American Gas Association

Assessing the Value of Natural Gas Storage

A Strategic Asset for Grid Reliability, System Resilience, and Operational Flexibility in a Changing Energy Landscape

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Executive Summary

Natural gas storage is a critical pillar of the U.S. energy system, enabling gas to be stored when demand is low and withdrawn when demand is high. This flexibility helps provide reliable and affordable energy delivery year-round to homes, businesses, and power generators and for delivery to other markets. Storage plays a key role in maintaining system balance, flexibility, and resilience in a market shaped by seasonal variability, extreme weather, and shifting consumption patterns. As the U.S. economy becomes increasingly energy-intensive, driven by new consumers, growing electric demand, digital technologies, artificial intelligence, and global trade, natural gas continues to serve as a stabilizing force in a more dynamic and demanding energy environment.

At the heart of this evolving landscape lies the natural gas storage network, which spans a range of technologies including underground storage in depleted oil and gas reservoirs, aquifers, and salt caverns, as well as liquefied natural gas (LNG) and compressed natural gas (CNG) storage. These resources not only help meet seasonal fluctuations and short-term surges in demand but also provide critical backup during unplanned disruptions. Many storage facilities are strategically co-located with baseload and peaking electricity generation sites to enhance supply flexibility and grid reliability. Storage supports a diverse set of market participants, including pipeline operators, local distribution companies (LDCs), electric utilities, and independent operators, by ensuring continuity of service and stabilizing prices in volatile market conditions. Market participants utilize storage for supply and optionality.[1] Ultimately, natural gas storage is a key component of the U.S. energy system that contributes to a diverse market and promotes reliable access to supply.

This report provides a comprehensive review of the current state and strategic importance of U.S. natural gas storage. It explores the value storage brings to the broader energy value chain and outlines the regulatory frameworks that govern it, including oversight from federal and state regulators. It also highlights emerging challenges and outlines the policy steps necessary to secure the role of storage in a rapidly transforming energy landscape. As energy systems grow more complex, natural gas storage will remain a vital asset to help ensure energy security, reliability, and affordability for the nation.

Storage is a Critical Component of the Energy System

Natural gas storage plays many roles in the U.S. energy system:

- **Balancing Seasonal Demand:** Storage enables producers and utilities to inject gas during low-demand months and withdraw it during winter heating or peak cooling periods. This seasonal flexibility is essential to ensure uninterrupted service and avoid costly infrastructure expansion.
- **Tempering Price Volatility:** Storage provides a key physical and financial asset that helps reduce consumer exposure to volatile prices and allows for market participants to contribute to a robust and liquid natural gas market. Merchant operators[2] may release gas when prices rise, boosting supply and

[1] In this context, optionality refers to the flexibility and strategic choices that natural gas storage provides to market participants.
[2] Merchant operators are private companies or entities that own gas in storage for commercial, profit-driven purposes rather than for regulatory, utility, or system-balancing obligations.

easing market pressure. Utilities often draw from storage to maintain reliability. In both cases, storage adds flexibility and optionality for market participants that can help stabilize prices and reduce price risk for consumers.

- **Providing Emergency Support:** Storage enhances system reliability and resilience during extreme events, such as hurricanes, polar vortices, wildfires, and pipeline outages. During Winter Storm Enzo on January 21, 2025, underground storage withdrawals reached a new record. In prior years, such as during Winter Storm Uri in 2021, nearly 340 Bcf was withdrawn in a single week—the second-largest draw in U.S. history. This source of supply may have mitigated service interruptions and price shocks**.**
- **Enabling Grid Flexibility and Renewable Integration:** As variable renewable electricity generation grows, natural gas storage provides a vital complement to enhance grid reliability by enabling more fuel on demand to natural gas-fired generators, particularly during times of pipeline constraint or disruption to other flowing supplies. Storage also offers fast-ramping, long-duration energy that can respond when renewable output dips. On January 21, 2025, storage withdrawals delivered nearly 21,100 GWh, 144 times the daily output of all U.S. pumped hydro and battery storage combined, demonstrating gas storage's unmatched scale and flexibility in supporting grid stability.

These benefits are increasingly valuable as electricity demand rises, particularly with the growth of data centers, industrial facilities, and new residential development. Natural gas storage ensures the system remains flexible in the face of this growth, delivering energy where and when it is needed most.

Emerging Pressures on Storage Infrastructure

There is a growing need for more gas infrastructure, including pipelines and storage. In recent years, U.S. natural gas production, pipeline capacity, and demand have all grown significantly, yet underground storage capacity additions have remained mostly flat. From 2014 to 2023, underground storage capacity grew at just 0.1 percent per year, down from 1 percent annually between 2000 and 2013. In contrast, LNG storage capacity more than doubled between 2021 and 2023, growing from 28.3 Bcf to 67.3 Bcf, largely driven by export growth and expanded use in areas without underground infrastructure.

The value of storage today is increasingly tied to its flexibility, optionality, and responsiveness, and that value has grown more important given today's current market trends. In several regions, notably the East, Midwest, and Mountain states, underground storage utilization has approached or exceeded 90 percent on average heading into the winter heating season over the past five years. However, increased price volatility in recent years may signal a growing need for more storage or a growing mismatch between infrastructure capacity and demand, especially if natural gas demand continues to grow at a pace that exceeds the necessary infrastructure and storage capacity additions. Between 2015 and 2019, daily Henry Hub price volatility averaged 43 percent; that figure rose to 71 percent between 2020 and 2024. Storage provides a physical and financial hedge to reduce risk against this volatility, enabling system operators and market participants to act in fast-changing conditions.

At the same time, the traditional economic valuation of storage has shifted. The simplest form of storage value is based on seasonal price spreads and optionality afforded by storage holders to provide physical and financial services to the market. However, the shape of the seasonal price curve has changed with evolving gas demand requirements, particularly in the electric power sector. Those seasonal price differences have narrowed with more gas consumed year-round, especially by power plants during the summer. Between 2013 and 2023, the average price spread was negative, at -$0.26 per MMBtu. In comparison, average spreads were positive in earlier decades. For example, between 1994 and 2003, the average spread was $0.46 per MMBtu.

Capacity Constraints, Delivery Challenges, and Planning Gaps

While storage facilities have proven their value during high-impact events, several structural and regulatory barriers continue to limit the system's overall effectiveness:

- **Storage capacity[3] constraints** limit the volume of gas that can be stored in regions where demand is rising, especially as electric generation increasingly relies on gas-fired capacity during both summer and winter peaks.
- **Limited withdrawal rates** can restrict how quickly gas can be deployed, particularly in older facilities or in areas with few pipelines or constrained pipeline capacity. This can lead to regional service bottlenecks during high-demand periods and lower optionality for storage providers to provide services to the broader market.
- **Project development timelines** remain long. Regulatory reviews, permitting processes, and inter-agency coordination requirements can add years to storage projects, discouraging investment and limiting responsiveness.
- **Market signals** do not always reflect the full range of storage benefits, especially for regulated entities that cannot recover value based on flexibility or grid support due to current market rules.

Despite these challenges, market fundamentals suggest the need for proactive storage expansion. The U.S. became the largest LNG exporter in 2023, averaging 11.2 Bcf per day of export volume. Domestic gas consumption, driven primarily by industrial activity and electric demand tied to data center growth, is also forecast to rise. In regions like the South Central, Mountain, and East, some additional storage is already being developed, but new projects have yet to materialize in other regions.

Policy Considerations and Strategic Action

To support energy reliability, affordability, and security, natural gas storage must be treated as a strategic infrastructure priority. That means recognizing its value, planning for its future, and ensuring the regulatory and investment frameworks are aligned with long-term system needs.

Key Considerations Include:

- **Targeted Expansion:** Storage capacity is approaching practical limits in several high-demand regions. Strategic investments in new underground and LNG facilities[4] will be essential, particularly where

[3] Natural gas storage capacity with respect to linepack is discussed in further detail in Section 2.
[4] LNG facilities are complexes designed to handle LNG and can vary by use. Types of LNG facilities are described in Section 2 and summarized in Table 2.

capacity utilization averages at or above 90 percent. These investments should align with growing residential loads, increased industrial consumption, and power sector needs.

- **Faster, Clearer Project Approvals:** Storage projects require years to move from concept to completion. Regulatory clarity and streamlined permitting can help remove bottlenecks and allow projects with broad system benefits to move forward more efficiently.
- **Improved Integration with Energy Planning:** Storage is not always considered in broader conversations about reliability, clean energy, or infrastructure planning. Including natural gas storage in state and regional energy plans will help ensure it is available when needed, particularly as grid flexibility becomes more important.
- **Recognition of Storage's Full Value:** Storage provides more than economic returns; it contributes to reliability, resilience, emergency preparedness, and consumer protection. These broader benefits should be reflected in how storage is valued in policy, regulation, and energy markets.
- **Support for Low-Carbon Pathways:** Current and future natural gas storage expansion supports and enables pathways to lower greenhouse gas emissions. By enhancing energy system flexibility, storage aids in the growth of renewable energy. Underground storage facilities can be utilized for renewable natural gas storage, enabling greater seasonal use. Additionally, natural gas storage could be repurposed for hydrogen-ready capabilities in future scenarios.

Regional and local market analysis could identify areas where new storage capacity may provide strategic value and reveal how market participants value existing storage assets. Quantifying differences between observed storage rates and theoretical benchmarks based on market pricing can highlight regional or local market opportunities for investment and help optimize storage capacity. Such analysis also sheds light on how operators today and in the future value storage optionality, flexibility, and reliability across various regions, providing insights critical to both commercial strategy and informed policymaking.

Beyond price signals, regional analysis can also quantify the broader "resilience dividend" that storage delivers. Stress-testing local demand and supply against extreme-weather scenarios, pipeline outages, and rapid renewable ramping reveals how incremental storage capacity can fortify reliability, support renewable integration, and protect consumers—insights that are essential for both commercial strategy and forward-looking energy policy.

Natural gas storage is a national asset that supports millions of customers, stabilizes markets, and protects energy delivery through routine operations and extraordinary events. As the U.S. energy system continues to evolve, the value of storage will only grow. Ensuring its continued reliability and flexibility is critical to maintaining a secure and resilient energy system.

1. Introduction

Natural gas is among the most flexible and dependable energy resources, essential for heating, electricity generation, and industrial processes across the country. The natural gas system delivers nearly three times more domestic energy during the winter heating season than the electric grid during summer peaks on average. Its reliability and value, however, significantly depend on infrastructure to store and deliver natural gas effectively and strategically.

Natural gas storage helps to ensure the operational flexibility, efficiency, and resilience of the U.S. energy system. By bridging the gap between continuous natural gas production and variable demand, storage enables reliable service across days and seasons, and in response to unanticipated disruptions. As the U.S. energy landscape evolves amid changing markets, technological innovation, regulatory developments, and global trends, a comprehensive understanding of natural gas storage, from basic infrastructure to market valuations and operations, has never been more important.

For over a century, the U.S. has stored natural gas underground in aquifers, salt caverns, and depleted reservoirs for on-demand market needs. Technology advancements through the 20th century introduced liquefied natural gas (LNG) and compressed natural gas (CNG), resulting in even more versatile, compact, and transportable storage options.

Purpose of the Report and Content Overview

This report provides a comprehensive overview of U.S. natural gas storage, exploring its technical foundations, market structure, strategic value, and future challenges. The discussion begins with an examination of storage fundamentals, highlighting its history, mechanics, and capabilities.

The report is separated into five core sections and conclusions:

- **Section 2. Storage Basics** discusses the history and development of natural gas storage and how natural gas is stored today.
- **Section 3. Market Landscape and Participants** describes the market participants utilizing and benefiting from natural gas storage and the jurisdictional considerations surrounding regulation and oversight of natural gas storage facilities.
- **Section 4. Seasonality, Reliability, and Resiliency** describes the ways in which natural gas storage contributes to the reliability and resiliency of the grid and how natural gas storage supports market stability in seasonal weather patterns.
- **Section 5. Value of Storing Natural Gas** details the intrinsic and extrinsic valuation of investment in natural gas storage.

- **Section 6. Constraints, Challenges, and Future Outlook** examines the current and future challenges facing natural gas storage and explores the need for regional expansion and strategic investment in response to evolving market pressures.
- **Section 7. Conclusions** emphasizes that storage capacity, infrastructure, and technology investments are essential to ensure that the U.S. can maintain a stable, reliable, and resilient energy system and strategically plan for future growth.

