Case)**
High U.S. Domestic Gas Demand	+2.2 Tcf (+7.2%)	+0.1 Tcf (+2.2%)	0 Tcf (N/A) (Same as Base Case)
NERA-Most Likely U.S. LNG Exports	N/A	N/A	+0.5 Tcf (+10%)
European Supply Diversification	N/A	N/A	+1.7 Tcf (+36%)

Table 5: Projected Reference Case Demand and Scenario Demand Shifts Relative to Reference Case (2035) (Primary Demand Cases)

2035			
Demand Case	**Consumption**	**Pipeline Natural Gas Exports**	**LNG Exports**
Reference	30.4 Tcf	3.8 Tcf	5.9 Tcf (16.2 Bcf/day)
	Consumption Shift (Relative to Reference Case)	**Pipeline Natural Gas Exports Shift (Relative to Reference Case)**	**LNG Exports Shift (Relative to Reference Case)**
High U.S. Domestic Gas Demand	+5.4 Tcf (+18%)	+0.2 Tcf (+5.6%)	+0.9 Tcf (+15%)
NERA-Most Likely U.S. LNG Exports	N/A	N/A	+3.4 Tcf (+58%)
European Supply Diversification	N/A	N/A	+2 Tcf (+33%)

7. U.S. NATURAL GAS SUPPLY AND MARKET IMPACTS FROM INCREASED NATURAL GAS DEMAND AND EXPORTS

7.1 Analysis of Supply and Demand Curves Under Different Market Outlook Scenarios for 2025 and 2035

In this section, we discuss NERA's analysis of the price impacts and associated natural gas pipeline infrastructure implications under the different market outlook scenarios (obtained by pairing the two supply cases with the four primary demand cases) analyzed for 2025 and 2035 using both supply and demand curves. The equilibrium natural gas price impacts for the scenarios are presented following the graphical supply and demand analysis of the different scenarios.

The graphs below, Figure 9 through Figure 12, show the supply curves for the Restrictive and Expanded Accessible Supply Cases (in black and gray respectively) with the total demand (domestic consumption, pipeline and LNG exports) represented as a dotted line for the various demand cases analyzed. The supply curves for 2025 are shown as the left panel while the curves for 2035 are shown as the right panel. The point of intersection between the supply curves and the demand curves yields the market equilibrium prices for the two supply cases that are reported in Table 6.

Figure 9: Restrictive and Expanded Accessible Supply Curves with Demand (Reference)

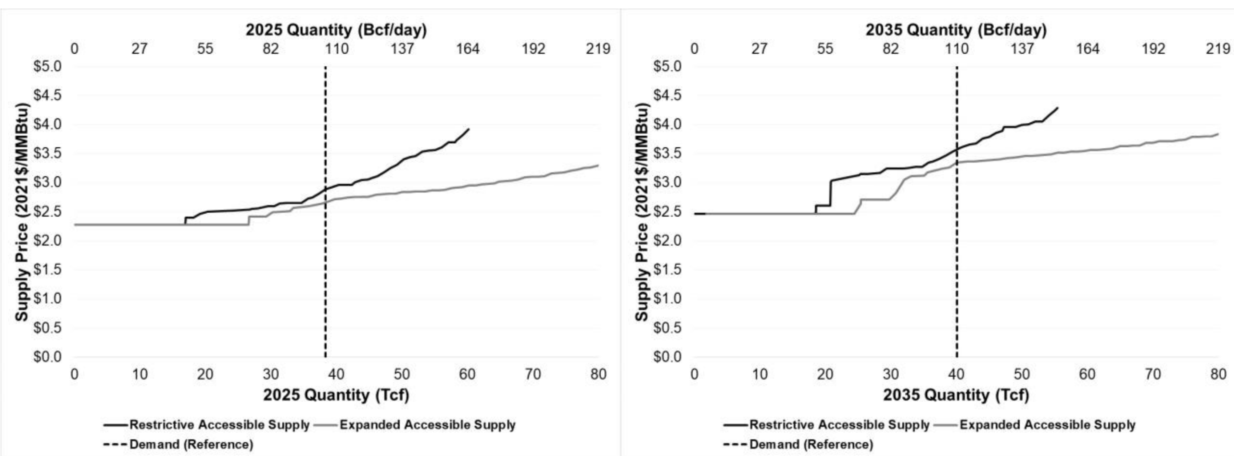


Figure 9 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the Reference Case. Under this scenario, total demand (domestic plus exports demand) in 2025 amounts to about 38.4 Tcf (shown by the dotted vertical demand curve). The demand curve intersects the supply curve for the Restrictive Accessible Supply case at about $2.90/MMBtu, the equilibrium price under this scenario. In the Expanded Accessible Supply case, the supply volumes available are larger with the curve pushed out further to the right and thus the demand curve intersects the supply curve at a lower equilibrium price of $2.65/MMBtu (intersection of the dotted line with the gray line). In 2035, the supply curves are pushed upward compared to 2025 suggesting an increasing natural gas price trajectory over time in the Reference case. Under the Reference case in 2035, total demand amounts to about 40.1 Tcf with the vertical demand curve intersecting the Restrictive and Accessible Supply case supply curves at $3.6/MMBtu and $3.35/MMBtu respectively. An increase in accessibility of supplies supports lower natural gas prices in both 2025 and 2035 as more volumes are supplied from lower cost regions.

Figure 10 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the High U.S. domestic demand case. Under this scenario, total demand (domestic plus exports demand) amounts to about 40.6 Tcf in 2025. However, since the exports demand in this case is only very slightly higher than the Reference case in 2025 (8.1 Tcf in 2025 compared to about 8 Tcf in the Reference Case as shown in Table 4) and since the equilibrium price is set by the marginal export volume, the natural gas price impacts in this scenario are very similar to that under the Reference Case scenario. In both the Restrictive and the Expanded supply cases, there are plenty of volumes that are available to support the high domestic demand levels without impacting the equilibrium price. In 2035, accessible supply for exports under the Restrictive Accessible Supply case is insufficient to meet the exports demand. However, in such a case, with supply inaccessibility, we extend the supply curve to calculate an adjusted equilibrium price (of about \$3.65/MMBtu) under the Restrictive supply case, while the demand curve intersects the Expanded Accessible Supply curve at a lower equilibrium price of \$3.35/MMBtu given the greater availability of accessible supply volumes, suggesting price benefits from increasing accessibility of supply.[134]

Figure 10: Restrictive and Expanded Accessible Supply Curves with Demand (High U.S. Domestic Gas Demand)

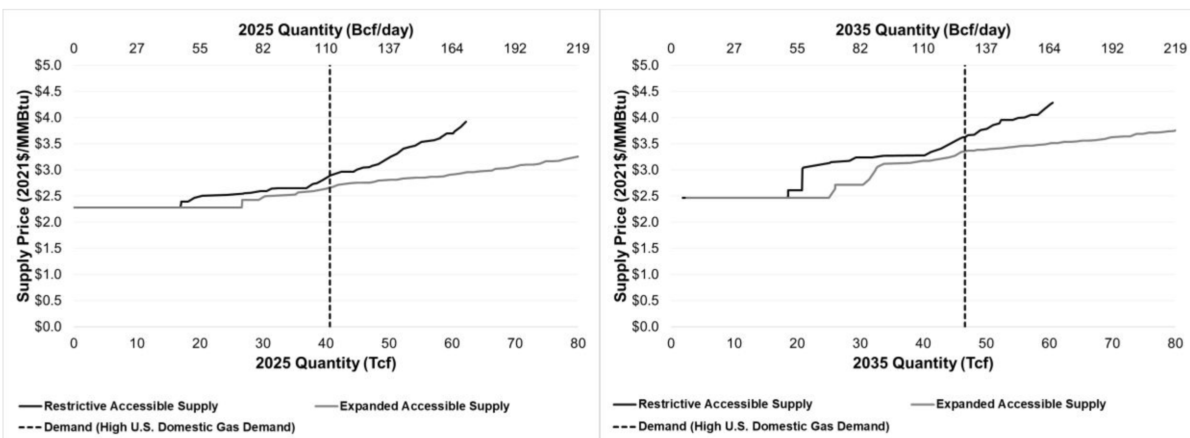


Figure 11 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the NERA-Most Likely U.S. LNG exports demand case. Under this scenario, while domestic demand is assumed to be the same as that in the Reference Case in both 2025 and 2035, total export demand is higher than that in the Reference case (8.5 Tcf in 2025 compared to about 8 Tcf in the Reference case and 13.1 Tcf in 2035 compared to about 9.7 Tcf in the Reference Case). This results in higher equilibrium price impacts under this scenario. In 2035, the price impacts under this scenario are also the highest across the various primary scenarios analyzed since the LNG export levels in 2035 for this scenario have the largest deviation compared to the Reference case LNG exports. In 2025, the intersection of the demand curve with the Restrictive Accessible Supply curve yields an equilibrium price of \$2.95/MMBtu. A lower equilibrium price of \$2.7/MMBtu is obtained under the Expanded Accessible Supply Case on account of the greater availability of accessible supply volumes. In 2035, under the Restrictive Accessible Supply, as described in the above case, the supply curve is extended to calculate an adjusted equilibrium price (of about \$3.8/MMBtu) while the equilibrium price obtained with Expanded

[134] A description of the methodology employed to calculate the adjusted prices are provided in Appendix I.

Accessible Supply is about $3.4/MMBtu, resulting a price benefit of $0.4/MMBtu from increasing accessibility of supplies.[134]

Figure 11: Restrictive and Expanded Accessible Supply Curves with Demand (NERA-Most Likely U.S. LNG Exports)

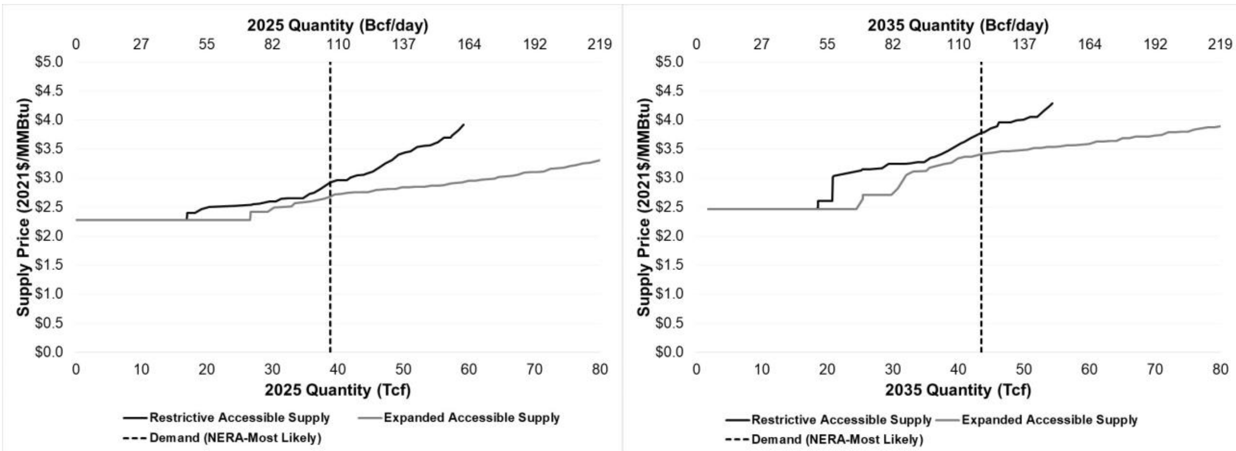
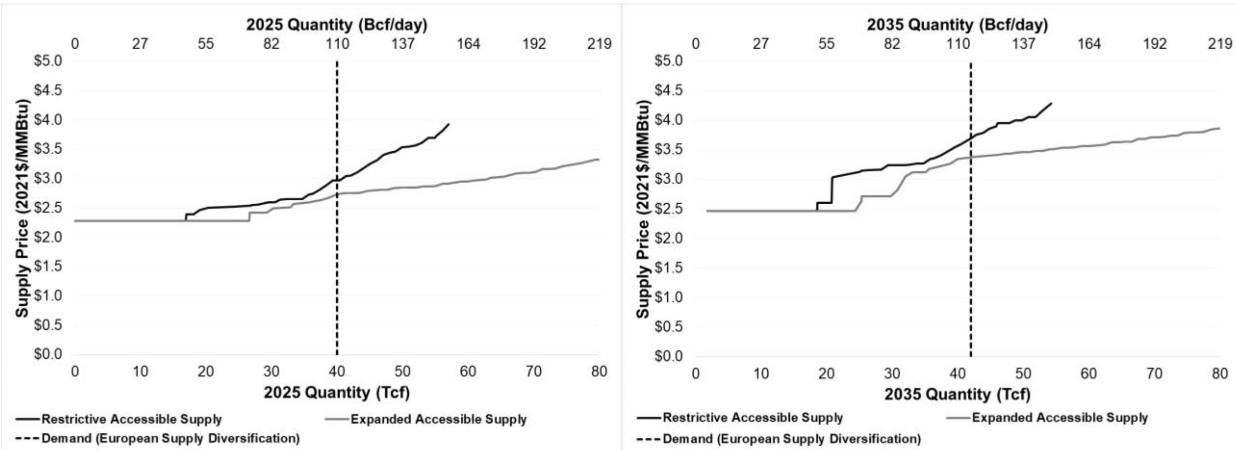


Figure 12 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the European Supply Diversification demand case. The equilibrium market price impacts under this scenario are higher than in the Reference case on account of the higher total level of exports (9.7 Tcf in 2025 and 11.6 Tcf in 2035 compared to 2025 and 2035 total export levels of 8 Tcf and 9.7 Tcf respectively in the Reference case). In 2025, the price impacts under this scenario are also the highest across the various primary scenarios analyzed since the LNG export levels in 2025 for this scenario have the largest deviation compared to the Reference case LNG exports. In 2025, the equilibrium market price impacts are $3/MMBtu and $2.75/MMBtu with the Restrictive and Expanded Accessible Supply cases respectively. In 2035 with Restrictive Accessible Supply, the total available supply is insufficient to satisfy total demand and the adjusted equilibrium price calculated is about $3.7/MMBtu while with Expanded Accessible Supply, the total demand curve intersects the supply curve at an equilibrium price of $3.35/MMBtu.[134] It should be noted that across the demand cases with higher LNG exports, the equilibrium prices are also modestly higher as the marginal volumes are increasing along the upward sloping supply curve.

Figure 12: Restrictive and Expanded Accessible Supply Curves with Demand (European Supply Diversification)



The supply and demand curve analysis for different levels of LNG exports shows that increasing accessibility of supply either by expanding new pipelines or by increasing pipeline utilization rates can mitigate price impacts especially when the natural gas market is tight and experiencing higher demand for exports.

Based on the supply and demand analysis, Table 6 shows the equilibrium natural gas market prices for the two supply cases and four primary demand cases as well as the price differences between the two supply cases for 2025 and 2035 across the various demand cases.[135] These price differences illustrate the natural gas price impacts from increasing pipeline infrastructure accessibility (as in the Expanded Accessible Supply case). Natural gas supply price impacts in 2025 range between $0.25/MMBtu and $0.3/MMBtu while in 2035, they range between $0.25/MMBtu and $0.4/MMBtu increases across the various scenarios analyzed.[136,137] The results show that without an increase in capacity utilization on existing pipelines or

[135] There are several upcoming LNG export capacity developments in Mexico that will rely on U.S. natural gas pipeline exports.. Of these, Phase 1 of ECA LNG with LNG export capacity of 3.25 MTPA (or 0.43 Bcf/day) which is currently under construction is expected to come online in 2024 (*See* ECA LNG - A World-Class Project to help Power the Global Energy Transition, Sempra Infrastructure, March 3, 2022 (available at https://semprainfrastructure.com/news-and-events/spotlight-stories/eca-lng-a-world-class-project-to-help-power-the-global-energy-transition). In 2025, the export supply volumes to Mexico (that are in excess of the AEO 2022 Reference Case pipeline export volumes) are sufficient to support Phase 1 of the ECA LNG terminal under both the supply cases. By 2035, sufficient export volumes exist to meet Mexico's domestic and LNG exports demand (from ECA LNG Phase 1) in both supply cases if natural gas pipeline infrastructure from the U.S. to Mexico are able to operate at levels higher than the historical maximum utilization levels.

[136] The natural gas price impacts estimated for scenarios where additional supply is needed to satisfy total export demand assumes that there is just sufficient supply expansion (either through an expansion in current pipeline takeaway capacities or adding new pipelines) occurring to match the requirement for supply. If supply expansions exceed this requirement, the price impacts would be lower.

