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Impact Analysis of U.S. Natural Gas Exports on Domestic Natural Gas Pricing

ENERGY VENTURES ANALYSIS

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Key Findings

1. The shale gas revolution resulted in a massive shift in U.S. natural gas supply and demand flows, ringing in a new era of low-cost natural gas supply and turning the U.S. into a global energy superpower.

2. Despite a record level of natural gas exports during the first six months of 2023, U.S. natural gas prices at Henry Hub averaged $2.48 per MMBtu, the lowest six-month average in over 35 years (outside of the COVID-19 pandemic).

3. Unique post-COVID-19 pandemic circumstances and U.S. coal market exposure to global markets—not U.S. LNG exports—were the primary factors behind domestic natural gas prices briefly increasing to 14-year highs in 2022.

4. Virtually unchanged LNG export terminal utilization from 2021 to 2023 and the substantial disconnect between domestic and international natural gas prices further highlight U.S. natural gas exports' minimal impact on domestic natural gas pricing.

5. Completion of U.S. LNG export terminals has had minimal impact on short-term domestic natural gas pricing due to their lengthy construction times as well as unique long-term financing and contracting structure.

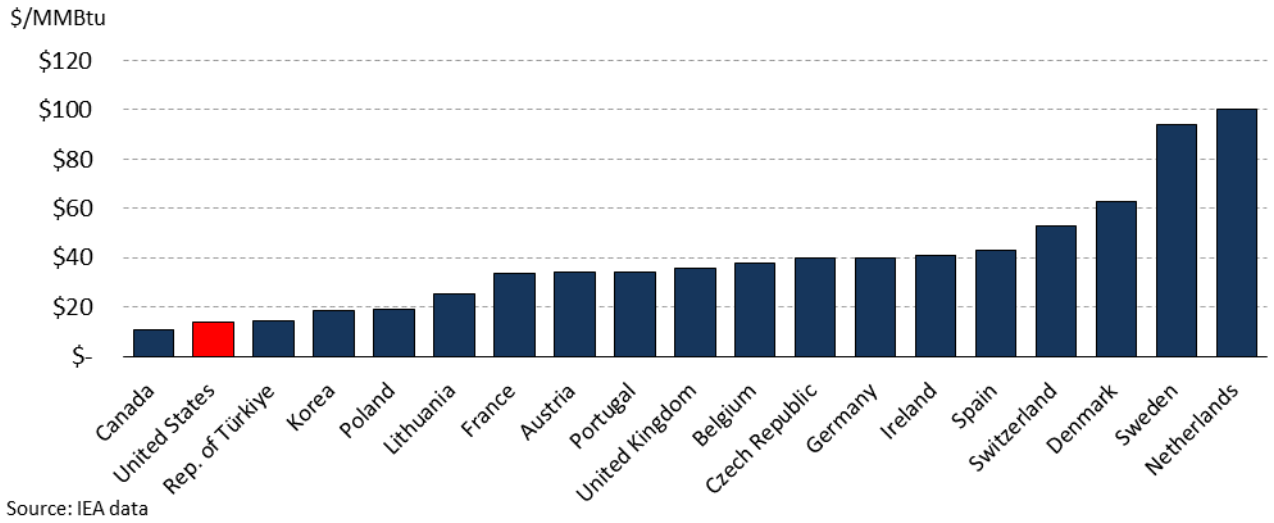
6. Increased U.S. natural gas exports have and will continue to create massive economic benefits for U.S. communities while providing global access to the reliable U.S. natural gas supply needed to further the global energy transition from higher greenhouse gas (GHG) emitting fuels to lower-GHG emitting natural gas.

7. Restricting natural gas infrastructure development will impede continued access to low-cost natural gas supply, regardless of U.S. LNG export levels.

Executive Summary

Over the last 15 years, the U.S. energy sector has undergone one of the most dramatic transformations in its history. The cost-effective combination of hydraulic fracturing and horizontal drilling enabled the economical exploration of previously inaccessible or cost-prohibitive natural gas and oil reserves across the United States. The increased low-cost supply base of both oil and natural gas ushered in the shale gas revolution around 2007. Since then, natural gas and oil production in shale plays has grown substantially, allowing the U.S. to become a net exporter of both natural gas and oil over the last six years. In 2023, the U.S. became the world's largest liquefied natural gas (LNG) exporter. Despite U.S. natural gas exports and domestic consumption reaching all-time highs in recent years, domestic residential natural gas prices remained among the lowest in the world. These trends illustrate that upstream production of America's abundant natural gas resources continues to effectively deliver affordable supplies in response to changing market conditions. Put simply, growing demand begets growing supply.

EXHIBIT ES-1: 2022 AVERAGE RESIDENTIAL NATURAL GAS PRICES BY COUNTRY



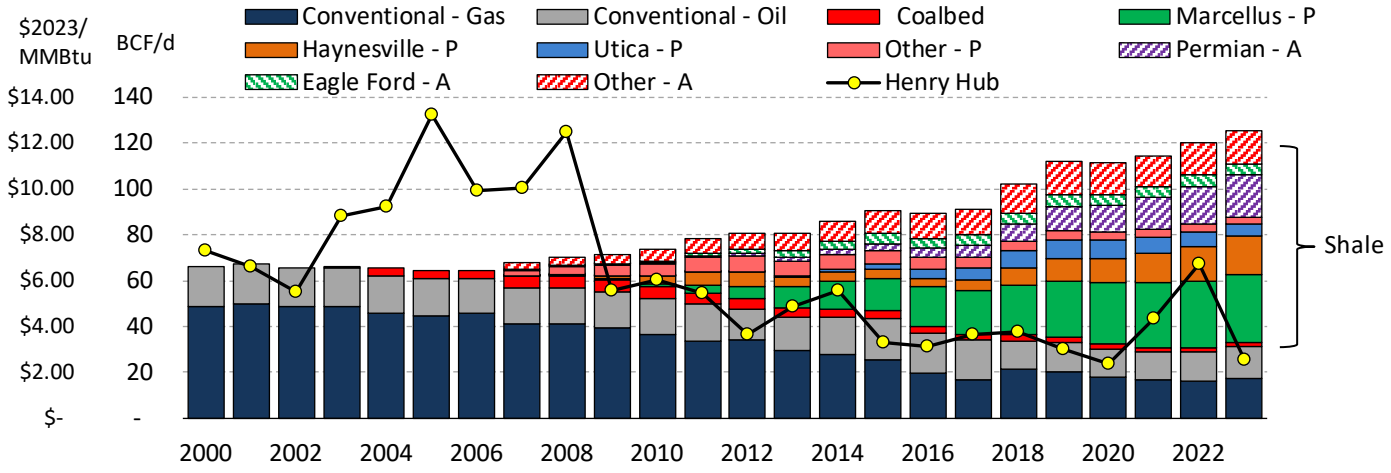
Source: IEA data

As the United States has risen to lead the world in LNG exports, critics of expanded export capacity have argued that this growth has increased financial burdens on U.S. natural gas consumers. In making this case, anti-export advocates point to the substantial rise in U.S. natural gas prices in 2022. This report provides an assessment of changes in the U.S. natural gas industry, essential context to the natural gas pricing anomaly of 2022, and a review of domestic and global benefits to U.S. natural gas exports.

Key findings of the report include:

- **The shale gas revolution resulted in a massive shift in U.S. natural gas supply and demand flows, ringing in a new era of low-cost natural gas supply and turning the U.S. into a global energy superpower**. Between 2007 and 2022, U.S. gross natural gas production from shale plays grew from virtually non-existent volumes to almost 90 billion cubic feet per day (BCF/d). Low-cost natural gas production from shale plays increased the U.S. total natural gas production and displaced higher-cost production from conventional natural gas and oil wells. The increased low-cost supply base of natural gas and oil enabled the United States to export more natural gas, crude oil, and petroleum products than it imported for the first time in its history. Natural gas prices at Henry Hub have averaged roughly $4.10/MMBtu for the last ten years, a reduction of more than 54% compared to the prior decade.

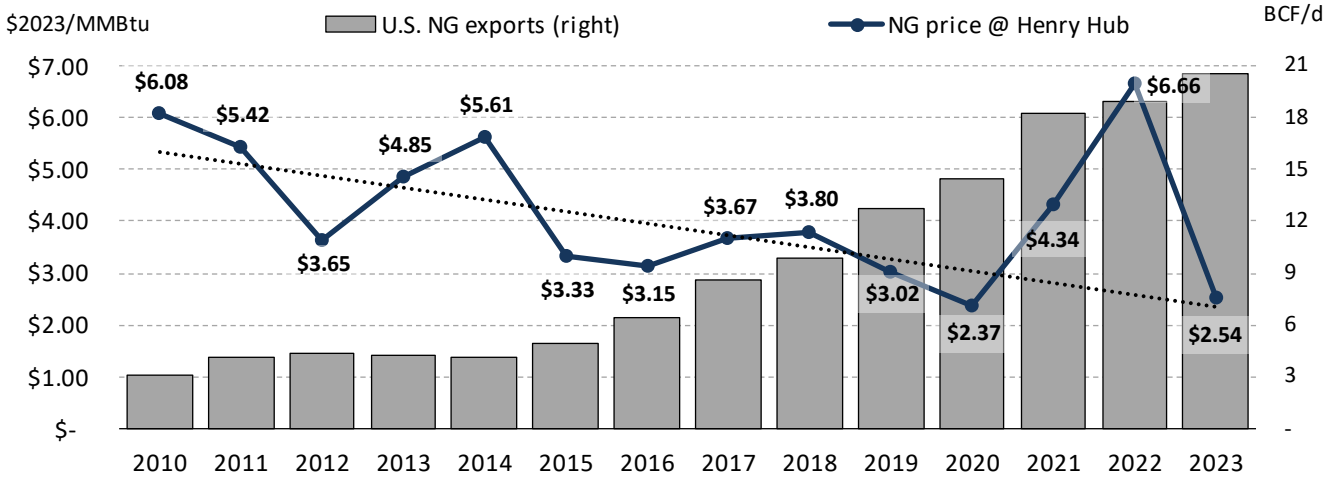
EXHIBIT ES-2: ANNUAL U.S. NATURAL GAS PRODUCTION VERSUS NATURAL GAS PRICES AT HENRY HUB



Source: EIA data; P - pure gas play; A - associated gas/primary oil play

- **Despite a record level of natural gas exports during the first six months of 2023, U.S. natural gas prices at Henry Hub averaged $2.48 per MMBtu, the lowest six-month average in over 35 years (outside of the COVID-19 pandemic).** The shale gas revolution and subsequent rise in Appalachian natural gas production massively changed the flow of the commodity across the U.S. natural gas pipeline network, increasing the amount of natural gas "trapped" in the South Central region. To take advantage of the surplus of natural gas in the region, U.S. companies developed new LNG export terminals along the Gulf and East coasts. Since the first LNG export terminal became operational in 2016, the U.S. has become the largest LNG exporter in the world, providing access to the U.S. low-cost natural gas while bringing massive economic benefits to the U.S. economy as a whole. Over the last 15 years, any substantial increase in natural gas demand from the industrial, electric power, or export sectors has been accompanied by a corresponding increase in U.S. natural gas production. For example, while LNG exports rose by roughly 14 Bcf/d between 2016 and 2023, dry gas production jumped by 31 Bcf/d. Despite total U.S. natural gas consumption almost doubling from 2010 to 2023, the 2023 average natural gas price of $2.54 per MMBtu was the second-lowest level in over 35 years, only exceeding 2020 COVID-19 pandemic lows by a few cents.

EXHIBIT ES-3: ANNUAL U.S. NATURAL GAS EXPORTS VERSUS NATURAL GAS PRICES AT HENRY HUB

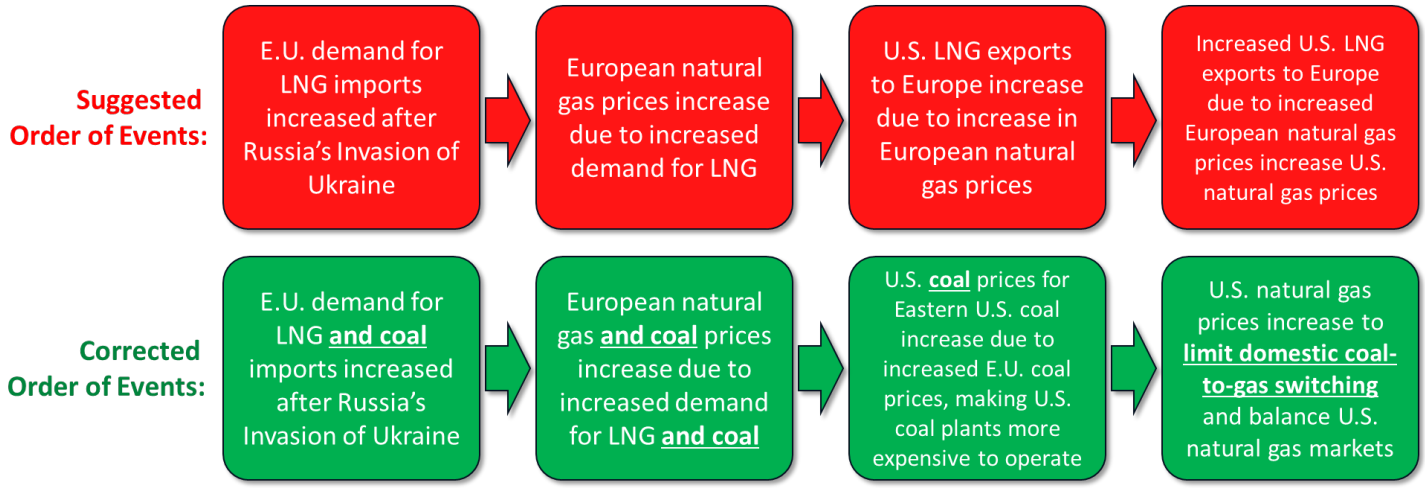


Source: EIA data; Note: trendline excludes 2022

- **Unique post-COVID-19 pandemic circumstances and U.S. coal market exposure to global markets—not U.S. LNG exports—were the primary factors behind domestic natural gas prices increasing to 14-year highs in 2022.** As domestic demand for energy commodities (i.e., coal, natural gas, and oil) returned during the summer of 2021, domestic production responded more slowly, due to issues such as supply chain challenges, increased corporate debt and a national labor shortage, causing fossil fuel inventories to dwindle rapidly. After Russia's February 2022 invasion of Ukraine upended the energy supply-demand balance in Europe, global coal and (albeit much later) natural gas prices rose to incentivize non-Russian imports into Europe. Due to the limited supply growth in the U.S. coal market, domestic coal prices rose rapidly, changing the relative economics of coal- and gas-fired power generators and causing increased amounts of natural gas to be consumed in the domestic power sector. Moreover, due to below-average domestic natural gas inventory levels, domestic natural gas prices then rose to match domestic coal prices, limiting additional coal-to-gas generation shifting in the power sector.

- **The virtually unchanged LNG export terminal utilization from 2021 to 2023** (**EXHIBIT *24***) **and the substantial disconnect between domestic and international natural gas prices** (**EXHIBIT *25***) **further highlight U.S. natural gas exports' minimal impact on domestic natural gas pricing**. Further, in 2022, the U.S. electric power sector accounted for the largest year-over-year increase in natural gas consumption – nearly three times as much as the increase in natural gas exports.