Additionally, Appendices A and B provide abbreviations and a glossary of terms, respectively, for the reader's reference.

To ground this discussion, the report begins by outlining the foundational elements of natural gas storage via the history, development, and current practices of storing natural gas in the U.S. This context establishes the technical baseline essential for understanding the broader operational, economic, and strategic themes addressed in the subsequent sections.

2. Storage Basics

Natural gas storage is foundational to energy system stability and efficiency, allowing operators to balance consistent supply against fluctuating demands. In this section, we first highlight recent capacity trends in both underground and LNG storage, then dive into the mechanics and performance metrics of underground facilities (cushion vs. working gas, deliverability, and injection rates), and finally survey supplemental options such as LNG terminals, linepack, and CNG.

To set the stage, recent EIA data highlight shifts in both underground and LNG storage capacity across the U.S. According to the Energy Information Administration (EIA), the demonstrated peak capacity[5] of underground storage in the lower 48 states increased by 3 percent to just over 4,200 billion cubic feet (Bcf) in the November 2023 reporting period after three consecutive years of falling demonstrated peak capacity.[6] Additionally, the U.S. reported the seventh largest net LNG storage withdrawal of nearly 8 Bcf in 2023, after a net addition of approximately 3.5 Bcf the year prior. Storing natural gas for future use provides a vital and reliable backup source for balancing supply disruptions, transmission pipeline issues, and unexpected peaks in demand so that

[5] Demonstrated peak capacity refers to the sum of the largest volume of working natural gas reported for each individual storage field during the most recent five-year period, regardless of when the individual peaks occurred.

[6] The EIA releases annual Underground Natural Gas Working Storage Capacity reports. The November 2023 reporting period encompasses data from December 2018 through November 2023. The next report is expected to be released in April 2025. For more information, visit https://www.eia.gov/naturalgas/storagecapacity/.

Note: The EIA calculates demonstrated peak capacity using individual operator data reported in the monthly 191 form. The most recent update is for November 2023. This report is released separately from their annual 191 publication, which was updated on December 2024 for the 2023 year.

The EIA Form EIA-191, Monthly Underground Gas Storage Report, provides data on the operations of all active underground storage facilities. Data are collected and mandated under the Federal Energy Administration Act of 1974, Public Law 93-275 and appear in EIA publications such as the annual field-level storage report and the demonstrated peak capacity report.

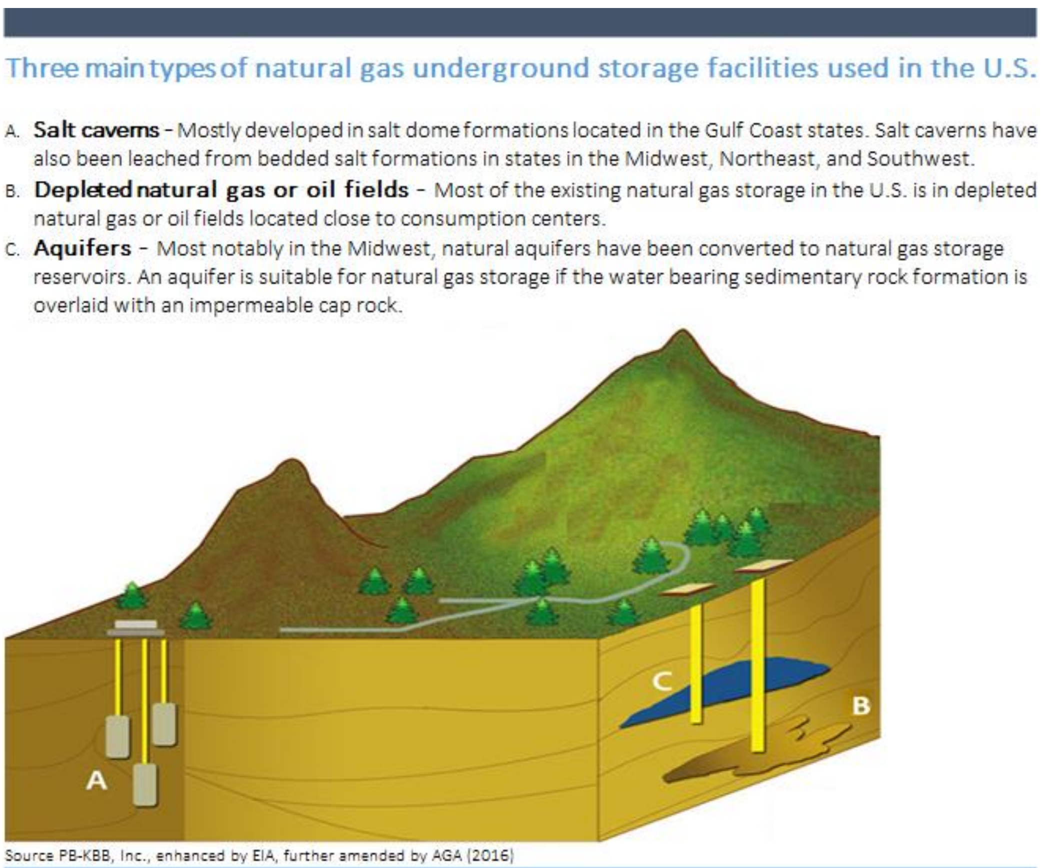
natural gas customers receive the reliable service they have come to expect. This section provides an overview of storage fundamentals to better understand the value natural gas storage offers.

Underground Natural Gas Storage

The beginning of natural gas storage dates to the early 20th century. In 1915, the first successful underground storage project was completed in Welland County, Ontario, and the following year, the first U.S. facility began operating in the Zoar gas field south of Buffalo, New York.[7] Through the 1930s, underground gas storage was primarily located in depleted oil or natural gas fields. Opportunities in geological storage development led to the use of aquifers and salt caverns between the 1940s and 1960s.[8] Today, most underground storage in the U.S. is found in depleted oil or natural gas fields that are closely located to pipelines, electric generation facilities, and natural gas markets.

Today, there are three types of underground storage facilities: salt caverns, depleted natural gas or oil fields, and aquifers. Figure 1 describes and illustrates each storage facility type.

Figure 1: Types of Underground Natural Gas Storage Used in the U.S.



[7] https://www.ferc.gov/industries-data/natural-gas/overview/natural-gas-storage/natural-gas-storage-background
[8] https://archives.datapages.com/data/phi/v17-2016/arthur-alleman-andersen.htm

The location of different underground storage field types depends on local geology and market access. Generally, most aquifers are located in the Midwest, with some also located in the West. By contrast, most salt caverns are located in the Gulf States. Depleted natural gas and oil fields repurposed for underground natural gas storage are found in many areas of the country.

Pressure plays a critical role in the maintenance and operation of storage facilities. All underground storage contains cushion gas and working gas. Cushion gas is the gas that remains in the storage reservoir as permanent inventory for a facility and is necessary to maintain adequate pressure and deliverability rates during the withdrawal season. Conversely, working gas is the natural gas actively being used for storage and withdrawal to meet customer demand. By extension, working gas capacity is the amount of gas at a facility that can be injected into the transmission or distribution system for use by customers, and is equal to the total maximum volume that a storage facility holds at any one time minus the cushion gas.[9]

In practical terms, the volume of working gas and these pressure-driven characteristics in the reservoir form the basis for contractual "ratchet" provisions, which shape the maximum allowable injection or withdrawal rates under the terms of a storage tariff agreement. The deliverability rate (*i.e.*, the amount of gas that can be withdrawn in one day) is highest when the facility is full and declines as gas is removed. A facility's injection rate is inverse to the deliverability rate, increasing as storage reserves deplete.[10] Cushion gas, working gas capacity, deliverability rates, and injection rates will vary between facilities, making ratchets essential to aligning contractual entitlements with the physical realities of underground storage.

The abilities and limitations of different types of facilities are listed in Table 1.

[9] https://www.eia.gov/naturalgas/storage/basics/
[10] *Id*.

Table 1: Overview of Underground Natural Gas Storage Types

	Description	Abilities	Limitations
Depleted Fields	• Formations that have been depleted of natural gas or oil resources, leaving behind underground fields capable of holding and storing natural gas • To maintain pressure in depleted reservoirs, approximately 50 percent of the gas must be left as cushion gas	• Large capacity • Geographical availability	• Low deliverability rates • Slow cycling
Aquifers	• Underground porous, permeable rock formations that act as natural water reservoirs • Cushion gas requirements can be between 50 to 80 percent of the total gas volume to maintain pressure	• High deliverability rates • Geographical flexibility • Large capacity potential	• Complex operation • Lower efficiency
Salt Caverns	• Formed from existing gas deposits, either salt domes or salt beds • Requires only 20 to 30 percent of total capacity to be used as cushion gas	• High deliverability rates • Fast cycling	• Limited total capacity

Source: FERC Natural Gas Storage – Storage Fields[11]

[11] https://www.ferc.gov/industries-data/natural-gas/overview/natural-gas-storage/natural-gas-storage-storage-fields

Liquefied Natural Gas Storage

Above-Ground LNG Storage Tanks
Source: U.S. Department of Energy

The process of storing LNG in the U.S. began a few years after the opening of the Zoar underground storage facility in Buffalo, New York. The first LNG plant began operation in 1917 in West Virginia, followed by the first commercial plant in 1939.[12] The liquefaction process requires cooling the gas molecules to around -260° Fahrenheit. The volume of LNG is about 600 times smaller than natural gas in its gaseous state, which helps improve storage and shipment efficiency.[13] Today, LNG is most commonly stored at import or export terminals, peaker plants, or satellite facilities.

At each of these storage sites, liquified gas is stored in single, double, or full containment systems that use auto-refrigeration to keep the tank's pressure and temperature constant.[14] LNG tanks can be constructed above or below ground, and depending on the type of facility, natural gas may be liquefied on-site or delivered to the storage facility via LNG transportation. LNG is typically transported using specially designed tank trucks, International Organization for Standardization (ISO) containers, and tanker or carrier ships.[15] Table 2 lists the facility types, features, and purposes in greater detail.

Liquefied Natural Gas (LNG) Cargo Ship
Source: U.S. Department of Energy

[12] National Association of State Fire Marshals. (2005). *Liquefied Natural Gas: An Overview of the LNG Industry for Fire Marshals and Emergency Responders. https://primis.phmsa.dot.gov/comm/publications/lng_for_fire_marshals_06-2005.pdf*
[13] https://www.energy.gov/fecm/liquefied-natural-gas-lng
[14] https://www.matrixpdm.com/an-introduction-to-lng-storage-systems
[15] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-facility-siting

Table 2: Overview of LNG Storage Facilities

	Description	Features
Import and Export Terminals	• LNG is stored in large-scale tanks before regasification[16] or shipment via specialized tanker ships • Export terminals: liquefaction capabilities • Import-only terminals: regasification capabilities	• Supply management • Demand support • Reduced market volatility
Peaker Plant	• LNG is stored in tanks connected to gas transmission or distribution pipelines for demand management • Gas is typically liquefied when demand is low and vaporized[17] for distribution when demand peaks to alleviate the load on the system • Most facilities are designed to provide five to 15 days of supply at the maximum send-out rate and refill in approximately 200 days[18]	• Includes liquefication and regasification capabilities • Seasonal demand management • Enhanced reliability • Strategically located in the pipeline system • Cost management
Satellite Facilities or Satellite Plants	• Serve the same function as peaker plants, but do not have liquefication capabilities • LNG is delivered to the site via tanker trucks	• Seasonal demand management • Enhanced reliability • Cost management

Source: PHMSA LNG Facility Siting[19]

Increasingly, LNG storage can also be co-located with electric power plants. Natural gas flows at a rate of around 20 to 30 miles per hour, depending on linepack[20] conditions, so co-location helps optimize pipeline capacity[21] and improve reliability for electricity producers and consumers of electricity and natural gas.[22] Pipeline capacity optimization, service reliability, and mobile or temporary LNG facilities are important considerations for the strategic deployment of LNG and the location of peak shaving[23] and satellite facilities along the gas distribution system.

