Short-Term Energy Outlook Supplement: Market Drivers and Other Factors Affecting Natural Gas Prices

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Executive Summary

The U.S. natural gas market that has emerged over the past two decades is larger, more dynamic, more subject to forces in international energy markets, and produces more volatile—although not necessarily higher—prices than in prior years. This *Short-Term Energy Outlook* (STEO) supplement describes the principal drivers that we anticipate will influence natural gas prices, supply, demand, and inventories, and it identifies key issues that may affect the U.S. natural gas market through the end of 2024. Although this report focuses on the next two years, the same fundamental dynamics we discuss in this report will continue to influence natural gas markets well into the future.

The U.S. natural gas market in early February 2023 is much different from what we forecast when we published our STEO *Winter Fuels Outlook* in October 2022, and reflects the significance of price volatility in the current industry. On average, we now expect wholesale U.S. natural gas prices during the last quarter of 2022 and the first quarter of 2023 to average more than 40% lower than in our October forecast. These significantly lower prices emerged even though we made very minor adjustments to our forecast: an increase of less than 0.5% consumption offset by and an increase of nearly 1% production. In the most recent example, temperatures across the United States in January were milder than any since 2006, and we reduced our Henry Hub natural gas price forecast in the February STEO update by more than 30%, almost $1.50 per million British thermal units (MMBtu).

Our most recent February STEO update includes forecasts through 2024 that illustrate several key market trends:

- Domestic production continues to grow.
- Growth in domestic consumption is slowing, particularly as renewable sources displace natural gas used to generate electricity.
- U.S natural gas trade remains steady, with high international prices in Asia and Europe supporting exports.
- Natural gas storage continues to balance supply and demand, reflect longer-term trends, and strongly influence prices.
- Prices remain volatile.

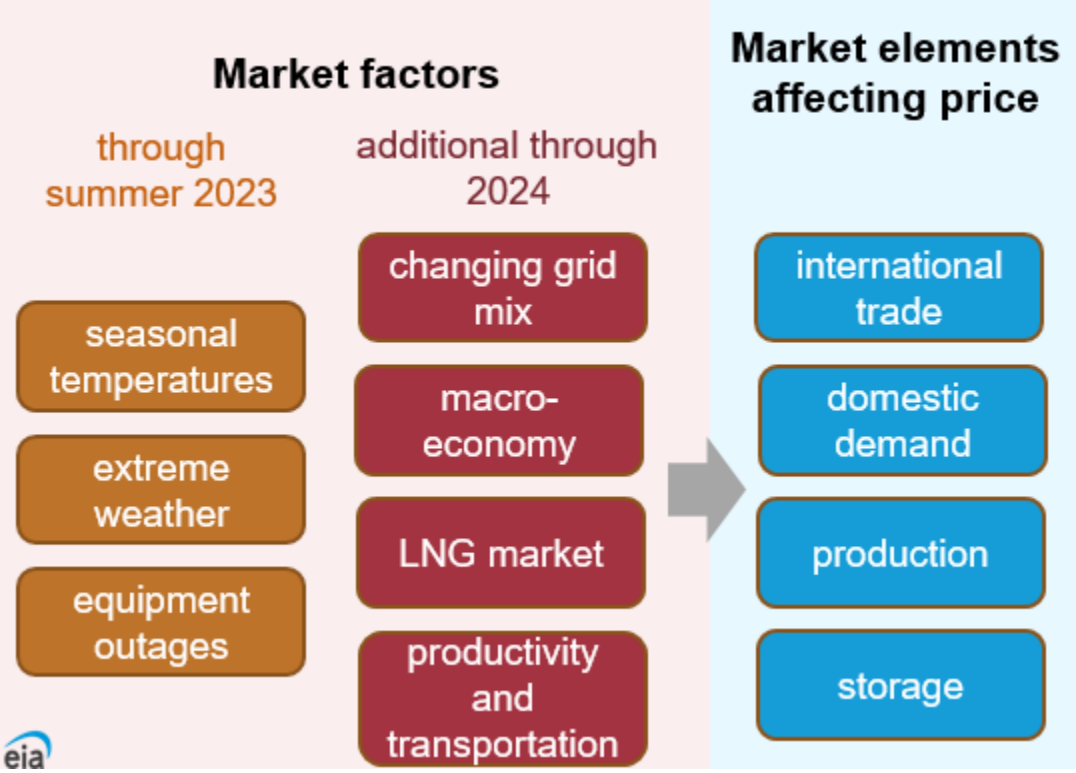
Through this year, the most significant factors affecting natural gas prices remain how cold the remainder of the winter will be and how warm the summer will be, how many and what kinds of extreme weather conditions will occur, and how many facilities will experience outages and for how long. By 2024, we could see additional effects on prices based on:

- Prevailing storage inventories at the end of the summer
- Emerging trends in macroeconomic growth
- Timing of renewable capacity additions
- Drilling investment and productivity

Because natural gas production, transportation, storage, consumption, and trading vary regionally across the United States, these factors will likely have different effects on natural gas prices across the country.

In this report, we will review how the U.S. natural gas market has changed over the past few decades and describe the resulting dynamics in the current market. Then, we will consider the most significant U.S. natural gas market factors and how those factors influence the elements that directly affect prices. Our analysis covers two timeframes through 2024: the first is now through this summer and the second is from the fall through 2024 (Figure 1). To conclude, we will briefly consider longer-term dynamics and our future forecasts.