[137] The price impacts are sensitive to supply elasticity assumptions. As higher supply elasticity values would result in a relatively elastic supply curve which would imply that for the same exports volume we would expect to see lower natural gas prices; while if the supply elasticity value is lower, then we would see a reverse effect on prices.

additional new pipeline being built, the equilibrium market prices would be higher up the supply curve resulting in greater price impacts.[138] By increasing accessibility of supply, the same volume of demand could be available at a lower equilibrium price. The equilibrium price is lower under the Expanded Supply case for all the demand scenarios. Among the various scenarios analyzed, the largest price impacts in 2025 are seen in the European Supply Diversification demand case, where the impacts are about 10% while in 2035, the largest price impacts are projected to occur in the NERA-Most Likely U.S. LNG Exports demand case where the impacts are also about 10%. The analysis also illustrates that if more pipeline infrastructure could be built, especially in the infra marginal supply source regions, the supply curve could be extended outwards allowing for low cost volumes to be available for domestic consumption or exports.

Table 6: Natural Gas Price Impacts from Increasing Supply Accessibility (Primary Demand Cases) (2021$/MMBtu)

		Supply Cases		
Year	**Demand Cases**	**Restrictive Accessible Supply**	**Expanded Accessible Supply**	**Change in Prices**
2025	Reference	$2.90	$2.65	-$0.25
	High U.S. Domestic Demand	$2.90	$2.65	-$0.25
	NERA-Most Likely U.S. LNG Exports	$2.95	$2.70	-$0.25
	European Supply Diversification	$3.00	$2.75	-$0.30
2035	Reference	$3.60	$3.35	-$0.25
	High U.S. Domestic Demand	$3.65[139]	$3.35	-$0.30
	NERA-Most Likely U.S. LNG Exports	$3.80[139]	$3.40	-$0.40
	European Supply Diversification	$3.70[139]	$3.35	-$0.35

7.2 Analysis of Cumulative U.S. Natural Gas Supply Potential and Demand

In this section, we discuss NERA's analysis of cumulative natural gas supply potential based on different projections, whether accessible supply under the different cases is sufficient to meet demand and impacts on natural gas price. Figure 13 shows the cumulative natural gas supply potential based on projected U.S. natural gas production from the AEO 2022 Reference Case and technically recoverable reserves (TRR) estimates from AEO 2022's Oil and Gas Supply Module.[140,141] The AEO 2022 Reference case production curve shows price inflection points at $3 and $3.50/MMBtu, with prices projected to rise significantly

[138] Supply constraints arising from insufficient pipeline infrastructure particularly in the east coast of the U.S. has the potential to increase natural gas prices. *See* Morgan Evans, "Calls to Build Out East Coast Natural Gas Pipelines Escalating as Bill Seeks Regulatory Certainty," Shale Daily, Natural Gas Intelligence, December 8, 2022 (available at https://www.naturalgasintel.com/calls-to-build-out-east-coast-natural-gas-pipelines-escalating-as-bill-seeks-regulatory-certainty/).

[139] The equilibrium market prices for these scenarios (where the total accessible supply is insufficient to meet total demand) is the adjusted marginal price on the export market supply curve. A description of the methodology employed to calculate the adjusted prices are provided in Appendix I.

[140] Annual Energy Outlook 2022, U.S. Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/).

[141] Oil and Gas Supply Module, Annual Energy Outlook 2022, U.S. Energy Information Administration, March 2022 (available at https://www.eia.gov/outlooks/aeo/assumptions/pdf/oilgas.pdf).

beyond a cumulative supply of 1,000 Tcf. The supply curve with the AEO 2022 TRR is seen to be relatively long and flat as additional volumes, especially from low cost regions, are available. In the absence of any system constraints and assuming that all the recoverable resources are available, there exists enough natural gas to support about 100 years of U.S. natural gas consumption. The TRR supply curve suggest significant natural gas supply (about 1,000 Tcf) available at or below $3/MMBtu and about 2,500 Tcf of resources available at $3.5/MMBtu or less.

Figure 13: Cumulative U.S. Natural Gas Supply Potential (AEO 2022, Reference Case and TRR)

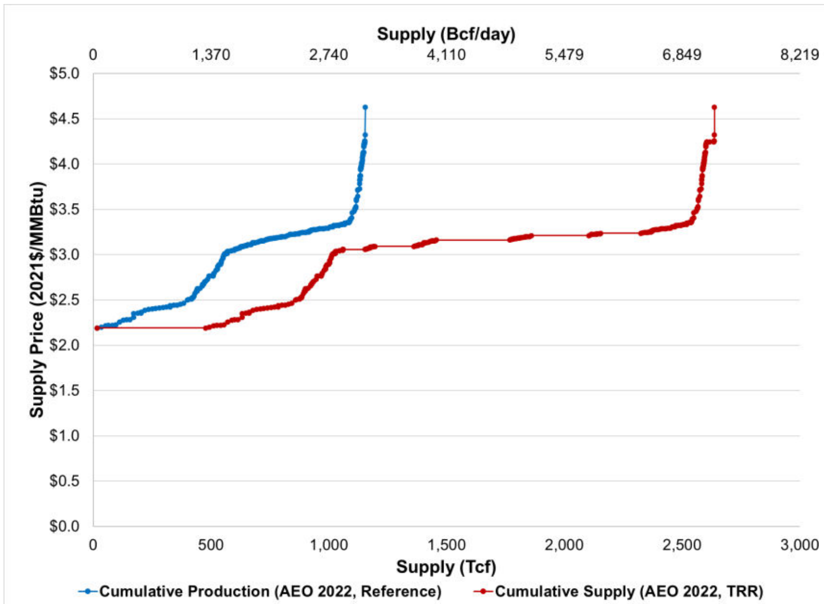


Figure 14 shows the cumulative natural gas supply potential based on the two supply cases (which are described above) along with the cumulative natural gas supply curves based on production from the AEO 2022 Reference Case and the AEO 2022 TRR potential. Even with natural gas resources being constrained by the availability of pipeline capacity, there are sufficient resources available at supply prices between $3 and $3.5/MMBtu. If natural gas flows were to be limited by current and under construction pipeline capacity and lower levels of pipeline capacity utilization (as in the Restrictive Accessible Supply case), an additional 1,000 Tcf of resources would be available at prices that are lower than the AEO 2022 Reference Case prices. If current, planned pipeline capacity and higher levels of pipeline capacity utilization were to set the bounds for supply (as in the Expanded Accessible Supply case), there would be an additional 3,000 Tcf of cumulative natural gas resources available below AEO 2022 Reference Case prices over the AEO projection years.

The volumes and prices corresponding to the AEO 2022, Reference supply curve (production base) and Restrictive supply curve are suboptimal to the TRR based supply curve because it reflects constraints in the movement and accessibility of low cost natural gas. The constraints have been exacerbated further with cancellation of several natural gas pipeline projects in recent years, as shown in Table 19**.**

Figure 15 shows the cumulative natural gas supply potential based on AEO 2022 TRR potential and cumulative U.S. demand (comprised of domestic consumption, natural gas pipeline exports and LNG exports) from the Reference market outlook scenarios.[142] It can be seen that there is sufficient supply of natural gas resources available in the U.S. to meet demand levels that are higher than the projected demand in the Reference case at relatively low natural gas prices.

Figure 14: Cumulative U.S. Natural Gas Supply Potential (AEO 2022, Reference Case, TRR, Restrictive and Expanded Supply Cases)

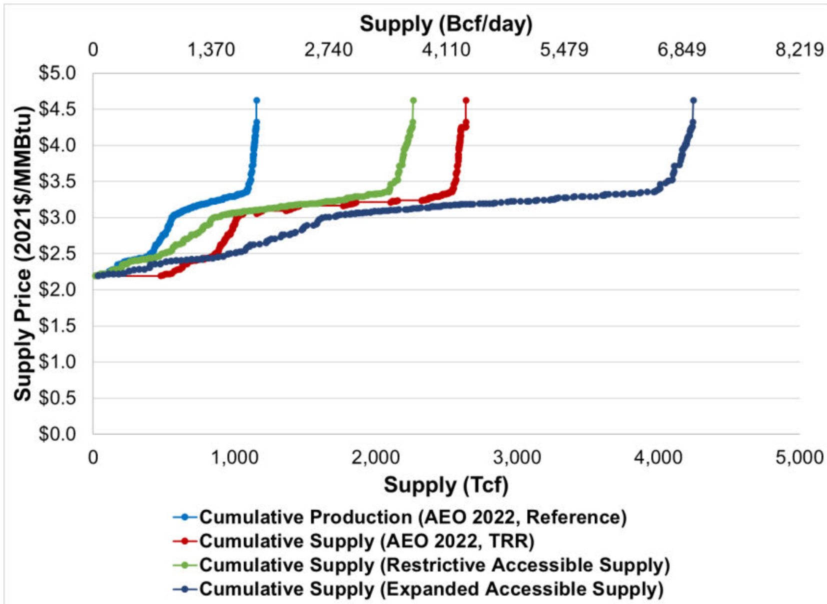
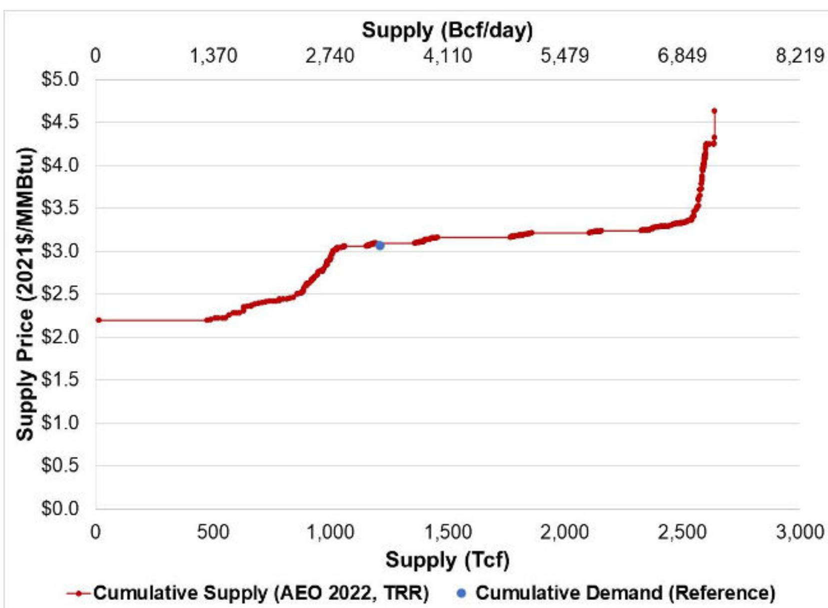


Figure 15: Cumulative U.S. Natural Gas Supply Potential and Demand (AEO 2022 TRR Supply, and Reference Market Scenarios Demand)



[142] These scenarios have the lowest and highest demand across the market outlook scenarios evaluated.

APPENDIX I. SUPPLY AND DEMAND SCENARIO ASSUMPTIONS

Construction of Supply Cases

To construct the supply cases for this study, we rely on U.S. EIA state-level data on current and future pipeline capacity as well as historical interstate and intrastate natural gas flows.[143] For the Restrictive Accessible Supply case, we consider current and under construction pipeline capacity while for the Expanded Accessible Supply case, we consider current, under construction and planned capacity.[144] We aggregate the U.S. EIA state-level data to the natural gas supply regions evaluated for this analysis to develop inter-regional and intra-regional natural gas pipeline capacity estimates.[145] For the Restrictive Accessible Supply case, the capacity estimates are then multiplied by the historical maximum inter-regional and intra-regional pipeline capacity (over the period 2016-2021) to calculate available supply while for the Expanded Accessible Supply case, the capacity estimates are multiplied with an assumed pipeline capacity utilization estimate of 80%.[146] We then disaggregate the available supply calculated into two distinct markets – the export market and the domestic market. For each region, the supply that comprises the export market includes:

- Supply from pipelines originating in the region and terminating in Canada and Mexico and
- Supply from pipelines originating in the region to the states of Texas and Louisiana (since the large majority of the LNG export capacity is located in these states).

For each region, supply for the domestic market is based on the rest of the inter-regional pipeline capacity (originating in the region) and the region's intra-regional pipeline capacity. The following steps are used to construct the supply curves for the domestic and export supply markets and for 2025 and 2035.

- For each supply region analyzed, we assume that natural gas supply volumes up to the EIA's projected production volumes are available at the region's projected supply price.[147]

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[143] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines); "U.S. state-to-state capacity," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines); "International & Interstate Movements of Natural Gas by State," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_ist_a2dcu_SAL_a.htm).

[144] For planned capacity, we include natural gas pipeline projects whose status is "Approved", "Applied" or "Announced" in the U.S. EIA's natural gas pipeline projects database.

[145] Each region's intra-regional capacity is calculated as the net pipeline capacity flows within that region.

[146] This assumption is based on trade press that pipeline utilization levels for several pipeline networks in the U.S. such as in the Appalachian basin and transmission corridors to the Midwest have been seeing significantly higher levels of utilization in the recent past (*See* "Gas production growth, pipeline constraints leave Appalachian cash basis lagging," S&P Global Commodity Insights, March 30, 2021 (available at https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/033021-gas-production-growth-pipeline-constraints-leave-appalachian-cash-basis-lagging); "Back To Zero - Appalachia's Dwindling Natural Gas Pipeline Takeaway Capacity," RBN Energy LLC, August 19, 2021 (available at https://rbnenergy.com/back-to-zero-appalachias-dwindling-natural-gas-pipeline-takeaway-capacity).

[147] The projected production volumes and supply prices for each of the supply regions are based on the Reference Case from EIA's AEO 2022 publication.

- The natural gas supply volumes that are in excess of EIA's projected production volumes for each of the regions are estimated. The excess supply volumes are calculated by subtracting the total available supply from EIA's projected production for regions where the projected production volumes exceed available supply estimated.
- The price increase associated with the excess supply volumes for each of the regions are calculated using an assumed natural gas supply elasticity.[148]
- The excess supply volumes are distributed over the calculated price increases in 1 Tcf increments.
- The natural gas supply volumes are re-ordered by the supply price from low to high across all the supply regions to obtain the domestic and export market supply curves.
- For demand cases where the available natural gas supply volumes in the export market are insufficient to satisfy the total demand for exports, the export market supply curve is extended by incorporating additional volumes equal to the gap between the total available export supply and the export demand.[149] The adjusted price at which these additional volumes are available is calculated using a natural gas price elasticity that is based on the marginal and inframarginal supply prices in the default export supply curve.
- The domestic and export market equilibrium prices are estimated from these supply curves with the point of intersection between domestic demand and export demand (pipeline plus LNG exports) on the supply curves yielding these prices.
- The natural gas supply volumes from the domestic and the export markets for the different supply regions are combined and then ordered (from lowest to highest) by supply price to construct a single supply curve with "unconstrained" volumes.
- As the final step, a supply curve consisting of only "accessible" volumes is constructed. The accessible supply volumes are developed using the unconstrained supply volumes by excluding the domestic supply volumes at prices that are above the domestic market equilibrium price but below the export market equilibrium price.[150] Following exclusion of these domestic supply volumes, the remaining domestic and export supply volumes are ordered (from lowest to highest) by supply price to construct the accessible supply curve.

The steps above are followed both for the Restrictive and the Expanded Accessible Supply cases. Figure 16 shows the estimated natural gas supply for the domestic market (left hand panel) and the export market (right hand panel) for the Restrictive Accessible Supply case by region. Under the Restrictive Accessible Supply case, available supply for the domestic market increases from 62.4 Tcf (or 170.9 Bcf/day) in 2021 to 63 Tcf (or 172.6 Bcf/day) in 2035 while, for the export market, available supply remains flat at 10.4

[148] We assume a natural gas supply elasticity of 0.93 in 2025 and 1.38 in 2035. These are drawn from NERA's 2018 LNG study. *See* 2018 NERA Study, p. 92.

[149] Under the Restrictive Accessible Supply case, there exists the need for additional supplies of 0.38 Tcf in the High U.S. Domestic Demand case, 2.2 Tcf in the NERA-Most Likely U.S. LNG exports case, 1.2 Tcf in the European Supply Diversification case in 2025, 0.33 Tcf in the 42 Bcf/day by 2035 demand case and 6.47 Tcf in the 55 Bcf/day by 2030 demand case in 2025 to close the gap between supply and exports demand. In 2035 under the Restrictive Accessible Supply case, the additional supply requirements are 9.07 Tcf in the 42 Bcf/day by 2035 demand case and 13.48 Tcf in the 55 Bcf/day by 2030 demand case. There are no additional supply requirements under the Expanded Accessible Supply case either in 2025 or 2035.

[150] These excess domestic supply volumes are unavailable to support the export market owing to accessibility constraints in intra-state and inter-state pipeline infrastructure.

