AEO2023 Issues in Focus: Effects of Liquefied Natural Gas Exports on the U.S. Natural Gas Market

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Executive Summary

To explore the effects of future U.S. liquefied natural gas (LNG) export volumes on domestic natural gas prices, we examined a range of potential LNG price and investment drivers using the same model we used to develop our *Annual Energy Outlook 2023* (AEO2023). The amount of U.S. LNG export capacity that will ultimately be built remains uncertain, and how this incremental capacity would affect domestic prices, consumption, and supply is a topic of interest in energy markets.

We designed three additional cases (beyond those in our AEO2023) that looked at lower international natural gas prices (Low LNG Price), higher international natural gas prices (High LNG Price), and higher prices with faster development of export facilities than we allowed in our AEO2023 cases (Fast Builds Plus High LNG Price). Across these cases, we found that LNG export volumes affected the resulting annual average U.S. natural gas price (Table 1). The resulting variation in natural gas prices in these three cases, however, was narrower than recent in history and our AEO2023, despite a wide variety of U.S. LNG export volumes.

LNG exports from the United States have steadily grown since 2016, when the first liquefaction unit—or *train*—at Sabine Pass in Louisiana entered service. Following several years of LNG capacity additions, the United States became the world's largest LNG exporter during the first half of 2022, when U.S. LNG exports averaged nearly 11.2 billion cubic feet per day (Bcf/d), about 12% of the dry natural gas[1] produced in the United States. In AEO2023, we project that total natural gas exports, by pipeline or as LNG, will become larger than any domestic end-use sector, including residential, commercial, industrial, and electric generation, by the early 2030s to become the largest component of U.S. natural gas demand in the AEO2023 Reference, High Oil Price, and High Oil and Gas Supply Cases.

Table 1. Summary of results in 2050, *Annual Energy Outlook 2023*

					2018–22 Range	
	Reference	Low LNG Price	High LNG Price	Fast Builds Plus High LNG Price	Low	High
Liquefied natural gas (LNG) exports (Bcf/d)	27.3	15.3	39.9	48.2	3.0	10.8
Henry Hub spot price (2022$/MMBtu)	$3.77	$3.28	$4.31	$4.81	$2.23	$6.52
Natural gas consumption (Bcf/d)	82.2	82.5	81.9	81.7	82.7	87.7
Industrial natural gas consumption, excluding lease and plant fuel (Bcf/d)	27.3	27.4	26.9	26.7	22.2	23.3
Electric power natural gas consumption (Bcf/d)	21.2	22.8	19.7	18.6	29.0	32.3
Natural gas share of electricity generation	22%	23%	20%	19%	34%	40%
Electric power price (2022¢/kWh)	11.0¢	11.0¢	11.1¢	11.2¢	12.1¢	12.3¢

Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023*
Note: Bcf/d=billion cubic feet per day, $/MMBtu=dollars per million British thermal units, ¢/kWh=cents per kilowatthour

[1] Dry natural gas is natural gas that remains after the liquefiable hydrocarbon portion has been removed from the natural gas stream (that is, natural gas after lease, field, or plant separation) and any volumes of nonhydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. Dry natural gas is also known as consumer-grade natural gas.

Analysis Design and Case Description

To assess how U.S. LNG exports responded to different assumptions about international LNG prices and the corresponding effects that those prices would have on the U.S. natural gas market, we developed three cases using our National Energy Modeling System (NEMS). These three cases incorporate assumptions that drive variations in the amount of LNG the United States will export through 2050.

We model U.S. energy markets explicitly in NEMS. Through 2027, the Reference case and all side cases published in AEO2023 incorporate U.S. LNG export projects that are either operating or under construction as of August 2022. After 2027, the cases run through NEMS add more U.S. LNG export capacity based on price differentials between international LNG prices and the cost of exporting LNG from the United States for delivery in Asia and Europe, along with annual constraints on the ability to build new capacity. As international LNG prices increase compared with domestic natural gas prices, U.S. LNG export capacity becomes more economical to build.