Figure 1. U.S. natural gas market factors and how they influence pricing elements



Source: U.S. Energy Information Administration
Note: LNG is an abbreviation for liquefied natural gas

Emergence of the Current U.S. Natural Gas Market

The U.S. natural gas market has changed significantly over the past two decades. We expect 92% more dry natural gas to be produced in the United States this year than in 2003—almost double—and we expect production to continue to grow in 2024 (Table 1). The current period of growing U.S. natural gas production began in 2006, when producers began to expand their application of fracking and horizontal drilling technologies in shale formations. The most rapid growth came immediately before the COVID-19 pandemic began; production grew more than 10% in both 2018 and 2019. Contraction in natural gas consumption during the initial phases of the pandemic reduced natural gas production by 1% in 2020, but production began to grow again in 2021 and 2022 in a range of 3% to 4%.

Greatly expanded production has driven down natural gas prices in the United States, making natural gas more competitive and triggering growth in consumption in all end-use sectors. However, U.S. natural gas consumption will have grown by a little more than 40% during the two decades from 2003 to 2023 as natural gas production almost doubled. Most of the growth in natural gas consumption occurred when generation of electricity using natural gas became less expensive than using coal, displacing coal's market share in the electric power sector. This year, we expect natural gas consumption by electric utilities will have grown by 130% from consumption in 2003. By the end of this year, commercial and industrial natural gas consumption will each have grown slightly more than 10% over that same two-decade period, but residential natural gas consumption will have actually shrunk slightly. More recently, renewables have begun to displace some of the share of natural gas used in U.S. electricity generation. Despite growth in renewable generation, natural gas remains the predominant fuel to generate electricity in the United States, making up well over one-third of the total in our forecasts through 2024.

Table 1. Key U.S. natural gas flows in STEO, estimated 2023 compared with 2003

U.S. natural gas market activity	2003		2023 (STEO estimate)		Growth 2003–23
	Volume (Bcf/d)	Share* (percentage)	Volume (Bcf/d)	Share* (percentage)	(percentage change)
Dry production	52.3	83%	100.3	93%	92%
Imports	10.8	17%	7.5	7%	-31%
Dry production plus imports	63.1	100%	107.8	100%	71%
Consumption					
Residential	13.9	22%	13.4	12%	-4%
Commercial	8.7	14%	9.5	9%	10%
Industrial	19.6	31%	22.8	21%	16%
Electric power	14.1	22%	32.4	30%	130%
Other	4.7	8%	8.9	8%	88%
U.S. total consumption	61.0	97%	87.0	81%	43%
Exports	1.9	3%	21.0	19%	1,026%
U.S. consumption plus exports	62.9	100%	108.0	100%	72%

Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook* (STEO), February 2023
* Share of total U.S. available natural gas
Note: Bcf/d=billion cubic feet per day. Sum of components may not equal 100% because of independent rounding.

Faster growth of U.S. natural gas production than consumption freed volumes that have largely been absorbed into international trade, resulting in rapid, significant growth in U.S. natural gas exports, particularly of liquefied natural gas (LNG). In 2003, the United States was a natural gas importing country; imported LNG and imports of natural gas by pipeline accounted for about 17% of U.S. natural gas supply. On an annual basis, the United States actually began exporting more natural gas than it imports in 2017. This year, we expect that almost 20% of the combination of U.S. natural gas production and imports will be exported. Natural gas imports, mainly by pipeline from Canada, still provide important support to regional markets in the United States, particularly in the West, the Midwest, and New England. At the same time, exports by pipeline to Mexico have become an important component of

the U.S. energy market as well. Since LNG exports from the Lower 48 states began in February 2016, U.S. LNG export capacity and LNG exports have grown rapidly. In the first half of 2022, the United States surpassed Qatar to become the world's largest LNG exporter, with exports averaging 11.1 billion cubic feet per day (Bcf/d), primarily as a result of recent expansions of U.S. LNG export capacity. LNG exports from the United States have become an important source of supply to Europe, particularly since Russia's full-scale invasion of Ukraine early in 2022. We expect U.S. net exports of natural gas to grow by a little more than 25% this year and by a little more than 10% in 2024.

Given the seasonal pattern of natural gas consumption in the United States, storage has long played an important role in U.S. natural gas price formation. It will continue to play a role in 2023, when we forecast more production, consumption, and exports. For much of 2022, U.S. natural gas storage inventories had fallen below recent historical averages. This winter, inventories have come much closer to average, and as of late January 2023, they have grown above average. More typical inventories, along with market expectations of continued production growth, moderated prices significantly from late in 2021 through much of 2022.

As a result of these dynamics, the U.S. natural gas market in early 2023 is much larger than it has been historically, with more production and consumption as well as rapidly growing exports. Together, these components make prices much more volatile, which we witnessed from when prices initially collapsed due to the pandemic in 2020, through significant increases in price during 2021 and 2022, and through their subsequent collapse into early February 2023. Given this natural gas price volatility, this report explores the most important factors that inform both our STEO forecasts and the uncertainty around them.