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[16] Regasification refers to the process of converting LNG back to its gaseous form.
[17] Vaporization is a step within the regasification process where a liquid physically changes to a gas.
[18] https://ingaa.org/wp-content/uploads/2014/05/21698.pdf
[19] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-facility-siting
[20] Linepack refers to the amount of gas stored in the pipes of the gas transmission or distribution system.
[21] Pipeline capacity is the maximum volume of gas that can flow through a pipeline at one time.
[22] https://www.energy.gov/sites/prod/files/2015/04/f21/AttachB_Aspen_GasStorage2012.pdf
[23] Peak shaving is a strategy that aims to reduce energy usage during periods of peak demand to promote energy system integrity and resilience. Peak shaving can take many forms, including demand response, energy efficiency, interruptible service, and, in the case of the electric grid, direct use natural gas service.

Mobile or temporary LNG facilities are small-scale and portable. They deliver gas directly to a pipeline for peak-shaving purposes or pressure maintenance during pipeline repair or assessment. Often, these facilities do not have storage capabilities and rely on LNG trucks for supply.[24]

Floating Storage Units (FSUs), or Floating Storage and Regasification Units (FSRUs), are another form of LNG storage used by the offshore industry and at LNG import and export terminals. FSUs are ships or barges that combine LNG storage with built-in regasification systems (in the case of FSRUs).[25] Old LNG carriers and tankers can be converted to FSUs and FSRUs, which shorten lead times and reduce costs. For this reason, floating storage solutions are becoming increasingly popular and are expected to play an important role as LNG technology continues to develop.[26]

Other Storage Options

In addition to underground and LNG storage, the natural gas system utilizes supplemental forms of storage to enhance operational flexibility and reliability. Two notable tools in this category are linepack and CNG.

Linepack is not a formal storage facility but an inherent feature of natural gas pipeline systems. Gas system operators, including local distribution companies (LDCs), can manage the amount of gas within transmission and distribution pipelines by adjusting pressure levels. This ability to “pack” additional natural gas molecules into the system serves as a short-term buffer against hourly fluctuations in supply and demand. Linepack helps enable system operators to respond to rapid intraday changes in demand, even in instances when upstream supply may be temporarily insufficient.[27]

CNG is another form of storage, produced by compressing natural gas to less than 1 percent of its volume at standard atmospheric pressure.[28] CNG offers a flexible, transportable form of natural gas storage that complements underground and LNG systems, particularly in areas without pipeline access or geological suitability for large-scale storage. CNG is stored in high-pressure cylinders and delivered via truck-based transport systems—referred to as virtual or mobile pipelines—to end-users such as utilities, industrial sites, or remote facilities.[29] These mobile storage options help meet local demand during peak events, outages, or infrastructure constraints and are commonly used in regions where underground or LNG storage is unavailable or limited.

CNG storage systems use various cylinder types that vary in pressure tolerance, weight, and capacity. Each type’s composition and design make it suitable for specific applications, such as bulk transportation, stationary storage, or vehicular applications.[30] Though CNG storage volumes are relatively small compared to underground or LNG storage, their modularity and portability make them a strategic asset. When deployed

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[24] https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/Jurisdiction_49_CFR_Part_193.pdf
[25] https://www.exxonmobillng.com/-/media/project/wep/exxonmobil-lng/lng-us/pdf/110-fsru.pdf
[26] https://www.econnectenergy.com/articles/how-does-regasification-of-lng-work
[27] American Gas Foundation. (2021). *Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience.* https://gasfoundation.org/wp-content/uploads/2021/01/Building-a-Resilient-Energy-Future-Full-Report_FINAL_1.13.21.pdf
[28] https://afdc.energy.gov/fuels/natural-gas-basics
[29] https://astforgetech.com/compressed-natural-gas-cng-storage-options-ultimate-guide/
[30] *Id*.

effectively, CNG enhances local system flexibility, supports peak-shaving operations, and contributes to overall reliability.

3. Market Landscape and Participants

Natural gas storage is a critical component of the effective operation of the natural gas system. For example, natural gas utilities and pipelines rely on access to natural gas storage for reliability during the winter heating season. Other market participants, including natural gas producers and marketers, rely on storage to balance production flows, particularly during the warmer months of the year, and deliver gas into the market at economically advantageous times.

This section will discuss the primary users of natural gas storage and the state and federal government regulators who oversee and promulgate regulations related to safety, operational issues, and market participation of storage facilities.

Physical and Operational Characteristics

Natural gas storage facilities are owned and operated by interstate pipeline companies, LDCs, LNG peak shaving operators, and independent operators. Natural gas stored in facilities owned by independent storage operators is often held under lease for shippers, marketers, and LDCs.

According to data from the EIA's 191 Field Level Storage Report for underground storage assets in 2023,[31] 53 percent of U.S. working gas capacity is owned and operated by interstate and intrastate pipeline companies, 22 percent by local distribution companies, and 25 percent by independent storage operators.[32] As shown in Table 3, pipeline companies own 43 percent of the total deliverability, while LDCs own 24 percent and independent companies own 33 percent. However, independently owned storage facilities have higher daily deliverability rates on average than those owned by pipeline or utility companies. Notably, the average deliverability rate for independently owned storage facilities is 0.41 Bcf per day, while LDC-owned facilities average 0.22 Bcf per day. Pipeline company facilities average 0.27 Bcf per day.

Differences in capacity and deliverability reflect the unique physical configurations and economic roles of each facility type. These differences influence how they are designed, operated, and optimized for specific market functions such as seasonal balancing, peak demand response, or short-term arbitrage.

[31] Data for 2023 was updated in December 2024.
[32] Data represents all reported storage assets, including active and inactive fields.

Table 3

U.S. Underground Storage Capacity by Owner Type

Billion Cubic Feet (Bcf)

	Working Gas Capacity (Bcf)	% of Total	Maximum Daily Delivery (Bcf/d)	% of Total
Pipeline	2,534	53%	50	43%
LDC	1,058	22%	29	24%
Independent	1,207	25%	39	33%
Total	**4,799**	**100%**	**117**	**100%**

Table: American Gas Association • Source: Energy Information Administration • Created with Datawrapper

Regulated storage (*i.e.,* utility-owned facilities*)* helps utilities to meet customer demand needs, while merchant storage (*i.e.,* pipeline and independently owned facilities) contract capacity to third-party shippers.[33] While some pipeline-owned storage is reserved for operational needs such as load balancing and system support, the majority is leased to other industry participants under merchant arrangements.[34] ICF International identifies these third-party shippers using FERC's Index of Customer data released by all interstate pipelines and certain independent storage operators in the first quarter of 2025. As illustrated in Figure 2, 60 percent of storage capacity is contracted by utilities, 27 percent by marketers, and 9 percent by pipelines.[35]

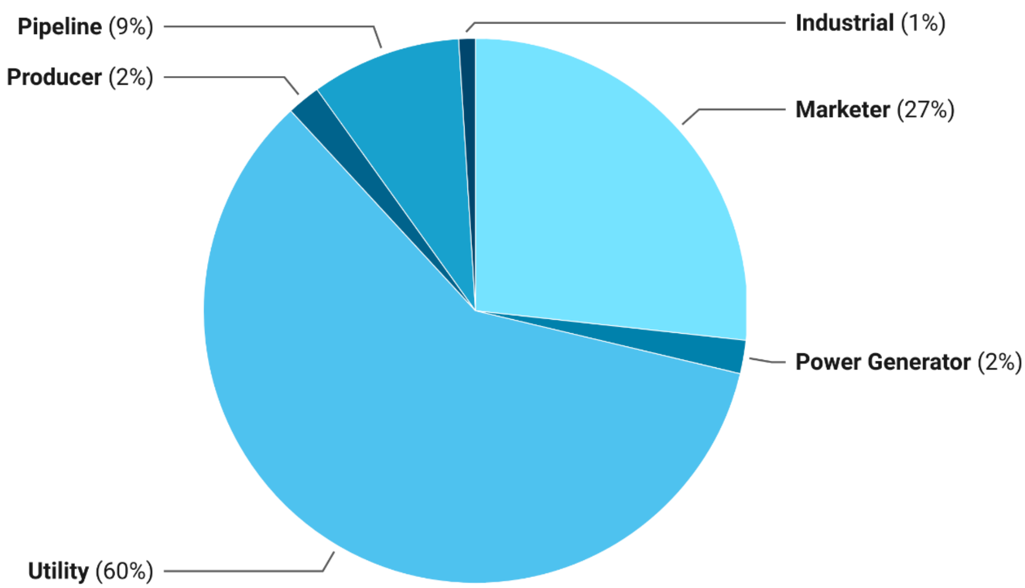
[33] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook.* https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pdf

[34] https://www.eia.gov/naturalgas/storage/basics/

[35] Note: Analysis reflects data from the EIA's 191 Field Level report as of December 2014. The share of storage capacity contracted by shipper industry will vary based on more recent data.

Figure 2

Contracted Underground Storage Capacity by Shipper Industry, Q1 2025



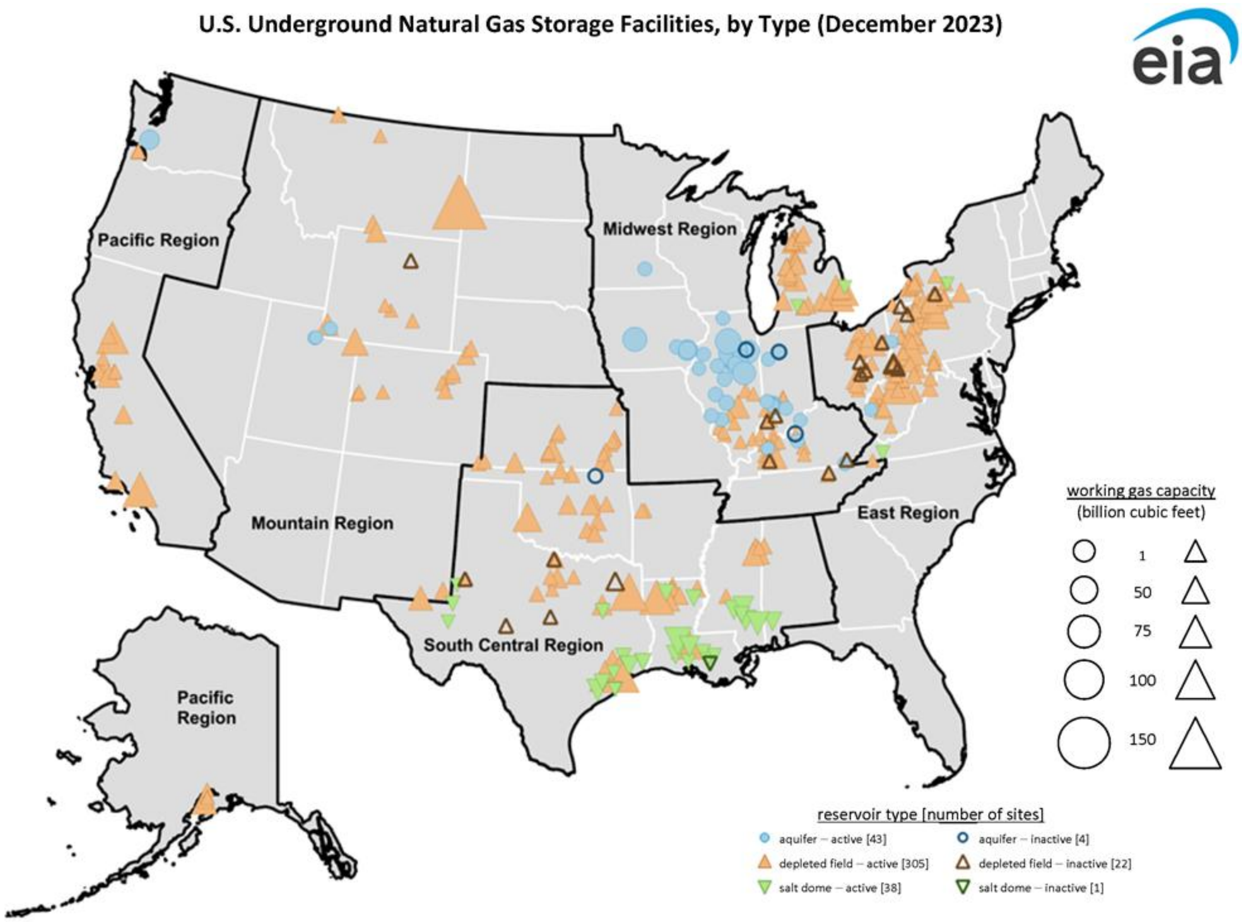
Percentages may not foot due to rounding.