Up to the constraint on building new capacity, this price difference drives the amount of U.S. LNG that is exported within the model.[2] In all cases, NEMS assumes that a maximum of 90% of baseload capacity can be utilized, which reflects real world operating conditions of LNG export facilities. The utilization of LNG export capacity might be further reduced if the regional spot price plus liquefaction, shipping, and regasification costs exceeds the LNG price in Asia or Europe.[3]

We developed two side cases, Low LNG Price and High LNG Price, in which we adjust assumptions in NEMS that change projected international LNG prices in Europe and Asia. These prices help determine the economics of building liquefaction facilities and exporting LNG given U.S. natural gas prices, shipping costs, and LNG prices abroad. We developed a third side case, the Fast Builds Plus High LNG Price case, which uses the same price parameters as the High LNG Price case. In addition, this case loosens the additional constraints we place in NEMS on how quickly new LNG export capacity is allowed to come online, which represents growing investments and efficiency gains in the construction of liquefaction units and allows more of these facilities to be constructed simultaneously in the model.

All three cases assume current laws and regulations, including our integration of the Inflation Reduction Act (IRA), with provisions as defined in the Appendix of the AEO2023 narrative. We use macroeconomic assumptions from S&P Global IHS Markit as of November 2022.

[2] In NEMS, LNG exports are largely based on differences of a simplified representation between the cost of supplying LNG and international LNG prices. In the real world, however, several simultaneous pricing mechanisms exist, such as trading based on spot prices, long-term oil-linked LNG contracts, and long-term Henry Hub-linked LNG contracts. For more information, see the Natural Gas Market Module Documentation.

[3] See Figure 3.6 in the Natural Gas Market Module Documentation for a more detailed explanation of the LNG demand curve.

Table 2. Description of cases

Case	Description
Reference case	We assume that up to three natural gas liquefaction trains, each with 200 billion cubic feet (Bcf) capacity, are built each year (a maximum of 600 Bcf of liquefied natural gas [LNG] capacity). This constraint on new capacity represents our assessment of the logistical challenges in building such large, complex facilities. We assume that world natural gas prices start at their recent historical ratio to the world oil price. Over time, the price of LNG becomes less tied to the world oil price as the ratio of flexibly priced LNG to the representative regional net natural gas demand increases relative to its base year level. The ratio reflects the tightness or looseness of the world LNG market pushing or pulling, respectively, world natural gas prices toward or away from the world oil price.
High LNG Price case	The High LNG Price case assumes that LNG prices in Europe and Asia are higher by an average of nearly 25% relative to the Reference case in 2050.
Low LNG Price case	The Low LNG Price case assumes that LNG prices in Europe and Asia are lower by an average of nearly 20% relative to the Reference case in 2050.
Fast Builds Plus High LNG Price case	In the Fast Builds plus High LNG Price case, we use the same higher price assumptions from the High LNG Price case, but we also assume four natural gas liquefaction trains, each with 200 Bcf capacity, can be built each year (a maximum of 800 Bcf of LNG capacity), a level that likely remains technically feasible.

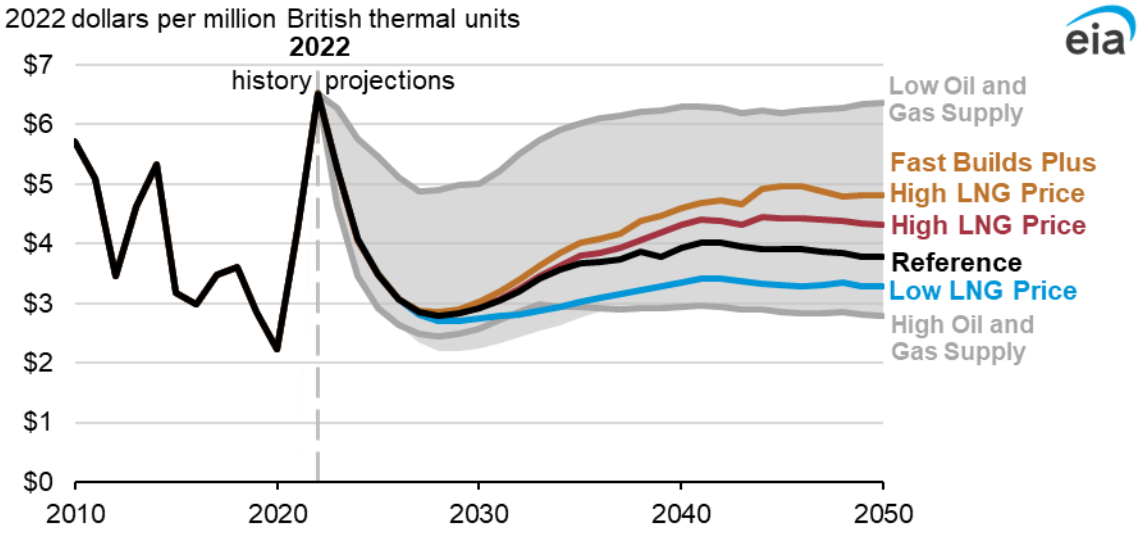
Data source: U.S. Energy Information Administration*, Annual Energy Outlook 2023*