Price Formation in the U.S. Natural Gas Market

Factors affecting the market in 2023

Three factors will be the most prominent in creating uncertainty in U.S. natural gas markets through the remainder of this winter and through the summer:

- Seasonal temperature variation
- Extreme weather events
- Equipment outages

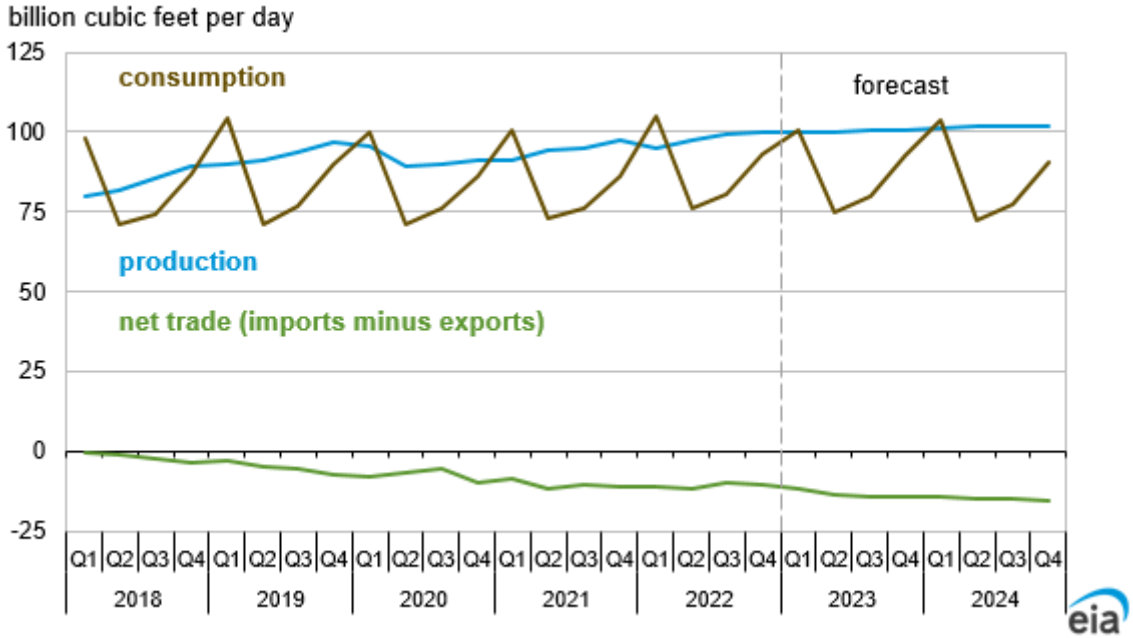
Each of these factors affects the market balance between supply and demand in different ways. We focused our analysis on effects during the winter and summer, when demand for natural gas is greatest.

Seasonal temperature variation

Typically, natural gas demand in the United States cycles seasonally, with the most domestic consumption in the winter when natural gas is used for space heating (Figure 2). Although this cycle has been shifting because natural gas-fired electricity generation in the summer has increased over time, U.S. natural gas consumption still peaks in January or February. Natural gas production does not have the same seasonal variations as consumption, and so natural gas held in storage is critical to balance

supply and demand (Figure 2). Moderate winter weather can reduce natural gas consumption, resulting in more natural gas left in storage at the end of March.

Figure 2. Quarterly U.S. natural gas balances (2018–2024)



Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook* (STEO), February 2023

During the summer, natural gas is typically injected into storage to prepare for the coming winter. Summer weather can affect how much natural gas can be injected during what is known as the *injection season*, which runs from April through October. Natural gas prices in the United States are strongly affected by volume of natural gas injected into storage during the summer, as we saw in the summer of 2021.

Extreme weather events

Cold weather during the winter in the United States is not uniform from day to day; it depends on waves of cold fronts that can occur throughout the winter. During the last full week of December 2022, a storm brought very cold temperatures to much of the United States, significantly increasing natural gas demand for space heating, decreasing production, and resulting in equipment failures. Similarly, during summer heat waves, natural gas consumption increases to generate electricity to meet cooling needs.

Natural gas production, processing, transportation, storage, and delivery systems involve complex systems made up of equipment that are subject to occasional failure for a number of reasons. Unexpected outages can have significant effects on natural gas production and consumption, and therefore prices. For example, during a cold snap in February 2021 that affected much of the Central United States and created extreme hardship for many energy customers, U.S. dry natural gas production declined significantly, mostly as a result of freeze-offs, which sharply increased prices.

Equipment outages

Not all natural gas market outages are related to weather. In June 2022, a fire at the Freeport LNG natural gas liquefaction plant in Texas led to a full facility shutdown, driving down the wholesale price of natural gas by almost one-third as a result of reduced U.S. exports. The outage made more natural gas available in the domestic market, resulting in increased injections into storage.

Seasonal temperatures, extreme weather events, and equipment outages can disturb the balance between consumption and production in the U.S. natural gas market, which can in turn affect prices. Let's consider some of those effects in more detail.

Consumption

Through next summer, the possible effects of seasonal and extreme weather on U.S. natural gas consumption vary significantly by sector. Each sector has different seasonal patterns of consumption (Table 2). These seasonal patterns are most pronounced in the residential, commercial, and electric power sectors, although the industrial sector does use natural gas extensively for space heating, which creates some seasonality in industrial consumption as well.