Chart: American Gas Association • Source: Hitachi Energy Velocity Suite, ICF International • Created with Datawrapper

As of December 2024, the EIA reported data for 413 underground storage facilities across the U.S. Of these facilities, 393 are active fields with a combined working gas capacity of 4,772 Bcf, spanning 31 states. The majority (79 percent) of these storage facilities are depleted reservoirs, while 11 percent are aquifers. The remaining 10 percent are salt domes. A map of active and inactive facilities located in the continental U.S. is provided in Figure 3.[36]

[36] Note: As of this report's release, the EIA has not published an updated map reflecting their December 2024 update. Figure 3 reflects 2022 data released in December 2023.

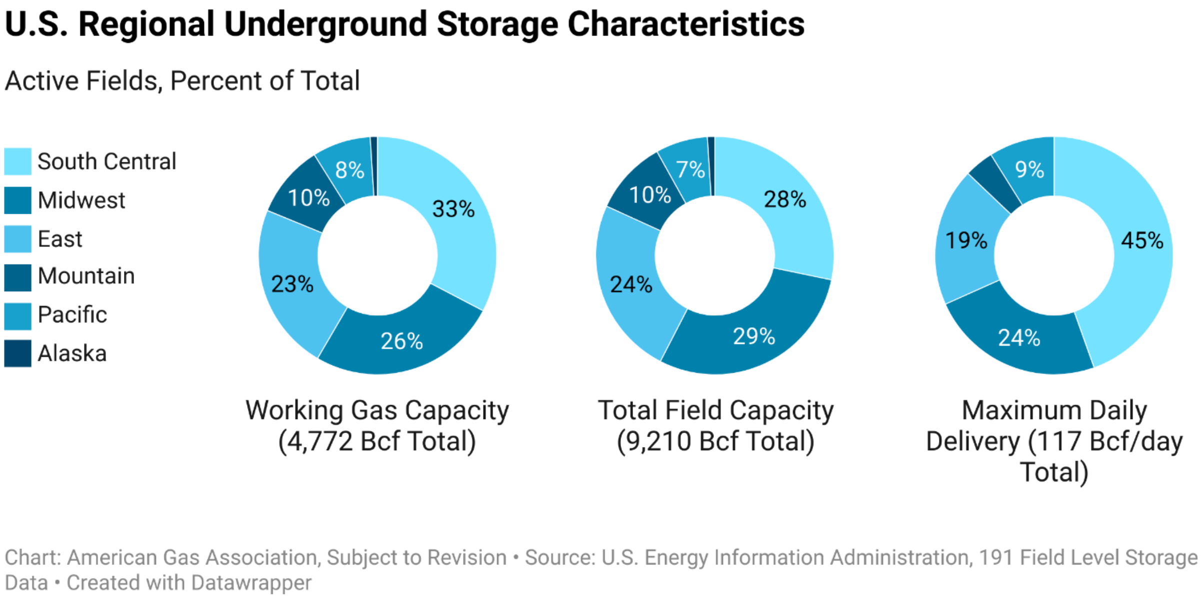
Figure 3



Source: Energy Information Administration

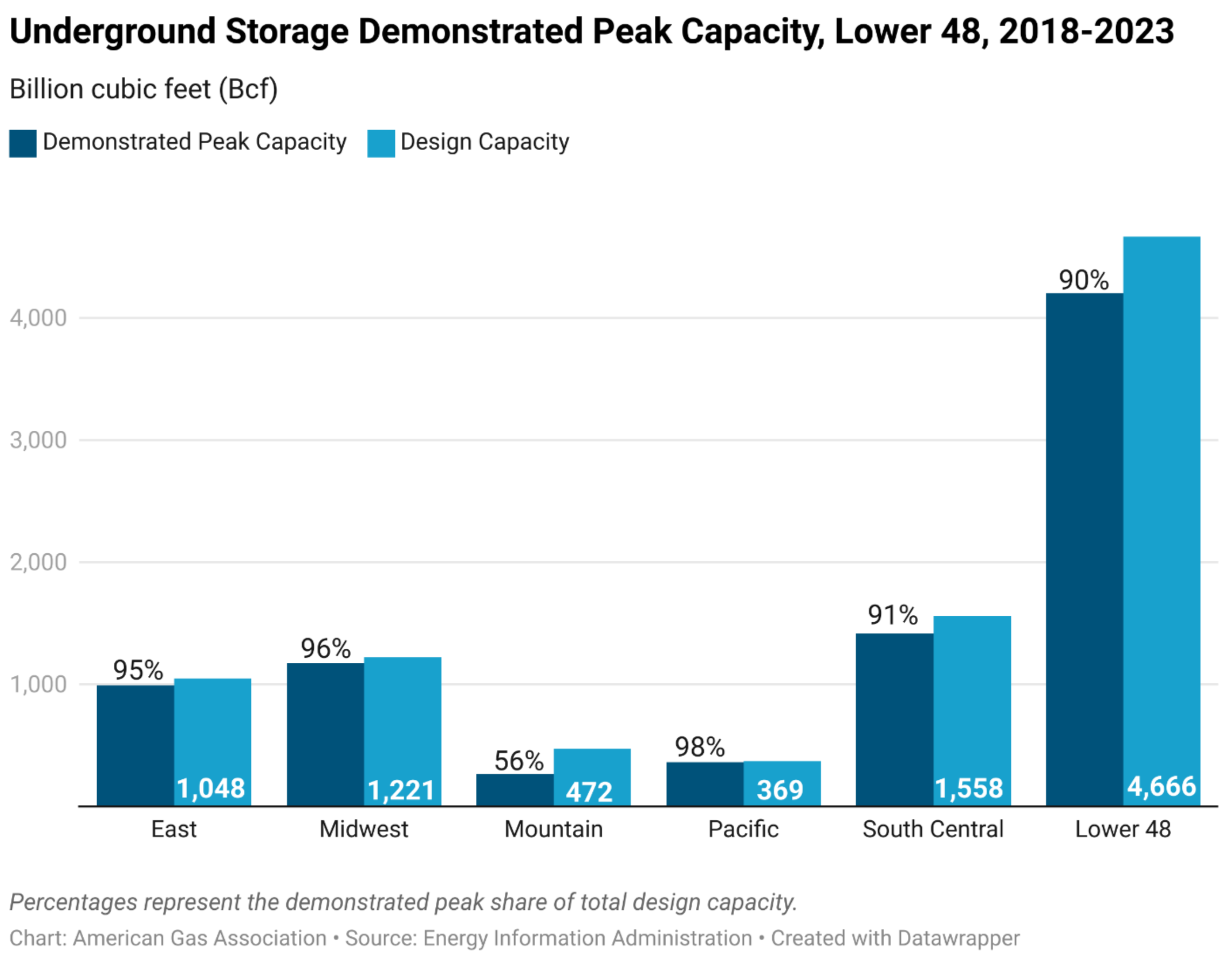
Regionally, active underground storage assets are most concentrated in the South Central, Midwest, and East, accounting for more than 80 percent of the total working gas capacity. Figure 4 provides an overview of regional storage characteristics.

Figure 4



As of November 2023, the demonstrated peak capacity of underground storage in the lower 48 was 90 percent. The data depicted in Figure 5 represents December 2018 through November 2023. In all regions except the Mountain, the demonstrated capacity exceeds 90 percent, reaching as high as 98 percent in the Pacific region. Determining storage asset utilization is based on the demonstrated peak capacity rather than the design capacity, as it is a more realistic measure of the capabilities of active storage fields.

Figure 5

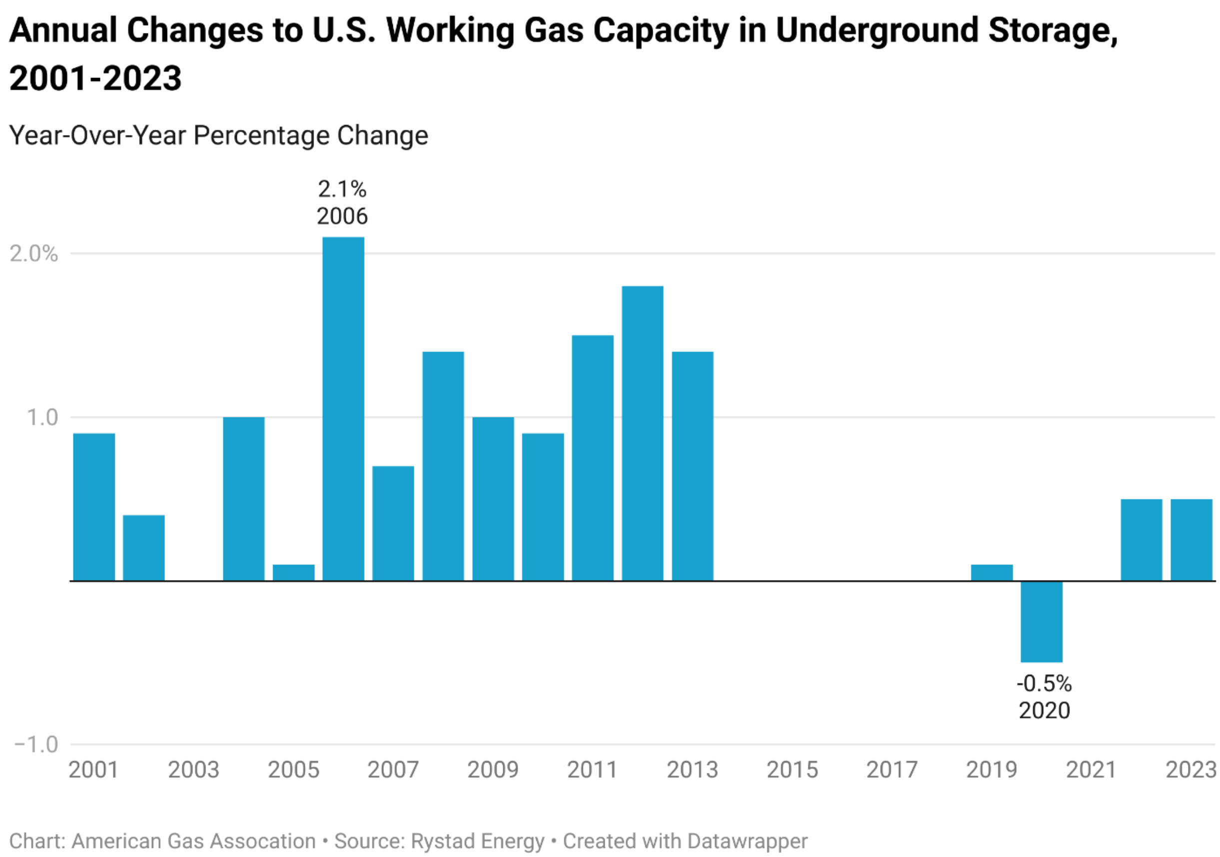


In recent years, capacity additions to underground storage have slowed significantly. Between 2001 and 2013, additions to working gas capacity grew steadily at an average rate of 1 percent per year. Between 2014 and 2023, the average annual growth rate slowed to 0.1 percent. In 2020, working gas capacity declined by 23.6 Bcf year-over-year, primarily driven by a 23 Bcf reduction in West Virginia after the Majorsville DP facility was taken offline until 2023.[37]

[37] Notably, the EIA's reported peak demonstrated capacity also declined in 2020 by a total of 8 Bcf year-over year. A 34 Bcf reduction in the Pacific region was the primary reason for this decline. It reflects the exclusion of pre-2015 peak levels at Aliso Canyon from the five-year average, following the facility's operational restrictions after 2015. *See* https://www.eia.gov/todayinenergy/detail.php?id=48216

Figure 6 illustrates the year-over-year trends of working gas capacity in underground storage from 2001 to 2023.