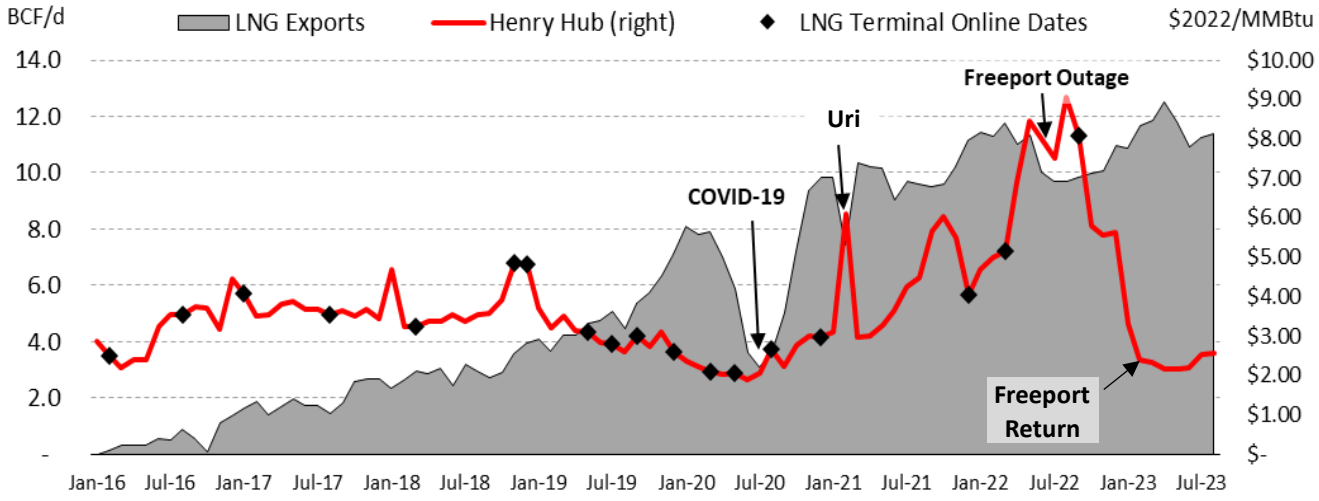
EXHIBIT ES-4: CORRECTED ORDER OF EVENTS OF 2022 U.S. NATURAL GAS PRICE ANOMALY



- **Completion of U.S. LNG export terminals has had minimal impact on short-term domestic natural gas pricing due to their lengthy construction times as well as unique long-term financing and contracting structure.** Due to their multi-year permitting and construction lead time, U.S. LNG export terminals must enter into long-term export contracts with off-takers for the majority of their capacity to ensure the financial viability of these multi-billion-dollar infrastructure projects. The lengthy project development process gives U.S. natural gas producers sufficient time to increase output to feed the new LNG export projects. As a result, the U.S. natural gas market already has accounted for the increased demand from a new LNG export terminal by the time the project is completed and loads its first vessel. Also, due to the long-term contracting nature for most of the scheduled LNG export volumes, the nominal natural gas flows to the new terminal are highly predictable and, therefore, priced into the U.S. natural gas market, resulting in little to no increase in domestic natural gas prices. However, unexpected losses of LNG flows can result in a sudden drop in natural gas prices, as shown by the Freeport LNG

incident and subsequent outage in the summer of 2022. Since natural gas is delivered on a continuous basis via pipelines, the unexpected loss of demand due to the Freeport LNG outage resulted in a substantial natural gas supply-demand market imbalance until the U.S. electric power sector absorbed the excess supply, returning domestic natural gas prices to pre-Freeport LNG outage levels. However, when Freeport returned to operation in February 2023, domestic natural gas prices were virtually unaffected, despite the 2.1 BCF/d increase in demand due to its predictable nature. This phenomenon is not unique to the LNG sector and can occur regardless of the source of demand.

EXHIBIT ES-5: U.S. LNG EXPORTS & TERMINAL COMPLETION DATES VS. NATURAL GAS PRICES AT HENRY HUB

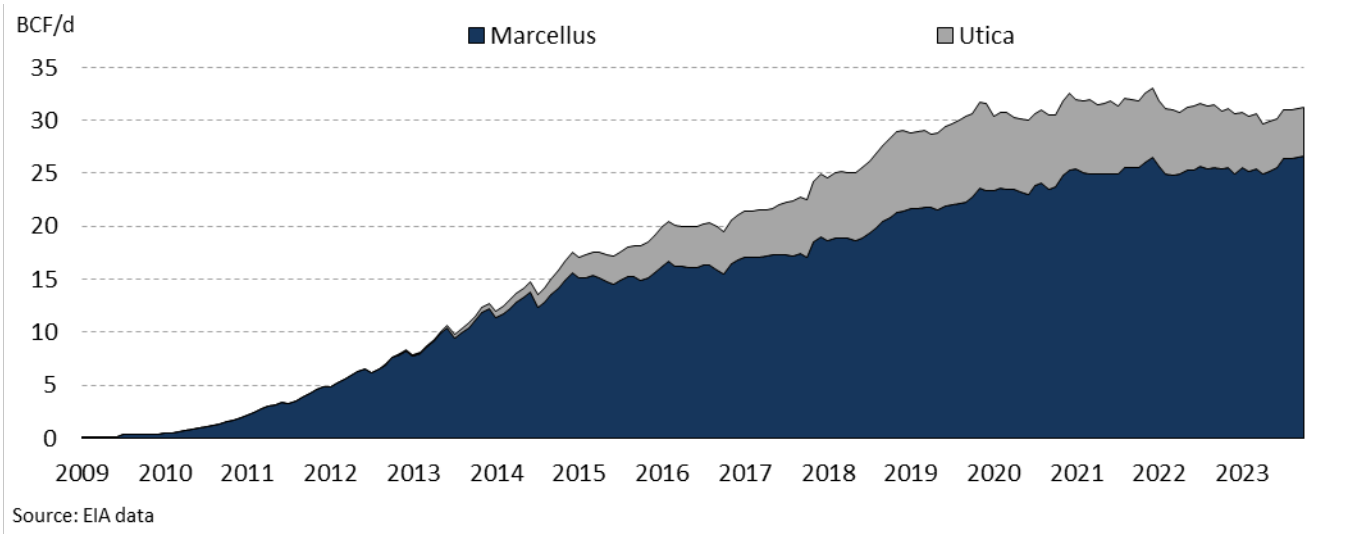


Source: EIA data

- **Increased U.S. natural gas exports have and will continue to create massive economic benefits for U.S. communities while providing global access to the reliable U.S. natural gas supply needed to further the global energy transition from higher greenhouse gas (GHG) emitting fuels to lower-GHG emitting natural gas.** The strong growth in U.S. natural gas production, transportation, and exports has brought substantial economic prosperity to regions (Haynesville, Permian, Bakken, Appalachia) previously known for high unemployment rates and low economic activity, benefitting local U.S. communities through royalty and tax payments, while increasing local employment. Increased U.S. natural gas exports will also allow for increased beneficial use of the fuel abroad as previously trapped natural gas will find its way into the global natural gas market. Access to U.S. natural gas also allows other countries to accelerate their transition away from coal, which was consumed at a record-setting level of 8.3 billion tonnes in 2022, to natural gas and renewables, reducing global GHG emissions while the economic benefits remain with U.S. communities.

- **Restricting natural gas infrastructure development will impede continued access to low-cost natural gas supply, regardless of U.S. LNG export levels.** In an LNG analysis conducted as part of its 2023 Annual Energy Outlook,[1] the U.S. Energy Information Administration (EIA) found that the continued expansion of U.S. natural gas infrastructure (e.g., gathering, lateral, intra, and interstate pipelines) was key to ensuring continued access to low-cost natural gas supply. Over the last few years, opposition by environmental groups and certain states toward new natural gas pipeline projects has slowed U.S. natural gas supply growth, especially in the Appalachian region, where natural gas production has not grown since late 2020 (**Exhibit ES-6**). This lack of sufficient pipeline takeaway capacity has resulted in increased volatility in domestic natural gas prices. Limiting the expansion of pipeline takeaway capacity will also limit future access to low-cost natural gas supply when current resources are depleted. Therefore, increased U.S. natural gas exports will encourage ongoing and future investment by U.S. companies in the natural gas supply, transportation, and storage infrastructure needed to enable continued domestic and abroad access to one of the world's lowest-cost natural gas supplies.

EXHIBIT ES-6: MONTHLY NATURAL GAS PRODUCTION IN THE APPALACHIAN REGION



Source: EIA data

[1] https://www.eia.gov/outlooks/aeo/IIF_LNG/

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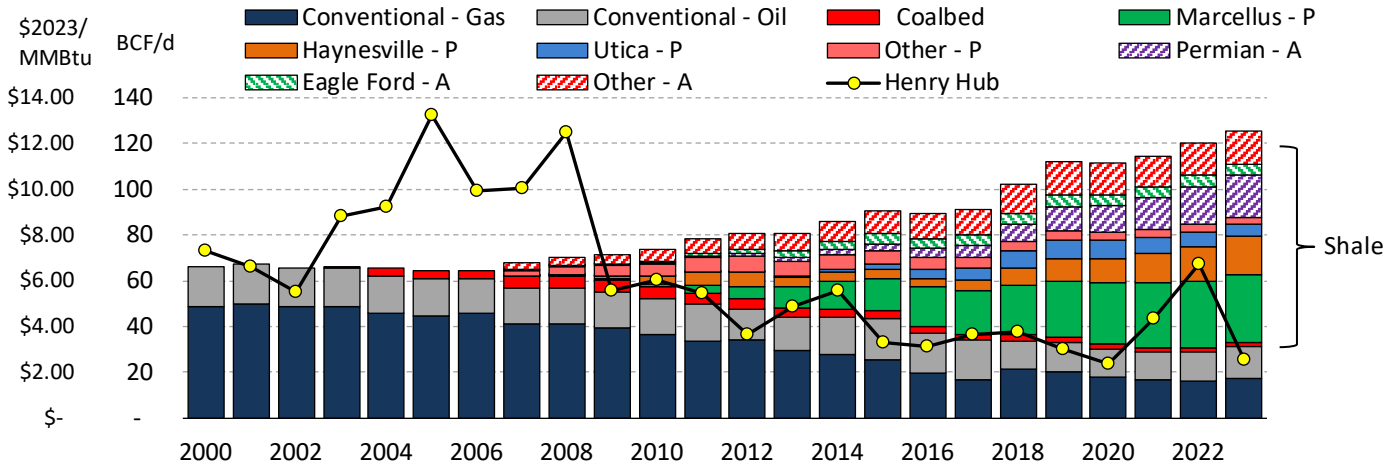
Introduction

Over the last 15 years, the U.S. energy sector has undergone one of the most dramatic transformations in its history. The cost-effective combination of hydraulic fracturing and horizontal drilling enabled the economical exploration of previously inaccessible or cost-prohibitive natural gas and oil reserves across the United States. The increased low-cost supply base of both oil and natural gas started the Shale Gas Revolution around 2007. Since then, natural gas and oil production in shale plays has grown substantially, as shown in **EXHIBIT *1***.

EXHIBIT 1: GROSS NATURAL GAS PRODUCTION BY SOURCE LOCATION



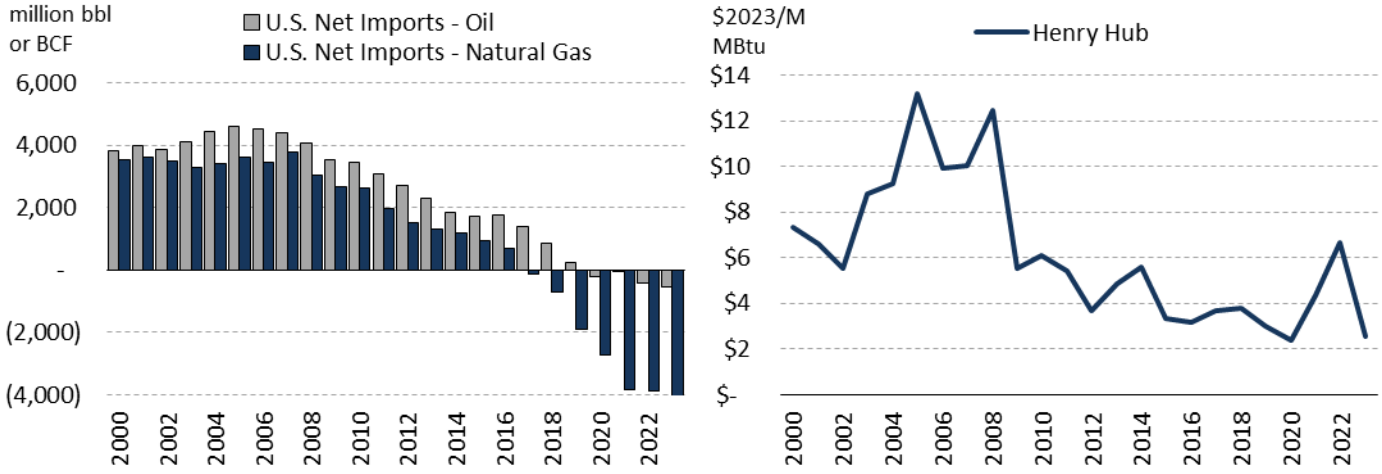
Source: EIA data; P - pure gas play; A - associated gas/primary oil play

Between 2007 and 2022, U.S. gross natural gas production from shale plays has grown from virtually non-existent to almost 90 billion cubic feet per day (BCF/d). Low-cost natural gas production from shale plays not only increased the U.S. total natural gas production but also displaced higher-cost production from conventional natural gas and oil wells.

Noteworthy is also the massive growth in natural gas production in shale plays primarily focused on oil exploration like the Permian, Bakken, or Eagle Ford basins, among others. This so-called associated natural gas production accounted for almost 30% of gross natural gas production in 2022.

As shown in **EXHIBIT *2***, the increased low-cost supply base of natural gas and oil enabled the United States to export more natural gas, crude oil, and petroleum products than it imported for the first time in its history.