Table 2. Forecast summer and winter U.S. natural gas consumption through winter 2024

Sector	Winter 2022–23		Summer 2023		Winter 2023–24	
	Volume (Bcf/d)	Share (percentage)	Volume (Bcf/d)	Share (percentage)	Volume (Bcf/d)	Share (percentage)
Residential	20.7	21%	4.3	5%	21.7	22%
Commercial	13.1	14%	5.1	6%	13.5	14%
Industrial	23.8	25%	21.4	27%	24.3	25%
Electric power	30.1	31%	40.3	51%	29.2	30%
Other	9.3	10%	8.6	11%	9.4	10%
Total	96.9	100%	78.6	100%	98.0	100%

Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook* (STEO), February 2023

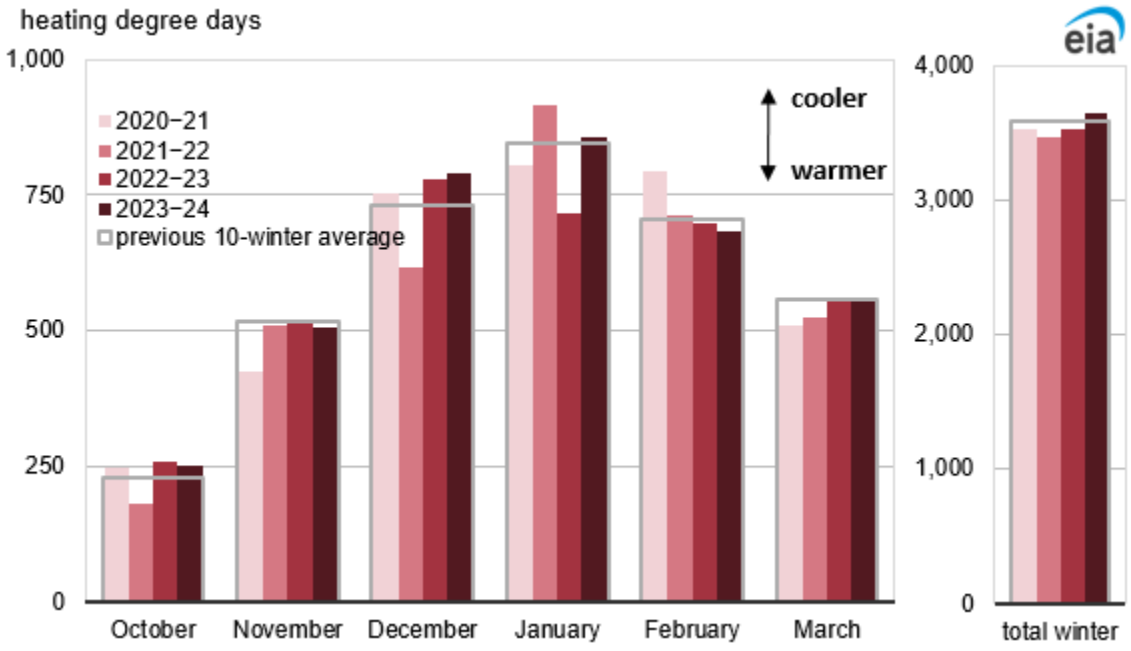
Note: In this table, winter is defined as October through March, summer as June through August. Bcf/d=billion cubic feet per day. Sum of components may not equal 100% because of independent rounding.

Residential and commercial consumption

In the United States, households and commercial businesses collectively consume the largest share of natural gas during the winter. We expect the combined share of consumption in the residential and commercial sectors to total about 35%, or close to 35 Bcf/d this winter and next. During the summer, the combined share of direct natural gas consumption in these sectors is much less, about 12%. Monthly natural gas consumption in the combined U.S. residential and commercial sectors during the winter can vary from less than 15 Bcf/d to almost 50 Bcf/d, mainly depending on prevailing temperatures.

We assess the effects of winter temperatures on space heating with heating degree days (HDDs). HDDs can vary significantly during the winter (Figure 3). Every month, we update our STEO forecasts based on the latest National Oceanic and Atmospheric Administration (NOAA) forecasts, but colder winter weather (more HDDs) will naturally increase natural gas consumption for space heating, and warmer weather (fewer HDDs) will result in less consumption.

Figure 3. Monthly winter U.S. heating degree days, population-weighted (2020–2024)



Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook* (STEO), February 2023
Note: EIA calculations are based on National Oceanic and Atmospheric Administration (NOAA) data. Our forecasts reflect NOAA's 14 to 16-month outlook.

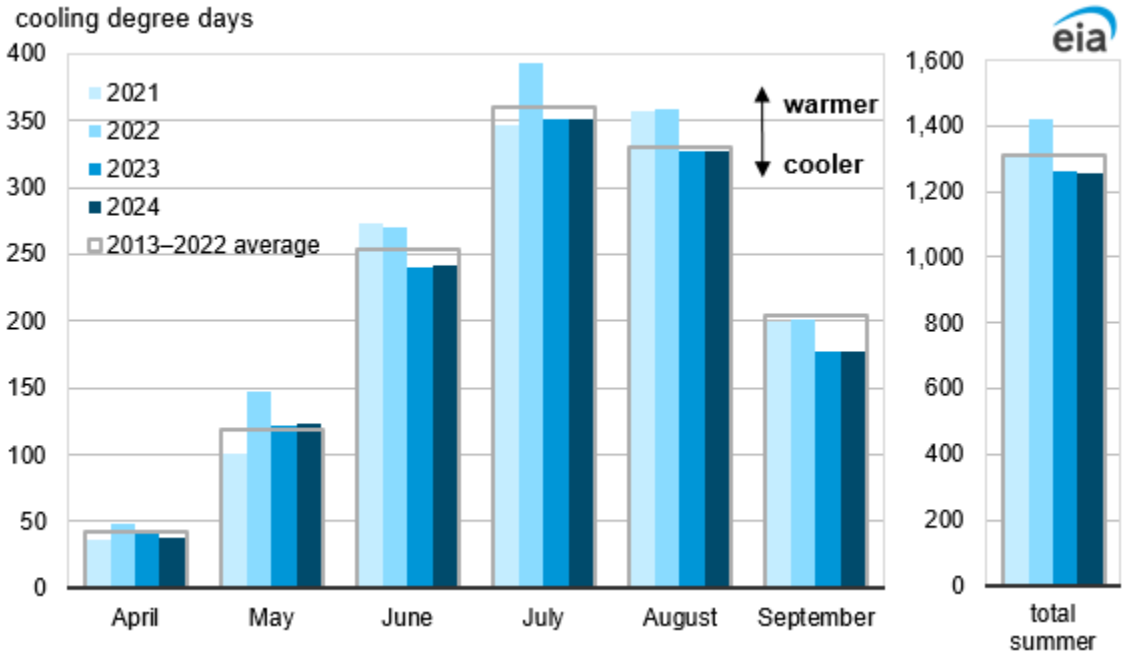
Extreme cold weather snaps can also increase natural gas consumption, although these increases usually last for less time. For example, at the end of December 2022, natural gas consumption in the U.S. residential and commercial sectors during a single week increased by 40%, or 15.7 Bcf/d, because of extremely cold temperatures, according to data from S&P Global Commodity Insights.