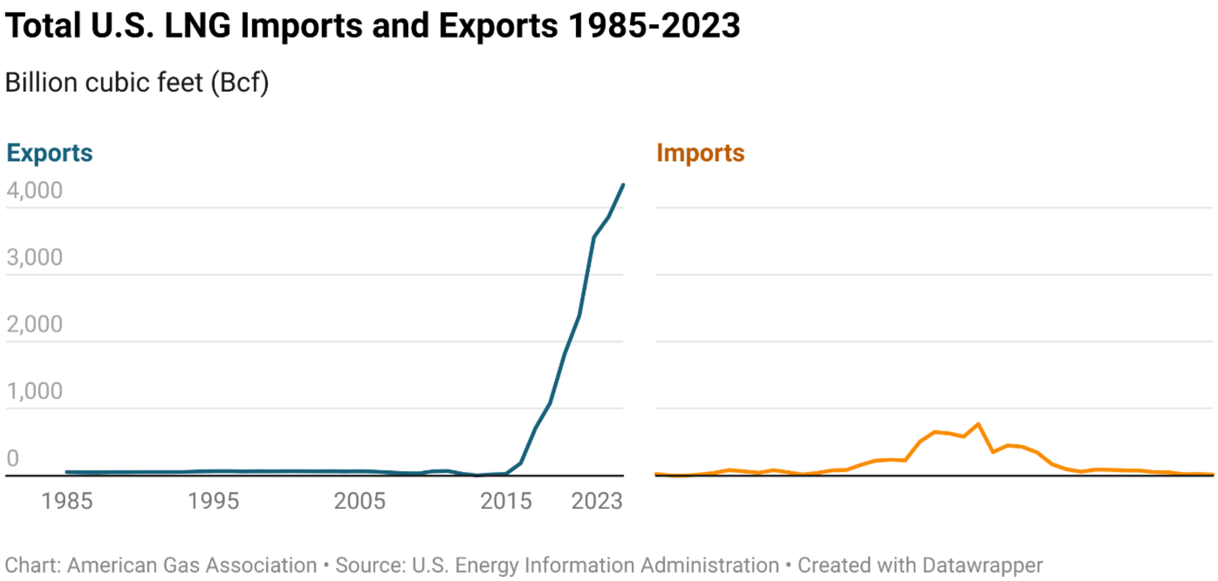
Figure 6



LNG storage capacity in service has grown over the last several years as U.S. LNG export capacity has expanded, driven by the so-called shale revolution,[38] since major export facilities have on-site LNG storage. As of 2023, U.S. LNG export volumes reached 11.2 Bcf per day, a seven-fold increase since 2013. This reflects the evolution of the U.S. from once a net importer of natural gas to now the world's leading exporter.[13] Figure 7 illustrates this shift.

[38] The shale revolution refers to the rapid growth in U.S. oil and natural gas production in the mid-2000s when new drilling techniques unlocked vast reserves of oil and natural gas from deep underground shale rock. As a result, the U.S. became the world's largest natural gas producer and significantly boosted domestic energy security. The shale boom reshaped global energy markets, lowered energy prices, and boosted energy independence.

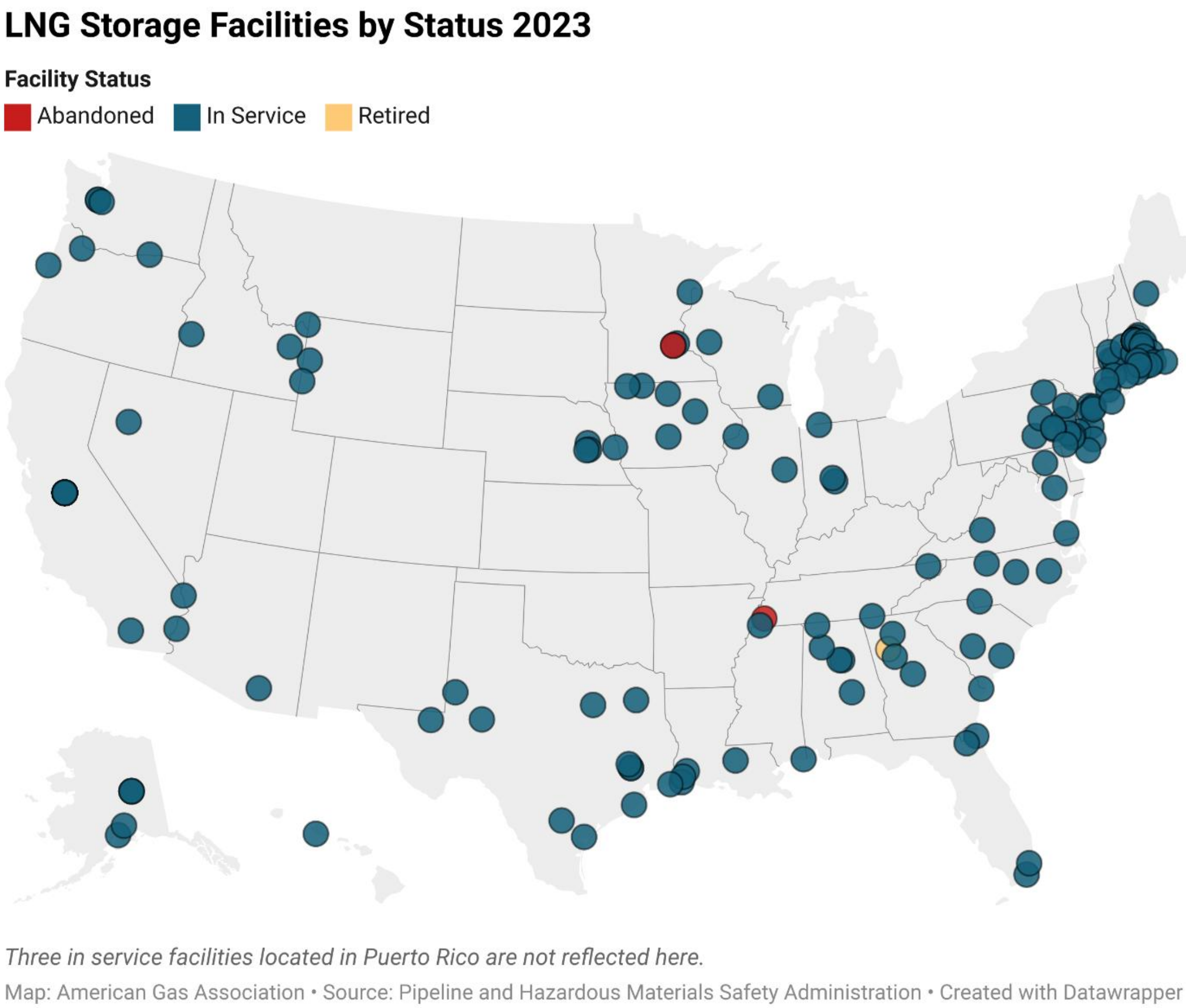
Figure 7



According to PHMSA, as of 2023, there are 182 total LNG storage facilities with a combined service capacity of 68.3 Bcf.[39] The majority of LNG storage facilities (*i.e.*, 96.7 percent) were in service as of 2023, offering more than 68.2 Bcf of capacity. Approximately 84.6 percent were classified as intrastate facilities, and more than half sourced LNG by truck. Most of the facilities were logged as peak shaving facilities (41.8 percent), followed by mobile/temporary facilities (22 percent), baseload (15.4 percent), and satellite (14.3 percent). The remaining facilities were logged as "other" for purposes such as storage with liquefaction, merchant, transportation, and peak shaving without fixed storage.[40] Many of these facility types are described in Table 2. Figure 8 illustrates facility location by facility status for all U.S. states. Three in-service facilities in Puerto Rico are not reflected on the map, and 12 additional facilities did not have an associated zip code. Eleven of those were logged as in service, and one was logged as abandoned.

[39] https://www.phmsa.dot.gov/data-and-statistics/pipeline/liquefied-natural-gas-lng-facilities-and-total-storage-capacities
[40] Note: This dataset does not include storage located at LNG export facilities.

Figure 8



Net additions to LNG storage also increased significantly between 2021 and 2023, raising the total capacity in service from 28.3 Bcf in 2021 to 68.2 Bcf in 2023, a 141.5 percent increase, according to PHMSA data. Over the same period, the total number of in-service LNG storage facilities increased by seven to 176. From 2014 to 2020, annual changes in LNG capacity in service were relatively low, averaging just 0.1 percent per year. Figure 9 shows the total LNG storage capacity in service and the annual percentage change in capacity between 2014 and 2023, as reported by PHMSA.[41]

[41] Note: PHMSA provides annual data reported by LNG operators as required by 49 CFR Parts 191 and 195. Available data for 2010 through 2023 indicate rising capacity to 347.9 Bcf in 2012, then steep drops to 75.5 Bcf in 2013 and 27.7 Bcf in 2014. Absent additional clarity as to why these trends occurred, AGA is not citing data before 2014 at this time. For more information, see https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

Figure 9

U.S. Total LNG Storage Capacity in Service, 2014-2023

Billion cubic feet (Bcf)

Chart: American Gas Association • Source: Pipeline and Hazardous Materials Safety Administration • Created with Datawrapper

Jurisdictional Considerations

Natural gas storage is regulated by a combination of federal agencies and state jurisdictions, depending on whether the storage facilities and related infrastructure operate in an interstate or intrastate capacity. At the federal level, the Federal Energy Regulatory Commission (FERC) regulates the construction and operation of interstate natural gas storage facilities, while PHMSA oversees the safety of underground storage facilities.

Following market evolutions brought about by the Natural Gas Policy Act of 1978, FERC issued Order 636 in 1992, which restructured the natural gas industry and, in part, required interstate pipeline companies to unbundle their sales and transportation services.[42] As a result, FERC enhanced competition by requiring open access to transmission networks to third parties, allowing for improved market efficiency while maintaining regulatory oversight of the rates charged for transporting natural gas.

Further, the Energy Policy Act of 2005 revised the Natural Gas Act and gave FERC authority to grant market-based rates for new storage capacity.[43] Specifically, FERC may authorize natural gas companies to provide storage and storage-related services at market-based rates for new storage capacity placed into service after August 2005, even if the company is unable to demonstrate it lacks market power. To make this authorization, FERC must determine that market-based rates are in the public interest and needed to encourage the construction of the capacity, and that customers are adequately protected.[44] FERC is required to ensure that reasonable terms and conditions are in place to protect consumers, and it must periodically review the market-

[42] https://www.ferc.gov/order-no-636-restructuring-pipeline-services
[43] Energy Policy Act of 2005, Pub. L. No. 109-58, section 312, 119 Stat. 594, 688 (2005) codified at 15 U.S.C. § 717c(f).
[44] https://www.ferc.gov/industries-data/natural-gas/natural-gas-storage

based rates authorized to ensure said rates remain just, reasonable, and not unduly discriminatory or preferential.

More recently, PHMSA revised its rules and procedures for the oversight of natural gas storage facilities following the Aliso Canyon incident in 2015. The final rule was published in 2020 and required mandatory compliance with recommended practices regarding the design, operation, and maintenance of underground storage facilities.[45] Further, the rule enhanced recordkeeping and reporting requirements for operators and instituted integrity management practices such as regular assessments and risk management protocols for underground facilities.

At the state level, regulatory oversight for natural gas storage typically falls under the purview of Public Utility Commissions (PUCs) or other state advisory agencies. State-level regulation focuses on intrastate facilities only and could include such components as siting and construction of new storage facilities, cost recovery, and safety oversight. For example, in 2023, the California Public Utilities Commission increased natural gas inventory levels at the Aliso Canyon Natural Gas Storage Facility in an effort to guard against price spikes.[46] In Texas, the Alternative Fuels Safety Department of the Railroad Commission (RRC) has oversight on natural gas storage and distribution of alternative fuels, including both LNG and CNG, conducts safety evaluations of facilities and equipment, and provides licensing and training for those working in the industry.[47] A separate agency, the Texas Commission on Environmental Quality, is responsible for overseeing emissions control from storage tanks and coordinates with the RRC.[48]

In the “Safety of Underground Natural Gas Storage Facilities” (85 FR 8104) rule issued in 2020, PHMSA clarified the roles and responsibilities of state regulatory agencies for underground storage facilities. As part of the rule, PHMSA reinforced that no existing state roles have been altered and that states can enforce more stringent safety standards for intrastate underground storage facilities so long as those standards comply with federal regulations. States also retained the authority for siting and permitting for intrastate facilities and environmental protections for surrounding areas.