Tcf (or 28.5 Bcf/day) from 2021 to 2035. Figure 17 shows the estimated natural gas supply for the domestic market (left hand panel) and the export market (right hand panel) for the Expanded Accessible Supply case by region. Under the Expanded Accessible Supply case, available supply for the domestic market increases from 104.1 Tcf (or 285.1 Bcf/day) in 2021 to 108 Tcf (or 295.8 Bcf/day) in 2035 while, for the export market, available supply increases from 20.6 Tcf (or 56.5 Bcf/day) in 2021 to 32.8 Tcf (or 90 Bcf/day) in 2035. The majority of the additional supply under the Expanded Accessible Supply case over the 2021-2035 period (about 78%) is expected to come from pipeline capacity additions in the Gulf Coast region while the rest is largely expected to come from capacity additions in the Southwest region (about 19%). Only about 1% of the capacity additions is projected to occur in the East region where abundant supplies of low-cost natural gas exist.

Figure 16: Natural Gas Supply for Domestic and Export Markets (Restrictive Accessible Supply Case)

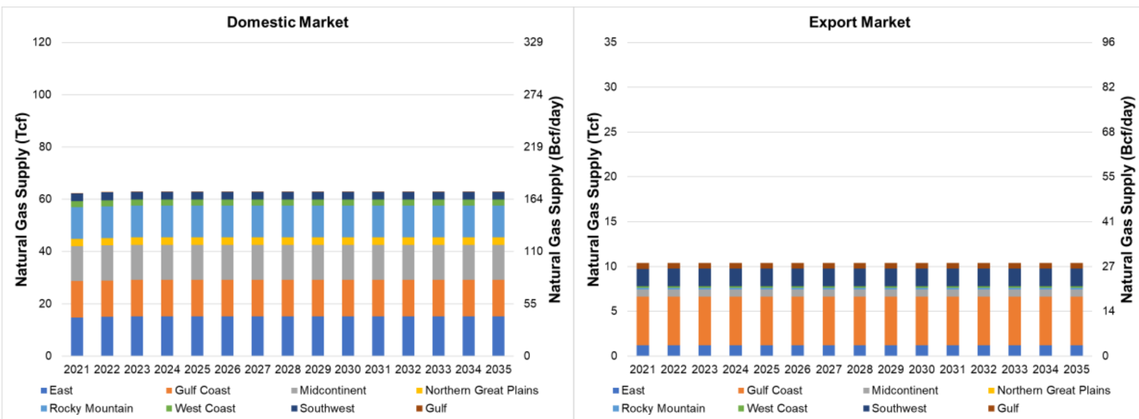
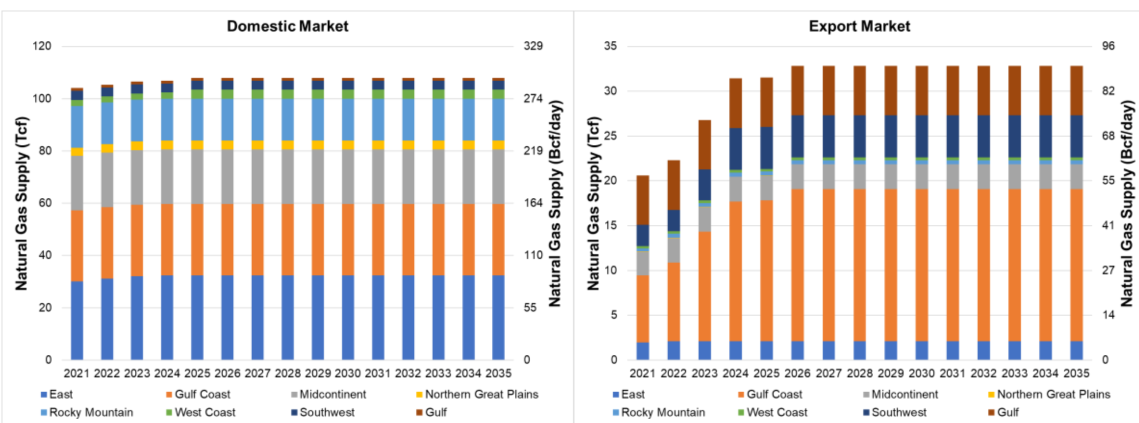


Figure 17: Natural Gas Supply for Domestic and Export Markets (Expanded Accessible Supply Case)



The following steps are used to calculate the maximum historical pipeline capacity utilization for the period 2016-2021.

- The first step involves aggregating U.S. EIA data on historical interstate and intrastate natural gas flows to the natural gas supply regions being analyzed in our study to develop inter-regional and intra-regional flows as well pipeline natural gas flows from the various regions to Canada and Mexico.

- The second step involves aggregating U.S. state-level pipeline capacity data to develop intra-regional, inter-regional and pipeline capacity to Canada and Mexico for each of the natural gas supply regions being analyzed in our study.
- The two steps above are carried out for each year from 2016 to 2021.
- The flows for each inter-regional and intra-regional leg and the flows to Canada and Mexico are divided by the pipeline capacity for the respective leg to obtain the utilization estimate for that leg for each year from 2016-2021.
- For each leg, the maximum utilization for the period 2016-2021 is calculated.

Table 7 presents the historical maximum pipeline capacity utilization for inter-regional and intra-regional flows and for natural gas exports to Canada and Mexico which was used to estimate available supply for the two supply cases.

Table 7: Historical Maximum Pipeline Capacity Utilization (2016-2021)

	To									
	East	Gulf	Midcontinent	Northern Great Plains	Pacific	Rocky Mountain	West Coast	Gulf Coast/Southwest	Canada	Mexico
From										
East	32%	-	30%	-	-	-	-	51%	50%	-
Gulf	-	-	-	-	-	-	-	10%	-	-
Midcontinent	53%	-	58%	29%	-	65%	-	26%	5%	-
Northern Great Plains	-	-	82%	67%	-	23%	-	-	3%	-
Pacific	-	-	-	-	0%	51%	-	-	-	45%
Rocky Mountain	-	-	69%	12%	46%	50%	65%	54%	-	51%
West Coast	-	-	-	-	89%	52%	50%	-	0%	-
Gulf Coast/Southwest	25%	-	27%	-	-	66%	-	41%	-	53%

Construction of Demand Cases

- **European Supply Diversification**

To determine the incremental LNG exports from the U.S. to Europe relative to the U.S. LNG exports under the AEO 2022 Reference Case, we rely on the following pieces of data.

- Natural gas import capacity and supply by source (pipelines and LNG) for 2021 for countries in Europe[151]
- Net European LNG imports by source for 2021 and January-August 2022[152]
- Current and projected regasification capacity for countries in Europe[153]
- Average historical regasification capacity utilization for countries in Europe[154]
- Historical natural gas imports (pipeline plus LNG imports) into Europe[155]

The following steps are used to calculate the incremental LNG exports from the U.S.

- For each year from 2023 to 2030, the total regasification capacity for countries in Europe is multiplied by the maximum historical utilization of regasification capacity in Europe from 2016-2021.[156,157]
- This is then multiplied by the share of LNG imports into Europe from the U.S. (for the January to August 2022 period) to calculate the effective demand in Europe for LNG exports from the U.S. for each of these years.[158]
- For 2031 through 2035, we assume that the effective demand calculated for 2030 applies.
- The effective demand estimate calculated for each of the years from 2031 to 2035 is subtracted from the IEO 2021 Reference Case projection for natural gas imports into Europe multiplied by the 2021 share that U.S. LNG imports comprised of total natural gas imports into Europe to calculate the incremental demand for LNG imports.[159]
- The incremental demand calculated is then added to the AEO 2022 Reference Case U.S. LNG exports to calculate the U.S. LNG exports for this demand case.

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[151] Natural Gas in Europe: The Potential Impact of Disruptions to Supply, IMF Working Papers, International Monetary Fund, July 19, 2022 (available at https://www.imf.org/en/Publications/WP/Issues/2022/07/18/Natural-Gas-in-Europe-The-Potential-Impact-of-Disruptions-to-Supply-520934).

[152] Net European LNG imports by source, 2021 and Jan-Aug 2022, International Group of Liquefied Natural Gas Importers (GIIGNL).

[153] GLE LNG Database (available at https://www.gie.eu/transparency/databases/lng-database/).

[154] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/)

[155] Statistical Review of World Energy, BP (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

[156] The maximum historical utilization of regasification capacity across all countries in Europe from 2016-2021 was estimated to be 90% using data from the IGU's World LNG Report publications.

[157] This calculation accounts for regasification capacity in Spain not connected to central Europe and thus not available to regasify U.S. LNG exports to satisfy natural gas demand in Europe.

[158] The share that LNG imports from the U.S. comprises of total LNG imports into Europe was reported to be 44% for the period January-August 2022 (based on GIIGNL data).

[159] The share that LNG imports from the U.S. comprises of total natural gas imports into Europe in 2021 was calculated to be 6% using data from BP's Statistical Review of World Energy.

Table 8 presents the total regasification capacity for countries in Europe for the period 2022-2030 while

Table 9 presents the estimated U.S. LNG exports to Europe for this period for the Reference and European Supply Diversification demand cases respectively.

Table 8: Total Regasification Capacity for Europe

2023	2024	2025	2026	2027	2028	2029	2030
Regasification Capacity (Tcf)							
7.1	7.6	8.0	8.8	8.8	8.8	8.9	9.0
Regasification Capacity (Bcf/day)							
19.4	20.7	21.8	24.1	24.1	24.1	24.4	24.6

Table 9: Estimated U.S. LNG Exports to Europe (Reference and European Supply Diversification)

2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference (Tcf)												
0.66	0.67	0.68	0.71	0.74	0.79	0.79	0.80	0.81	0.81	0.81	0.82	0.82
Reference (Bcf/day)												
1.8	1.8	1.9	1.9	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
European Supply Diversification (Tcf)												
2.0	2.2	2.4	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.8	2.8	2.8
European Supply Diversification (Bcf/day)												
5.5	6.1	6.5	7.4	7.4	7.4	7.5	7.6	7.6	7.6	7.6	7.6	7.6

- **China/India Increased Demand Pull for U.S. LNG Exports**

To determine the incremental LNG exports from the U.S. to China/India relative to the U.S. LNG exports under the AEO 2022 Reference Case, we rely on the following pieces of data.

- Current and projected regasification capacity for China and India[160]
- Average historical regasification capacity utilization for China and India[161]
- Historical natural gas imports (pipeline plus LNG imports) into Europe[162]

To calculate the incremental LNG exports from the U.S., the following steps are followed.

[160] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/)

[161] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/)

[162] Statistical Review of World Energy, BP (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

- For each year from 2023 to 2035, the total regasification capacity for China and India is multiplied by the maximum historical utilization of regasification capacity for these two regions from 2016-2021.[163]
- This is then multiplied by the share of LNG imports into China and India from the U.S. for 2021 to calculate the effective demand in these two regions for LNG exports from the U.S. for each of these years.[164]
- The effective demand estimate calculated for each of the years from 2031 to 2035 is subtracted from the IEO 2021 Reference Case projection for natural gas imports into China and India multiplied by the 2021 share that U.S. LNG imports comprised of total natural gas imports into these two regions to calculate the incremental demand for LNG imports.[165]
- The incremental demand calculated is then added to the AEO 2022 Reference Case U.S. LNG exports to calculate the U.S. LNG exports for this demand case.

Table 10 presents the total regasification capacity for China and India for the period 2022-2030 while Table 11 presents the estimated U.S. LNG exports to these two regions for this period for the Reference and China/India Increased Demand Pull demand cases respectively.

Table 10: Total Regasification Capacity for China and India

2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Regasification Capacity (Tcf)												
11.3	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
Regasification Capacity (Bcf/day)												
30.9	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3	31.3

Table 11: U.S. LNG Exports to China and India (Reference and China/India Demand Pull)

2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Reference (Tcf)												
0.64	0.68	0.77	0.82	0.84	0.85	0.89	0.91	0.95	0.99	1.00	1.03	1.07
Reference (Bcf/day)												
1.76	1.86	2.11	2.24	2.29	2.34	2.45	2.50	2.61	2.71	2.73	2.83	2.93
China/India Demand Pull (Tcf)												
1.25	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
China/India Demand Pull (Bcf/day)												
3.42	3.46	3.46	3.46	3.46	3.46	3.46	3.46	3.46	3.46	3.46	3.46	3.46

[163] The maximum historical utilization of regasification capacity for China from 2016-2021 was reported to be 85% while for India, it was reported to be 87% based on IGU's World LNG Report publications.

[164] The share that LNG imports from the U.S. comprises of total LNG imports into China and India was estimated to be 11% and 17% for 2021 based on data from BP's Statistical Review of World Energy.

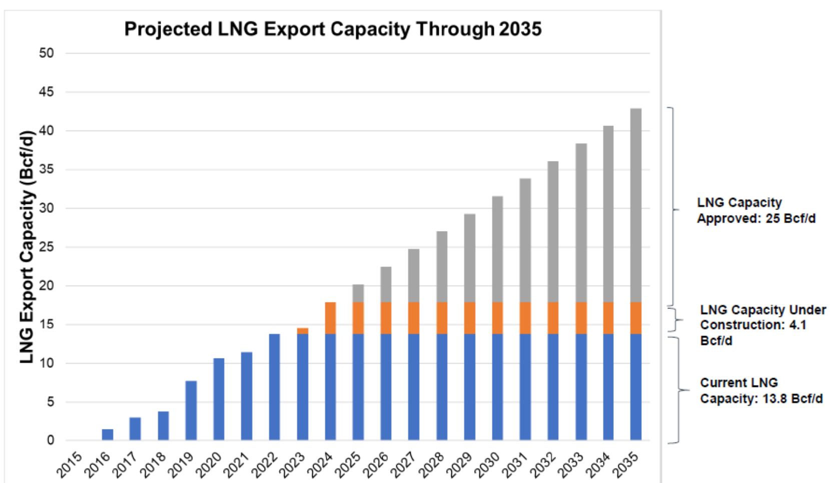
[165] The share that LNG imports from the U.S. comprises of total natural gas imports into China and India in 2021 was calculated to be 8% and 17% using data from BP's Statistical Review of World Energy.

APPENDIX II. DEMAND SENSITIVITY CASES

There are three demand sensitivity cases analyzed for this study. These cases are based on current, under construction and approved projects from EIA and FERC publications, total LNG export applications received by the DOE and on an optimistic natural gas demand outlook for Asia. These demand sensitivity cases simulated LNG exports that are much higher that the most likely volumes to assess the magnitude of impacts with the caveat that these export volumes not only require liquefaction facilities to be built on an aggressive timeline but also pipeline infrastructure build out beyond levels that are planned.[166]

- Demand Sensitivity Case 1 (42 Bcf/day by 2035 LNG Export Capacity Build-Out) – Under this case, the projected LNG exports are based on current, under construction and approved projects drawn from EIA and FERC publications.[167] Thus, this case considers LNG export capacity that is currently operational, is under construction and expected to be operational over the next few years or has been approved by the FERC but has not begun construction yet. The trajectory considers current and under construction LNG export capacity that is scheduled to come online by 2024. After 2024, it is assumed that LNG export capacity will be built such that all the approved projects in the pipeline would come online by 2035 amounting to total LNG export capacity build-out of 42 Bcf/day. This trajectory is shown in Figure 18. In this case, it is assumed that the domestic natural gas consumption and pipeline natural gas exports from the U.S. are the same as that in the Base Case.

Figure 18: Projected LNG Export Capacity Through 2035 (42 Bcf/day LNG Export Capacity Build-Out by 2035)



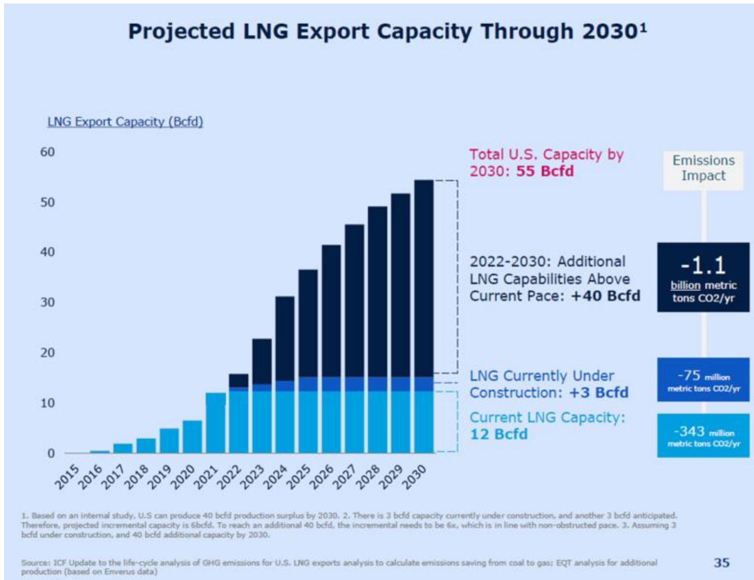
- Demand Sensitivity Case 2 (55 Bcf/day by 2030 LNG Export Capacity Build-Out) – Under this case, the projected LNG exports are based on a trajectory that assumes that in the 2022-2030

[166] As demonstrated in the NERA Study (2018), there is low probability of achieving exports of such high volumes.