Consumption for electricity generation

In the United States, natural gas used to generate electricity makes up the largest share of natural gas consumption during the summer; we expect this share to total about 50% this summer, or a little more than 40 Bcf/d. During the winter, consumption to generate electricity is less, about 30%. As natural gas consumption for electric generation has grown over time, a smaller monthly peak has emerged during the summer, generally in July or August. Extreme heat events can increase natural gas consumption for brief periods as well.

Similar to HDDs, we use cooling degree days (CDDs) to measure how warm a summer is. We see significant variation over time in summer heat, which can lead to deviations in natural gas consumption for electricity generation during the summer (Figure 4). Every month, we update our STEO forecasts based on the latest NOAA forecasts; warmer summer weather (more CDDs) will increase natural gas consumption by the electric power sector, and cooler weather (fewer CDDs) will reduce consumption.

Figure 4. Monthly summer U.S. cooling degree days, population-weighted (2021–2024)



Data source: U.S. Energy Information Administration, *Short-Term Energy Outlook* (STEO), February 2023
Note: EIA calculations are based on National Oceanic and Atmospheric Administration (NOAA) data. Our forecasts reflect NOAA's 14 to 16-month outlook.

The U.S. electric power sector has been consuming more natural gas in the winter than it had previously. For example, in January 2022, the electric power sector's natural gas consumption reached about 31.0 Bcf/d, up from 20.9 Bcf/d in January 2012. As space-heating technologies have developed and the use of electric heat pumps has grown, natural gas consumed to generate electricity for space heating has increased along with already established direct end-use consumption for space heating.

Extreme weather events can also influence natural gas-fired power generation. These disruptions tend to be short, but heat waves and other disruptions can increase or decrease consumption for longer periods. For example, hurricanes typically reduce electricity demand due to transmission and generation outages. We provide useful information about electric generation by relevant regional sectors of the U.S. grid on an hourly basis in our Hourly Electricity Grid Monitor.

In another example, a heat dome in the western United States during late summer 2022 brought record-breaking temperatures to the region, particularly California. The heat dome led to record electricity demand in California and increased natural gas consumption for power generation. Power burn rose 13%, or 2.3 Bcf/d, above the five-year average for that time of year, according to data from S&P Global Commodity Insights.

Production

Winter weather events that bring extremely cold temperatures can constrain natural gas production as well as increase demand. Cold weather can cause freezes-offs at wells, temporarily reducing production.

The December 2022 winter storm reduced production widely, particularly in the Northeast. U.S. production dropped by 12%, or 11.5 Bcf/d, during the last full week of December, according to data from S&P Global Commodity Insights, and much steeper daily reductions occurred at the height of the storm.

Unscheduled or ongoing pipeline maintenance can influence natural gas pipeline availability at key segments and limit natural gas supply in affected areas. For example, continued maintenance restricted deliveries on the El Paso Natural Gas pipeline that moves natural gas from West Texas into Southern California in December. Maintenance events may require rerouting of natural gas flows and lead to storage withdrawals in regions with restricted inbound capacity.

International trade

Similar to production, international trade in U.S. natural gas does not show the same kind of seasonality as domestic consumption. International LNG pricing has supported natural gas liquefaction for export at close to capacity volumes for some time, and despite some recent moderation in prices in Asia and Europe, we anticipate that international prices will continue to support robust LNG exports for some time. In addition, development of Permian resources and pipeline systems should continue to support growth in natural gas exports by pipeline into Mexico.

Extreme weather can affect LNG liquefaction plant operations for short periods as tropical storms and hurricanes disrupt shipping near LNG berths. For example, Hurricane Laura made landfall in August 2020 and halted LNG exports from Sabine Pass and Cameron LNG. Extreme weather-related events can also damage electrical and marine infrastructure. In the last several years, persistent fog in February limited LNG port traffic in several LNG export ports in the Gulf of Mexico. Five of the seven operating U.S. LNG export terminals are located on the Gulf Coast.

U.S. LNG export facilities currently can receive a total of about 14 Bcf/d of natural gas to liquefy for export, including their losses and energy conversion costs. As of September 2022, we estimate U.S. LNG export capacity reached 11.4 Bcf/d on a baseload basis and 14.0 Bcf/d on a peak day. We expect export by LNG tankers and natural gas pipelines to grow through the end of next year (Figure 2).