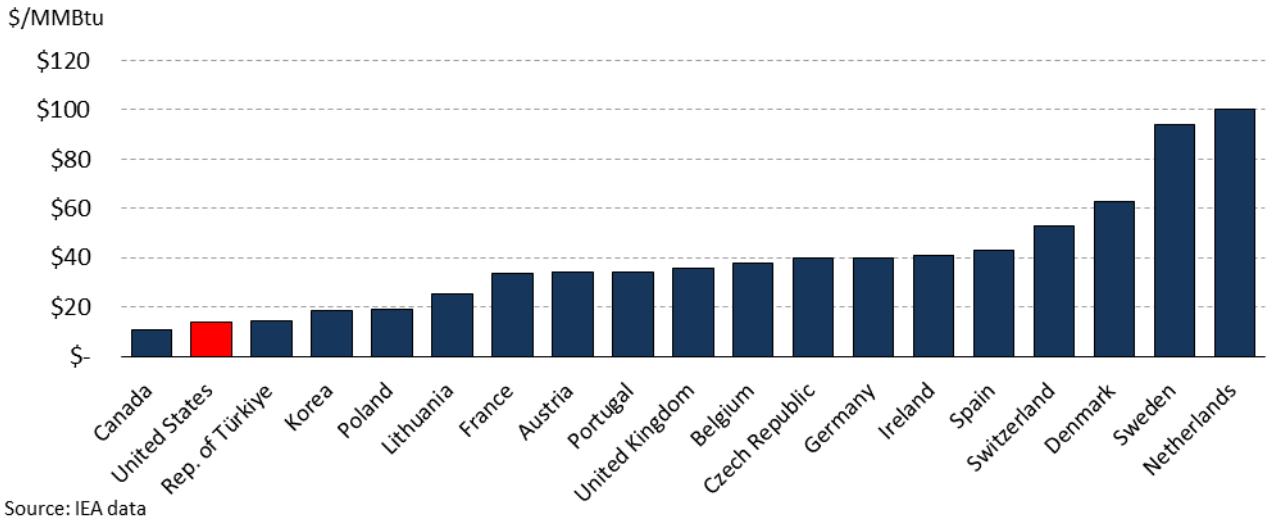
EXHIBIT 2: U.S. NET IMPORTS OF OIL & NATURAL GAS (LEFT) AND ANNUAL NATURAL GAS PRICES @ HENRY HUB (RIGHT)



Source: EIA data; 2023 annualized based on 11 months of data

In 2017, the U.S. exported more natural gas than it imported for the first time. Since then, the U.S. has become one of the world's largest exporters of liquified natural gas (LNG). In 2020, the U.S. also exported more crude oil and petroleum products than it imported for the first time. The massive increase in the low-cost supply of both oil and natural gas also resulted in dramatic reductions in domestic prices for the two products. For the last ten years, natural gas prices at Henry Hub in Southwestern Louisiana, one of the world's most prominent natural gas trading hubs, have averaged about $4.10/MMBtu, a reduction of over 54% compared to the first ten years of this century. Notably, U.S. natural gas prices are among the lowest in the world, as shown in **EXHIBIT *3***.

EXHIBIT 3: 2022 AVERAGE RESIDENTIAL NATURAL GAS PRICES BY COUNTRY



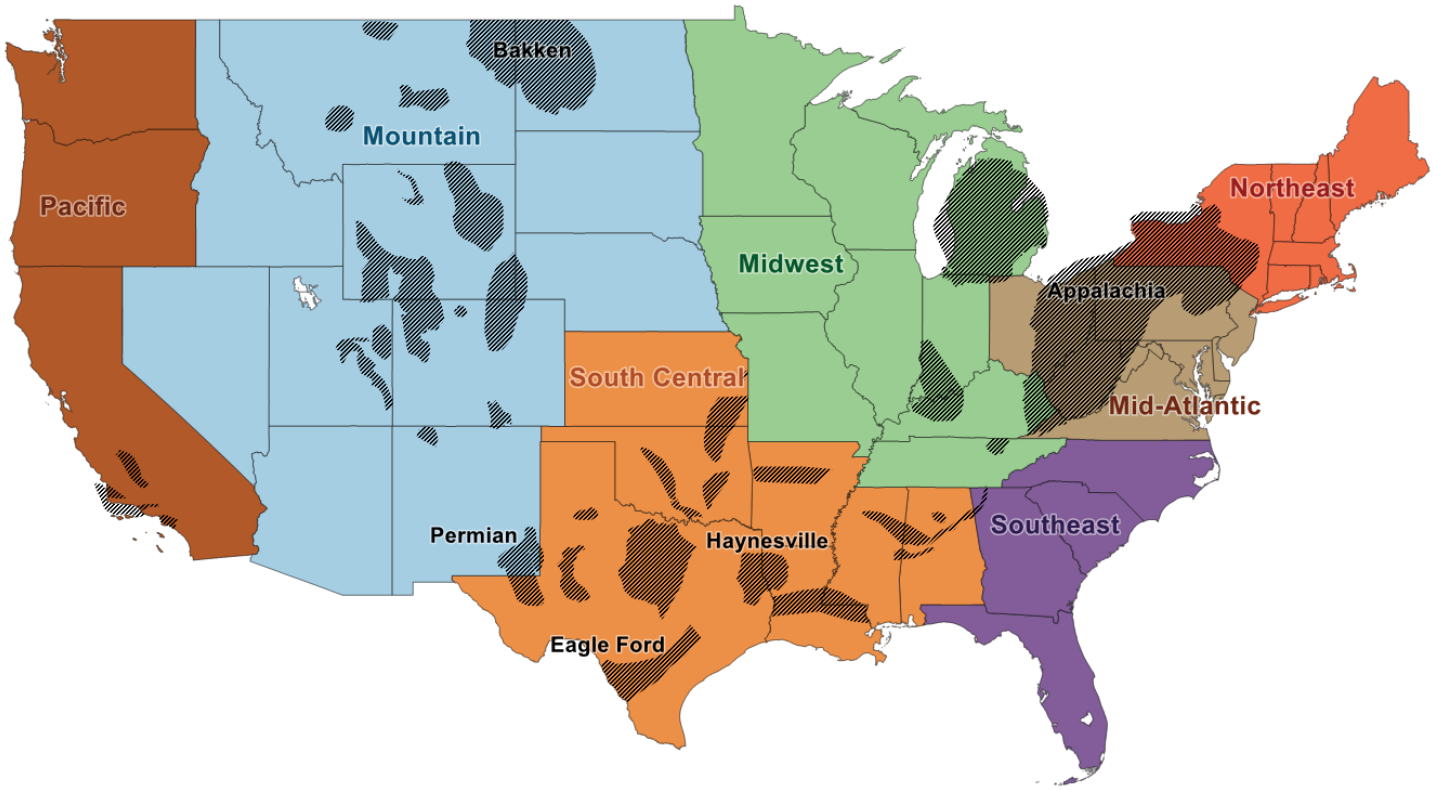
Source: IEA data

Due to the substantial structural changes in the U.S. natural gas and oil sectors, the U.S. has made considerable investments in increasing its natural gas export capacity, both via LNG export terminals along the U.S. East and Gulf coasts and via natural gas pipelines to Mexico. Additional LNG export terminals and cross-border pipeline projects are at various planning and development stages to expand the U.S. current natural gas export capacity. Critics of these projects question the necessity and overall impact of increased exports on U.S. consumers, claiming that they would lead to increased economic burdens on end-use customers. This report analyzes the historical impact of increased U.S. natural gas exports on U.S. natural gas consumers, highlights the unique situation of 2021 and 2022, and presents some of the many positive impacts of U.S. natural gas exports, both domestic and abroad.

Changes in Regional Natural Gas Production & Consumption since 2007

Before examining the impact of LNG and pipeline exports of natural gas on U.S. consumers and domestic natural gas prices, it is important to provide context and a brief historical review of the reasons behind the exponential growth of U.S. natural gas exports over the last decade. **EXHIBIT *4*** shows the regional division of the Lower-48 states by EIA natural gas storage region[2] and the major U.S. natural gas and oil plays.

EXHIBIT 4: EIA NATURAL GAS STORAGE REGIONS & MAJOR U.S. SHALE PLAYS

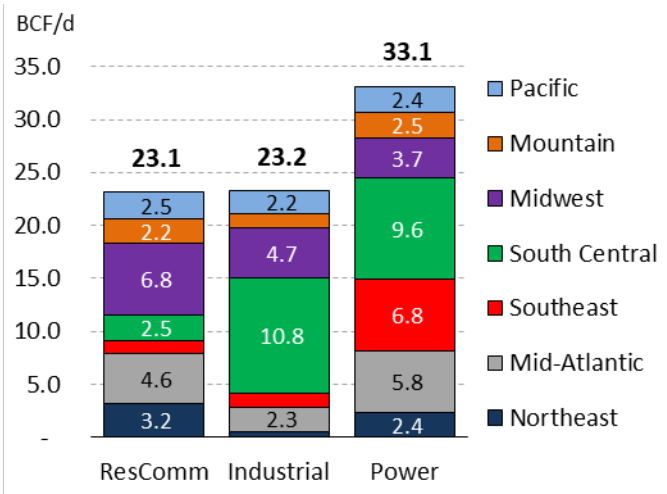


As shown in **EXHIBIT *1***, U.S. natural gas production has grown tremendously since the beginning of the Shale Gas Revolution around 2007. While virtually non-existent before 2008, Appalachian natural gas production (Marcellus, Utica, and Devonian shale plays) has grown to over 30 BCF/d or 31% of dry natural gas production by the end of 2022, which has created a massive paradigm shift in regional natural gas production and consumption patterns.

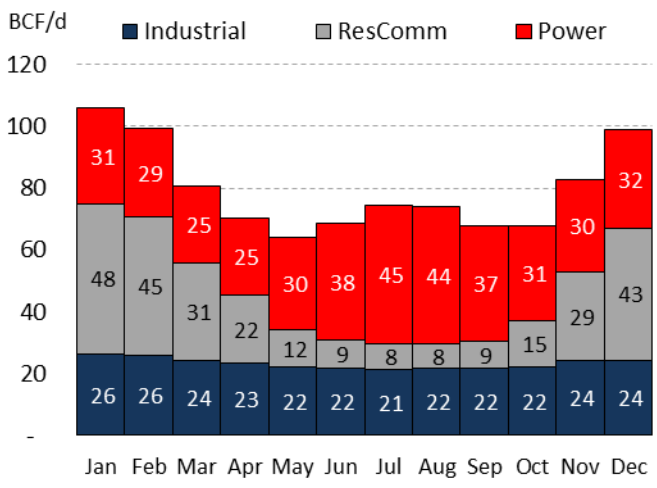
Almost all of the natural gas consumed domestically is consumed by end-use customers in the residential and commercial (ResComm), industrial, and electric power sectors. As shown in **EXHIBIT *5***, there exist notable regional differences in natural gas consumption by domestic end-use sector, as well as the monthly natural gas consumption pattern by end-use sector.

[2] EIA's "East" natural gas storage region has been further divided into Northeast, Mid-Atlantic, and Southeast, as shown in the map.

EXHIBIT 5: 2022 REGIONAL NATURAL GAS CONSUMPTION BY END-USE SECTOR (LEFT) & TOTAL U.S. 2022 MONTHLY CONSUMPTION BY END-USE SECTOR (RIGHT)



Source: EIA data



Source: EIA data

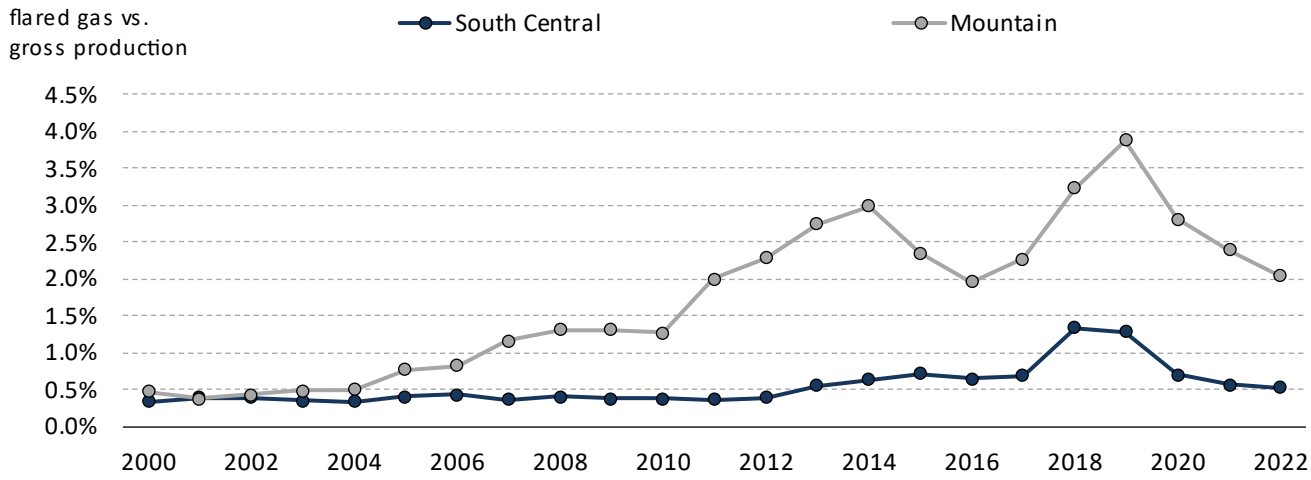
Residential and commercial (ResComm) natural gas consumption, primarily used for cooking and space heating, is disproportionately concentrated in the northern regions. The Midwest, Northeast, and Mid-Atlantic regions accounted for over 63% of ResComm natural gas consumption in 2022. Conversely, almost half of the industrial natural gas consumption is concentrated in the South Central region that includes the U.S. Gulf Coast. Similarly, the Southeast and South Central regions account for about half of the natural gas consumption in the U.S. electric power sector.

There also exist substantial differences in monthly consumption of natural gas between end-use sectors. Since natural gas in the ResComm sector is primarily used for space heating, its consumption peaks during the winter months. Conversely, natural gas consumption in the power sector peaks during the summer months when electricity demand peaks and natural gas is generally readily available.

Since the beginning of the shale gas revolution, the historic growth in Appalachian natural gas production and subsequent natural gas pipeline projects allowed the Northeast, Mid-Atlantic, and Midwest regions to be increasingly supplied by Appalachian natural gas. As a result, increasing amounts of natural gas produced in the South Central region from conventional and newly developed shale gas & oil resources were “stranded” in the region, causing regional natural gas prices to decline and disconnect from the natural gas price at Henry Hub. For example, natural gas prices at Waha hub (price point representative of the Permian basin) traded as low as $2.94/MMBtu below Henry Hub in May 2019. As a result of the lower prices, domestic natural gas consumption in South Central increased from about 17.5 BCF/d in 2010 to 22.9 BCF/d in 2022, primarily driven by growth in the industrial and electric power sectors.

Notably, as exploration activity in primarily oil shale plays like the Bakken Basin in North Dakota and the Permian Basin in West Texas and East New Mexico increased, so did the amount of flared and vented associated natural gas due to a lack of takeaway pipeline capacity and regional consumption. **EXHIBIT *6*** shows the natural gas flaring intensity by region.

EXHIBIT 6: FLARING INTENSITY BY PRODUCTION REGION



Source: EIA data

Although EPA increased the financial burden of flaring or venting excess natural gas, only increased pipeline takeaway capacity and natural gas export possibilities via pipelines to Mexico or LNG export terminals along the U.S. Gulf of Mexico resulted in a notable reduction in flared and vented natural gas over the last three years.

Overview of Historical U.S. Natural Gas Exports

As mentioned previously, the Shale Gas Revolution and subsequent rise in Appalachian natural gas production massively changed the flow of the commodity across the U.S. natural gas pipeline network, increasing the amount of natural gas "trapped" in the South Central region. To take advantage of the vast oversupply of natural gas in the region, U.S. companies developed new LNG export terminals along the Gulf and East coasts. **EXHIBIT *7*** shows the currently operational U.S. LNG export terminals.