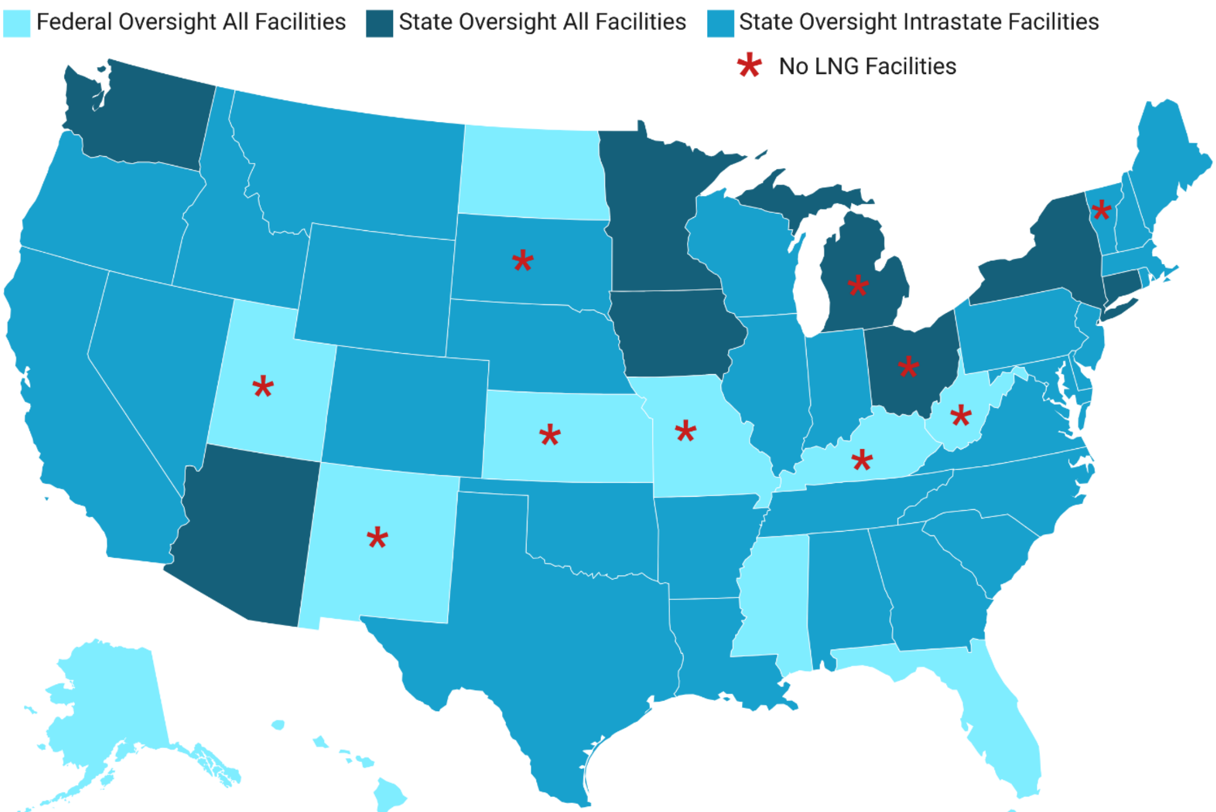
Similarly, LNG storage facilities are overseen by regulatory bodies such as FERC, PHMSA, state-level agencies, and the U.S. Coast Guard (USCG). Depending on the location and use of an LNG facility, it may be regulated by several federal and state regulatory agencies at the same time.[49] The Natural Gas Pipeline Safety Act of 1968, which authorizes PHMSA to regulate the pipeline transportation of natural gas and other gases, includes the transportation and storage of LNG.[50] PHMSA “has the exclusive authority to establish and enforce safety regulations for onshore LNG facilities.”[51] These regulations are contained in the Code of Federal

[45] Safety of Underground Natural Gas Storage Facilities. 85 FR 8104. https://www.federalregister.gov/documents/2020/02/12/2020-00565/pipeline-safety-safety-of-underground-natural-gas-storage-facilities
[46] https://www.cpuc.ca.gov/news-and-updates/all-news/cpuc-takes-action-to-enhance-energy-affordability-for-ratepayers-in-southern-california-2023
[47] https://rrc.texas.gov/about-us/organization-and-activities/rrc-divisions/oversight-safety-division/
[48] https://www.tceq.texas.gov/permitting/air/guidance/newsourcereview/tanks/nsrauth_tanks.html
[49] https://www.ferc.gov/natural-gas/lng
[50] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/jurisdiction-lng-plants
[51] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-regulatory-documents

Regulations (CFR) at Title 49 Part 193 and apply to LNG facilities that receive or deliver gas to a pipeline regulated under 49 CFR 192. State agencies often work in partnership with PHMSA to ensure that both federal and state requirements are met. The map in Figure 10 depicts the various regulatory authorities over intrastate and interstate facilities.[52]

Figure 10

U.S. Regulatory Authority Over Intrastate & Interstate LNG Facilites



Hawaii updated to reflect in-service facility as of 2018. D.C. is federally regulated but has no LNG facilities.

Map: American Gas Association • Source: Pipeline and Hazardous Materials Safety Administration (PHMSA) • Created with Datawrapper

Like PHMSA, FERC is responsible for inspecting peak-shaving, LNG satellite facilities, and vehicular fuel LNG plants connected to the interstate gas transmission system.[53] PHMSA is responsible for the standards that govern the location and design of interstate LNG facilities, while FERC is responsible for determining whether the proposed facilities meet public interest requirements. The agencies have established a Memorandum of Understanding (MOU) outlining the coordination framework.[54] LNG projects are approved and built under

[52] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/jurisdiction-lng-plants
[53] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-regulatory-documents
[54] https://www.ferc.gov/news-events/news/ferc-phmsa-sign-mou-coordinate-lng-reviews

FERC's oversight as long as the facility is in operation.[55] Moreover, under Section 3 of the Natural Gas Act, FERC authorizes the siting and construction of near-shore LNG import or export facilities. Additionally, companies that want to import LNG into or export it from the U.S. must be authorized to do so by the Department of Energy (DOE).[56]

The USCG, in coordination with the Maritime Administration (MARAD), oversees the safety, security, and environmental regulation of LNG deepwater ports and marine transfer areas at waterfront facilities.[57] The USCG conducts waterway suitability assessments, manages the deepwater port licensing process, and develops regulatory guidance for design, construction, and operation phases. These responsibilities are governed by federal laws, including the Maritime Transportation Security Act and the Deepwater Port Act.[58]

Market Interactions

U.S. underground, LNG, and CNG storage are essential for balancing supply and demand, providing service to consumers, and mitigating market risk. Therefore, storage assets are inherently valuable as operational resources and help to reduce consumer exposure to price volatility.

In the domestic market, underground storage inventories serve as a key indicator of relative natural gas supply and demand trends, and changes to underground storage may trigger a commensurate price response in the market.[59] Comparing current storage levels to historical averages can help identify if the market is experiencing deficits or surpluses relative to typical storage levels, where current inventories are often measured against a rolling five-year average or other historical metrics. Working gas inventory deficits or surpluses relative to historical levels can result from demand patterns due to weather or other macroeconomic factors, shifts in flowing gas supplies due to changes in natural gas production or infrastructure maintenance, and other market events.

For example, a severe winter heating season may produce higher-than-average withdrawals on storage inventories, leaving lower-than-average inventories in storage. Similarly, a warmer-than-normal winter can have the opposite effect. The 2023-2024 winter was the warmest on record for the U.S., with an average temperature of 37.6° Fahrenheit, 5.4 degrees above average, and resulted in a surplus of storage inventories of 262 Bcf above the five-year maximum for the week ending March 29, 2024.[60] The interaction between storage and demand seasonality is discussed further in Section 4.

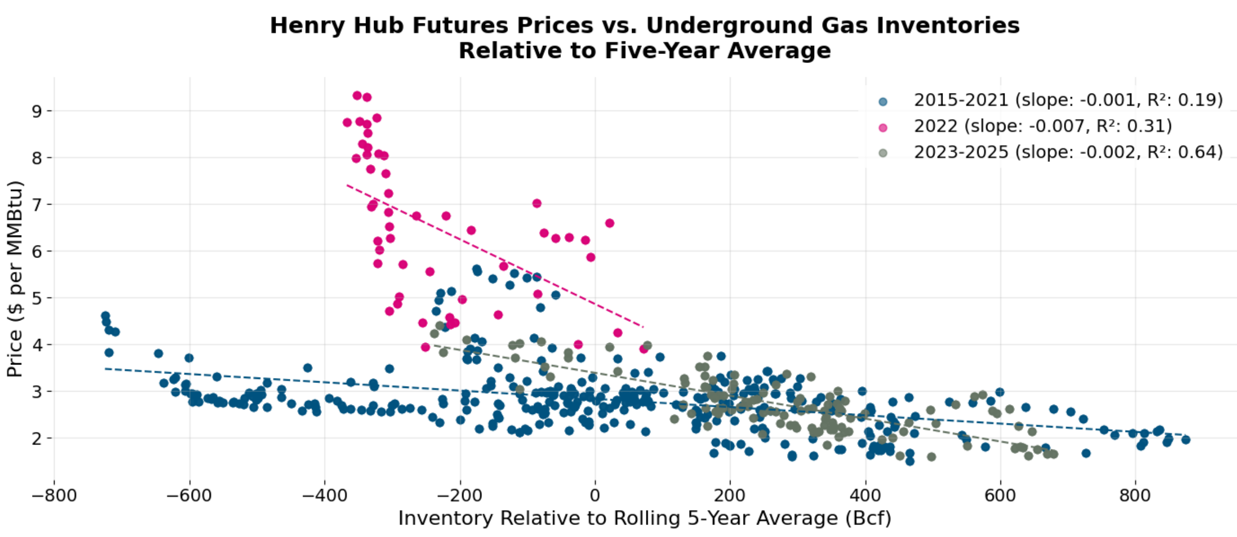
The amount of gas in storage also influences natural gas prices because fluctuating inventory levels can prompt traders to adjust their purchasing strategies and shape expectations for future supply availability. Additionally, when storage inventories are low, spot prices may be more responsive to the impact of structural

[55] https://www.ferc.gov/natural-gas/lng
[56] https://www.energy.gov/fecm/articles/does-role-lng-sector
[57] https://www.phmsa.dot.gov/pipeline/liquified-natural-gas/lng-regulatory-documents
[58] *See also* 33 CFR Parts 127.
[59] Rubaszek, M., & Uddin, G. S. (2020). The Role of Underground Storage in the Dynamics of the US Natural Gas Market: A Threshold Model Analysis. *Energy Economics, 87*, 104713. https://doi.org/10.1016/j.eneco.2020.104713
[60] https://www.noaa.gov/news/us-had-its-warmest-winter-on-record

shocks, such as weather disasters, economic shifts, or supply disruptions.[61] In 2024, Henry Hub spot prices hit historic lows during a period of higher-than-average storage inventories following the 2023-2024 winter heating season. In real terms, prices averaged $1.51 per MMBtu in March 2024, the lowest monthly price on record. Spot prices also reached the lowest annual average of $2.21 per MMBtu in 2024.[62]

Figure 11 plots Henry Hub futures prices against underground storage inventories relative to the rolling five-year average. Simple trend lines have been included for select periods before and after 2020. Three distinct trends emerge. Between 2015 and 2020, prompt-month natural gas futures prices appear modestly responsive to changes in storage inventory levels, with prices rising moderately as inventories show increasing deficits relative to the five-year average. During 2022, prompt-month natural gas futures prices were much more responsive to changes in inventory levels. This trend is largely driven by natural gas price increases that began in the spring of 2022 and extended through the summer before moderating by the end of 2022. The third trend from 2023 to 2025 is more in line with pre-2022 patterns. It's important to note that global commodities all saw a run-up in pricing during this period in 2022, so the relative contribution of North American market fundamentals versus other market factors contributing to the higher natural gas prices during 2022 is not clear. Therefore, predictions about where the market may be headed in the future cannot be inferred from this chart.