Facility outages introduce uncertainty into our forecasted export volumes. Currently, the Freeport LNG natural gas liquefaction plant outage that began in June 2022 appears to be preventing about 2.0 Bcf/d from being exported. By the end of June 2022, after the outage began, the Henry Hub price fell by more than 31%, or almost $3.00/MMBtu, as more natural gas originally destined for international markets was instead sold domestically. Freeport LNG's unplanned outage played a role in making more natural gas available in the second half of 2022 for both storage and consumption in the electric power sector. On January 26, 2023, Freeport LNG received approval from the Federal Energy Regulatory Commission to begin cooldown of some of its systems. Subsequent approvals are necessary for restarting the facility and enabling transfer of LNG to vessels.

Natural gas imports by pipeline from Canada play an important role in stabilizing the U.S. market during cold winter months. For example, during an extreme winter weather event in February 2021, imports from Canada increased to 9.5 Bcf/d, the most since February 2011. During the cold weather in this past

December, net imports from Canada increased 62% in the last full week of December, according to data from S&P Global Commodity Insights.

Storage

Particularly cold weather in the winter can require increased withdrawals from storage. Natural gas withdrawals from storage typically provide more than 20% of the U.S. supply available to meet demand from December through February. On a daily basis, natural gas withdrawals from storage can account for more than 40% of available U.S. supply, according to data from S&P Global Commodity Insights. Conversely, particularly hot weather during the summer can reduce the amount of natural gas injected into storage.

We report U.S. natural gas storage inventories on a weekly basis, and storage volume estimates from market analysts are easily accessible and generally highly accurate. Most U.S. storage is designed to help manage broad seasonal variations in temperature. Some storage technologies that use salt caverns and are mainly in the South Central United States are better designed to meet shorter-term supply and demand disruptions. In our weekly reporting, we separate inventory estimates between salt and non-salt technologies in our South Central region to assess how well production and consumption can be balanced in the face of longer- and shorter-term disruptions.

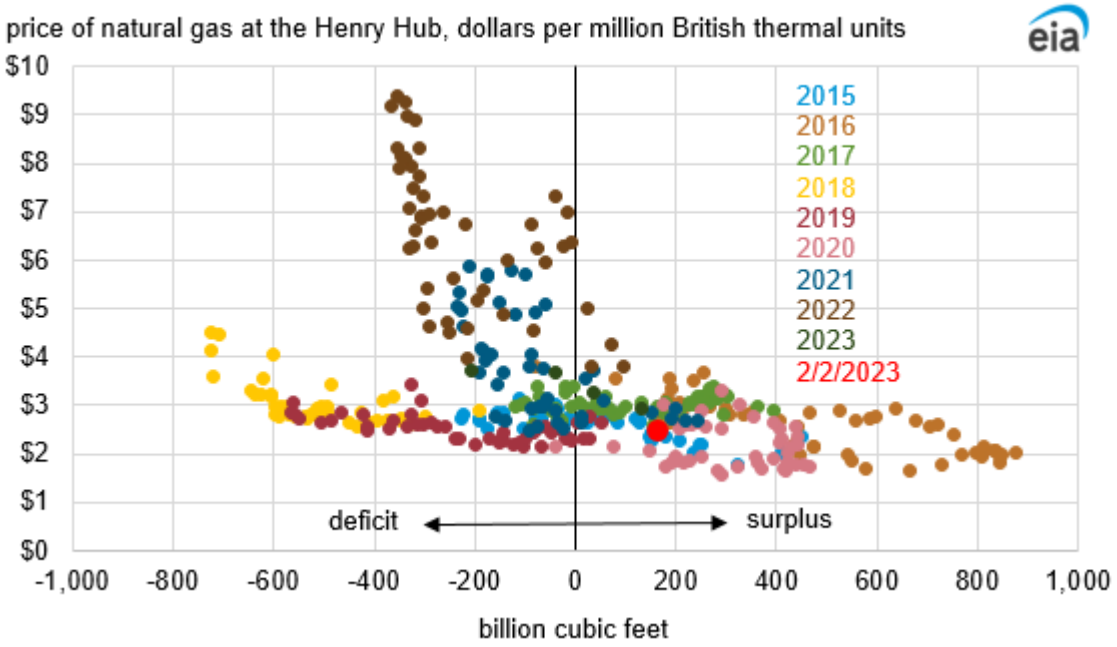
Deviations in seasonal temperature, extreme weather events, and equipment outages can affect consumption, production, storage, and trade of natural gas. The next section describes the effect on wholesale natural gas prices.

Wholesale prices

Wholesale prices of natural gas in the United States react to changes in seasonal temperatures, extreme weather events, and equipment outages largely in the context of how much inventory is held in storage. To track the current inventory of natural gas at the national and regional level, we publish a weekly comparison of the current inventory to the inventory at the same time in the previous year and to the average inventory over the previous five years. The five-year average is a proxy for deviations of inventories from *normal*.

At different times over the past three decades, wholesale natural gas prices have reacted differently in relationship to the amount of natural gas in storage (Figure 5). Before the COVID-19 pandemic, when production was growing vigorously in relationship to consumption and export growth, prices were not particularly sensitive to storage inventories. Prices became much more sensitive to storage inventories after the pandemic and particularly during 2022 when production growth fell behind growth in electricity generation and LNG exports, prices were high, and storage inventories were relatively low.

Figure 5. U.S. near-month natural gas futures prices and weekly working natural gas storage inventories minus the five-year average



Data source: U.S. Energy Information Administration, *Underground Natural Gas in Storage by All Operators* and *Natural Gas Spot and Futures Prices*

Factors such as hotter or colder seasonal weather, extreme weather, and facility outages have more muted effects on U.S. natural gas prices when storage inventories are high, but they can drive larger price movements when inventories are low. For example, increased heating demand for natural gas during the winter of 2021–2022 drew more from U.S. natural gas storage than normal. By the end of March 2022, the least natural gas was held in U.S underground storage for that time of the year since 2019. On an inflation-adjusted basis, the average monthly Henry Hub spot price reached a 12-month high of $8.34/MMBtu in May 2022, the highest since November 2008.