EXHIBIT 7: OPERATIONAL U.S. LNG EXPORT TERMINALS

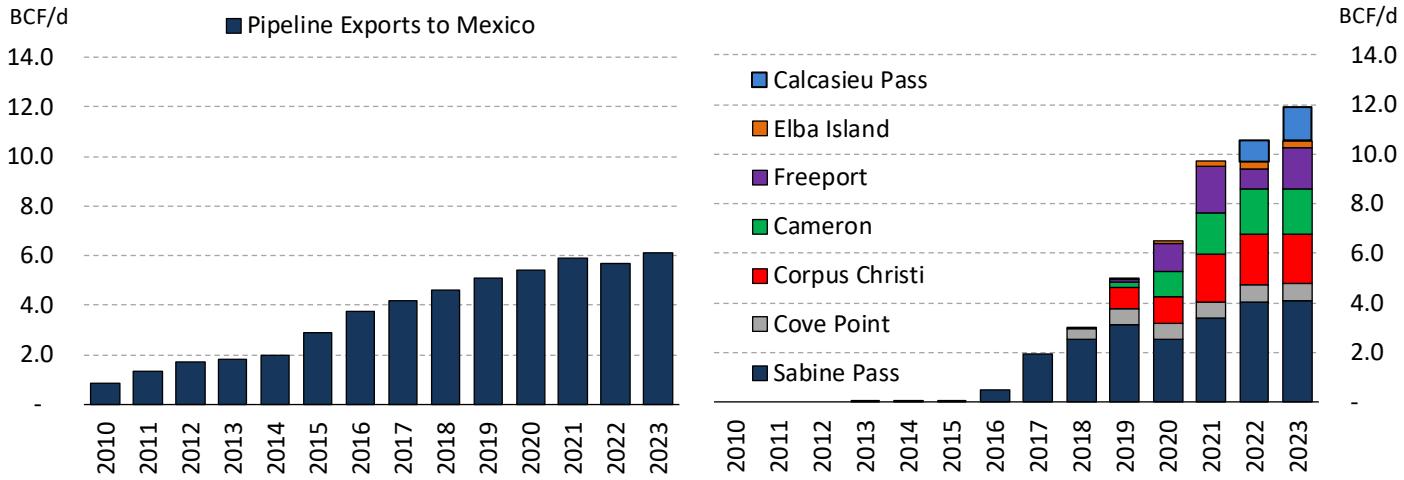
Operator	Project name	State	Online date	Export capacity *(BCF/d)*
Cheniere Energy	Sabine Pass	LA	Feb-16	4.55
Berkshire Hathaway	Cove Point	MD	Mar-18	0.76
Cheniere Energy	Corpus Christi	TX	Dec-18	2.40
Sempra LNG	Cameron	LA	May-19	1.98
Freeport LNG	Freeport	TX	Sep-19	2.13
Kinder Morgan	Elba Island	GA	Sep-19	0.36
Venture Global LNG	Calcasieu Pass	LA	Mar-22	1.58
			U.S. Total (end of 2022):	**13.76**

Cheniere Energy's Sabine Pass LNG export terminal located in Southwestern Louisiana became the first operational LNG export terminal in 2016, and has since grown to become the largest U.S. export terminal with a capacity of over 4.5 BCF/d. At the end of 2022, seven LNG export terminals were operational, totaling 13.76 BCF/d of export capacity. Notably, only two projects, Berkshire Hathaway's Cove Point and Kinder Morgan's Elba Island LNG terminals, totaling just over 1 BCF/d, are located outside Texas and Louisiana.

Additionally, U.S. companies invested significantly in increasing the natural gas pipeline capacity to neighboring Mexico, allowing associated natural gas production from the Permian Basin to be exported instead of flared. The recent Mexican pipeline network expansion, both intra-country and cross-border pipelines, allowed for increased U.S. natural exports to Mexico, which, in turn, displaced higher-cost Mexican natural gas production and LNG imports.

EXHIBIT *8* shows U.S. natural gas pipeline exports to Mexico (left) and LNG exports by terminal (right). Since 2014, U.S. natural gas pipeline exports to Mexico increased from about 2 BCF/d to over 5.7 BCF/d in 2022. With the start of operations at the Sabine Pass LNG export terminal in 2016, U.S. LNG exports have grown to 10.6 BCF/d in 2022. The Sabine Pass, Corpus Christi, and Cameron LNG export terminals accounted for over 83% of total LNG exports in 2022.

EXHIBIT 8: U.S. NATURAL GAS PIPELINE EXPORTS TO MEXICO (LEFT) & LNG EXPORTS (RIGHT)

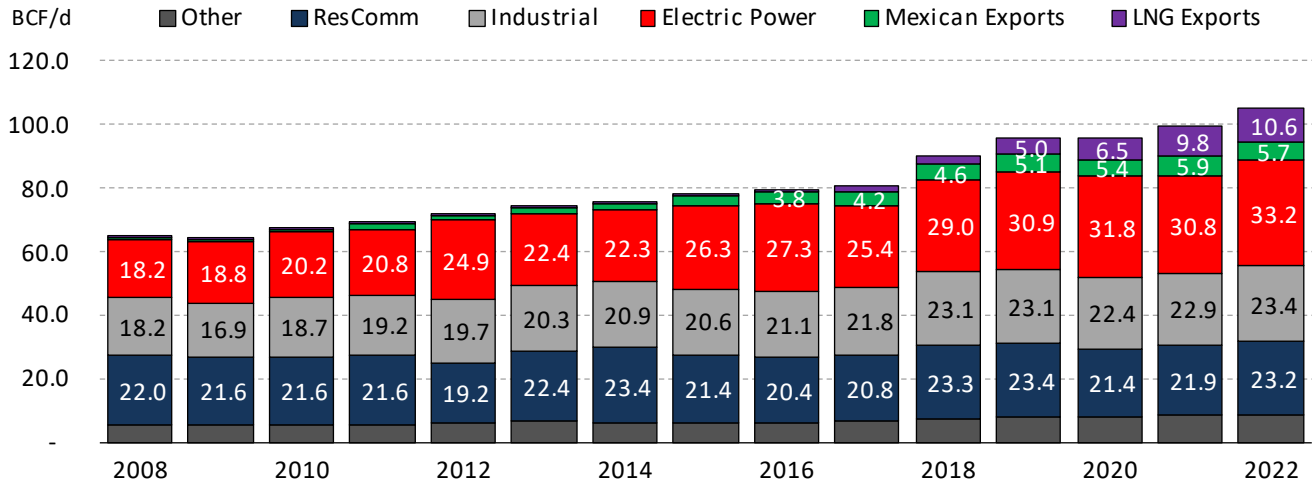


Source: EIA data

EXHIBIT *9* shows the total U.S. natural gas demand by end-use sector, pipeline exports to Mexico, and LNG exports[3]. Since 2008, U.S. natural gas demand has grown from roughly 66 BCF/d to over 107.4 BCF/d in 2022. U.S. pipeline and LNG exports have grown from around 2 BCF/d to almost 19 BCF/d over the same period, accounting for about 17% of total U.S. natural gas demand. The U.S. electric power sector has seen similar growth over the past 15 years, growing from about 18 BCF/d in 2008 to over 33 BCF/d in 2022, accounting for about one-third of total U.S. natural gas demand.

[3] Export values referenced in the chart are actual exports. Losses during liquefaction, storage, transportation, etc. are included in the "Other" category.

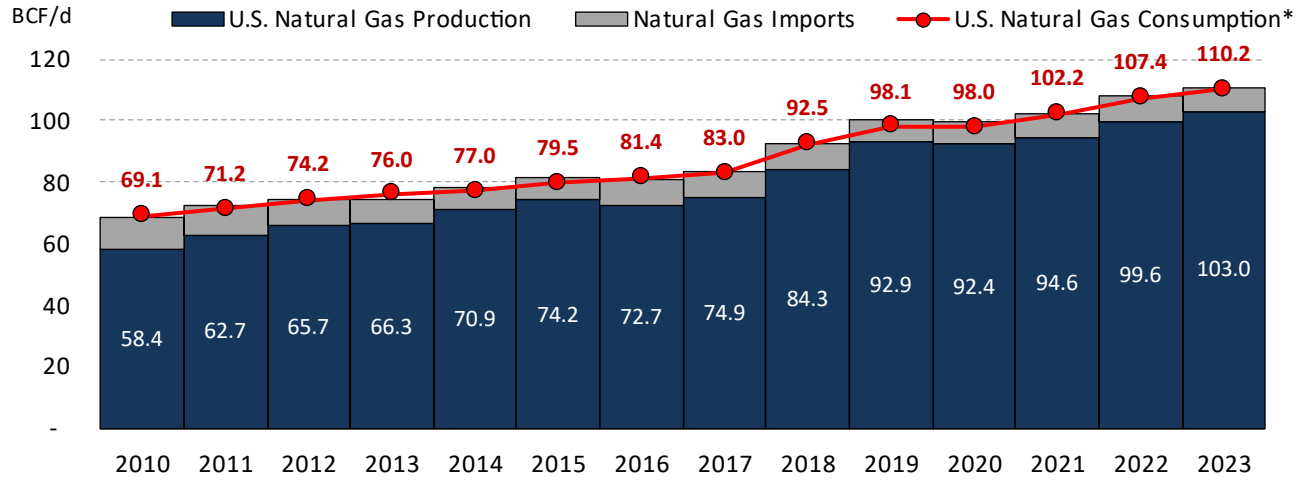
EXHIBIT 9: U.S. NATURAL GAS DEMAND BY SECTOR



Source: EIA data

Over the last 15 years, any substantial increase in natural gas demand has been followed by a continuous increase in U.S. natural gas supply, as shown in **EXHIBIT *10***. Despite U.S. natural gas production almost doubling from 2010 to 2023, natural gas prices during the first six months of 2023 have been at their lowest level since 2010 (excluding the COVID-19 period of April to September 2020). These supply-demand dynamics indicate a well-functioning market, particularly in light of the fact that prices have remained relatively stable throughout this period of enormous change in the U.S. energy system.

EXHIBIT 10: ANNUAL AVERAGE U.S. NATURAL GAS SUPPLY AND DEMAND



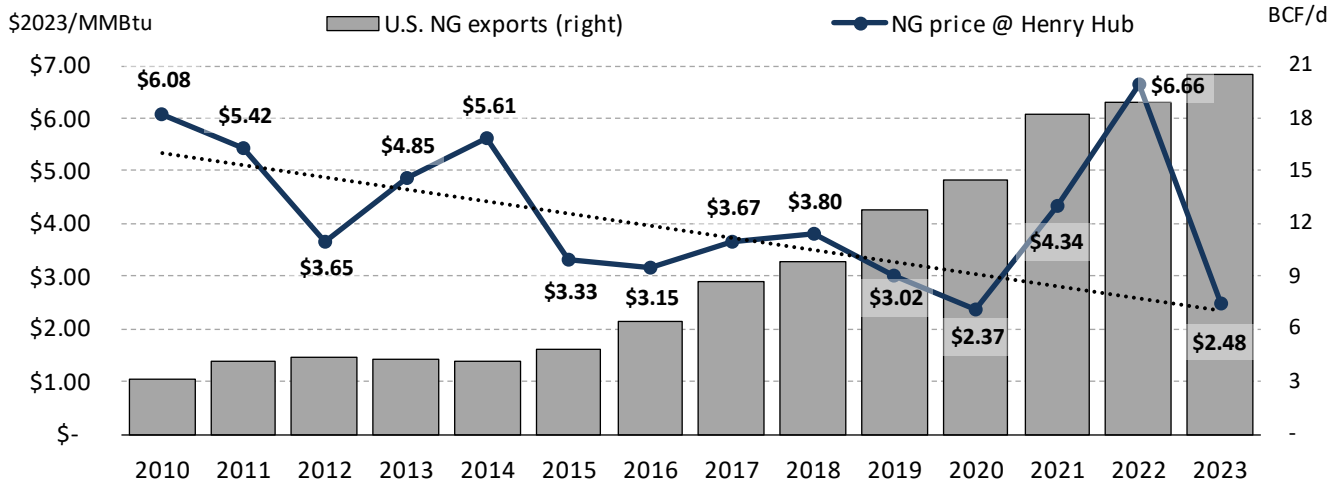
Source: EIA data; *includes LNG and pipeline exports

Review of Historical U.S. Natural Gas Price Formation

As shown in **EXHIBIT *11***, U.S. natural gas consumers have enjoyed the lowest natural gas prices in U.S. history over the last decade. Excluding the pricing anomaly of 2022, which this report will examine in more detail in the next chapter, U.S. natural gas prices at Henry Hub averaged $4.10/MMBtu over the last decade, a decline of over 54% from the first decade of this century, when natural gas prices averaged almost $9/MMBtu.

Furthermore, despite U.S. natural gas exports growing rapidly since 2016, natural gas prices have continued to decline. During the six years leading up to the rise in U.S. natural gas exports (2010 to 2016), natural gas prices at Henry Hub averaged $4.58/MMBtu. During the following six years (2017 to 2022), natural gas prices averaged less than $4.00/MMBtu. During the first half of 2023, when U.S. natural gas exports averaged a record 20.4 BCF/d, natural gas prices at Henry Hub averaged $2.43/MMBtu, the lowest 6-month average in this century outside of the height of the COVID-19 pandemic (April to October 2020). **EXHIBIT *11*** shows the annual average natural gas price at Henry Hub and U.S. natural gas exports.

EXHIBIT 11: U.S. NATURAL GAS EXPORTS & ANNUAL AVERAGE NATURAL GAS PRICES @ HENRY HUB

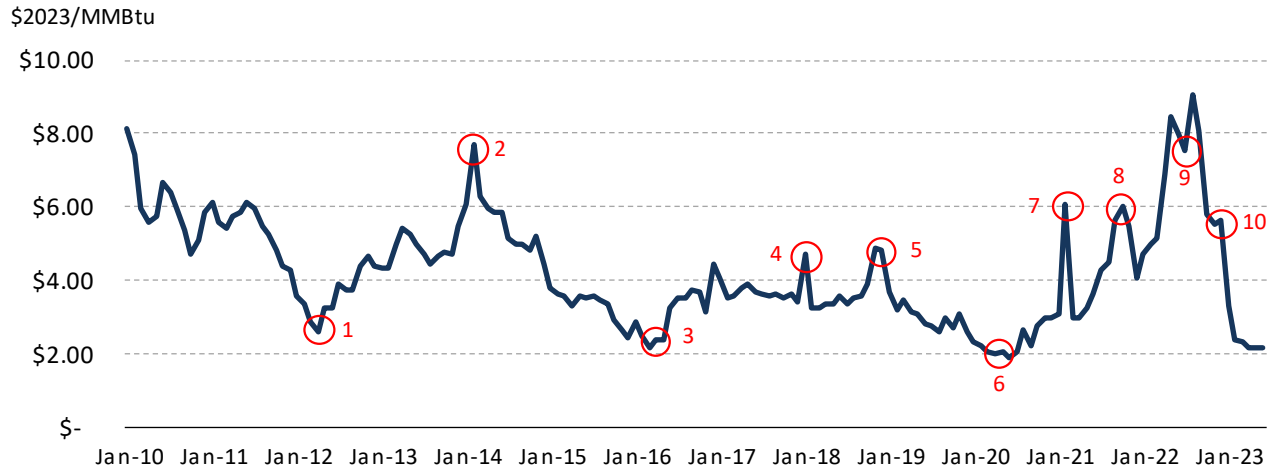


Source: EIA data; Note: trendline excludes 2022

To better understand why natural gas prices continued to decline over the last six years despite U.S. natural gas exports rising to record levels, it is worth examining the various factors influencing the value of natural gas in the United States and its regional differences.

As described and shown in **EXHIBIT *5***, natural gas is consumed in four major sectors across the U.S.: As a cooking and heating fuel in the residential and commercial sectors, as fuel input in many industrial processes and power generation, as well as a commodity for export. According to basic economic theory, any change in demand of a commodity, while the supply of said commodity is held constant, will impact the commodity's price. **EXHIBIT *12*** shows monthly natural gas prices at Henry Hub with select annotated events explaining the observed price impact.