Figure 11



LNG storage is far smaller than underground working-gas inventories, yet it can also influence domestic market pricing and supply availability. Peak shaving facilities are critical for meeting peak day demand requirements and maintaining gas distribution system pressures during periods of high demand or supply constraints. As mentioned in Section 2, peak shaving facilities are designed to supplement short-term supply, with inventories often utilized over just a few days, followed by a gradual refill taking place over several months. This process

[61] Rubaszek, M., & Uddin, G. S. (2020). The Role of Underground Storage in the Dynamics of the US Natural Gas Market: A Threshold Model Analysis. *Energy Economics, 87*, 104713. https://doi.org/10.1016/j.eneco.2020.104713
[62] Prices adjusted for inflation using U.S. Bureau of Labor Statistics December 2024 CPI-U.

can be extended if the market faces a prolonged period of heightened prices. Because peak shaving facilities sit behind the citygate, the price of gas at key hubs across the U.S. is less likely to be directly impacted by LNG storage inventory levels at peak shaving facilities operating behind the citygate.[63]

LNG export facilities offer a different kind of flexibility. Although they generally run at baseload to meet long-term contracts, they can curtail feedgas during periods of exceptionally high demand, particularly in winter months, redirecting gas into the market to serve domestic supply needs.[64] LNG export facilities can also vaporize stored LNG and send it into the market, depending on contractual and commercial conditions and arrangements.[65]

International markets also depend on LNG storage. Floating storage units (FSUs), as well as tanks at LNG import and export facilities, can contribute as buffers to smooth supply-demand imbalances. If global LNG markets face oversupply or weakened demand, gas tends to be stored at import and export facilities or on FSUs as the market adjusts to the demand shifts. In contrast, if global LNG markets experience supply shortages or heightened demand, LNG is often withdrawn from these facilities. In either case, the price of LNG in different regions converges toward the price of natural gas in the region those facilities serve. Additionally, at LNG import facilities, low storage can indicate increasing domestic demand or supply constraints and vice versa.

U.S. LNG feedgas is one component of domestic demand that helps shape domestic supply-demand fundamentals, which in turn shape domestic pricing. Even as LNG exports have grown significantly since 2016, according to industry research, there is little evidence that LNG feedgas for exports has had a sustained or significant direct impact on domestic prices to date.[66] Expectations are that U.S. LNG export demand will continue to rise, and with it, evolving dynamics regarding domestic and international markets. Importantly, as LNG export demand grows, additional domestic natural gas storage will likely be needed to support market flexibility.[67]

4. Seasonality, Reliability, and Resiliency

Paramount to the discussion of the value that storage provides to the domestic energy system are the seasonality, reliability, and resiliency that storage offers. Stored natural gas plays a crucial role during key seasonal shifts, such as heat waves and severe cold events, as well as hurricanes and wildfires. Natural gas

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[63] The “citygate” is generally the point where natural gas is transferred from an interstate or intrastate pipeline to a local natural gas utility. *See* https://www.aga.org/research-policy/resource-library/natural-gas-prices/

[64] Feedgas is the amount of natural gas delivered via pipeline to liquefaction facilities to be converted to LNG.

[65] https://www.spglobal.com/commodity-insights/en/news-research/latest-news/lng/012224-us-lng-exporters-canceled-cargoes-amid-freeze-as-us-gas-prices-surged

[66] https://lngallies.com/wp-content/uploads/2024/02/USLNG-Study-2024-02-15.pdf

[67] https://www.spglobal.com/commodityinsights/ko/market-insights/latest-news/natural-gas/032824-us-gas-prices-to-be-increasingly-linked-to-international-markets-through-lng

service to homes and power generators is enhanced by the availability of underground and LNG storage, which serves to mitigate disruptions to the delivery system or to meet significant short-term demand requirements.

Storage is also critical for providing year-round system reliability and resiliency for natural gas customers and for other parts of the energy system. Reliability and resiliency are distinct concepts. Resilience is "the ability of the energy system to prevent, withstand, adapt, and recover from a system disruption."[68] In contrast, reliability "focuses on the ability of the energy system to deliver services in the quantity and with the quality demanded by end-users."[69] The key distinction between these two concepts is the event type. A reliable system responds adequately to high-probability, low-impact events and disruptions such as common storms. In contrast, a resilient system responds effectively to low-probability, high-impact events such as hurricanes.

Seasonal Role of Stored Natural Gas

In the U.S., natural gas consumption patterns are influenced by various structural and seasonal factors, including temperatures. Natural gas consumption typically peaks during the winter months due to the significant demand for residential and commercial heating. However, natural gas consumed by the electric power sector for electricity generation tends to peak in the summer months when warmer temperatures drive consumer demand for more electricity for air conditioning.[70]

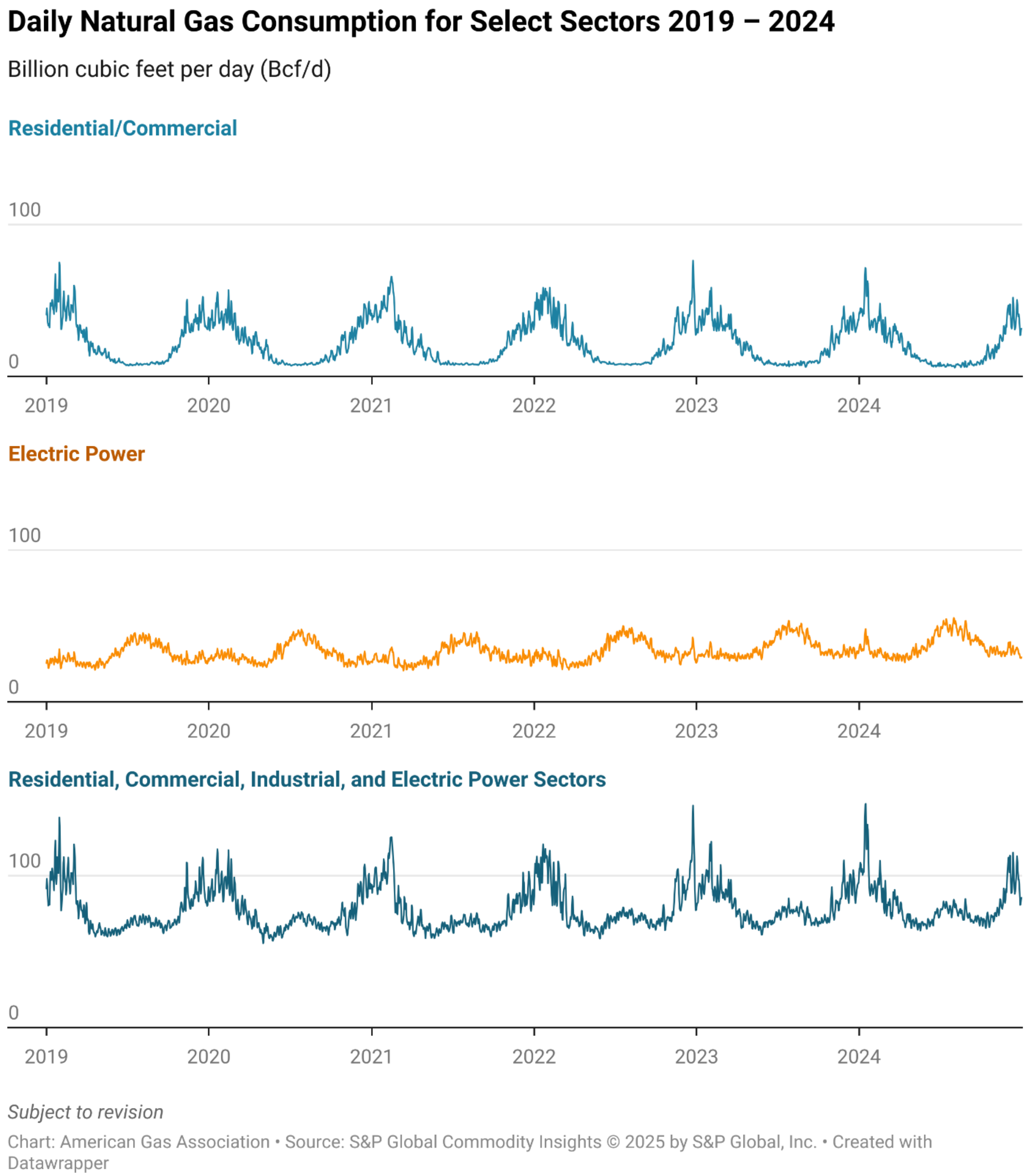
Figure 12 depicts daily residential/commercial and electric power sector demand from 2019 through 2024. As the chart shows, residential/commercial demand peaked on December 24, 2022, for this period. Comparatively, the electric power sector reached an all-time daily consumption record on August 1, 2024.

[68] American Gas Foundation. (2022). *Enhancing and Maintaining Energy System Resilience: Areas of Focus and Change*. https://gasfoundation.org/wp-content/uploads/2022/10/AGF-Enhancing-and-Maintaining-Gas-and-Energy-System-Resiliency-Report-NOV.pdf

[69] *Id*.

[70] Natural gas demand in the Industrial sector follows a similar pattern to the Residential and Commercial sector in that demand tends to peak during the winter and trough during the summer. However, the range of demand peaks and troughs is much narrower with Industrial sector consumption.

Figure 12



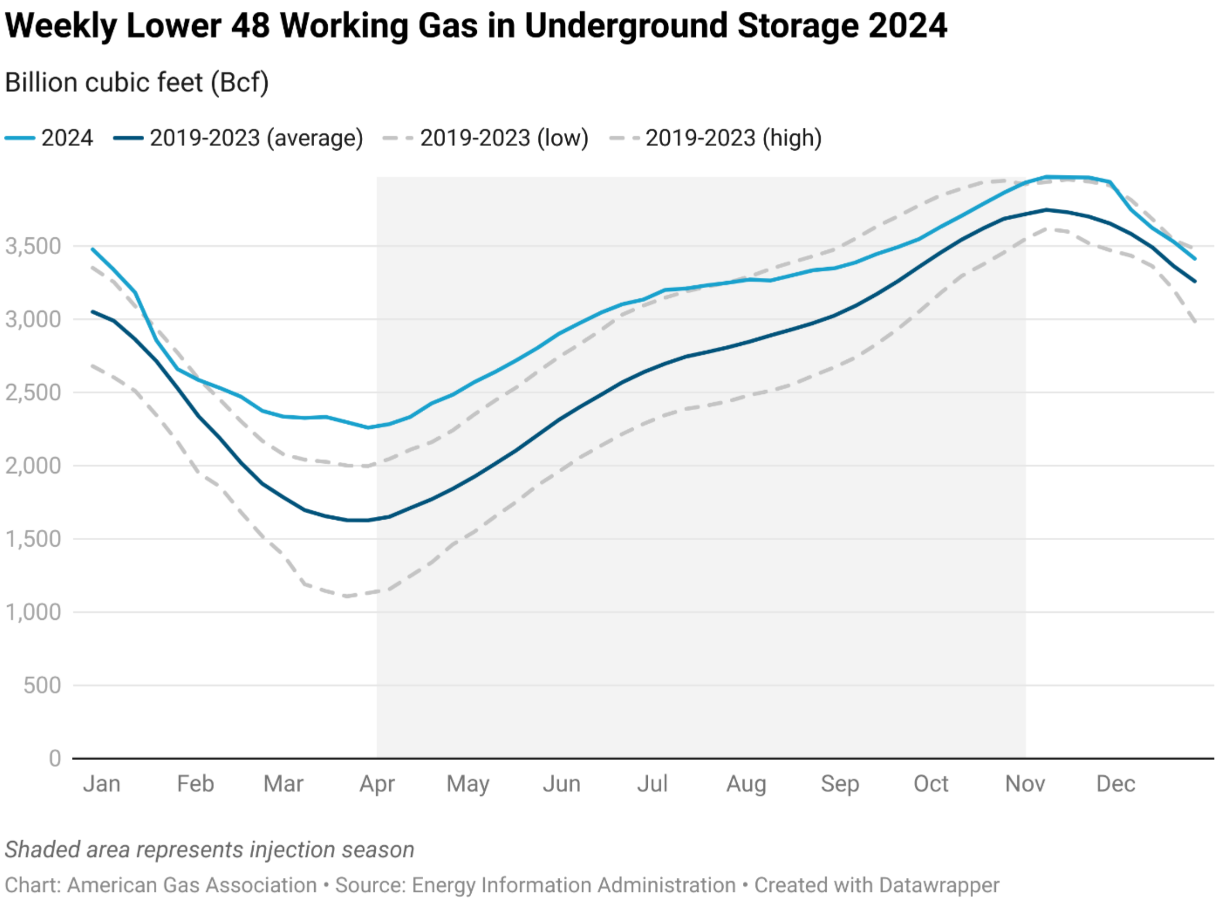
The U.S. generally injects excess natural gas produced during the warmer months (*i.e.*, injection season, which runs from April 1 to October 31 of each year) and generally withdraws stored natural gas as needed during the colder months (*i.e.*, withdrawal season, which runs from November 1 to March 31 of each year). Various factors, such as changes in demand or production, can impact storage levels during each of these seasons. As demand increases, such as during the winter months or heat waves in the summer, stored natural gas becomes essential to maintain resilience and reliability.