At the end of January 2023, stocks were slightly higher than average, and some possible paths for the rest of the year are:

- If seasonal temperatures, extreme weather, or equipment outages increase consumption through the remainder of the winter and if spring inventories are tight, overall prices will rise in anticipation of the challenge of filling storage before the next winter. If consumption increases but spring inventories are greater than average, prices will fall.
- If demand for electricity generation is strong during the summer and it appears that storage may not fill by the fall, spot prices will rise. But futures prices for the winter will also rise, creating economic incentives to store. If the summer is mild, prices will drop.

- If U.S. natural gas storage is tight in the fall, spot and futures prices through the next winter will begin high. The converse is also true: if inventory levels are high, these prices could be quite low.

The next section describes the unique regional considerations that affect natural gas prices.

Regional variations

Although some natural gas fundamentals affect the United States as a whole, natural gas markets operate on an inherently regional basis. Regional natural gas markets are influenced by unique geographies, weather, proximity to supplies, availability of storage, adequacy of transportation, fuel substitutes for electric generation, and trading liquidity. As a result, we explore several important regional distinctions.

California

Given its location far from currently significant U.S. natural gas production and its resulting need for pipeline connections to meet demand, California natural gas markets can look very different from other regions. Spot natural gas prices at key California trading hubs, such as the Pacific Gas & Electric Citygate and the Southern California Gas Citygate, averaged more than $18/MMBtu in November and December, 2022, and remained high through much of January. In January 2023, according to S&P Global Commodity Insights, California natural gas consumption increased 7%, natural gas use for power generation increased by 22%, and natural gas flows into California increased by 1% compared with January 2022. Although it is too early to tell, the excessive rainfall in California may have improved the prospects for hydroelectric generation in the state this summer, which could reduce summer natural gas demand from the electric power sector.

Pacific Northwest

The Pacific Northwest, including Idaho, Oregon, and Washington, can experience significant wholesale natural gas price volatility in response to extreme weather events. The market relies on natural gas transported from the Rockies, Canada, and California. Cold weather events can drive rapid increases in heating demand for natural gas. For example, in December 2022, the U.S. West Coast and Western Canada experienced widespread cold weather that increased natural gas consumption. The effects of increased demand in the Pacific Northwest were compounded by reduced imports from Canada and limits on flows from California, both of which were experiencing increased demand as result of the event. As a result, the spot price for natural gas at the Sumas natural gas trading hub, near the Washington State and British Columbia border, traded at an average of about $27/MMBtu during December, up from an average of about $10/MMBtu in November.

New England

Supplies of natural gas by pipeline into New England can become constrained during periods of high demand. The region lacks underground storage to help mitigate supply and demand imbalances. As a result, LNG imports can be a key marginal source of supply. On peak demand days, imported LNG has contributed up to 35% of New England's natural gas supply. In the winter of 2021–2022, New England had to compete for LNG in the high-priced global market. At the beginning of this winter, LNG prices in

the global market were even higher due to increased demand in Europe because of reduced imports from Russia, but prices have moderated as of early February.

Texas

Unlike the relatively winterized natural gas production infrastructure in northern areas of the country, natural gas production infrastructure in Texas and other parts of the southern United States are more susceptible to the effects of extremely cold weather. For example, in one week during the cold snap in February 2021 that affected much of the central United States, U.S. dry natural gas production declined by 21%, mostly as a result of well freeze-offs. The drop in natural gas supply sharply increased regional wholesale natural gas prices; the Henry Hub spot price almost doubled. The winter storm increased regional prices to a greater extent. For example, the Oneok Gas Transmission price in Oklahoma topped $1,000/MMBtu.

Factors Contributing to Price Formation in the U.S. Natural Gas Market into 2024

The main residential and commercial sector issue likely to affect natural gas prices through the end of 2024 would be the prospect for colder-than-normal temperatures during the winter of 2023–2024. These effects could be stronger or weaker depending on U.S. storage inventories at the end of summer 2023. Although seasonal temperature variations as well as extreme weather and equipment outages will remain relevant beyond this summer, an additional set of factors come into focus when considering how markets might evolve through the end of 2024.

Macroeconomic trends

Macroeconomic trends affect industrial activity, and therefore they affect natural gas consumption in the U.S. industrial sector. A key issue affecting industrial natural gas use through the end of 2024 will be the possibility of recession and its severity. The start of new, expanded, or previously closed industrial facilities such as petrochemical, fertilizer, and steel plants could increase industrial natural gas demand.

The COVID-19 pandemic illustrates the effect of macroeconomic trends. In May 2020, one of the first months of the pandemic, U.S. industrial consumption of natural gas averaged 19.9 Bcf/d, the least during that month since 2016, when industrial consumption was in the middle of an extended period of growth. Reduced consumption in 2020 resulted from the economic slowdown associated with the pandemic. Industrial consumption of natural gas averaged 22.3 Bcf/d for all of 2020 before increasing to 22.7 Bcf/d in 2021 and to our current estimate of 23.2 Bcf/d for 2022.