EXHIBIT 12: MONTHLY NATURAL GAS PRICES @ HENRY HUB



Source: EIA data

1. Supply glut of Summer 2012
2. 2014 Polar Vortex
3. Supply glut of Summer 2016
4. 2018 Winter Storm
5. November 2018 Snowstorm
6. COVID-19 pandemic demand destruction
7. Winter Storm Uri (Feb 2021)
8. Post-COVID-19 Demand Recovery
9. Freeport LNG fire
10. Winter Storm Elliott

As evidenced in **EXHIBIT *12***, weather patterns differing from the norm have the largest impact on U.S. natural gas prices. Extreme cold weather events like Winter Storm Uri and Elliott can send natural gas prices soaring, as increased natural gas demand for heating in the ResComm and power generation in the electric power sectors outpaced natural gas supply. Conversely, warmer-than-normal winter weather can create a surplus of natural gas supply that suppresses natural gas prices well into the following summer. Natural gas supply disruptions due to hurricanes affecting production regions in South Central can also affect short-term natural gas prices.

Additionally, the major natural gas demand sectors have different noticeably different impacts on regional natural gas prices due to the regional differences in natural gas consumption described previously. **EXHIBIT *13*** shows the correlation coefficients[4] between regional natural gas prices and regional natural gas consumption by sector for the seven years leading up to the rise in U.S. natural gas exports and the last six and a half years, including and excluding the anomaly of 2022. In the table below, green correlation coefficients highlight a positive relationship, while red correlation coefficients highlight a negative or inverse relationship. The more saturated the color shading, the more significant the relationship.

[4] For reference, the correlation coefficient is a statistical measure of the strength of a linear relationship between two variables. Its value can range from -1 to 1. A correlation coefficient of -1 describes a perfect negative, or inverse, correlation, with values in one series rising as those in the other decline, and vice versa. A coefficient of 1 shows a perfect positive correlation, or a direct relationship. A correlation coefficient of 0 means there is no linear relationship.

EXHIBIT 13: REGIONAL CORRELATION COEFFICIENTS BY DEMAND SECTOR VS. REGIONAL NATURAL GAS PRICES

	2010 - 2016			2017 - 2023				2017 - 2023 (excl. 2022)			
	ResComm	Industrial	Power	ResComm	Industrial	Power	U.S. Exports	ResComm	Industrial	Power	U.S. Exports
Northeast	0.42	0.43	(0.31)	0.44	0.42	(0.05)	0.04	0.54	0.50	(0.20)	(0.33)
Mid-Atlantic	0.45	0.22	(0.63)	0.26	0.38	(0.04)	0.14	0.52	0.46	(0.41)	(0.34)
Southeast	0.41	(0.02)	(0.41)	0.11	0.12	0.24	0.21	0.43	0.14	(0.24)	(0.32)
Midwest	0.22	0.10	(0.49)	0.05	0.04	(0.00)	0.24	0.37	0.38	(0.40)	(0.33)
South Central	0.25	(0.44)	(0.28)	0.09	0.07	0.02	0.20	0.34	(0.22)	(0.21)	(0.22)
Mountain	0.19	0.03	(0.31)	0.27	0.18	(0.04)	0.32	0.37	0.12	(0.14)	0.08
Pacific	0.18	(0.26)	(0.03)	0.33	(0.32)	0.23	0.35	0.46	(0.20)	0.18	0.19

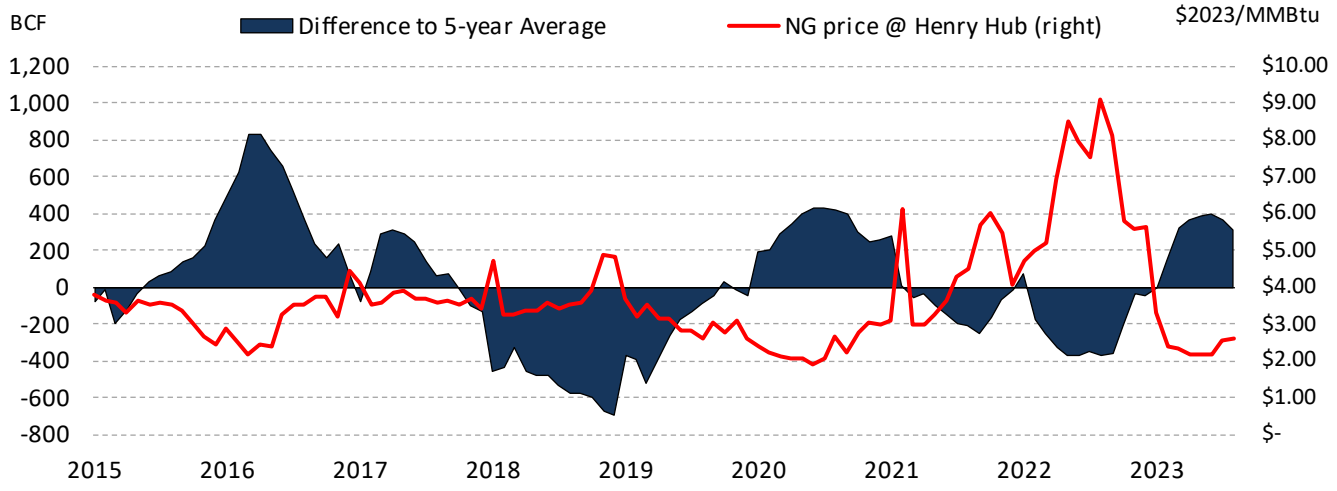
Note: correlation coefficients were calculated using monthly state-level EIA NG demand data aggregated on a regional level vs. $2023/MMBtu regional monthly average NG prices

Unsurprisingly, changes in natural gas demand in the ResComm sectors and regional natural gas prices are most strongly correlated in regions with significant ResComm demand during the winter heating season (e.g., Mid-Atlantic and Northeast regions). Conversely, the region with the highest industrial demand (i.e., South Central) shows a negative correlation between industrial demand and regional natural gas prices. As natural gas prices in the region decreased, industrial demand for the fuel increased as more industrial demand (re)located to the region.

Also evident from **EXHIBIT *13*** is the role the power sector (and, in addition, U.S. exports since 2017) plays in the overall supply-demand-price relationship of natural gas. As indicated by the negative correlation coefficient across all regions before 2017 and all but one region after that, power sector natural gas demand acts as a universal "balancing" factor for the overall U.S. natural gas market. As natural gas prices decline primarily due to short-term market oversupply, power sector natural gas consumption increases to consume the excess natural gas. On the other hand, as natural gas prices rise due to market "tightness", power sector natural gas consumption declines while other forms of electric generation (primarily coal) increase. Since 2017, a similar effect has been observed for the relationship between U.S. natural gas exports and regional natural gas prices.

One of the most accurate and widely used indicators for current natural gas supply-demand balances and their effect on natural gas prices is the current U.S. natural gas storage level versus the previous 5-year average, as shown in **EXHIBIT *14***.

EXHIBIT 14: LONG-TERM U.S. NATURAL GAS STORAGE DIFFERENCE VS. 5-YEAR AVERAGE & HENRY HUB NG PRICE



Source: EIA data

In the U.S., excess natural gas supply during the non-winter season (i.e., injection season – April through October) is stored in physical and geological storage facilities across the country. U.S. natural gas storage is also considered a significant source of natural gas supply during the winter months (withdrawal season – November through March), when natural gas consumption generally outpaces domestic natural gas production. Comparison to historical inventory levels at similar

points in time (e.g., 5-year average) allows natural gas market participants to assess if the current natural gas market balance is either "tight" (i.e., supply shortfall) or "loose" (i.e., excess supply).

As shown in **EXHIBIT *14***, historically, excess natural gas storage levels (positive difference to the 5-year average) coincide with low(er) natural gas prices. In contrast, periods of tight natural gas storage levels (negative difference to the 5-year average) coincide with high(er) natural gas prices. As explained previously, natural gas demand changes in the ResComm sector and fundamental changes in domestic production levels are primarily responsible for short-term storage surpluses or shortfalls, while more flexible demand sectors such as electric power and, more recently, exports allow for a rebalancing of natural gas inventories and the natural gas market as a whole.

The Natural Gas Pricing Anomaly of 2022

As described extensively in the previous section, natural gas prices (and, at large, all commodities) are affected by changes in demand and supply of the commodity. To better understand what happened in 2022, we need to review two fundamental economic principles—the interrelationship between supply, demand, and prices and the substitution effect.

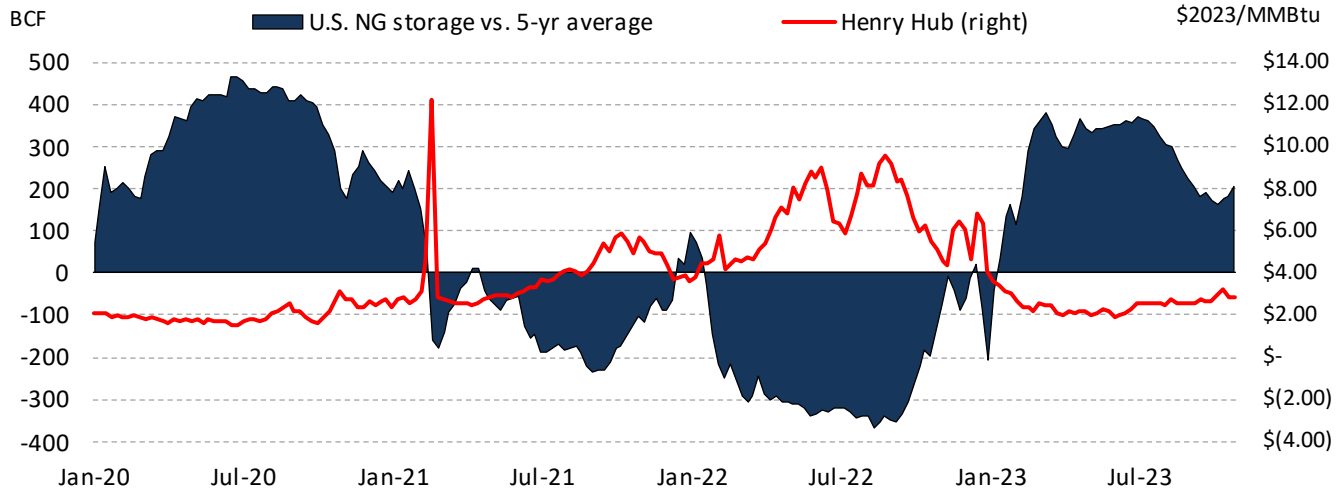
In general, as demand rises, prices rise, incentivizing increased supply. As a result of increased supply, market prices return to the so-called equilibrium price where demand and supply curves intersect. Vice versa, as demand declines, prices for the commodity decline, discouraging excess supply levels. As supply declines, prices increase until the market returns to equilibrium. Since there are significant differences in how fast supply and demand can change (increasing supply usually involves hiring and training new personnel, buying more input materials and supply, and expanding output capability, among other things), the time it takes for a market to return to equilibrium generally depends on how fast supply can increase or decrease. Therefore, as the old market saying goes, "The cure to high prices is high prices."

Another critical economic mechanism to review is the substitution effect. In general, as the price for one commodity rises, consumers of said commodity will increase the consumption of another commodity that can be used to substitute the commodity with rising prices. Therefore, as the price for one commodity rises, the incremental demand for the commodity declines as more consumers switch to the substituting commodity, which, in turn, will limit the price increase the primary commodity will experience. As explained in this section, neither of these economic market principles held true in 2022, resulting in the highest annual average natural gas price since the commodity market crash of 2008.

To understand what happened in 2022, we must first examine what happened in the lead-up to the period in question. In 2020, the COVID-19 global pandemic upended daily life across the globe. Demand for certain commodities plummeted overnight as people were ordered to stay home to protect against the virus. For example, demand for petroleum products fell to record lows in April 2020, causing crude oil prices to fall below $0 per barrel as refineries could not intake any additional crude oil due to the disappearance of diesel and gasoline demand across the country. Unemployment and corporate debt rose as companies tried to adjust their output to new demand levels caused by the pandemic.

As pandemic restrictions waned in 2021 and economic activity slowly returned to normal, demand for virtually all goods and services rose once again. However, corporate debt and a nationwide labor shortage caused by the pandemic limited the responsiveness of supply across the entire energy sector. Additionally, Winter Storm Uri in February 2021 resulted in a massive short-term natural gas supply disruption while demand soared to meet the increased demand in the ResComm and electric power sectors. As a result, the natural gas sector quickly consumed the massive storage surplus of almost 500 BCF versus the 5-year average accumulated during the first few months of the pandemic and fell to a storage shortfall of over 230 BCF in September, as shown in **EXHIBIT *15***.

EXHIBIT 15: 2020-2023 U.S. NATURAL GAS STORAGE DIFFERENCE VS. 5-YEAR AVERAGE & HENRY HUB NG PRICE

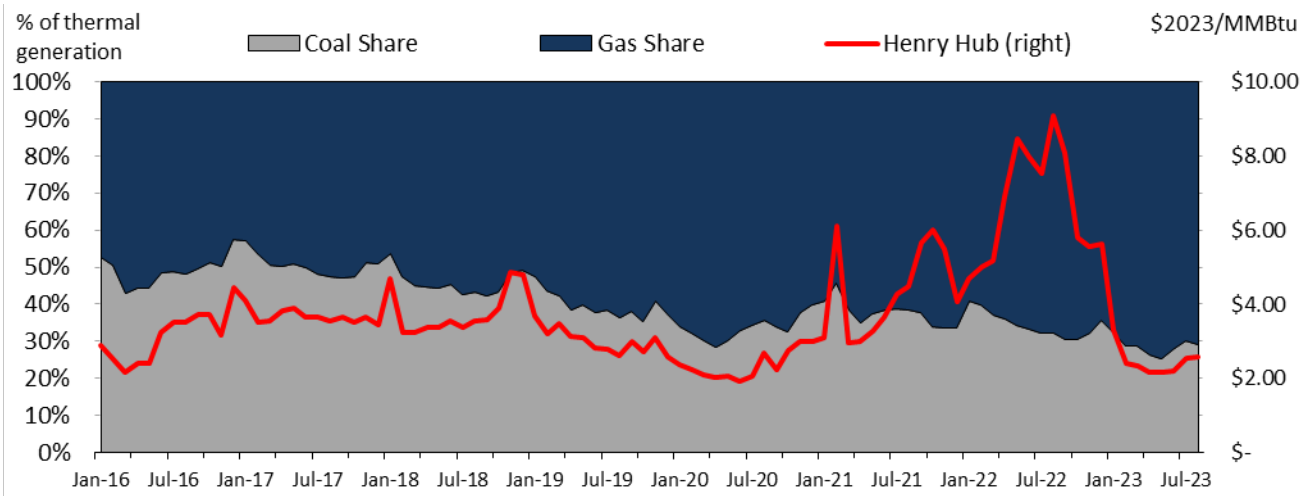


Source: EIA data

Due to the labor shortage and the large, accumulated debt of natural gas exploration companies, corporate austerity in capital spending resulted in a delayed supply response to the increasing natural gas prices as natural gas demand returned in 2021. U.S. natural gas prices at Henry Hub doubled from about $2.50/MMBtu in March 2021 to over $5.00/MMBtu at the end of September, while the shortfall of natural gas inventories to the 5-year average continued to widen. Once U.S. natural gas production responded towards the end of Q3 of 2021, the storage shortfall began to decline, resulting in prices falling below $4.00 in December 2021.