This analysis does not model international energy markets and so does not account for interactions between U.S. natural gas exports and world natural gas markets. We do not model constraints such as regasification capacity abroad, the availability of LNG tanker vessels, and potential competition from LNG exports originating in other countries, any one of which could affect U.S. LNG export volumes. In addition, we do not project the destination of U.S. LNG exports, nor do we account for shocks to the market. For example, the most recent international natural gas consumption inputs to the model come from our *International Energy Outlook 2021* and so do not account for recent events, such as Russia's full-scale invasion of Ukraine.

NEMS optimizes the disposition of natural gas between domestic sectors and exports to the international market. When international prices rise, it creates incentives for more LNG exports because adding new LNG capacity becomes more economical as the spread between the cost of producing LNG in the United States and the price that exporters can sell the LNG abroad increases. Domestic natural gas prices and production rise to balance the market and meet U.S. natural gas consumption and exports according to supply curves. Within the domestic market, the degree to which the model can substitute natural gas for other sources varies by sector. In the electric power sector, for example, sources such as renewables plus battery storage is a viable alternative source for natural gas when natural gas prices rise.

Natural gas demand in the residential and commercial sectors is less sensitive to changes in the natural gas price compared with the electric power sector. Although sufficiently high natural gas prices can encourage increased electrification of the residential and commercial sectors, natural gas consumption

Figure 2. Natural gas spot price at the Henry Hub, AEO2023



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

Natural gas production on the Gulf Coast is the most economical supply source to meet higher LNG export volumes

U.S. natural gas production varies across the cases to meet LNG export volumes. We project more natural gas production in the High LNG Price and Fast Builds Plus High LNG Price cases and less natural gas production in the Low LNG Price case than in the AEO2023 Reference case. In the High LNG Price case, 10% more natural gas is produced in the United States in 2050 relative to the 115.3 Bcf/d projected in the Reference case. In the Fast Builds Plus High LNG Price case, we project 17% more natural gas production in 2050 compared with the Reference case, reaching 134.6 Bcf/d in 2050. In the Low LNG Price case, natural gas production decreases by 10% compared with the Reference case in 2050. By comparison, in 2050, we project production of 80.2 Bcf/d in the Low Oil and Gas Supply case and 136.2 Bcf/d in the High Oil and Gas Supply case, the AEO2023 cases with lowest and highest natural gas production, respectively.

Table 3. Natural gas production regions for select side cases in 2050, AEO2023

billion cubic feet

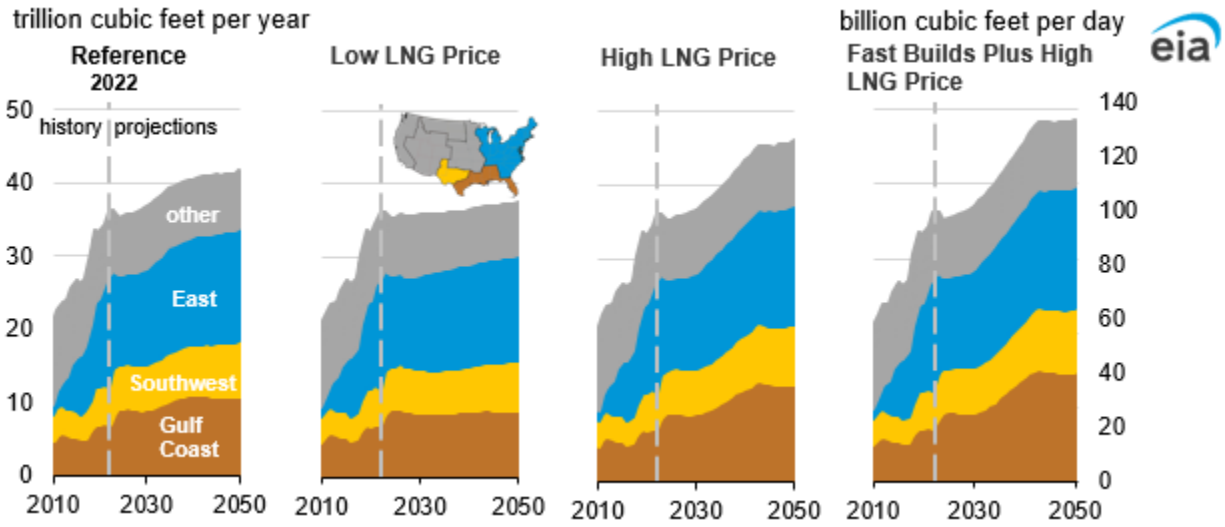
AEO2023 side case	East	Gulf Coast	Southwest	Total dry gas production
Reference	42.5	30.0	20.3	115.3
Low LNG Price	39.8	24.7	19.0	104.1
High LNG Price	44.3	36.1	22.3	127.1
Fast Builds Plus High LNG Price	45.1	39.8	23.9	134.6
Low Oil Price	39.4	26.2	11.2	96.1
High Oil Price	44.4	33.5	33.3	136.0
Low Oil and Gas Supply	35.4	18.9	12.0	80.2
High Oil and Gas Supply	44.1	36.6	25.4	136.2

Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)

Most of the projected increase in natural gas production in the High LNG Price and the Fast Builds Plus High LNG Price cases occurs in the Gulf Coast producing region, which includes the Eagle Ford and Haynesville plays (Figure 3 and Appendix). The Gulf Coast supplies most of the incremental natural gas destined for LNG export terminals in Texas and Louisiana because of favorable drilling economics, available existing natural gas pipeline capacity, and less expensive pipeline transportation. All new LNG capacity added through 2050 in these cases is in either Texas or Louisiana. In the AEO2023 Reference case, dry natural gas production on the Gulf Coast grows to 30.0 Bcf/d, or 26% of Lower 48 dry production, by 2050. Gulf Coast production grows to 36.2 Bcf/d in the High LNG Price case and to 39.9 Bcf/d in the Fast Builds Plus High LNG Price case, accounting for 29% and 30% of Lower 48 dry production, respectively. Gulf Coast production in the Fast Builds Plus High LNG Price case is nearly 9% higher in 2050 compared with the High Oil and Gas Supply case, despite higher total projected production in the High Oil in Gas Supply Case. This increase suggests that it is more favorable to supply growth in U.S. LNG exports with natural gas produced on the Gulf Coast than in other parts of the United States.

The Southwest region, which includes the Permian Basin and the Barnett play, has the second-fastest natural gas production growth in the High LNG Price case (22.2 Bcf/d) and Fast Builds Plus High LNG Price case (23.8 Bcf/d) by 2050, compared with 20.3 Bcf/d in the Reference case. However, the Southwest region's share of total dry natural gas production remains constant in all four cases at 18%.

Figure 3. Lower 48 dry natural gas production by region, AEO2023



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: *Other* includes offshore natural gas production.

We project that less natural gas needed to support U.S. LNG exports in the Low LNG Price case results in 10% lower projected natural gas production in 2050, at 104.1 Bcf/d, compared with the AEO2023 Reference case. Like in the cases featuring higher LNG exports, the Gulf Coast region was the most responsive natural gas-producing region in the Low LNG Price case; projected production in the region was 18% lower than in the AEO2023 Reference case.

cases, ranging from a low of 11.0 cents per kilowatthour (¢/kWh) in the Low LNG Price case to a high of 11.2 ¢/kWh in the Fast Builds Plus High LNG Price case.

Natural gas consumption in the manufacturing sector (known in AEO2023 as *other industrial*) is slightly responsive to natural gas price signals, ranging from a low of 26.7 Bcf/d in the Fast Builds Plus High LNG Price case to a high of 27.5 Bcf/d in the Low LNG Price case. Generally, natural gas consumption in the manufacturing sector is moderately responsive to changes in natural gas prices but less responsive than natural gas consumption in the electric power sector. Instead, natural gas consumption for manufacturing primarily responds to changes in the value of shipments of industries that use a significant amount of natural gas, such as the bulk chemical or food industries. Although industrial fuel choices may change some, based on fuel prices, these *Issue in Focus* cases use the same macroeconomic and value of shipment assumptions as in the AEO2023 Reference case, Because NEMS includes little macroeconomic feedback, this assumption limits consumption changes in the manufacturing sector.

For all three LNG cases, we project U.S. energy-related carbon dioxide emissions in 2050 will be within 1% of the Reference case, largely because total domestic consumption in all sectors varies so little across these cases.