[167] U.S. Liquefaction Capacity, U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php); North American LNG Export Terminals, Federal Energy Regulatory Commission (available at https://cms.ferc.gov/media/north-american-lng-export-terminals).

period, an additional 40 Bcf/day of LNG export capacity would be built such that the total LNG export capacity by 2030 amounts to 55 Bcf/day[168] (which represents the volume of LNG export applications received by DOE) as shown in Figure 19.[169] In this case, it is assumed that the domestic natural gas consumption and pipeline natural gas exports from the U.S. are the same as that in the Base Case.

Figure 19: Projected LNG Export Capacity Through 2030 (55 Bcf/day LNG Export Capacity Build-Out by 2030)



- Demand Sensitivity Case 3 (China/India Increased Demand for U.S. LNG Exports) – Under this case, it is assumed that the growth in natural gas demand in China and India will motivate higher demand for LNG exports to these two regions from the U.S. The projected level of U.S. LNG exports to these two regions are determined using projected regasification capacity, the historical maximum capacity utilization of regasification facilities in these two regions and the historical share that U.S. LNG exports into these regions comprise of total LNG imports.[170] In this case, it is assumed that the domestic natural gas consumption and pipeline natural gas exports from the U.S. are the same as that in the Base Case. Figure 20 shows the projected LNG exports under this case compared to the Reference case.

[168] "55 Bcf/day of LNG Export Applications Received by DOE," Oil & Gas 360, March 21, 2017 (available at https://www.oilandgas360.com/55-bcfd-lng-export-applications-received-doe/).

[169] "Unleashing U.S. LNG, The Largest Green Initiative on the Planet, " EQT, March 2022 (available at https://www.eqt.com/wp-content/uploads/2022/03/LNG_Final.pdf).

[170] For a description of the assumptions and methodology used to construct this scenario, see Appendix I.

Figure 20: Projected LNG Exports (China/India Increased Demand for U.S. LNG Exports)

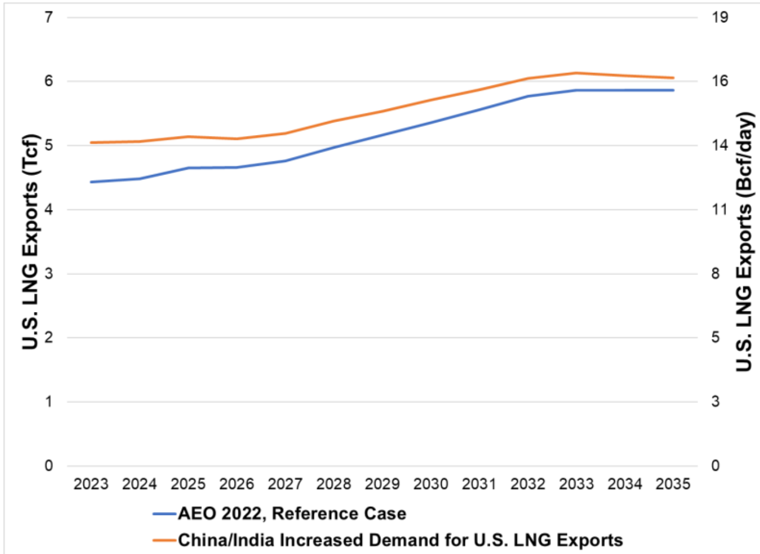


Table 12 outlines the six sensitivity market scenarios that are analyzed in this study obtained by pairing the two supply cases described in Section 6.1 and the three demand sensitivity case described above. Table 12 also outlines the scenario levers that relate to domestic consumption, pipeline natural gas exports and LNG exports for each of the six market outlook scenarios.

Table 12: Sensitivity Market Outlook Scenarios

Market Outlook Scenario	Demand Scenario	Supply	Consumption	Pipeline Natural Gas Exports	LNG Exports
Sensitivity Scenario 1	42 Bcf/day by 2035	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	42 Bcf/day by 2035 LNG Export Capacity Build-Out
Sensitivity Scenario 2	Demand Sensitivity Case 2 (55 Bcf/day by 2030)	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	55 Bcf/day by 2030 LNG Export Capacity Build-Out
Sensitivity Scenario 3	Demand Sensitivity Case 3 (China/India Demand Pull)	Restrictive Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	China/India Increased Demand for U.S. LNG Exports
Sensitivity Scenario 4	Demand Sensitivity Case 1 (42 Bcf/day by 2035)	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	42 Bcf/day by 2035 LNG Export Capacity Build-Out
Sensitivity Scenario 5	Demand Sensitivity Case 2 (55 Bcf/day by 2030)	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	55 Bcf/day by 2030 LNG Export Capacity Build-Out
Sensitivity Scenario 6	Demand Sensitivity Case 3 (China/India Demand Pull)	Expanded Accessible Supply	AEO 2022 Reference	AEO 2022 Reference	China/India Increased Demand for U.S. LNG Exports

Table 13 and Table 14 present the projected domestic consumption, pipeline natural gas exports and LNG exports for the Reference Case and the differences in each of these demand variables relative to the Reference Case for the demand sensitivity cases for 2025 and 2035 respectively.

Table 13: Projected Reference Case Demand and Demand Shifts Relative to Reference Case (2025) (Sensitivity Demand Cases)

2025			
Demand Case	**Consumption**	**Pipeline Natural Gas Exports**	**LNG Exports**
Reference	30.4 Tcf	3.4 Tcf	4.7 Tcf (12.9 Bcf/day)
	Consumption Shift (Relative to Reference Case)	**Pipeline Natural Gas Exports Shift (Relative to Reference Case)**	**LNG Exports Shift (Relative to Reference Case)**
42 Bcf/day by 2035	N/A	N/A	+2.7 Tcf (+58%)
55 Bcf/day by 2030	N/A	N/A	+8.9 Tcf (+190%)
China/India Demand Pull	N/A	N/A	+0.5 Tcf (+11%)

Table 14: Projected Reference Case Demand and Demand Shifts Relative to Reference Case (2035) (Sensitivity Demand Cases)

2035			
Demand Case	**Consumption**	**Pipeline Natural Gas Exports**	**LNG Exports**
Reference	30.4 Tcf	3.8 Tcf	5.9 Tcf (16.2 Bcf/day)
	Consumption Shift (Relative to Reference Case)	**Pipeline Natural Gas Exports Shift (Relative to Reference Case)**	**LNG Exports Shift (Relative to Reference Case)**
42 Bcf/day by 2035	N/A	N/A	+10 Tcf (+167%)
55 Bcf/day by 2030	N/A	N/A	+14 Tcf (+242%)
China/India Demand Pull	N/A	N/A	+0.2 Tcf (+3%)

Table 15 shows the equilibrium natural gas market prices for the two supply cases and four sensitivity demand cases as well as the price differences between the two supply cases for 2025 and 2035 across the various demand cases. [171] These price differences illustrate the natural gas price impacts from increasing pipeline infrastructure accessibility (as in the Expanded Accessible Supply case). Natural gas supply price

[171] There are several upcoming LNG export capacity developments in Mexico that will rely on U.S. natural gas pipeline exports.. Of these, Phase 1 of ECA LNG with LNG export capacity of 3.25 MTPA (or 0.43 Bcf/day) which is currently under construction is expected to come online in 2024 (*See* ECA LNG - A World-Class Project to help Power the Global Energy Transition, Sempra Infrastructure, March 3, 2022 (available at https://semprainfrastructure.com/news-and-events/spotlight-stories/eca-lng-a-world-class-project-to-help-power-the-global-energy-transition). In 2025, the export supply volumes to Mexico (that are in excess of the AEO 2022 Reference Case pipeline export volumes) are sufficient to support Phase 1 of the ECA LNG terminal under both the supply cases. By 2035, sufficient export volumes exist to meet Mexico's domestic and LNG exports demand (from ECA LNG Phase 1) in both supply cases if natural gas pipeline infrastructure from the U.S. to Mexico are able to operate at levels higher than the historical maximum utilization levels.

impacts in 2025 range between $0.25/MMBtu and $0.55/MMBtu while in 2035, they range between $0.25/MMBtu and $0.50/MMBtu across the various scenarios analyzed.[172,173] The results show that without an increase in capacity utilization on existing pipelines or additional new pipeline being built, the equilibrium market prices would be higher up the supply curve resulting in greater price impacts.[174] It can also be seen that the price impacts are significantly greater in the demand cases with higher levels of LNG exports compared to the Reference case levels such as in the 42 Bcf/day by 2035 and 55 Bcf/day by 2030 demand cases. Under the Restrictive case with large LNG exports leading to higher overall demand for natural gas prices are rising much faster (steeper supply curve) than in the Expanded supply cases, hence the equilibrium price separation between the Restrictive and the Expanded supply cases are much more pronounced (larger price benefits). Among the various scenarios analyzed, the largest price impacts in 2025 are seen in the 55 Bcf/day by 2030 demand case, where the impacts are about 16% while in 2035, the largest price impacts are projected to occur in the 42 Bcf/day by 2030 demand case where the impacts are about 12%.

Table 15: Natural Gas Price Impacts from Increasing Supply Accessibility (Sensitivity Demand Cases) (2021$/MMBtu)

		Supply Cases		
Year	**Demand Cases**	**Restrictive Accessible Supply**	**Expanded Accessible Supply**	**Change in Prices**
2025	42 Bcf/day by 2035	$3.10	$2.80	-$0.30
	55 Bcf/day by 2030	$3.50[175]	$2.95	-$0.55
	China/India Demand Pull	$2.95	$2.70	-$0.25
2035	42 Bcf/day by 2035	$4.05[175]	$3.55	-$0.50
	55 Bcf/day by 2030	$4.20[175]	$3.75	-$0.45
	China/India Demand Pull	$3.60	$3.35	-$0.25

Figure 21 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the 42 Bcf/day by 2035 demand outlook.

[172] The natural gas price impacts estimated for scenarios where additional supply is needed to satisfy total export demand assumes that there is just sufficient supply expansion (either through an expansion in current pipeline takeaway capacities or adding new pipelines) occurring to match the requirement for supply. If supply expansions exceed this requirement, the price impacts would be lower.

[173] The price impacts are sensitive to supply elasticity assumptions. As higher supply elasticity values would result in a relatively elastic supply curve which would imply that for the same exports volume we would expect to see lower natural gas prices; while if the supply elasticity value is lower, then we would see a reverse effect on prices.

[174] Supply constraints arising from insufficient pipeline infrastructure particularly in the east coast of the U.S. has the potential to increase natural gas prices. *See* Morgan Evans, "Calls to Build Out East Coast Natural Gas Pipelines Escalating as Bill Seeks Regulatory Certainty," Shale Daily, Natural Gas Intelligence, December 8, 2022 (available at https://www.naturalgasintel.com/calls-to-build-out-east-coast-natural-gas-pipelines-escalating-as-bill-seeks-regulatory-certainty/).

[175] The equilibrium market prices for these scenarios (where the total accessible supply is insufficient to meet total demand) is the adjusted marginal price on the export market supply curve. A description of the methodology employed to calculate the adjusted prices are provided in Appendix I.

Figure 22 shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the 55 Bcf/day by 2030 demand outlook. Figure **23** shows the supply curves for the Restrictive and Expanded Accessible Supply cases with demand for the China/India Demand Pull demand outlook. The left panel in each of the graphs below show the supply curves and demand for 2025 while the right panel show the supply curves and demand for 2035.

Figure 21: Restrictive and Expanded Accessible Supply Curves with Demand (42 Bcf/day by 2035)

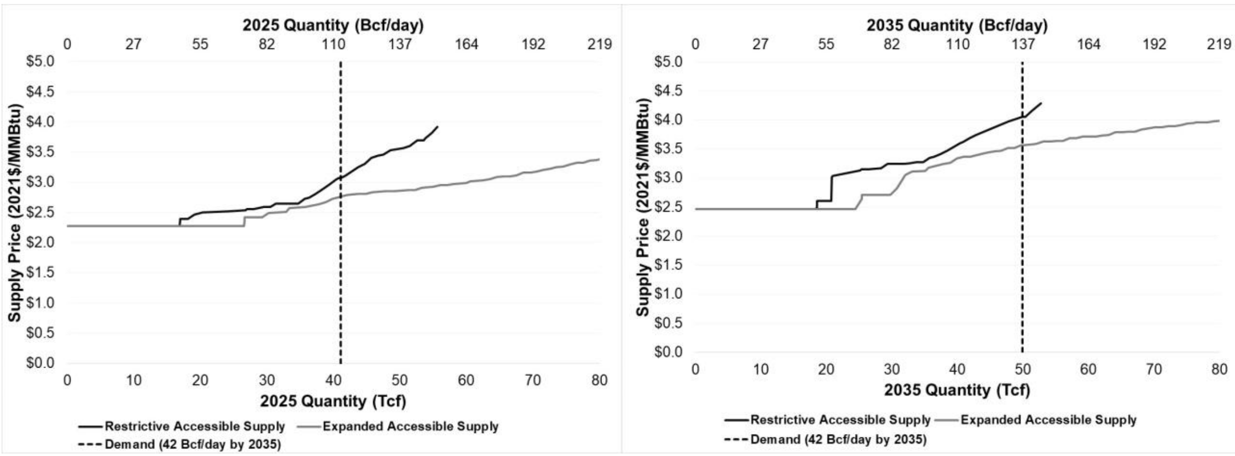


Figure 22: Restrictive and Expanded Accessible Supply Curves with Demand (55 Bcf/day by 2030)

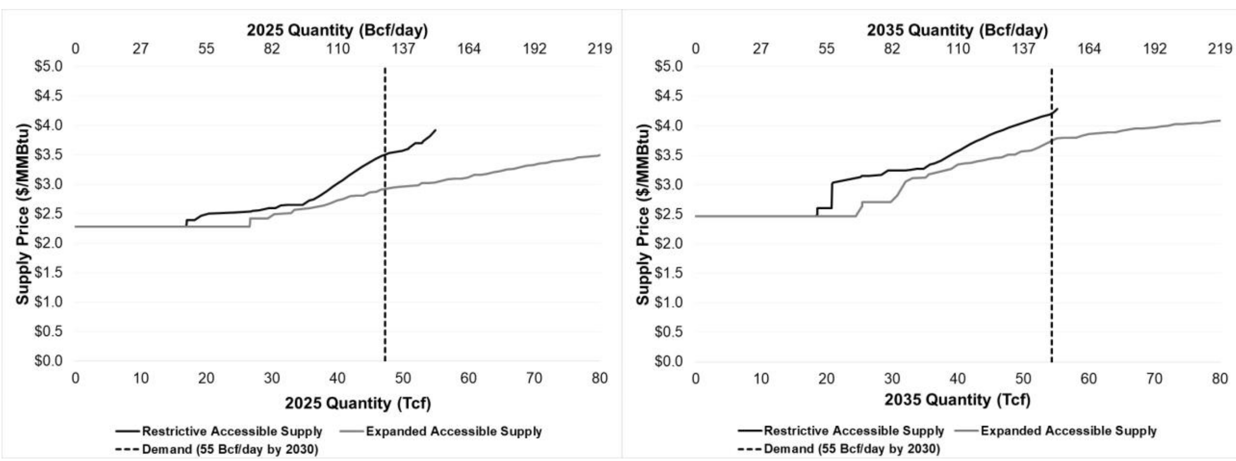
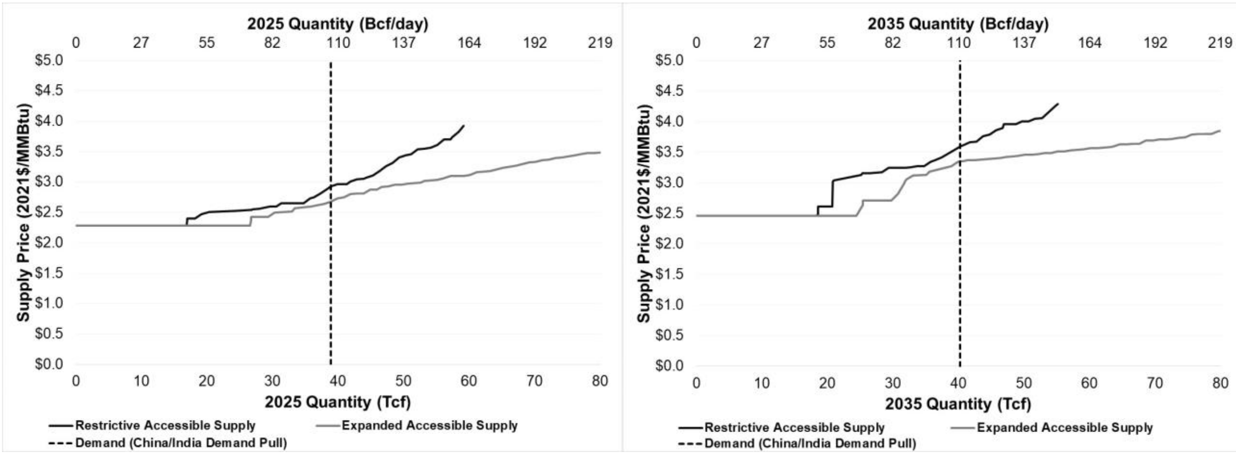


Figure 23: Restrictive and Expanded Accessible Supply Curves with Demand (China/India Demand Pull)



APPENDIX III. HISTORICAL AND CURRENT TRENDS IN THE U.S. AND GLOBAL NATURAL GAS MARKET

U.S. Natural Gas Market

1. Natural Gas Production and Reserves

U.S. natural gas production has undergone a major shift in its composition since the late 2000s. Prior to this period, natural gas was produced primarily from conventional gas formations. However, since about 2007, natural gas production from unconventional gas formations (such as from shale gas and coalbed seams) have increased. Figure 24 presents natural gas gross withdrawals by source type. Natural gas withdrawals from shale gas formations have increased by about ten-fold from 2008 to 2020. On the other hand, it can be seen that natural gas production from conventional gas wells has declined over the same period. From 2008 to 2020, total U.S. natural gas gross withdrawals grew by about 58% with the ten-fold increase in shale gas production more than offsetting the 55% decline in withdrawals from conventional sources.