Due to a lack of substitution possibilities, the ResComm sector tends to be the most inflexible, or "inelastic," of the major natural gas demand sectors. As temperatures fall, residential and commercial customers increase their natural gas consumption for heating, largely irrespective of price, since the only choice for a home or building with natural gas heating is heat or no heat, which, in some circumstances, is literally a decision of life or death. On the other hand, due to its competition with coal, the U.S. power sector is arguably the most flexible or elastic of the major natural gas sectors. **EXHIBIT *16*** shows the competition between coal and natural gas in the U.S. power sector and the relationship to natural gas prices at Henry Hub.

EXHIBIT 16: U.S. COAL AND NATURAL GAS POWER GENERATION SHARE VS. HENRY HUB NG PRICE



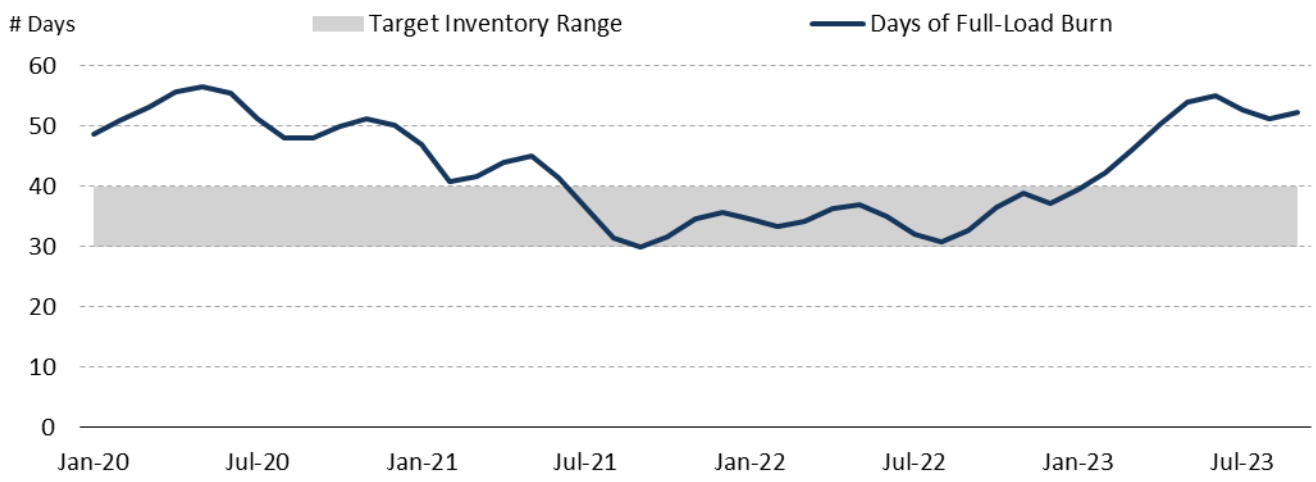
Source: EIA data

The above exhibit shows a strong correlation between coal and gas generation share and U.S. natural gas prices. As natural gas prices increase, the operating cost for natural gas-fired power plants increases, making them less economical to run than some of their coal-fired counterparts. As natural gas prices continue to rise, more and more natural gas generation and, therefore, natural gas consumption is displaced by increased coal generation.

In 2021, as natural gas prices began to rise and natural gas production could not quickly respond, increasing amounts of natural gas generation were displaced by coal generation, effectively limiting how fast and how high natural gas prices could rise during that summer. Once domestic natural gas production responded to the higher demand and prices, reducing the natural gas storage shortfall, natural gas prices fell, and natural gas generation quickly took back market share from its coal-fired counterparts.

However, it is important to highlight that this notable shift from natural gas to coal generation during the summer of 2021 had trickle-down effects that the U.S. natural gas market would feel for most of 2022. U.S. coal companies felt the same effects of the labor shortage and corporate debt caused by the COVID-19 pandemic, which limited production response from their natural gas counterparts. However, due to slower response in coal supply and delivery adjustments during the height of the pandemic, U.S. coal plants entered 2021 with on-site coal inventories well above their target levels, as shown in **EXHIBIT *17***.

EXHIBIT 17: MONTHLY U.S. COAL INVENTORIES AT COAL POWER PLANTS VS. TARGET LEVELS[5]



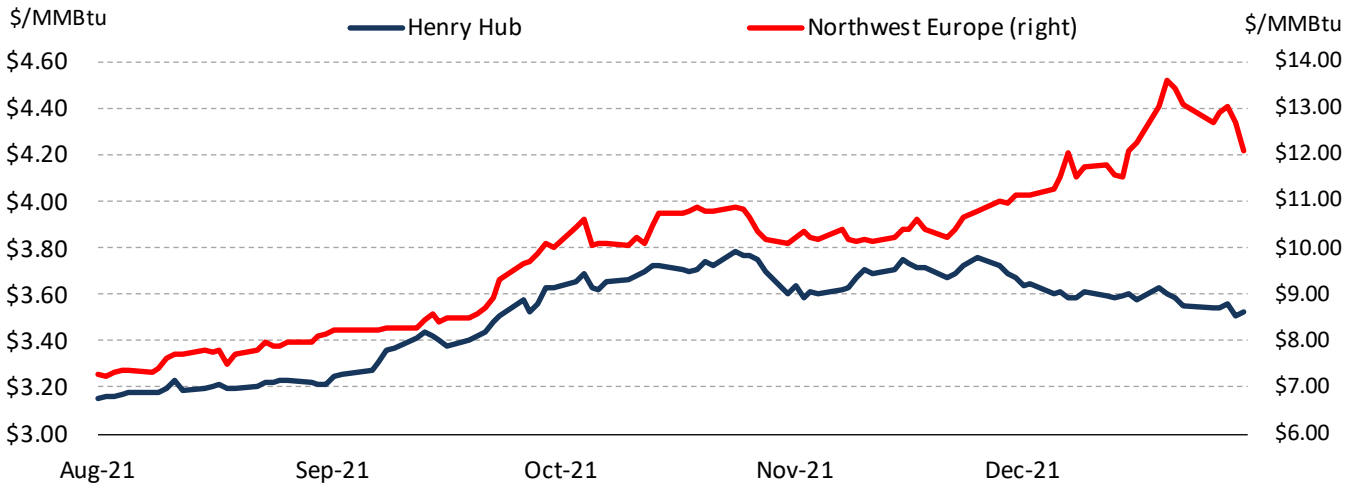
Source: EVA Coal Stockpile Report

As natural gas prices began to rise in 2021 and more natural gas-fired power plants were being displaced by coal-fired plants, coal inventories began to decline rapidly, from over 55 days of full-load burn to 30 days by September 2021. According to EIA, in September 2021, coal inventories fell to their lowest levels in over 40 years[6], limiting utilities' capacity to fuel switch in response to rising natural gas prices. As natural gas production rose and natural gas prices fell, some power generation shifted back to natural gas, allowing coal inventories to partially recover before the start of 2022.

Also worth highlighting is the relationship between U.S. and European natural gas prices. **EXHIBIT *18*** shows the daily natural gas prices for the U.S. (at Henry Hub) and Northwest Europe (at Title Transfer Facility – TTF).

[5] Days of Full-load burn measures the number of days a coal plant can operate at 100% given the current size of on-site fuel inventory.
[6] https://www.eia.gov/todayinenergy/detail.php?id=50558

EXHIBIT 18: U.S. VERSUS EUROPEAN DAILY NATURAL GAS PRICES: AUGUST TO DECEMBER 2021



Source: Bloomberg

Due to the proximity and price advantages, the United States is the primary supplier of LNG to the European market. However, before the Russia-Ukraine War, Europe received most of its natural gas at a lower cost than LNG from Russia via pipeline. Therefore, U.S. LNG has historically been Europe's marginal natural gas supply. As a result, any change in U.S. natural gas prices was and still is often reflected in European natural gas prices. As U.S. gas prices rose throughout September and into October, European natural gas prices followed suit. However, U.S. and European natural gas prices disconnected in November 2021 as increased U.S. natural gas production caused prices to fall. Meanwhile, Europe required additional natural gas from other LNG exporting countries, as signaled by increasing European natural gas prices. If European natural gas prices, in fact, dictated U.S. natural gas prices, as some critics of increased U.S. natural gas exports allege, that price disconnect would not have materialized.

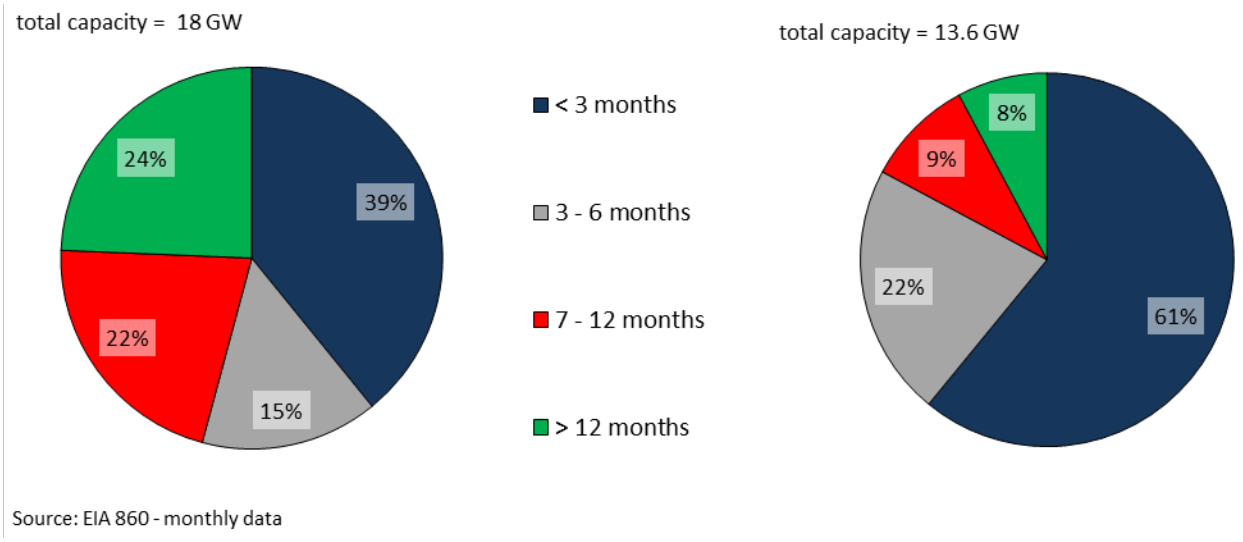
In summary, as the U.S. energy sector entered 2022, natural gas inventories just rebalanced against the 5-year average due to the slow return of domestic natural gas production. Meanwhile, coal inventories at U.S. coal-fired power plants were at the low end of their target levels, with the coal supply chain (mining and transportation) still operating at well-below pre-pandemic levels. As electricity demand and natural gas for heating increased during January and February, so did natural gas prices.

However, due to the low coal inventories entering 2022, many regulated utilities limited coal consumption at their coal plants to their scheduled coal deliveries since coal production and transportation increases were still severely limited. As a result, the substitution effect between coal and natural gas in the U.S. power sector disconnected, as shown in **EXHIBIT *16***. Therefore, despite rising natural gas prices due to the rapidly increasing natural gas inventory shortfall, natural gas consumption in the power sector continued to rise as coal generation was constrained by low inventories, further exacerbating the natural gas inventory shortfall. Despite natural gas prices reaching post-shale gas revolution record highs in the summer of 2022, natural gas generation in the power sector continued to rise. Increased electricity demand driven by above-average summer heat, over 14 GW of coal plant retirements in 2022 alone, the rest of the coal fleet limited by record-low inventories, and significantly delayed completion of new renewable energy projects due to supply chain issues post-pandemic, left natural gas as the only resource with the flexibility to increase electric generation output. To further prove the point, EIA reported in the summer of 2022, "in past years, the electric power sector has substituted natural gas-fired generation with coal-fired generation when natural gas prices have risen. However, in recent months, coal power

plants have responded less than in the past as an alternative source of generation, most likely as a result of continued coal capacity retirements, constraints in fuel delivery to coal plants, and lower-than-average stocks at coal plants." [7]

EXHIBIT *19* shows the magnitude of renewable energy project delays post-COVID-19 pandemic in 2021 and 2022. Between July 2021 and June 2022, over 60% of solar and almost 40% of wind projects experienced a delay of more than three months. Almost one-quarter of solar projects, or 4.5 GW, were delayed by over a year due to shortfalls in solar panel supply, increasing the reliance on natural gas power plants in 2021 and 2022 as coal plant retirements continued.

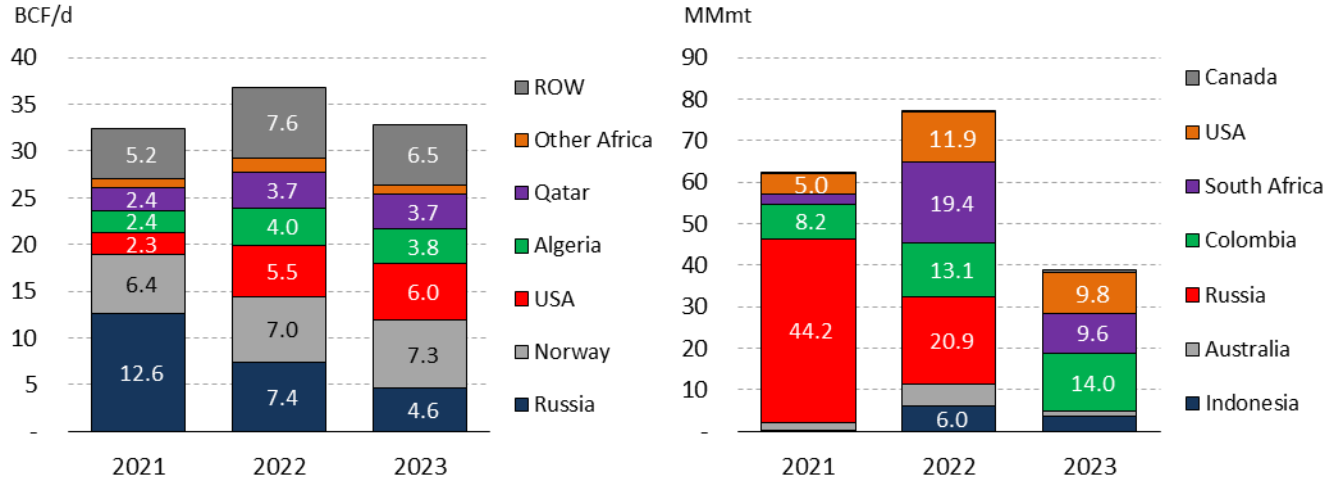
EXHIBIT 19: U.S. SOLAR (LEFT) AND WIND (RIGHT) PROJECT DELAYS BETWEEN JULY 2021 AND JUNE 2022



Source: EIA 860 - monthly data

Further exacerbating the energy market tightness in the U.S. and globally in 2022 was Russia's invasion of neighboring Ukraine beginning in February 2022. As shown in **EXHIBIT *20***, Russia was the primary supplier of thermal coal (used primarily in power generation) and natural gas to Europe before Russia's Invasion.