Strength of international LNG market

In 2022, U.S. LNG export facilities operated close to maximum (peak) utilization rates, averaging 87% in the first half of the year, and we expect that they will continue to operate at high utilization rates through 2024, supported by the difference between domestic and international natural gas prices. When international LNG and natural gas forward prices in LNG-importing international markets exceed U.S. LNG export prices and delivery costs, U.S. LNG exports tend to be fully dispatched. When international prices fall below delivered prices, U.S. LNG exports may be curtailed, as was the case in the summer of 2020. That summer, spot and forward prices in Asia and Europe traded at historic lows, averaging less than $3.00/MMBtu. U.S. LNG exports declined to about one-third of available liquefaction export capacity.

China's continued economic recovery from the pandemic and Russia's full-scale invasion of Ukraine are likely to keep international natural gas prices elevated relative to the United States, encouraging high and sustained levels of LNG exports. However, exports could decline if, as noted above, we see a sustained downturn in economic growth.

A changing electricity grid

Over time, we expect to see shifts in the mix of sources used to generate electricity, which will affect natural gas use. Although some of these effects will be clear in the summer of 2023, we will begin to see additional effects as we enter into the summer of 2024.

Renewables

Developers and project planners plan to add about 38 gigawatts (GW) of new renewable energy capacity from October 2022 to September 2023. Plans include 23 GW of new solar photovoltaics, 7 GW of new wind, and about 8 GW of battery storage. We expect the new generating capacity to backfill retiring coal plants and displace some natural gas-fired generation. We forecast that a combination of solar photovoltaic and wind generation will account for 18% of U.S. generation in 2024, up from 16% this year.

Repeated atmospheric river conditions that brought large amounts of rain and snow to the West and especially California so far this water year (which started on October 1, 2022) have established significant snowpack at high elevations and somewhat replenished reservoirs after many years of significant drought. Stronger hydroelectric production would displace the use of natural gas in generating electricity. Whether these improved hydrologic conditions endure through the spring will make a difference in how much natural gas is consumed for electricity generation during the summer of 2023. Whether these conditions are repeated next winter will affect natural gas consumption in 2024.

Natural gas

The deployment of natural gas combined-cycle gas turbine (CCGT) plants is slowing after decades of growth. Developers and project planners plan to add about 5 GW of new CCGT capacity in 2023, but after that, the number of confirmed new projects drops considerably. New CCGT plants represent a

small share of expected future capacity due to strengthening growth in use of renewable energy sources. We expect some simple-cycle gas turbine (SCGT) plants to be built over the next three years, in part to provide back-up power to intermittent renewable energy sources. However, SCGT plants typically only run 10% to 15% of the time, which results in much less natural gas use than a CCGT facility.

Drilling productivity and transportation capacity

Although U.S. natural gas production continues to grow, sustaining that growth will depend on how several issues are resolved. Sustaining natural gas production in the United States, including the development of shale resources, depends on the continuous drilling of new wells. Soon after production starts from any new natural gas or oil well, the rate of production from that well begins to decline. Production from a typical U.S. shale well can decline significantly in its first year. Stronger or weaker prospects for natural gas prices and resource development costs will affect production over time. The trajectory of near- and mid-term crude oil prices will also influence drilling decisions during the next two years, especially oil drilling in the Permian Basin, which generates significant amounts of associated natural gas. In addition, we expect elevated international natural gas prices to encourage more LNG exports, which in turn would encourage more production.

Over the past few years, some exploration and production companies announced intentions to shift priorities to strengthen their balance sheets after the pandemic and the effects of pre-pandemic production growth. The remaining drilling companies tend to be financially stronger, but higher development costs have also been increasing the capital expenditures required for growing production. The outlook for growing natural gas production over the next two years will depend partly on how well exploration and production companies can address inflation, labor needs, and material and equipment shortages.

Reduced drilling productivity could limit production growth. A cornerstone of natural gas production growth since at least 2014 has been the ability to produce more natural gas from new wells with fewer rigs. Exploration and production companies improved productivity over the years through drilling longer horizontal segments of wells, drilling multiple wells from the same location, deploying new types of rigs, optimizing well-spacing and locations, and making other technological improvements. However, our *Drilling Productivity Report* indicates that natural gas production generally fell on a per rig basis during the first full-month of operation for new U.S. wells in 2022.

Lack of transportation capacity could also limit natural gas production through the end of 2024. The pace of natural gas capacity additions in the three most productive U.S. natural gas-producing shale basins—Permian, Haynesville, and Appalachia—will affect how quickly these regions contribute additional natural gas supplies. About 1.4 Bcf/d of eastbound take-away capacity from the Permian Basin is due to come online by the end of 2023 and another 2.5 Bcf/d by the end of 2024. Haynesville may need additional capacity to meet future southbound market growth. Our data on natural gas pipelines includes six projects with possible in-service dates in 2023 or 2024 planned for Appalachia; two of these projects are under construction.

Finally, because most natural gas production in the Permian Basin is associated natural gas from oil wells, the effects of oil prices on the drilling and completion programs of U.S. exploration and production companies in the Permian Basin will be a significant driver of natural gas production.

Longer-Term Considerations

Several additional factors could materially affect domestic natural gas markets beyond 2024. Macroeconomic growth, new climate and energy policies, changes in the electricity resource mix, and capital investment trends could strongly affect domestic consumption. Shifting energy security needs, geopolitical events, and international climate policy could affect growth in export capacity. Several factors may influence long-term natural gas supplies, including investment in exploration and production activities, crude oil prices, productivity gains, and the availability of favorable gross margins for the delivery of U.S. LNG in destination markets.

We will explore the effects of varying volumes of LNG exports on U.S. natural gas markets through 2050 in an upcoming *Annual Energy Outlook 2023* Issues in Focus article.