As shown in Figure 24, in 2008, natural gas supply from coalbed seams and shale gas constituted about 19% of total gross withdrawals while, by 2020, they comprised of nearly 72% of the total. Figure 25 shows the proven natural gas reserves in the U.S. by source type. U.S. natural gas reserves have grown significantly over the 2008-2020 period, increasing by nearly eight-fold. The portion of the resource base comprised of conventional and tight resources have been able to maintain its reserves level to support future production. The commercialization of shale gas production from natural gas formations has resulted in a significant total increase in the level of reserves. From 2008 to 2020, total proven natural gas reserves have increased by nearly 86% while supporting increasing annual levels of natural gas production, see Figure 25.

Figure 24: U.S. Natural Gas Gross Withdrawals By Source Type[176]

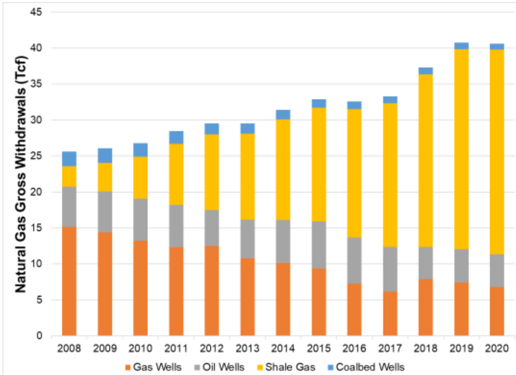


Figure 25: U.S. Natural Gas Proven Reserves[177]

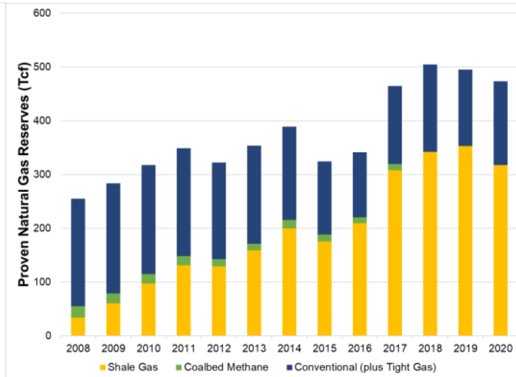


Figure 26 shows the geographic location of the shale plays in the U.S., with substantial resource plays in Texas (Permian, Barnett, Eagle Ford and Haynesville) as well as the Northeast region (Marcellus and Utica) and a few other resources such as Niobrara (Rockies area), Woodford (OK) and Fayetteville (AR).

Figure 26: U.S. Shale Plays

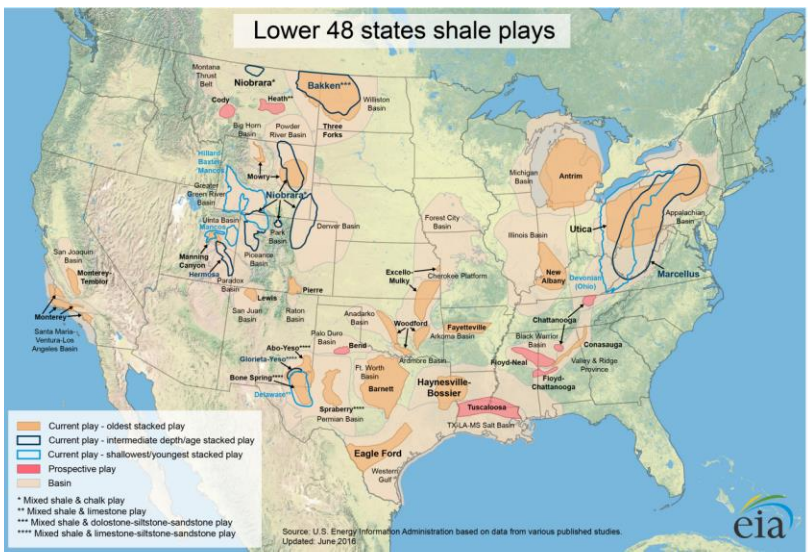


Figure 27 illustrates how shale gas production has grown with time and has become more locationally diverse. In 2008, shale gas production was about 13% (2.5 Tcf) of total U.S. dry natural gas production. The Barnett play comprised about 40% (1.4 Tcf) of total shale gas production with the Permian play and the Fayetteville play accounting for another 17% of total shale gas production. By 2021, shale gas production increased to 27.2 Tcf annually, comprised of about 80% of total U.S. dry natural gas production. In 2021, production from the Barnett play comprised of only about 3% (0.68 Tcf) of total

176 "Natural Gas Gross Withdrawals and Production," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_a.htm).

177 "Proved reserves, reserves changes, and production," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#exploration).

shale gas production. The Marcellus play was the highest in terms of production, producing about 9.1 Tcf or about one third of total shale gas production. In 2021, the Haynesville play produced about 4.1 Tcf of shale gas or about 15% of total shale gas production, while the production from the Permian play increased to 4.6 Tcf in 2021 (from 0.34 Tcf in 2008), comprising about 17% of total shale gas production. The Utica play produced about 2.5 Tcf in 2021 which comprised about 9% of total shale gas production.

The Marcellus play (which covers portions of Pennsylvania, West Virginia, Ohio and New York) and the Permian Basin in West Texas account for the majority of natural gas currently produced in the U.S. In 2021, these two regions accounted for 26% and 13% of total dry natural gas production, respectively.[178] Natural gas production from the Marcellus shale play grew at an annual average rate of 40% from 2010 to 2019 compared to 5% from 2020 to 2021 while in the Permian shale play, natural gas production grew at an annual average of 29% from 2010 to 2019 compared to 10% from 2020 to 2021.

Figure 27: Annual Shale Gas Production by Major Play[179]

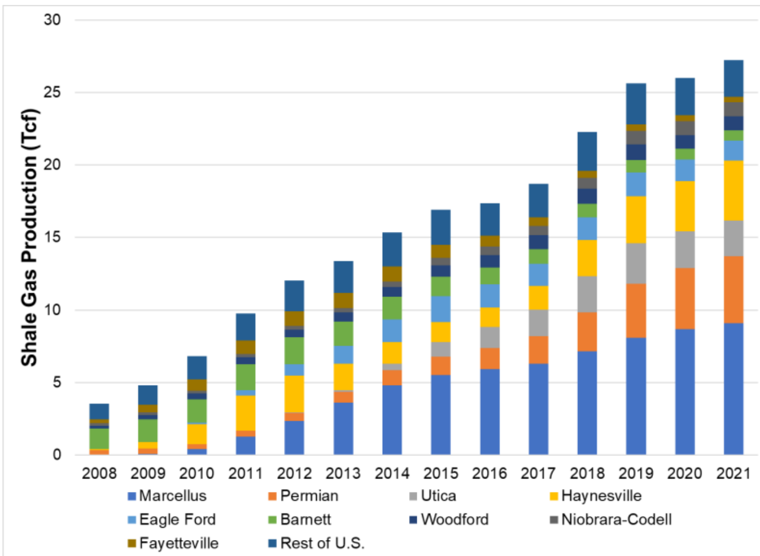


Figure 28 shows the change in the shale gas proven reserve estimates for the major plays over the 2008-2020 period. In 2020, the Marcellus play was estimated to have the greatest reserves amounting to about 129 Tcf followed by the Permian play with reserves amounting to about 53 Tcf. It can also be seen that the reserve estimates across all the major plays are greater than in 2008 with the exception of the Barnett play where the amount of proven reserves has declined by half from about 22 Tcf in 2008 to 11 Tcf in 2020. In addition to the increase in reserve estimates, rig efficiency has increased from 2008 through 2021. Figure 29 shows the historical increase in economic efficiency and scale economies in shale gas production through the natural gas production per rig by region over the 2008-2021 period. It can be seen that the production per rig across all the regions has generally been increasing over time, driven by innovations in horizontal drilling enabling more natural gas to be produced by a single well as well as

[178] "Dry Shale Gas Production Estimates by Play," U.S. Energy Information Administration, September 29, 2022 (available at https://www.eia.gov/naturalgas/data.php#production).

[179] "Dry shale gas production estimates by play," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#production).

technological developments with the completion of wells.[180] The greatest increase in rig productivity was seen in the Appalachia region which includes the Marcellus and Utica shale gas formations. The rig productivity in the region has increased from below 0.01 Bcf/day in 2008 to 0.39 Bcf/day, more than a fifty-fold increase. The other producing regions which have shown significant increases in rig productivity include the Bakken region (North Dakota and Montana) where rig productivity has increased by more than thirty-fold (from 0.001 Bcf/day in 2008 to 0.04 Bcf/day in 2021) and the Haynesville region (Louisiana and Texas) where rig productivity has increase by about eleven-fold (from 0.015 Bcf/day in 2008 to 0.16 Bcf/day in 2021). While rig productivity has increased, the number of crude oil and natural gas rigs has declined from nearly 1,900 rigs in 2008 to 478 rigs in 2021.[181]

Figure 28: Shale Gas Reserves by Major Play[182]

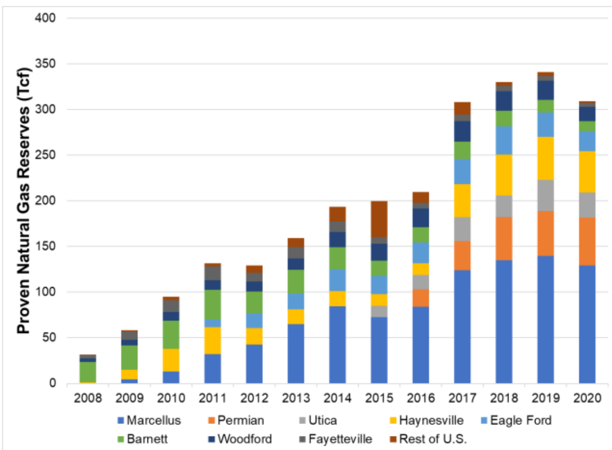
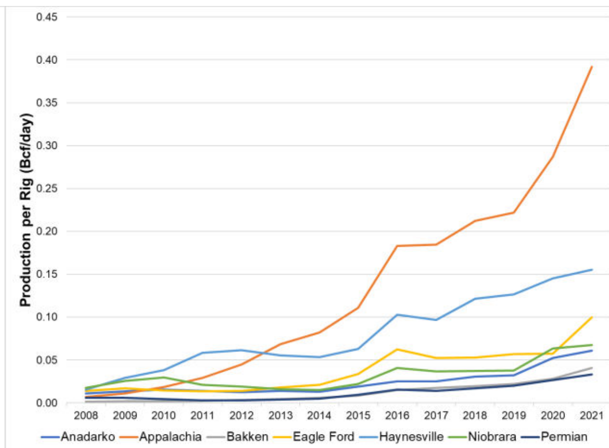


Figure 29: Annual Natural Gas Production per Rig by Producing Region[183]



2. Natural Gas Consumption

Total U.S. natural gas consumption has shown continued growth since the economic recession in 2008, increasing 28% from 21.5 Tcf in 2008 to 27.4 Tcf in 2021 as shown in Figure 30.[184] This increase has been largely driven by an increase in natural gas demand in the electric power sector which was about 69% higher in 2021 compared to 2008 levels. Industrial sector demand for natural gas was about 23% higher in 2021 compared to 2008 while residential and commercial sector demand was essentially flat across the same time period. Natural gas demand for vehicle fuel in the transportation sector, although

[180] "Will Productivity Ride to the Rescue of US Oil Producers… or Become the Villain?" Forbes Media LLC, October 15, 2021 (available at https://www.forbes.com/sites/thebakersinstitute/2021/10/25/will-productivity-ride-to-the-rescue-of-us-oil-producersor-become-the-villain/?sh=169d447b5647).

[181] "Crude Oil and Natural Gas Drilling Activity," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_enr_drill_s1_m.htm)..

[182] "U.S. shale plays: natural gas production and proved reserves." U.S. Crude Oil and Natural Gas Proved Reserves, year-end 2020 (available at https://www.eia.gov/naturalgas/crudeoilreserves/).

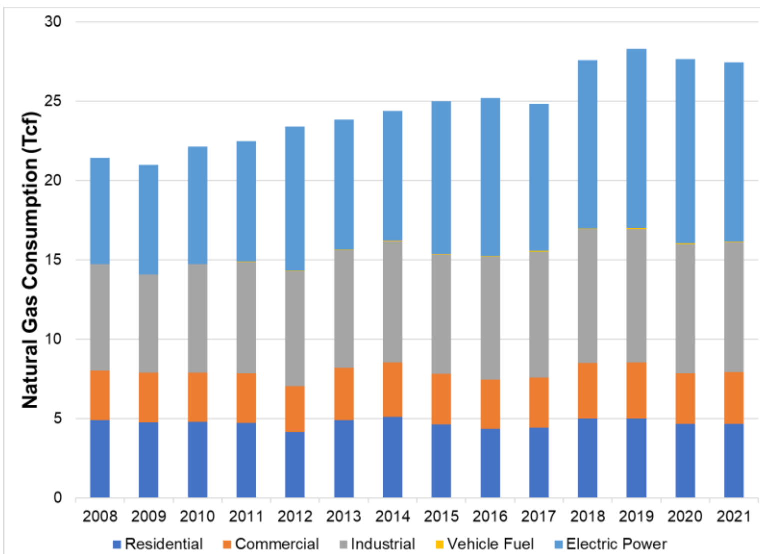
[183] Drilling Productivity Report, U.S. Energy Information Administration (available at https://www.eia.gov/petroleum/drilling/).

[184] "Total consumption," U.S. Energy Information Administration, as of July 2022 (available at https://www.eia.gov/naturalgas/data.php#consumption).

relatively small compared to other sectors, has been steadily increasing since 2008 and amounts to about 0.05 Tcf in 2021 (compared to 0.03 Tcf in 2008). As of 2021, natural gas demand for the electric power sector accounted for 41% of total domestic natural gas demand, the industrial sector accounted for 30%, and the residential and commercial sector demand accounted for 29%. Vehicle fuel in the transportation sector accounted for less than 1% of total U.S. natural gas demand.

The increase in natural gas by the electric power sector has been driven by a greater reliance on natural gas for power generation due to environmental and cost reasons. For example, natural gas-fired generating units have replaced retired coal-fired generating units that have nearly double the greenhouse gas emissions than their natural gas counterparts. Lower historical natural gas prices in the U.S. relative to other regions in the world have provided its industrial sector with a competitive advantage and have contributed to an increase in the industrial sector's demand for natural gas. The increase in natural gas demand for vehicle use has been driven primarily by a shift from diesel to natural gas as a fuel in public transportation such as buses.