EXHIBIT 20: ANNUAL NATURAL GAS (LEFT) AND THERMAL COAL (RIGHT) IMPORTS BY ORIGIN COUNTRY INTO EUROPE



Source: EU trade data; ROW - Rest of World

Source: EU trade data

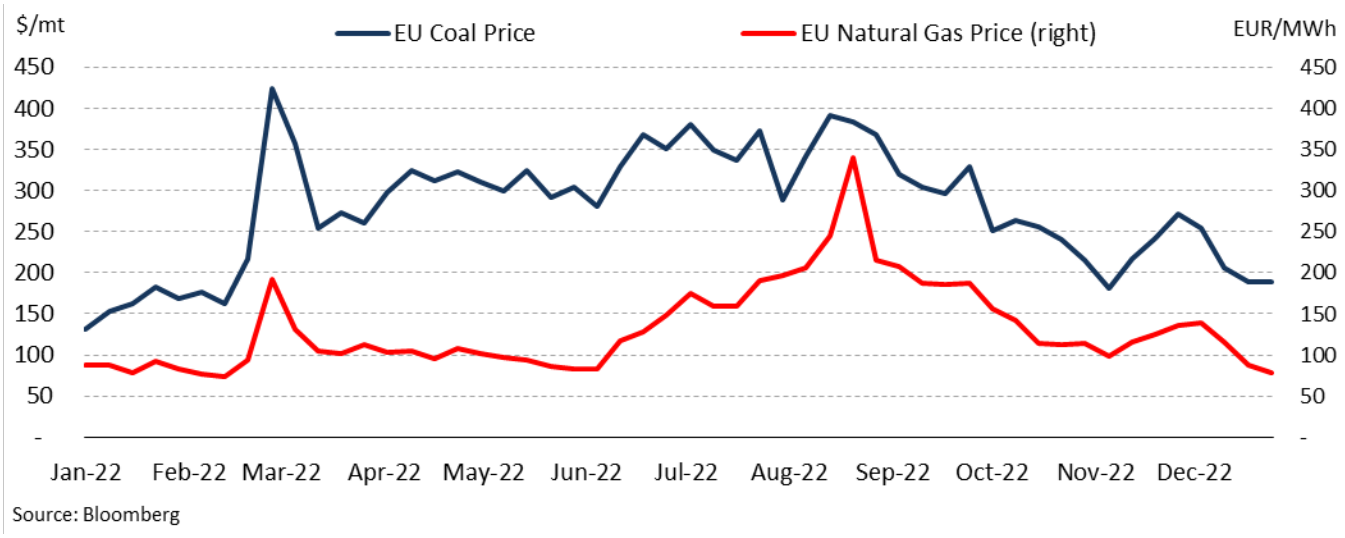
In 2021, Russia accounted for over 70% of thermal coal and almost 40% of natural gas imports into Europe. As Russia's invasion of Ukraine began, European countries and their Western allies began to impose sanctions on imports of Russia's

[7] https://www.eia.gov/todayinenergy/detail.php?id=52798

energy commodities, including coal, oil, and natural gas. Just one month later, European countries announced an import ban on all Russian coal beginning August 10, 2022. As a result, European coal prices jumped from $130/mt entering 2022 to over $400/mt the week following Russia's invasion of Ukraine, and averaged well above $320/mt for the following six months (March through September) to encourage additional coal imports from other countries.

Although European countries never officially imposed sanctions on Russian natural gas imports, serious supply concerns about natural gas pipeline flows from Russia to the E.U. persisted. To limit any increase in natural gas consumed in the European power sector, European natural gas prices had to rise in lockstep with European coal prices. As a result, European natural gas prices rose during the first half of 2022, albeit more modestly (except for the week of the invasion), averaging 100 EUR/MWh. European natural gas prices increased further during the summer of 2022 to minimize the amount of coal-to-gas-switching in the European power sector and preserve natural gas inventories. As shown in **EXHIBIT *21***, European natural gas prices reached a record high of 339 EUR/MWh at the end of August when Russia announced an unplanned maintenance outage at the Nord Stream natural gas pipeline, which directly connects Russia and Germany.

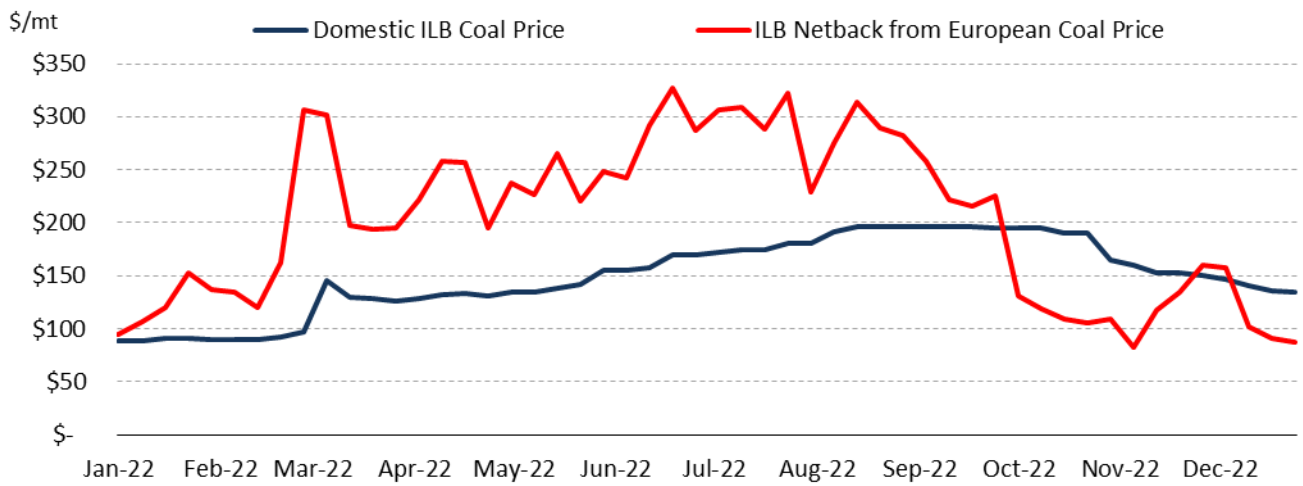
EXHIBIT 21: 2022 EUROPEAN COAL AND NATURAL GAS PRICES



Source: Bloomberg

The United States quickly materialized as one of the alternative supply sources for European coal imports due to U.S. coal quality characteristics and proximity. However, as mentioned previously, U.S. coal supply in 2022 was severely constrained. Additionally, most of the produced U.S. coal was already contracted for by U.S. electric utilities that required new inflows to at least maintain their already low coal inventories. Therefore, European coal buyers competed with domestic coal buyers for only a small amount of coal that was not already contracted for delivery in 2022, especially from the Eastern U.S. coal basins (i.e., Northern Appalachia – NAPP, Central Appalachia – CAPP, and Illinois Basin – ILB). As a result, U.S. coal prices began to increase significantly as the arbitrage to Europe for Eastern U.S. coal began to widen, as shown in **EXHIBIT *22***. At their peak during mid-2022, European coal prices more than tripled relative to their pre-war levels in January 2022.

EXHIBIT 22: U.S. ILB COAL PRICE VS. NETBACK TO EUROPEAN COAL PRICE

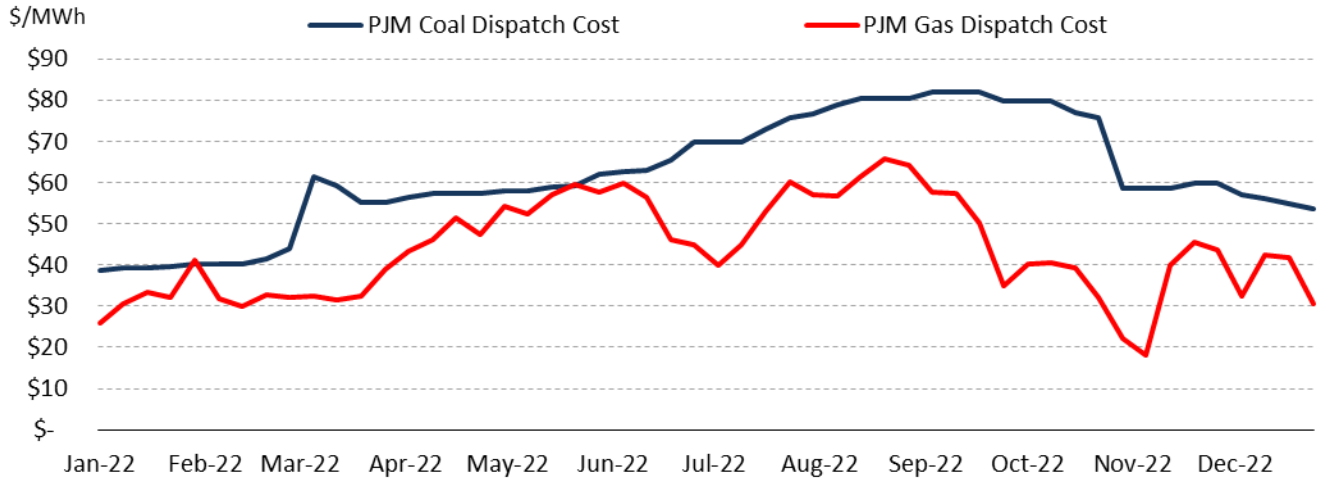


Source: EVA Global Thermal Coal Report

Following Russia's invasion of Ukraine, U.S. Eastern coal prices collectively jumped $40/mt week-over-week, increasing the dispatch cost for coal plants relying on U.S. coal with exposure to the export market. The arbitrage of U.S. coal exports to Europe remained well above domestic price until the end of Q3 2022, when European natural gas and coal prices began to fall as supply concerns for the commodities in Europe eased.

Due to the jump in U.S. coal prices and, in turn, the increased dispatch cost of U.S. coal plants, natural gas prices responded in kind to limit the amount of coal-to-gas switching in the power sector. **EXHIBIT 23** shows an example of coal versus natural gas dispatch economics for 2022 in the PJM Interconnection.

EXHIBIT 23: 2022 COAL VS. NATURAL GAS DISPATCH COST IN PJM



Source: EVA Coal-to-Gas Price Sensitivity Outlook: assumes NAPP coal, 10.5 HR, $4 O&M vs. Gas 7.5 HR, $2 O&M

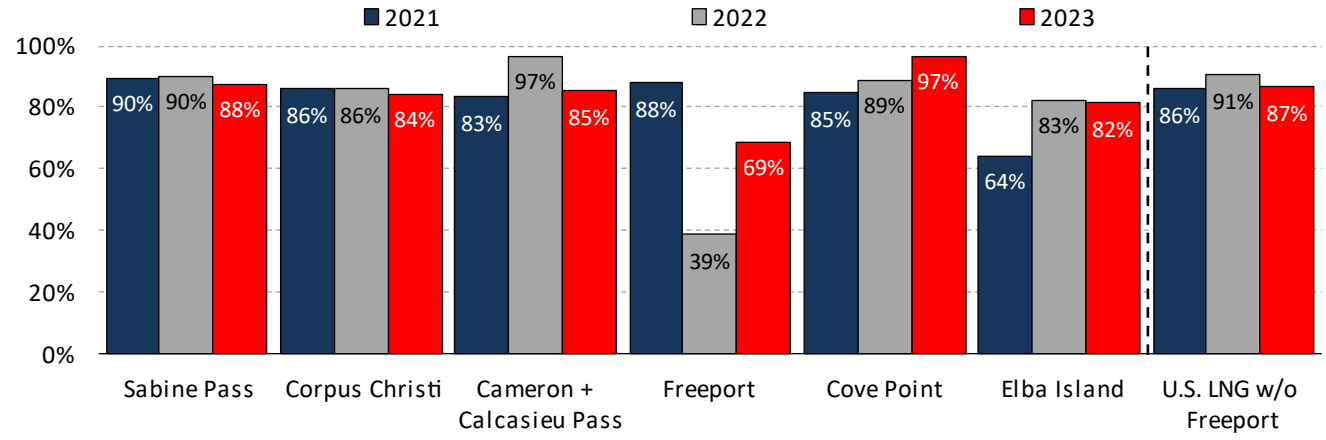
Although European natural gas and coal prices jumped at the end of February, with U.S. coal prices responding just a week later, U.S. natural gas prices did not begin to rise until early April increased U.S. power sector natural gas demand quickly increased the U.S. natural gas inventory shortfall versus the 5-year average, as shown in **EXHIBIT *15***. U.S. natural gas prices briefly dipped at the end of June when an explosion at the Freeport LNG export terminal halted all exports from the facility for the foreseeable future, allowing an additional 2.1 BCF/d of natural gas supply to flow into the power sector. However, as coal prices and the natural gas inventory shortfall remained high, natural gas prices quickly rebounded to limit further coal-to-gas switching. U.S. natural gas prices began to ease after milder-than-expected September weather significantly

reduced electricity demand and, in turn, natural gas consumption in the power sector, while steadily increasing natural gas supply allowed natural gas inventories to rise quickly, reducing the shortfall to the 5-year average.

In summary, it was not natural gas exports but rather a confluence of unusual coal market factors—limited domestic inventories, reduced fuel-switching capacity, and heightened demand for U.S. coal exports to Europe—that served as the primary factor behind increased domestic natural gas prices in 2022.

To further illustrate the limited impact of global natural gas prices on U.S. LNG exports, **EXHIBIT *24*** shows the approximate utilization of the seven U.S. LNG export terminals, as well as the average U.S. LNG utilization with and without the Freeport terminal.

EXHIBIT 24: AVERAGE ANNUAL LNG EXPORT TERMINAL UTILIZATION

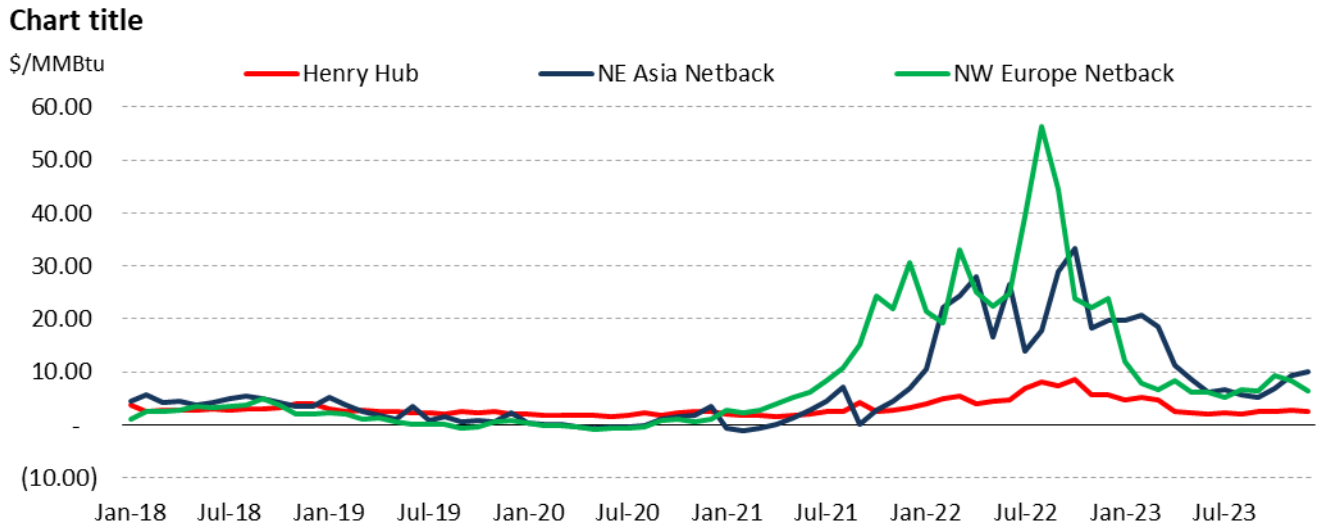


Source: EIA & Census data

Despite 2021 U.S. natural gas prices at Henry Hub averaging more than $2.00/MMBtu, or 35%, below 2022 levels, LNG terminal utilization was virtually unchanged between the two years. Excluding the Freeport LNG terminal due to the explosion and fire, which halted all exports from the facility for the second half of 2022, U.S. LNG utilization rates increased minimally year-over-year, from 86% to 91%, primarily driven by the recent completion of the Calcasieu Pass terminal and, therefore, a non-existent need for a planned maintenance outage in 2022. During the first eight months of 2023, when natural gas prices averaged less than $2.50/MMBtu, LNG export utilization remained at 87%.