Figure 30: Natural Gas Consumption By End-Use Sector[185]



3. Natural Gas Supply, Demand, and Prices

Figure 31 presents the historical U.S. natural gas supply and demand components, which highlights the robust growth in natural gas supply followed by the lagged increase in U.S. natural gas consumption. Since 2017, U.S. natural gas production has exceeded consumption while the U.S. has become an increasing exporter of natural gas. Natural gas production in 2021 was about 69% higher than production levels in 2008 (34.1 Tcf in 2021 compared to 20.2 Tcf in 2008) while consumption levels were only about 30% higher than 2008 levels (30.3 Tcf in 2021 compared to 23.3 Tcf in 2008). Natural gas imports

[185] "Total consumption," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#consumption).

decreased by about 30% in 2020 (compared to 2008) while natural gas export levels were nearly seven-fold higher primarily driven by an increase in LNG exports from the U.S.

Figure 32 presents historical monthly Henry Hub natural gas prices from 2008 to June 2022. The development of shale gas resources has resulted in a general decrease in prices over the years. Prior to 2008, natural gas prices were relatively higher as a consequence of the growth in natural gas use by electric generators combined with the continued depletion of conventional natural gas resources. The higher natural gas prices incentivized the development of higher cost conventional natural gas resources and also contributed to natural gas being imported in the form of liquefied natural gas. In 2009, two factors contributed to a precipitous drop in natural gas prices. The first was the recession brought on by the financial crisis which resulted in a decline in economic activity and industrial output. This in turn resulted in lower demand for natural gas. The second factor was the emerging ability of natural gas producers to employ new drilling and production technologies for producing natural gas from shale gas formations. This contributed to increased natural gas production in increasing quantities at lower prices with prices remaining low despite increasing natural gas demand. Further, after 2009 the economy slowly recovered and as a result economic activity increased, creating greater demand for natural gas. Another spike in natural gas occurred in 2014 which was the consequence of polar vortex-like cold conditions experienced across much of the U.S., which drove up the demand for natural gas and depleted storage inventories.[186] In 2021, U.S. natural gas prices were higher compared to the prices in 2020. This was driven by a colder than-average 2020-21 winter season which contributed to an increase in natural gas demand for heating in several regions of the U.S., strong natural gas demand in the electric power sector and relatively modest new production growth. The strong electric generation demand for natural gas was caused by a warmer than average summer, which kept electricity demand elevated, and lower levels of generation from coal-fired generating resources on account of higher coal prices and significant plant retirements in recent years. By June 2022, natural gas prices rose to as high as $8/MMBtu largely as a consequence of tight supply in the U.S. market. The tightness in supply was from unusually low levels of natural gas storage inventories combined with cold spring weather followed by a heat wave that created more demand than was normal at the time of the year.[187] Another factor that has potentially contributed to supply tightness in recent years are pipeline takeaway constraints, particularly in the Appalachian region which has placed a limit on the amount of natural gas that can be moved out of the region and to key demand centers.[188]

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[186] "Weekly Natural Gas Storage Report," U.S. Energy Information Administration (available at https://ir.eia.gov/ngs/ngs.html).

[187] Patti Domm, "Natural gas prices have already doubled this year. A hot summer could push them even higher, "CNBC, May 17, 2022 (available at https://www.cnbc.com/2022/05/17/natural-gas-prices-have-already-doubled-this-year-a-hot-summer-could-push-them-even-higher.html).

[188] Sheetal Nasta, "Back To Zero - Appalachia's Dwindling Natural Gas Pipeline Takeaway Capacity," RBN Energy, August 18, 2021 (available at https://rbnenergy.com/back-to-zero-appalachias-dwindling-natural-gas-pipeline-takeaway-capacity).

Figure 31: Natural Gas Supply and Demand[189]

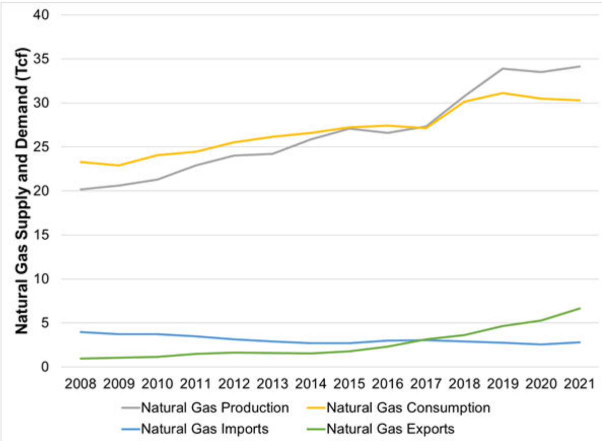
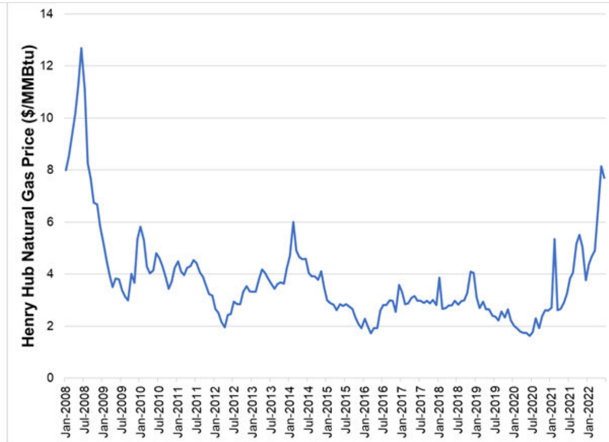


Figure 32: Historical Natural Gas Henry Hub Prices[190]



4. Natural Gas Trade

Figure 33 shows the historical pipeline imports and exports between Canada, Mexico and the U.S. It can be seen that the pipeline imports from Canada have been declining while the pipeline exports to Mexico have been increasing. Pipeline exports to Canada increased from 2008 to 2012 but have since remained relatively flat. It can also be seen that the volume of natural gas imported into the U.S. from Canada has been relatively small. In 2021, pipeline imports from Canada were about 2.8 Tcf, about 22% lower than the import levels in 2008 of 3.6 Tcf. The pipeline exports to Mexico have increased by about five-fold from 0.36 Tcf in 2008 to about 2.2 Tcf in 2020. The pipeline exports to Canada in 2021 were about 0.94 Tcf compared to 0.56 Tcf in 2008, about a 68% increase.

[189] "Natural gas overview," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#summary).

[190] "Henry Hub Natural Gas Spot Price," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/hist/rngwhhdm.htm).

Figure 33: Natural Gas Pipeline Trade[191]

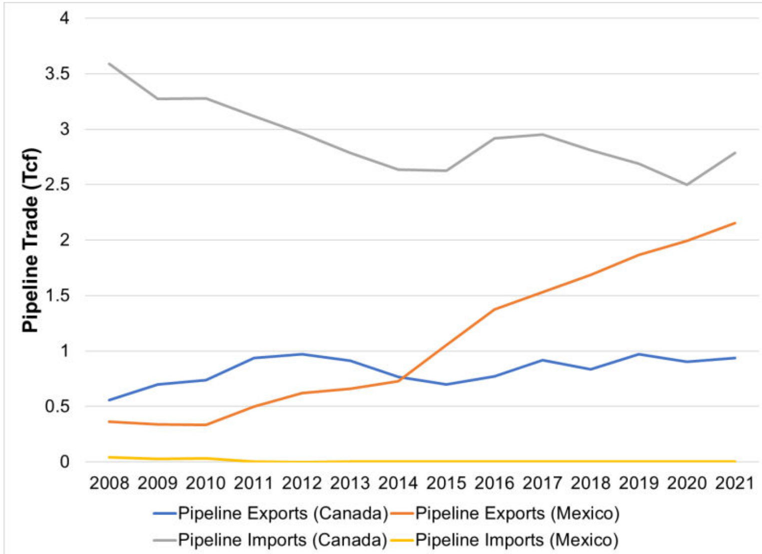


Figure 34 shows the historical liquefied natural gas imports and exports from and to the U.S. It can be seen that LNG imports into the U.S. have steadily declined with the import levels in 2021 (0.02 Tcf or 0.06 Bcf/day) about 94% lower than the levels in 2008 (0.35 Tcf or 0.96 Bcf/day). LNG exports from the U.S. have significantly increased over the past 10 years. In 2021, the U.S. exported about 3.6 Tcf (or 9.8 Bcf/day) of LNG compared to about 0.04 Tcf (or 0.13 Bcf/day) in 2008, about a ninety-fold increase. Figure 35 shows the liquefied natural gas exports from the U.S. by destination region. It can be seen that up until 2015, all the LNG exports from the U.S. were to Asia (and specifically Japan). After 2015, there was greater diversification of destinations for U.S. LNG exports. In 2021, the largest share of LNG exports went to Asia (about 4.6 Bcf/day or 47% of total LNG exports) followed by exports to Europe (about 3.3 Bcf/day or 34% of total LNG exports). In Asia, both South Korea and Japan each comprised about 19% (or 1.24 Bcf/day) of the total LNG exports while in Europe, the two countries that constituted the largest share of exports were Spain (9% or 0.59 Bcf/day) followed by the United Kingdom (8% or 0.53 Bcf/day).

[191] "U.S. imports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_impc_s1_m.htm); "U.S. exports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_m.htm).

Figure 34: Liquefied Natural Gas Trade[192]

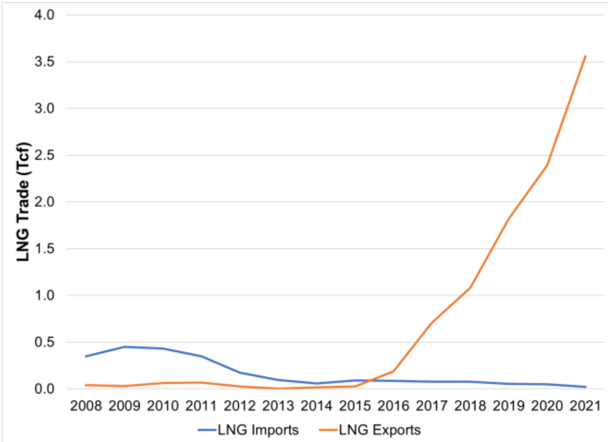
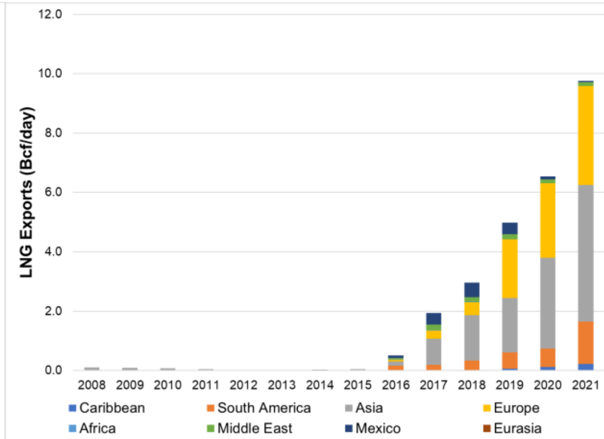


Figure 35: Liquefied Natural Exports (By Destination Region)[193]



5. LNG Liquefaction Export Capacity

Table 16 shows the LNG liquefaction export capacity for terminals in the U.S. which are currently in commercial operation, under construction or in the commissioning phase. The total export capacity for terminals in operation are about 13.6 Bcf/day(or 102.1 MTPA)[194] while the total capacity for terminals which are currently under construction or in the commissioning phase is 6.93 Bcf/day(or 49.1 MTPA). The total export capacity for terminals which have been approved but have not yet begun construction amounts to 22.7 Bcf/day(or 160.7 MTPA) as shown in Table 17.

[192] "U.S. imports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_impc_s1_m.htm); "U.S. exports by country," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_m.htm).

[193] U.S. Natural Gas Exports and Re-Exports by Country, U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_move_expc_s1_a.htm).

[194] 1 MTPA of LNG approximately equals 48.7 Bcf.

Table 16: U.S. LNG Liquefaction Export Capacity (Commercial Operation, Commissioning/Under Construction)[195]

Project Name	DOE-Authorized Export Capacity to FTA Countries	
	Bcf/day	**MTPA**
Commercial Operation		
Sabine Pass	4.6	34.6
Cove Point	1.0	7.8
Elba Island	0.5	4.0
Corpus Christi	2.4	18.2
Cameron	2.1	14.9
Freeport	2.1	16.3
Calcasieu Pass (Trains 1-9)	0.9	6.2
Total	**13.6**	**102.1**
Under Construction/Commissioning		
Calcasieu Pass (Trains 10-18)	0.9	6.2
Golden Pass	2.6	18.1
Plaquemines LNG Phase 1	1.9	13.3
Corpus Christi Liquefaction Stage III	1.6	11.5
Total	**6.9**	**49.1**

Table 17: U.S. LNG Liquefaction Export Capacity (Approved)[196]

Project Name	DOE-Authorized Export Capacity to FTA Countries	
	Bcf/day	**MTPA**
Cameron LNG Train 4	1.4	10.0
Magnolia LNG	1.2	8.8
Lake Charles LNG	2.0	15.0
Plaquemines LNG Phase 2	1.5	10.7
Driftwood LNG	3.9	27.6
Freeport LNG Train 4	0.7	5.1
Port Arthur LNG	1.9	13.5
Texas LNG	0.6	4.0
Rio Grande LNG	3.6	27.0
Gulf LNG	1.5	11.6
Delfin FLNG	1.8	13.0
Alaska LNG	2.6	20.0
Total	**22.7**	**160.7**

[195] "U.S. liquefaction capacity," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#imports).

[196] "U.S. liquefaction capacity," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#imports). Approval for LNG export does not guarantee that the project will be constructed.

6. Natural Gas Pipeline Capacity, Storage Volumes, and Rig Counts

The U.S. natural gas pipeline system is dynamic and has a history of adapting to changing market conditions. The expansion of existing pipelines and the construction of new pipelines have occurred in response to either regional growth in natural gas demand or to the development of new natural gas production. Further, the shale gas boom has also contributed to modifications to the existing pipeline systems to allow for bidirectional flow (called reversal projects). Figure 36 illustrates the annual natural gas pipeline additions which have occurred over the 2008-2021 period. It can be seen a peak in terms of pipeline capacity additions occurred in 2008 reflecting the development of LNG import projects and debottlenecking. It can also be seen that another peak occurred in 2018 reflecting the increase in LNG export capacity in the U.S. Over the 2008-2021 period, new pipelines contributed to about 28.5 Tcf (or 78.1 Bcf/day) of additional capacity, existing pipeline expansions contributed to about 29.6 Tcf (or 81.2 Bcf/day) of additional capacity while reversal projects contributed to about 8.2 Tcf (or 22.5 Bcf/day) of additional pipeline capacity. A total of 7.4 Bcf/day or 2.7 Tcf of interstate natural gas pipeline capacity was added in the U.S. during 2021.[197] This was the lowest amount of capacity added to interstate transmission since 2016, the year before LNG exports from the U.S. began to gather momentum. About 5 Bcf/day(or 1.8 Tcf) of interstate pipeline capacity additions were in the Texas and the Gulf Coast markets with most of the capacity additions intended to serve growing LNG export demand, primarily by connecting other interstate pipelines with LNG export terminals. Two of the three new pipeline projects completed in 2021 in the Texas and the Gulf Coast region were built to facilitate improved natural gas delivery to Venture Global's newly commissioned Calcasieu Pass LNG export terminal in Louisiana. These projects include:[198]

- Venture Global's TransCameron pipeline, a 1.9 Bcf/day24-mile lateral that delivers natural gas to the Calcasieu Pass LNG terminal via interconnections with other interstate pipelines.
- Enbridge's Cameron Extension Project, a 0.75 Bcf/day expansion on the Texas Eastern Transmission pipeline (TETCO) that connects with the TransCameron pipeline.

The other major project in the Gulf Coast region was the Double E pipeline, a 1.35 Bcf/day, 135-mile pipeline that provides new capacity from the producing areas of the Permian Basin in southeastern New Mexico to the Waha Hub in West Texas. The Northeast had the second-most interstate natural gas pipeline capacity additions totaling 1.60 Bcf/day during 2021. About half of this new capacity was associated with two related projects:

- The 0.58 Bcf/day Leidy South Expansion Project on the Transcontinental Pipeline increased pipeline capacity from the Appalachia Basin into East Coast markets.
- The National Fuel Gas Supply Corporation's FM 100 Project expanded its system by 0.33 Bcf/day in response to the additional Transcontinental Pipeline capacity available.

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[197] Interstate pipelines are those that cross state borders and those that serve export demand, both at pipeline border crossings and at terminals exporting LNG. *See* "Natural gas interstate pipeline capacity additions decrease in 2021," U.S. Energy Information Administration, February 24, 2022 (available at https://www.eia.gov/todayinenergy/detail.php?id=51398).

[198] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

The natural gas pipeline network in the U.S. will also continue to expand into the future. Figure 37 illustrates potential pipeline capacity additions from projects over the next couple of years. The projects which are currently under construction have the greatest probability of being completed while only a fraction of the projects which have been announced are expected to achieve commercialization. The probability of a project being built increases significantly once the project has been granted FERC approval.

Figure 36: Historical Natural Gas Pipeline Capacity Additions[199]

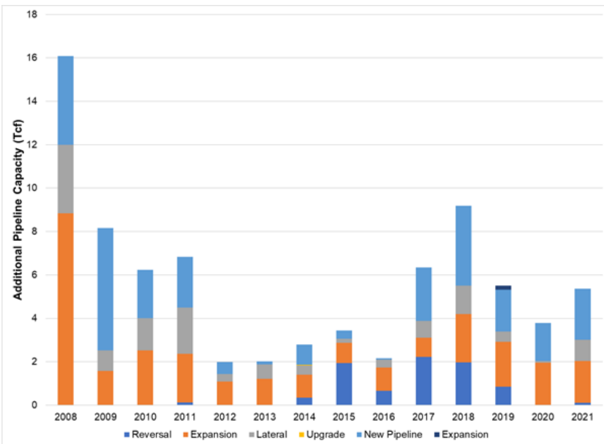
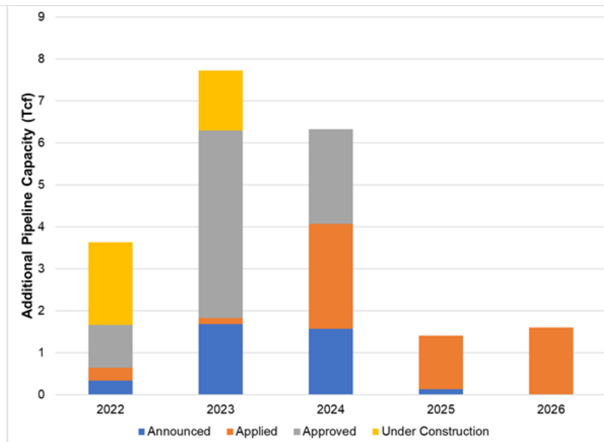


Figure 37: Future Natural Gas Pipeline Capacity Additions[200]



Over the 2022-2026 period, pipeline projects which are currently under construction have the potential to add 3.4 Tcf (or 9.3 Bcf/day) of capacity while pipeline projects that have either been announced, approved or where an application has been submitted have the potential to add about 17.3 Tcf (or 47.4 Bcf/day) of capacity. Nearly 51% of the projected additional pipeline capacity for the projects that are under construction originate in states in the Northeast region,[201] while the majority of the remaining additional capacity (46%) originate in states in the South Central region.[202] Similarly, about 51% of the projected additional pipeline capacity for the projects under construction end in states in Northeast region while the while the majority of the remaining additional capacity (47%) end in states in the South Central region. Table 18 outlines the natural gas pipeline projects that are currently under construction. About half of the pipeline capacity currently under construction (1.6 Tcf or 4.3 Bcf/day) and about 80% of the planned pipeline projects (13.1 Tcf or 36 Bcf/day) are designated to serve LNG export demand. About 8.5 Tcf or 23.3 Bcf/day of additional pipeline capacity are associated with major projects that have either

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[199] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

[200] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

[201] The Northeast region include Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia and West Virginia.

[202] The South Central region includes Alabama, Arkansas, Kansas, Louisiana, Mississippi, Oklahoma and Texas.

been cancelled or placed on hold in the lower-48 states as of 2020.[203] The majority of these projects are intra-regional projects beginning in Texas or Louisiana. Several key pipeline projects have also been cancelled in the Appalachian region, including the Atlantic Coast Pipeline (1.5 Bcf/day), the PennEast Pipeline (1.1 Bcf/day) and the Constitution Pipeline (650 MMcf/day).[204] Table 19 summarizes the natural gas pipeline projects in the lower-48 states which have been cancelled or placed on hold in the recent past (since 2020).

Table 18: Natural Gas Pipeline Projects (Under Construction)[205]

Project Name	Project Type	Year in Service Date	Beginning State	Ending State	Additional Capacity (MMcf/day)
134th Street Lateral Project	Lateral	2022	IL	IN	70
Adelphia Gateway Project	Conversion	2023	PA	PA	250
AGL International Paper Pipeline	Lateral	2022	GA	GA	12
Alberta Xpress Project	Expansion	2022	MI	LA	165
Central Corridor Pipeline Extension	Expansion	2022	OH	OH	1
Golden Pass LNG Bidirectional Pipeline	Expansion	2022	LA	TX	2,500
Greene Interconnect Project	Expansion	2022	WV	WV	1,000
Gulf Run Pipeline	New Pipeline	2023	LA	LA	1,650
Gulfstream Phase VI Expansion Project	Expansion	2022	AL	FL	78
Mountain Valley Pipeline	New Pipeline	2023	WV	VA	2,000
Oasis Pipeline Modernization Project	Expansion	2022	TX	TX	60
Supply Header Project[206]	Expansion	2022	PA	WV	1,500

[203] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines). Major pipeline projects are defined as projects with additional capacity greater than or equal to 500 MMcf/day.

[204] "Atlantic Coast Pipeline Cancelled as Delays and Costs Mount," The New York Times, July 5, 2020 (available at https://www.nytimes.com/2020/07/05/business/atlantic-coast-pipeline-cancel-dominion-energy-berkshire-hathaway.html); "PennEast becomes the latest to scuttle a natural gas pipeline project," Reuters, September 27, 2021 (available at https://www.reuters.com/business/energy/penneast-end-development-pennsylvania-new-jersey-natgas-pipe-2021-09-27/); "Williams, Partners Abandon Constitution Pipeline Project, North American Energy Pipelines," February 25, 2020 (available at https://www.napipelines.com/williams-partners-abandon-constitution-pipeline-project/).

[205] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

[206] The U.S. EIA's natural gas pipeline project tracker (released on April 29, 2022) includes Dominion Energy's Supply Header project as being under construction with a year in-service date of 2022. However, following cancellation of the Atlantic Coast Pipeline, the related Supply Header project is also reported to having been canceled with restoration efforts for the Atlantic Coast Pipeline and Supply Header project lands currently underway. *See* "Restoration Proposed for ACP, SHP Lands May Avoid Significant Impacts, Says FERC Staff," Natural Gas Intelligence, July 26, 2021 (available at https://www.naturalgasintel.com/restoration-proposed-for-acp-shp-lands-may-avoid-significant-impacts-says-ferc-staff/).

Table 19: Natural Gas Pipeline Projects (Cancelled or On Hold)[207]

Project Name	Project Type	Beginning State	Ending State	Additional Capacity (MMcf/d)
Atlantic Coast Pipeline	New Pipeline	WV	NC	1,500
Constitution Pipeline	New Pipeline	PA	NY	650
Creole Trail Expansion Project 2	Reversal	LA	LA	1,500
Permian Global Access Pipeline	New Pipeline	TX	LA	2,000
Permian to Katy Pipeline	New Pipeline	TX	TX	2,000
Western Energy Storage and Transportation (WEST) Header Project	New Pipeline	UT	MX	2,000
Wright Interconnect Project	Expansion	NY	NY	650
Bluebonnet Market Express Pipeline	New Pipeline	TX	TX	2,000
Delhi Connector Pipeline	New Pipeline	LA	LA	2,000
Gemini Gulf Coast Pipeline	New Pipeline	TX	TX	1,500
Haynesville Global Access Pipeline	New Pipeline	LA	LA	2,000
Lake Charles Expansion (Magnolia LNG)	Reversal	LA	LA	1,362
Pacific Connector	New Pipeline	OR	OR	1,200
Pecos Trail Pipeline	New Pipeline	TX	TX	1,850
PennEast Pipeline Phase 1	New Pipeline	PA	NJ	1,107

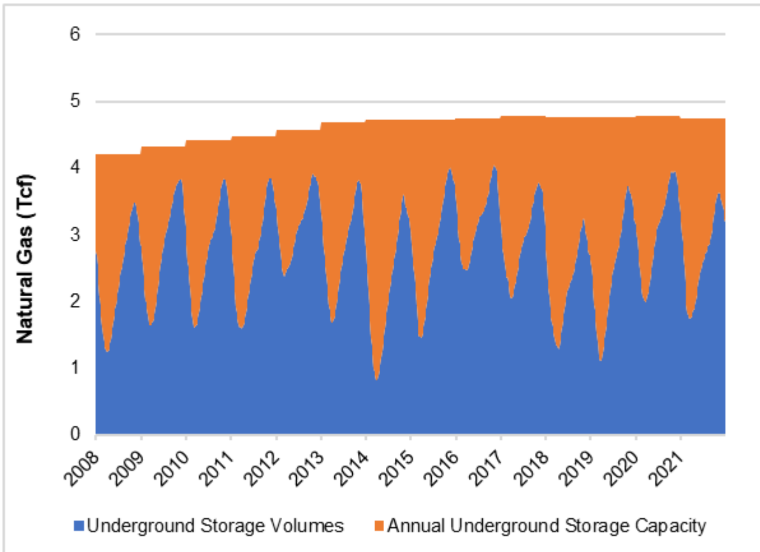
Figure 38 illustrates historical weekly working natural gas underground storage volumes and annual working natural gas underground storage capacity in the lower-48 states over the 2008-2021 period.[208] It can be seen that working natural gas storage capacity has increased slightly over this period. In 2008, storage capacity was 4.2 Tcf while in 2021, storage was 4.8 Tcf, about a 14% increase. Figure 39 shows the crude oil and natural gas rotary rigs in operation in the U.S. over the 2008-2021 period. It can be seen that the total rig count has declined since its peak in 2012 of 1,919 rigs to 478 rigs in 2021. The number of natural gas rigs has precipitously declined from its peak in 2008 where nearly 1,500 rigs were in operation to 98 rigs in 2021. Meanwhile, the number of crude oil rigs grew significantly from 2009 to 2014 when it peaked at 1,527. The crude oil rig count averaged 380 in 2021. Figure 40 shows the locational diversity of natural gas-specific rotary rigs in the U.S. for the main shale plays and how they

[207] "Pipeline projects," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#pipelines).

[208] EIA working natural gas underground storage data only reports storage volumes for the lower-48 states. EIA annual working natural gas underground storage capacity is reported as of June 30 of each year. The EIA began reporting working natural gas underground storage capacity data for Alaska in 2013. Alaska's working natural gas capacity has remained at 67.9 Bcf since 2013 but is not included in Figure 16. Hawaii does not have any underground natural gas storage.

have changed over the 2011-2021 period. In the Marcellus basin, the average number of natural gas rotary rigs in operation has declined from 129 rigs in 2011 to 29 rigs in 2021, a decline of about 77% while in the Haynesville basin (Louisiana, Texas), the average number of natural gas rigs has declined from 137 rigs in 2011 to 46 rigs in 2021, a decline of about 66%. Sharper declines in average natural gas rig counts have occurred in the Permian (Texas and New Mexico), Barnett (North Dakota and Montana), Woodford (Oklahoma), and Fayetteville (Arkansas) basins as seen in Figure 40.

Figure 38: Working Underground Natural Gas Storage Volumes and Capacity[209]



[209] "Underground storage – all operators," U.S. Energy Information Administration (available at https://www.eia.gov/naturalgas/data.php#storage).

Figure 39: Crude and Natural Gas Rotary Rigs in Operation[210]

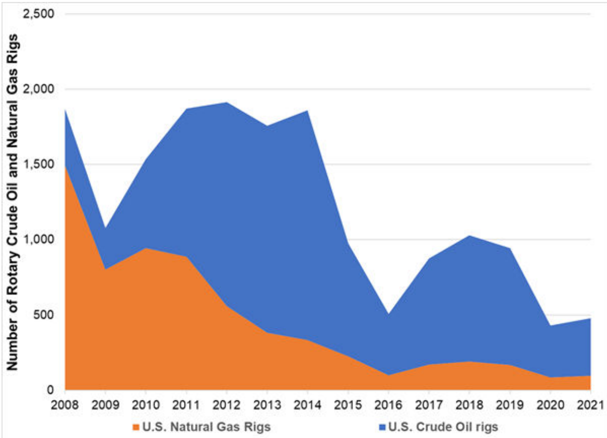
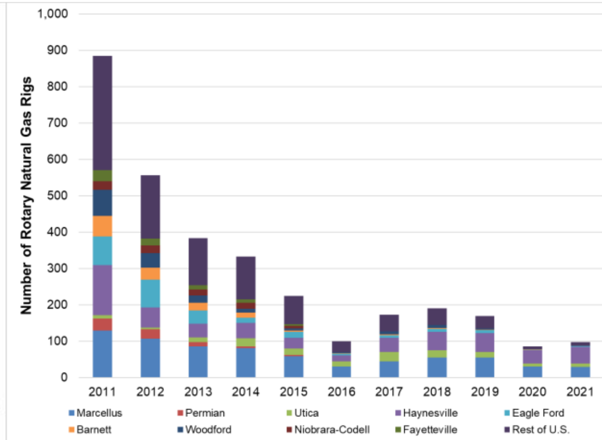


Figure 40: Natural Gas Rotary Rigs in Operation (by Basin)[211]



Rest of the World Natural Gas Market

1. Natural Gas Production and Consumption

Figure 41 presents the natural gas production across the various regions of the world (excluding the U.S.). In 2021, world natural gas production was about 25% higher than production levels in 2008. The largest increases in natural gas production were seen in Asia Pacific and the Middle East where natural gas production levels were higher by about 57% and 83% in 2021 respectively compared to the 2008 production levels in these regions. In Europe, natural gas production levels were about 34% lower in 2021 compared to 2008 production levels. The production levels in the other regions of the world have relatively flat over the 2008-2021 period. For context, including the U.S., global natural gas production increased 33%, from 107 Tcf to 143 Tcf, over the 2008-2021 period. Figure 42 presents the natural gas consumption across the various regions of the world (excluding the U.S.). World natural gas consumption has grown at a faster rate compared to natural gas production with consumption levels in 2021 about 36% higher than consumption levels in 2008. As with production, the largest increases in natural gas consumption were seen in Asia Pacific and the Middle East where natural gas consumption levels were higher by about 83% and 71% in 2021 compared to the 2008 consumption levels in these regions. In Europe, natural gas consumption levels were slightly lower (about 9% lower) in 2021 compared to 2008. The consumption levels in the other regions of the world were relatively flat.

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[210] "Crude Oil and Natural Gas Drilling Activity," U.S. Energy Information Administration (available at https://www.eia.gov/dnav/ng/ng_enr_drill_s1_m.htm).

[211] North America Rotary Rig Count Pivot Table, Rig Count, Baker Hughes (available at https://rigcount.bakerhughes.com/na-rig-count).

Figure 41: Rest of World Natural Gas Production (by Region)[212]

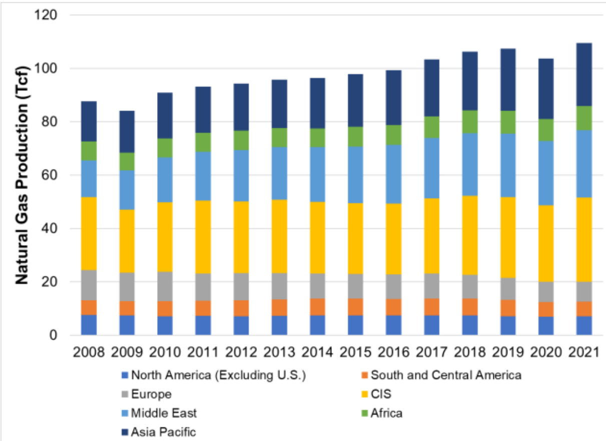
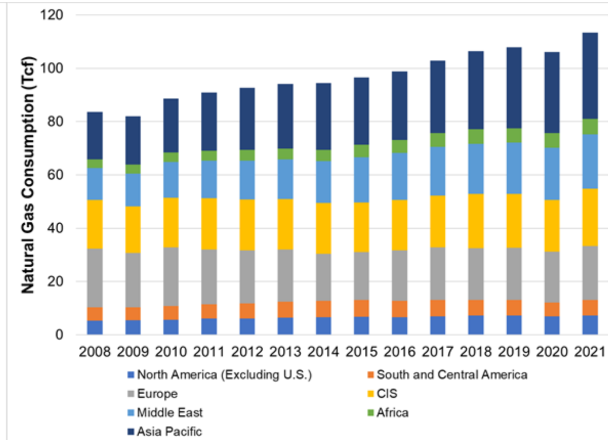


Figure 42: Rest of World Natural Gas Consumption (by Region)[213]



2. Natural Gas Trade

Figure 43 presents the natural gas net import levels across the various regions of the world (excluding the U.S.) comprising of both pipeline and LNG trade over the 2008-2021 period. It can be seen from the figure that Europe and Asia Pacific have historically been net importers of natural gas while Africa, the Middle East and the CIS region have all been net exporters of natural gas. In 2021, Europe had net imports of about 11.9 Tcf, a slight increase compared to its net import levels in 2008 of about 11.7 Tcf. In 2021, Asia Pacific had net import levels of 1.7 Tcf, a slight decline compared to its net import levels in 2008 of about 2 Tcf. In 2021, Africa had net exports of 3.3 Tcf compared to 3.9 Tcf in 2008. The CIS region had net export levels of 9.7 Tcf in 2021 compared to 8.3 Tcf in 2008. In the Middle East, net export levels in 2021 have increased by more than two-fold since 2008 (4.7 Tcf in 2021 compared to 1.9 Tcf in 2008). North America (excluding the U.S.) has evolved from being a net exporter in 2008 with net exports of 2.5 Tcf to a net importer of natural gas in 2021 with net imports of 0.4 Tcf. Similarly, South and Central America has evolved from a net exporter in 2008 with net exports of 0.6 Tcf to a net importer in 2021 with net imports of 0.4 Tcf.