The primary reason for the disconnect between domestic or international natural gas prices and LNG export terminal utilization is the massive discount of U.S. natural gas prices to their global counterparts due to the low-cost supply in the U.S. **EXHIBIT *25*** shows the U.S. LNG netbacks to the two major global LNG trading hubs, TTF in Northwest Europe and JKM (Japanese-Korean Marker) in Northeast Asia, versus the U.S. natural gas price at Henry Hub.

EXHIBIT 25: U.S. NATURAL GAS PRICES @ HENRY HUB VS. EUROPEAN & ASIAN NETBACK PRICING



Source: EVA Monthly Natural Gas Outlook

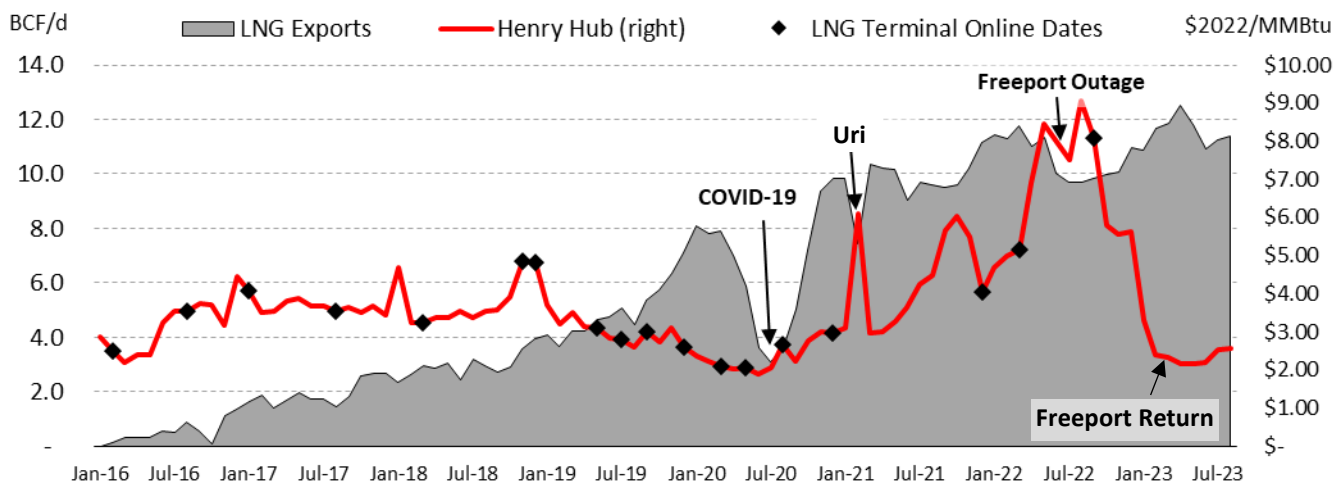
After global LNG netbacks languished below domestic natural gas prices for most of 2020, resulting in an LNG utilization rate of just 66%, the arbitrage to Europe opened during the summer of 2022, resulting in higher LNG export utilization rates in 2021. However, despite the LNG arbitrage to Northwest Europe rising to over $55/MMBtu, U.S. natural gas prices at Henry Hub did not rise above $10/MMBtu, highlighting the disconnect between global LNG prices and the impact of U.S. natural gas exports on domestic natural gas prices.

LNG Export Contracting and June 2022 Freeport LNG Fire

When examining the impact of LNG export terminals on domestic natural gas pricing, it is worth highlighting the difference from other energy commodities such as crude oil or coal. Due to their multi-year permitting and lengthy construction lead time, virtually all U.S. LNG export terminals have entered into long-term export contracts for virtually all of their expected LNG export capacity with foreign entities to ensure the financial viability of these multi-billion dollar infrastructure projects. Furthermore, due to the multi-year construction lead time, U.S. natural gas producers have sufficient time to increase natural gas output ahead of the new LNG export project coming online. As a result, the U.S. natural gas market already accounts for the increased demand from a new LNG export terminal by the time the project is completed and loads its first vessel. Also, due to the long-term contracting nature for most of the LNG export volumes scheduled to be exported, the nominal natural gas flows to the new terminal are highly predictable and, therefore, priced into the U.S. natural gas market, resulting in little to no increase in domestic natural gas prices. Conversely, any sudden loss of LNG flows will result in a sudden drop in natural gas prices, as shown by the Freeport LNG explosion, fire, and subsequent outage in the summer of 2022.

EXHIBIT *26* shows the weekly natural gas flows to U.S. LNG export terminals and the U.S. natural gas price at Henry Hub.

EXHIBIT 26: U.S. LNG EXPORTS & TERMINAL COMPLETION DATES VS. NATURAL GAS PRICES AT HENRY HUB



Source: EIA data

In June 2022, equipment malfunction and human error resulted in an explosion and fire at the Freeport LNG terminal in Freeport, Texas. Following the fire and explosion, the Freeport LNG terminal, which has a nominal export capacity of 2.1 BCF/d, was offline for repairs for over eight months and did not restart operations until February 2023. Since natural gas is delivered on a continuous basis via natural gas pipelines, the sudden loss of natural gas demand due to the Freeport LNG outage resulted in a substantial natural gas supply-demand market imbalance. As explained in detail earlier in this section, any sudden change in supply or demand of a commodity will result in an immediate price impact until the market rebalances. When natural gas prices fell following the Freeport LNG outage due to the brief market oversupply, consumption in other natural gas demand sectors, primarily in the U.S. electric power sector, quickly absorbed the additional 2.1 BCF/d of natural gas supply. As the market rebalanced, natural gas prices returned to pre-Freeport LNG outage pricing set by the domestic competition of coal and natural gas-fired power plants in the U.S. electric power sector described previously. However, when Freeport returned to operation in February 2023, domestic natural gas prices were virtually unaffected despite the staged return of 2.1 BCF/d of natural gas demand due to the foreseeable and predictable increase in natural gas demand.

Domestic & Global Benefits of U.S. Natural Gas Exports

A report discussing the potential impacts of increased U.S. natural gas exports on U.S. consumers would be incomplete without discussing some of the domestic and global benefits of U.S. natural gas exports. Although not exhaustive, this section provides an overview of the potential benefits of increased U.S. natural gas exports.

First, and arguably most important to U.S. consumers, the massive increase in domestic natural gas and crude oil production brought substantial economic growth to regions previously affected by low job availability and high unemployment rates. States like North Dakota, Texas, Louisiana, Arkansas, Ohio, and Pennsylvania have experienced massive growth in employment in the oil and natural gas sector. The increase in direct employment also resulted in employment and economic benefits in industries supporting the oil & natural gas industry, including supplies and maintenance materials used in oil and natural gas production (i.e., indirect jobs) as well as industries relying on the increased spending power of people employed directly or indirectly by the oil and natural gas industry, such as retail and hospitality sectors (i.e., induced jobs). Furthermore, increased oil and natural gas production activity has also brought a noticeable increase in local and state tax revenue through royalties, property taxes, sales tax, and income tax payments. These increased tax revenues often support vital local public services such as schools, libraries, and first responders. Future

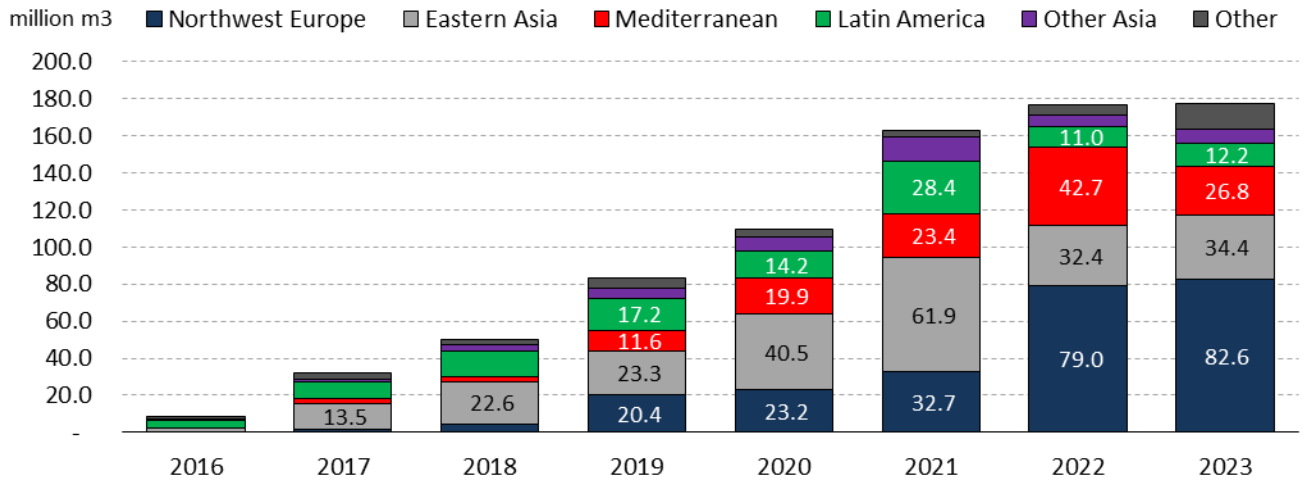
growth in U.S. natural gas exports helps protect these local economies against future economic decline as domestic ResComm and electric power sectors transition from natural gas to renewable energy.

Second, increased U.S. natural gas exports allow for previously flared and vented natural gas to be used efficiently in other sectors domestically and abroad. As shown in **EXHIBIT *6***, a substantial amount of natural gas produced in primary oil fields, such as the Permian and Bakken basins, is currently vented or flared due to the lack of existing takeaway capacity or nearby demand to consume the excess associated natural gas production. Increased U.S. natural gas exports to Mexico, which, in turn, will supply the newly proposed Mexican LNG terminals along the Pacific and Gulf coasts, will result in lower amounts of natural gas being wasted through venting or flaring and instead be used beneficially in other sectors around the world. As a result, the U.S. and global greenhouse gas (GHG) inventory will be reduced due to the increased beneficial use of natural gas.

Third, increased U.S. natural gas exports provided a much-needed alternative to Russian natural gas for U.S. allies across Europe in 2022 and beyond. In 2022, U.S. LNG exports to Europe proved essential for European countries to ensure adequate natural gas supply for the 2022/23 winter heating season while significantly reducing its imports of and payments for Russian natural gas supply, which, in turn, had and continues to have severe economic impacts on the Russian economy. This transatlantic collaboration in the face of an energy crisis emphasized the U.S.'s position as a reliable leader in energy, and the show of solidarity fortified American relations with the European continent. Additionally, increased certainty surrounding natural gas supply into Europe allowed Germany to advance its goal of retiring its remaining coal fleet by eight years to the end of 2030, as natural gas-fired power plants supplied by low-cost U.S. natural gas have gained market share over their coal-fired counterparts.

Fourth, future growth in U.S. LNG exports will likely be focused on supplying developed and developing countries in Africa and Asia. **EXHIBIT *27*** shows historical U.S. LNG exports by destination region.

EXHIBIT 27: U.S. LNG EXPORTS BY DESTINATION REGION



Source: Kpler Analytics

As previously mentioned, U.S. LNG exports to Northwest Europe significantly increased in 2022 as European countries displaced Russian natural gas deliveries. In 2021, most U.S. LNG cargoes left for shore in East Asia, primarily Japan and South Korea. Both countries have publicly announced that they will reduce their reliance on coal and nuclear power and replace it with LNG and renewables. Additionally, following Russia's invasion of Ukraine, both countries have sought to diversify their natural gas supply and will rely more heavily on U.S. LNG in the upcoming years as new U.S. LNG projects are completed.

Fifth, although increased U.S. LNG exports are unlikely to decrease global natural gas consumption, they will likely shift the economic benefit of global natural gas production. At its core, recipients of U.S. LNG exports provide substantial economic benefits to domestic, local, and state economies described previously by paying for U.S. LNG cargoes. As U.S. natural gas exports increase, not only do the economic benefits increase, but they also shift these economic benefits from other countries to the U.S. For example, increased U.S. LNG exports to Europe in 2022 and 2023 brought advantages to the U.S., as the economic benefits of natural exports to Europe shifted from the Russian to the U.S. economy. Due to the low cost of U.S. LNG compared to other countries, any increase in U.S. LNG exports has the potential to displace another country's LNG exports, shifting and increasing the economic benefit to the U.S.

Lastly, increased U.S. LNG exports also provide access to lower-cost natural gas supply in the global market. This allows other developing Asian countries, such as India, Malaysia, Vietnam, or Indonesia, to consider natural gas-fired power plants to meet their growing electricity demand. U.S. climate envoys have previously encouraged developing countries to transition their plans for future electricity generation from new coal to natural gas-fired power plants. While not as low-GHG intensive as renewable energy projects, every coal plant replaced by a natural gas-fired one reduces the power plant's GHG emission profile by more than 50%. Additionally, natural gas-fired power plants have proven superior to their coal-fired counterparts in efficiently integrating higher shares of renewable energy generation. The near-guarantee of future access to low-cost U.S. natural gas supply can prove essential to allow for a quicker transition to lower-GHG-intensive fuels and help mitigate the global impacts of climate change.

Conclusion

The goal of this report was to educate on U.S. natural gas price formation, present the regional differences in natural gas production and consumption following the Shale Gas Revolution, analyze the events surrounding the price anomaly of 2022, and provide an overview of some of the benefits associated with increased U.S. natural gas exports.

As U.S. natural gas exports increase and their overall share of U.S. natural gas consumption increases, their impact on domestic natural gas prices will depend on how the increase in export demand is supplied. EIA's AEO 2023 analysis found that access to a substantial low-cost natural gas supply and the decline in natural gas consumption in other end-use sectors[8] limited the increase in domestic natural gas prices. At the same time, increased U.S. natural gas exports provide massive economic benefits to local and state economies through employment and tax revenue. Increased global access to low-cost U.S. natural gas supply also has the potential to reduce climate-change-inducing GHG emissions in the U.S. and abroad by displacing higher-GHG-emitting energy sources such as oil or coal.

Lastly, as the events of 2021 and 2022 have shown, current U.S. policies have the potential to negatively impact U.S. natural gas price levels and volatility, regardless of the level of U.S. natural gas exports. Continued coal retirements in the U.S. power sector will limit the amount of natural gas consumption in the U.S. electric power sector that can be displaced by coal generation through the substitution effect, effectively removing the downward pressure on U.S. natural gas prices during periods of supply shortfall. Additionally, U.S. policies restricting investment in U.S. natural gas infrastructure (supply, transportation, storage) also reduce the benefit of increased natural gas supply and impede access to low-cost natural gas supply in the future when current resources are depleted.

[8] EIA's analysis forecasted declining natural gas consumption in the residential and commercial sectors due to electrification and in the power sector due to the increase of renewable generation from wind and solar.