[212] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html). The CIS region refers to the Commonwealth of Independent States and includes Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan and Uzbekistan.

[213] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

Figure 43: Rest of World Natural Gas Net Imports (by Region)[214]

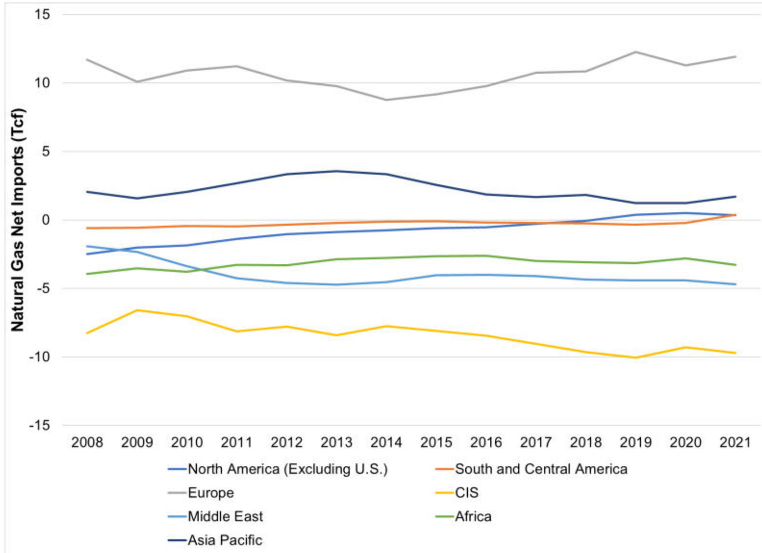


Figure 44 presents the share of LNG exports from the U.S. as a percentage of each region's total natural gas imports. It can be seen that for three of the regions (South and Central America, Asia Pacific and Europe), the share that LNG exports from the U.S. comprise of the region's total natural gas imports have been increasingly historically since 2016.[215] In 2021, U.S. LNG exports comprised of nearly 53% of the natural gas imports into South and Central America while for Asia Pacific and Europe they comprised of about 20% and 9% respectively. For the Middle East and Africa, this share peaked at about 15% in 2019 and declined to about 8% in 2021 while for North America (except for the U.S.) which comprises of Canada and Mexico the share that U.S. LNG exports comprised of the region's total natural gas imports was about 1% in 2021.

Figure 45 presents the share of LNG exports from the U.S. as a percentage of each region's total natural gas consumption. For the same three regions (South and Central America, Asia Pacific and Europe), the share that LNG exports from the U.S. comprise of the region's total natural gas consumption has been increasing since 2015. In 2021, U.S. LNG exports comprised of nearly 10% of the natural gas consumption in South and Central America while they comprised of about 5% of the total natural gas consumption in Europe and the Asia Pacific. From 2018 through 2021, Asia imported the largest share of U.S. LNG exports, incentivizing cargo deliveries through both long-term supply agreements and relatively high spot prices.[216] However, U.S. LNG exports to Europe significantly increased in 2022 as a result of the Russia-Ukraine conflict.[217]

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[214] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

[215] Prior to 2016, LNG exports from the U.S. were primarily to Japan.

[216] Ibid.

[217] Ibid. A more detailed description regarding the Russia-Ukraine conflict and other geo-political considerations affecting the global LNG markets can be found in Section 4.2.

Figure 44: U.S. LNG Exports (as a Percentage of the Region's Natural Gas Imports)[218]

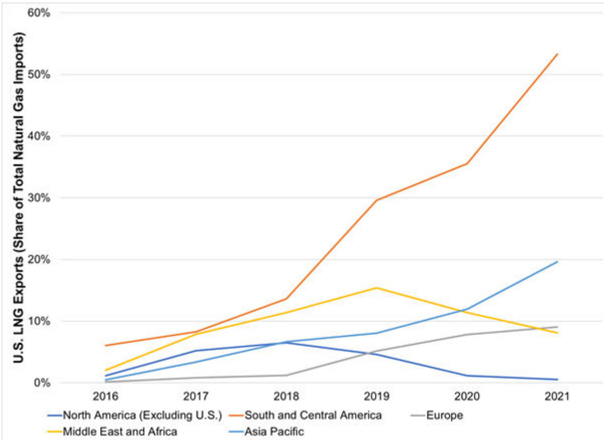

Figure 45: U.S. LNG Exports (as a Percentage of the Region's Total Natural Gas Consumption)[219]

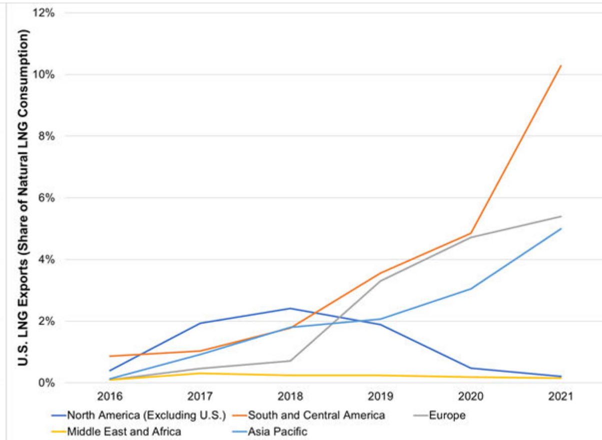

Table 20 presents the intra and inter-regional LNG flows for world regions (excluding the U.S.) in 2021. The largest intra-regional LNG flows are between the countries in Asia Pacific with the flows amounting to 6.2 Tcf (or about 17 Bcf/day) while the largest inter-regional flows occurred from the Middle East to the Asia Pacific and amounted to 3.5 Tcf (or 9.6 Bcf/day) followed by the LNG flows from the Middle East to Europe amounting to 0.8 Tcf (or 2.2 Bcf/day). Table 21 presents the intra and inter-regional natural gas pipeline flows occurring between the world regions in 2021. The largest intra-regional pipeline flow occurred between the countries in Europe with the flows amounting to 4.8 Tcf (or 13.2 Bcf/day) while the largest inter-regional flows occurred from the CIS region to Europe and amounted to 6.6 Tcf (or 18 Bcf/day) followed by the flows from the CIS region to Asia Pacific amounting to 1.7 Tcf (or 4.8 Bcf/day).

[218] Ibid.

[219] Ibid.

Table 20: Intra and Inter-regional LNG flows by Region in 2021 (Tcf)[220]

	To						
	North America (Excluding U.S.)	South and Central America	CIS	Europe	Middle East	Africa	Asia Pacific
From							
North America (Excluding U.S.)	-	-	-	-	-	-	-
South and Central America	0.03	0.15	-	0.13	0.01	-	0.13
CIS	-	-	-	0.61	-	-	0.79
Europe	-	0.01	-	0.03	0.01	-	0.08
Middle East	-	0.08	-	0.80	0.20	-	3.50
Africa	-	0.01	-	1.12	0.08	-	0.67
Asia Pacific	0.01	0.00	-	0.00	0.00	-	6.21

Table 21: Intra and Inter-regional Pipeline flows by Region in 2021 (Tcf)[221]

	To						
	North America (Excluding U.S.)	South and Central America	CIS	Europe	Middle East	Africa	Asia Pacific
From							
North America (Excluding U.S.)	-	-	-	-	-	-	-
South and Central America	-	0.44	-	-	-	-	-
CIS	-	-	1.50	6.59	0.01	-	1.74
Europe	-	-	0.00	4.81	-	-	-
Middle East	-	-	0.02	0.32	1.12	0.14	-
Africa	-	-	-	1.31	0.03	0.32	-
Asia Pacific	-	-	-	-	-	-	0.88

3. Natural Gas Liquefaction and Regasification Capacity

Globally, about 6.9 MTPA (or 0.9 Bcf/day) of liquefaction capacity was brought online in 2021, increasing global liquefaction capacity to about 460 MTPA (or 61.3 Bcf/day) at the end of the year.[222] In the first four months of 2022, an additional 12.5 MTPA (Or 1.7 Bcf/day) of liquefaction capacity was brought online, bringing the total global liquefaction capacity to about 472 MTPA (or 62.9 Bcf/day) as of April 2022.[223] Table 21 and Table 22 below detail the current and planned liquefaction capacity, excluding the U.S.

[220] BP Statistical Review of World Energy, June 2022 (available at https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html).

[221] Ibid.

[222] World LNG Report 2022, International Gas Union, July 2022 (available at https://www.igu.org/resources/world-lng-report-2022/).

[223] Ibid.

Table 22: Current Rest of World Liquefaction Export Capacity[224]

Region	MTPA	Bcf/day	Countries
Asia Pacific	160	21.4	Australia, Brunei, Indonesia, Malaysia
Middle East	100	13.3	Qatar, Oman, Yemen, United Arab Emirates
Africa	78	10.4	Algeria, Angola, Cameroon, Egypt, Equatorial Guinea, Libya, Nigeria
CIS	28	3.7	Russia
South and Central America	16	2.2	Peru, Trinidad and Tobago
Europe	4.2	0.6	Norway
Total	**386**	**51.5**	

Table 23: Planned Rest of World Liquefaction Export Capacity[225]

Project	Country	Region	Start Year	MTPA	Bcf/day
Portovaya LNG T1-T2	Russia	CIS	2022	1.5	0.20
Tangguh LNG T3	Indonesia	Asia Pacific	2022	3.8	0.51
Coral-Sul FLNG	Mozambique	Africa	2022	3.4	0.45
Arctic LNG 2 T1	Russia	CIS	2022	6.6	0.88
Tortue/Ahmeyim FLNG T1	Mauritania	Africa	2023	2.5	0.33
Arctic LNG 2 T2	Russia	CIS	2024	6.6	0.88
Energia Costa Azul T1	Mexico	North America	2024	3.25	0.43
NLNG T7	Nigeria	Africa	2024	8.0	1.07
LNG Canada T1-T2	Canada	North America	2025	14.0	1.87
Mozambique LNG T1-T2	Mozambique	Africa	2025	12.88	1.72
North Field T1-T4 (Expansion)	Qatar	Middle East	2025	32	4.27
Ust Luga LNG T1-T2	Russia	CIS	2025	13.0	1.73
Arctic LNG 2 T3	Russia	CIS	2026	6.6	0.88
Pluto LNG T2 (Expansion)	Australia	Asia Pacific	2026	5.0	0.67
Total				**119**	**15.9**

At the end of 2021, there existed about 827 MTPA (or 110 Bcf/day) of global receiving (or regasification capacity) in regions that are outside the U.S. as shown in Table 24.[226] About 49.8 MTPA (or 6.64 Bcf/day) of regasification capacity was added in 2021 of which floating regasification units (or FSRUs) made up 68%.[227] In total, FSRU regasification capacity totaled 15% of global regasification capacity as of 2021.[228] FSRU capacity has grown significantly over the past few years and is expected to continue its global market share growth, as the terminals are quicker to construct. However, LNG vessels must be specifically equipped to unload cargos at FSRU terminals and conventional vessels vastly outnumber FSRU-compatible vessels. Table 25 presents the planned regasification import capacity for regions in the

[224] Ibid.

[225] Ibid.

[226] Ibid.

[227] Ibid.

[228] Ibid.

world (apart from the U.S.). By 2024, the planned capacity amounts to about 162 MTPA (or 21.6 Bcf/day).[229] Most of this planned capacity is located in the Asia Pacific region and particularly in China (nearly 70% of the total).

Table 24: Current Rest of World Regasification Import Capacity[230]

Region	MTPA	Bcf/day	Countries
Asia Pacific	557	74.3	Japan, South Korea, China, India, Chinese Taipei, Thailand, Pakistan, Indonesia, Singapore, Bangladesh, Malaysia, Myanmar
Europe	176	23.4	Spain, United Kingdom, Turkey, France, Italy, Netherlands, Belgium, Portugal, Greece, Poland, Lithuania, Croatia
South and Central America	40.5	5.40	Brazil, Argentina, Chile, Jamaica, Dominican Republic, Colombia, Panama
North America	24.6	3.28	Mexico, Canada
Middle East	23.2	3.09	Kuwait, United Arab Emirates, Jordan, Israel
Africa	5.7	0.76	Egypt
Total	**827**	**110**	

Table 25: Planned Rest of World Regasification Import Capacity[231]

Project	Country	Region	Start Year	MTPA	Bcf/day
Terminal Gas Sul LNG	Brazil	South and Central America	2022	4	0.53
GNL Talcahuano	Chile	South and Central America	2022	2.3	0.31
Binhai LNG	China	Asia Pacific	2022	6	0.80
Guangxi (Beihai) LNG	China	Asia Pacific	2022	3.5	0.47
Hongkong Offshore LNG	China	Asia Pacific	2022	6.1	0.81
Qidong LNG	China	Asia Pacific	2022	1	0.13
Tianjin (CNOOC)	China	Asia Pacific	2022	3.8	0.51
Yueyang LNG	China	Asia Pacific	2022	1.5	0.20
Zhangzhou LNG	China	Asia Pacific	2022	6	0.80
Hamina LNG	Finland	Europe	2022	0.6	0.08
Ghana Tema	Ghana	Africa	2022	2	0.27
Dabhol LNG	India	Asia Pacific	2022	6	0.80
Dhamra LNG	India	Asia Pacific	2022	5	0.67
H-Gas LNG Gateway	India	Asia Pacific	2022	6	0.80
Jafrabad FSRU	India	Asia Pacific	2022	5	0.67
Karaikal LNG	India	Asia Pacific	2022	1	0.13
Al-Zour LNG	Kuwait	Middle East	2022	11	1.47
Puerto Sandino LNG	Nicaragua	South and Central America	2022	1.3	0.17

[229] Ibid.

[230] Ibid.

[231] Ibid.

Pagbilao LNG	Philippines	Asia Pacific	2022	5	0.67
Senegal FSRU	Senegal	Africa	2022	2.5	0.33
Sao Paulo LNG	Brazil	South and Central America	2023	3.78	0.50
Chaozhou Huaying LNG	China	Asia Pacific	2023	6	0.80
Longkou Nanshan LNG	China	Asia Pacific	2023	5	0.67
Shandong (Qingdao LNG)	China	Asia Pacific	2023	7	0.93
Tianjin (Sinopec)	China	Asia Pacific	2023	7.8	1.04
Tianjin Nangang LNG	China	Asia Pacific	2023	5	0.67
Wenzhou LNG	China	Asia Pacific	2023	3	0.40
Yantai LNG	China	Asia Pacific	2023	5.9	0.79
Zhuhai LNG	China	Asia Pacific	2023	3.5	0.47
Taoyuan LNG	Chinese Taipei	Asia Pacific	2023	3	0.40
Chhara LNG	India	Asia Pacific	2023	5	0.67
Swinoujscie LNG	Poland	Europe	2023	4.5	0.60
Nong Fab LNG	Thailand	Asia Pacific	2023	7.5	1.00
Hai Linh LNG	Vietnam	Asia Pacific	2023	3	0.40
Thi Vai LNG	Vietnam	Asia Pacific	2023	1	0.13
Yangjiang LNG	China	Asia Pacific	2024	2.8	0.37
Energas Terminal	Pakistan	Asia Pacific	2024	5.6	0.75
Batangas Bay LNG	Philippines	Asia Pacific	2024	3	0.40
Total				**162**	**21.6**

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