During the summer months, the pace of injections may slow as summer cooling demand redirects volumes toward end uses such as electric power generation. In fact, in some regions, the demand during peak summer months can be so large that it necessitates net withdrawals from storage during the injection season.[71] Similarly, if production lags annual trends due to weather-related events (*e.g.*, hurricanes impacting production and transmission hubs) or market pressures (*e.g.*, falling natural gas prices leading to producer curtailments), injection volumes into underground storage tend to slow.

Figure 13 depicts the changes in working gas in underground storage for the lower 48 throughout 2024. The graph shows increasing working gas storage volumes during the injection season and declining underground inventories during the withdrawal season. According to the EIA, weekly storage levels were 3,476 Bcf as of December 29, 2023, and 3,336 Bcf as of January 5, 2024. For the week ending December 27, 2024, total underground inventory was 3,413 Bcf, 154 Bcf higher than the five-year average from 2019 to 2023. In 2024, weekly underground storage levels exceeded both the five-year average and the upper end of the five-year range in approximately 60 percent of the weeks.

[71] Assuming production levels are not increasing in tandem.

Figure 13



Annual LNG storage volume addition and withdrawal data indicate significant variability year-to-year, although the data is not available at the same weekly detail as underground storage inventories.[72] Over the last two decades, the EIA reports average net LNG withdrawals of 4.4 Bcf per year for 12 of those years, while the remaining eight years represent net LNG additions of 2.2 Bcf per year. Overall, net LNG withdrawals for the U.S. averaged 1.8 Bcf per year for the most recent 20-year period.

LNG storage facilities are particularly critical for meeting peak winter demand, especially in regions with pipeline capacity constraints and limited access to underground storage facilities. For example, due to geological unsuitability, New England has no underground storage facilities, so it relies on LNG for 28 percent of its design day[73] supply in the winter.[74] LNG storage facilities are also commonly used for peak shaving

[72] In the context of LNG storage, storage additions are similar to underground storage injections in that LNG is being placed into storage.
[73] Design day refers to the coldest hypothetical winter day when demand is expected to reach its highest peak. Natural gas utilities use the design day as a tool for system planning and winter heating season preparation.
[74] https://northeastgas.org/about-lng

electricity demand during the summer. As such, unlike refill and withdrawal seasons for underground storage, there is not a general withdrawal and refill cycle for LNG.

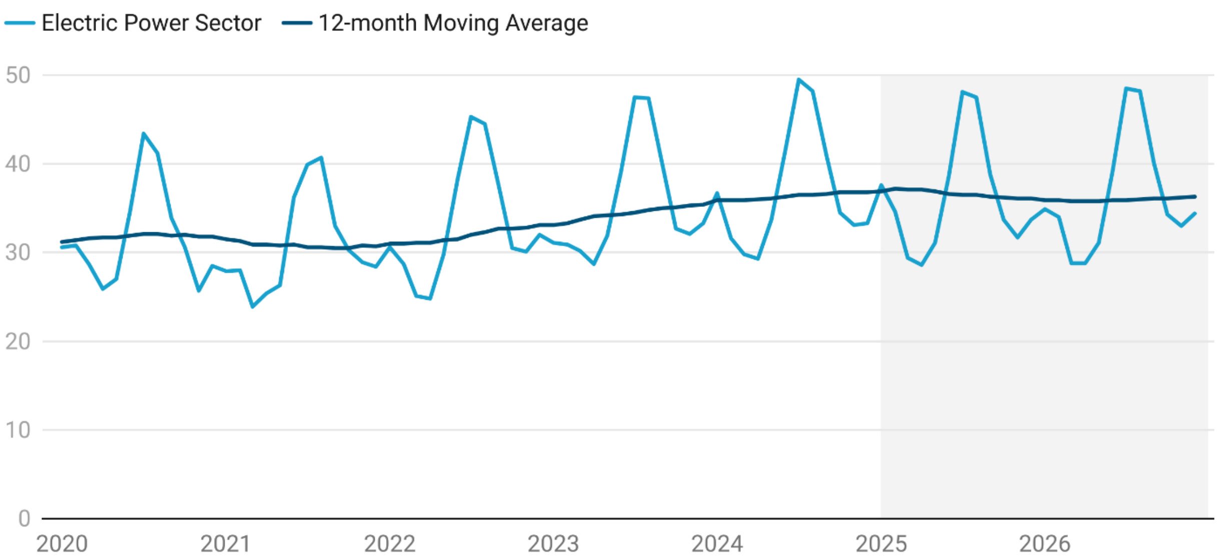
Changing Landscape of Electric Generation

Over the last two decades, natural gas consumption by end-use sector has evolved in response to changing domestic needs.[75] According to the EIA, the industrial sector was the leading end-use consumer of natural gas in 2001, accounting for approximately 36 percent of total end-use consumption.[76] By 2024, that number had declined to about 29 percent. In contrast, demand in the electric power sector nearly doubled over the same period, increasing its share of domestic demand from 26.1 percent in 2001 to 45.3 percent in 2024.[77] Figure 14 shows the monthly trend of natural gas consumed by the electric power sector between January 2020 and December 2024, and projected demand through the end of 2026.

Figure 14

U.S. Natural Gas Consumption in the Electric Power Sector 2020 to 2026

Billion cubic feet per day (Bcf/d)



Subject to revision

Chart: American Gas Association • Source: EIA March 2025 Short-Term Energy Outlook • Created with Datawrapper

Both average and peak natural gas use in the electric power sector have increased. In the 2018 refill season, peak day demand for natural gas in the electric power sector was 43.2 Bcf per day. By the 2024 refill season, peak day demand had increased more than 28 percent to 55.3 Bcf per day. Similarly, the average demand for

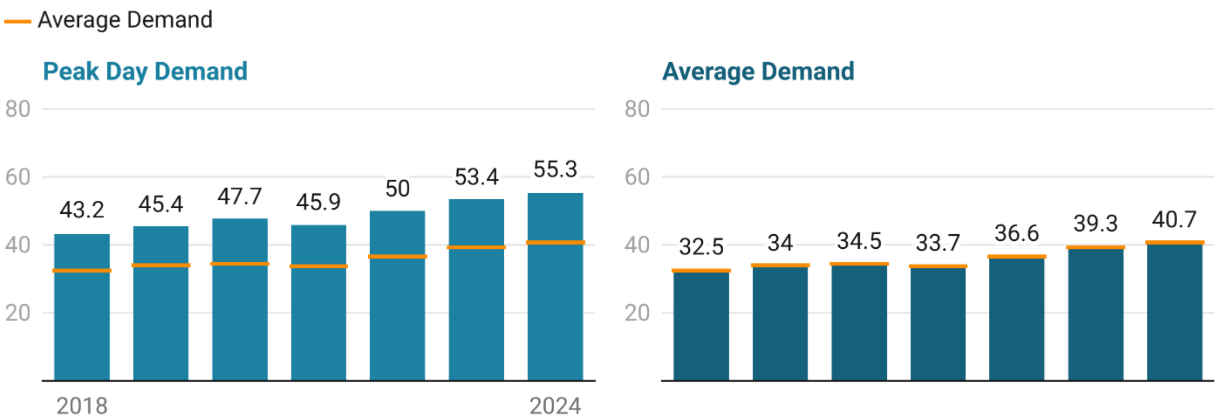
[75] In this context, end-use refers to natural gas consumption by the residential, commercial, industrial, and electric power sectors only.
[76] https://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_m.htm
[77] Over the same period, total natural gas consumption in the power sector increased by approximately 7.6 trillion cubic feet (Tcf) or 142 percent. For 2024 year-to-date through October, total natural gas consumed by the power sector was 11.5 Tcf.

natural gas during this time grew from 32.5 Bcf per day to 40.7 Bcf per day, an increase of just over 25 percent. From the 2018 to 2024 refill seasons, peak day demand has been 1.4 times larger than average demand. Figure 15 illustrates this trend. Comparatively, peak day and average demand during what are generally the two hottest months of the year—July and August—are nearly on par, with peak day demand being 1.1 times larger than average demand for each of these years.

Figure 15

Refill Season Electric Power Sector Natural Gas Demand

Billion cubic feet per day (Bcf/d)



Date ranges reflect April 1 through September 30 of each year.

Chart: American Gas Association • Source: S&P Global Commodity Insights © 2025 by S&P Global, Inc. • Created with Datawrapper

Coal plant retirements, low natural gas prices, low wind and hydropower output, and high cooling demand in some regions have also increased the demand for natural gas in the power sector.[78] The increased use of natural gas for electric generation has shifted the seasonality of demand and reduced seasonal price spreads. This fundamentally erodes the valuation of underground storage and impacts its use during the refill season. Section 5 will discuss the valuation of underground and LNG storage facilities, including seasonal price spreads, in further detail by considering both market-based and regulatory values.

During the summer months, total underground storage withdrawals have trended upward since 2011.[79] In the summer of 2024, withdrawals reached an all-time high of 548 Bcf. Power demand also set a new daily record during this period, reaching 7.1 million MWh on August 2, 2024.[80] Between 2011 and 2024, summer withdrawals from underground storage grew at a compound annual growth rate[81] (CAGR) of 3.9 percent. By

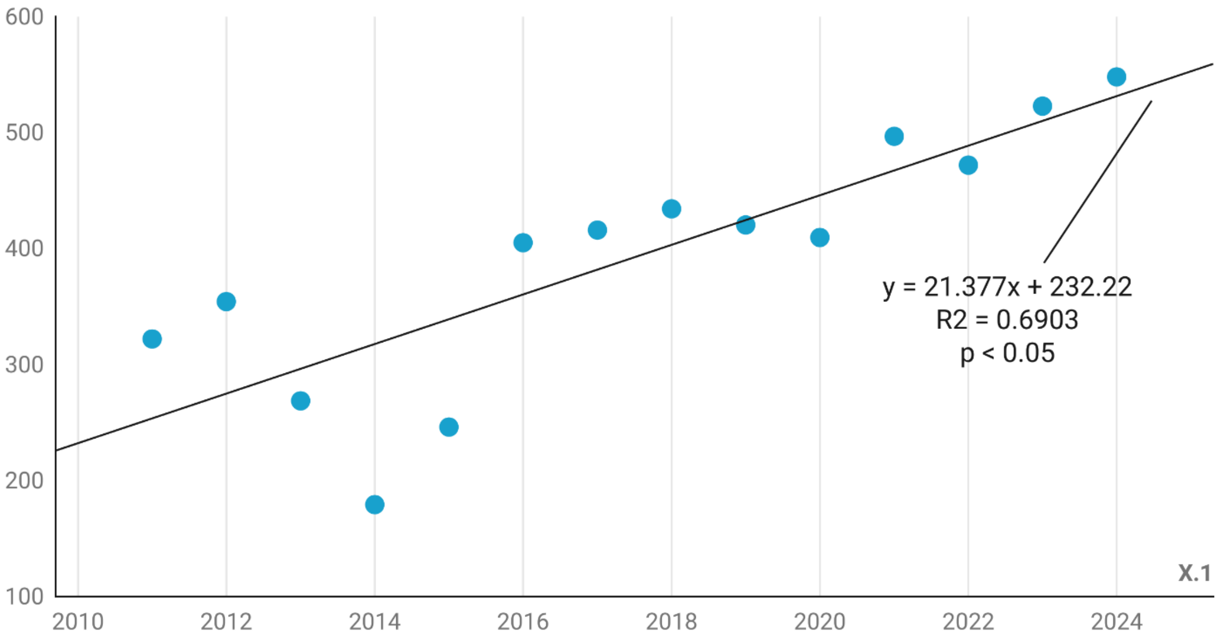
[78] https://www.iea.org/commentaries/natural-gas-is-now-stronger-than-ever-in-the-united-states-power-sector
[79] Summer months include June, July, and August.
[80] https://www.eia.gov/todayinenergy/detail.php?id=63404
[81] The compound annual growth rate (CAGR) measures the average annual growth rate over a period of time under the assumption that growth happened at a steady, compounded rate each year.

comparison, summer withdrawals grew at a 6.0 percent CAGR from 2020 through 2024. Figure 16 illustrates total summer withdrawals by year, as reported by the EIA.

Figure 16

Lower 48 Total Summer Withdrawals from Underground Storage 2011 – 2024

Billion cubic feet (Bcf)



Summer withdrawals represent the months of June, July, and August of each year

Chart: American Gas Association • Source: Energy Information Administration • Created with Datawrapper

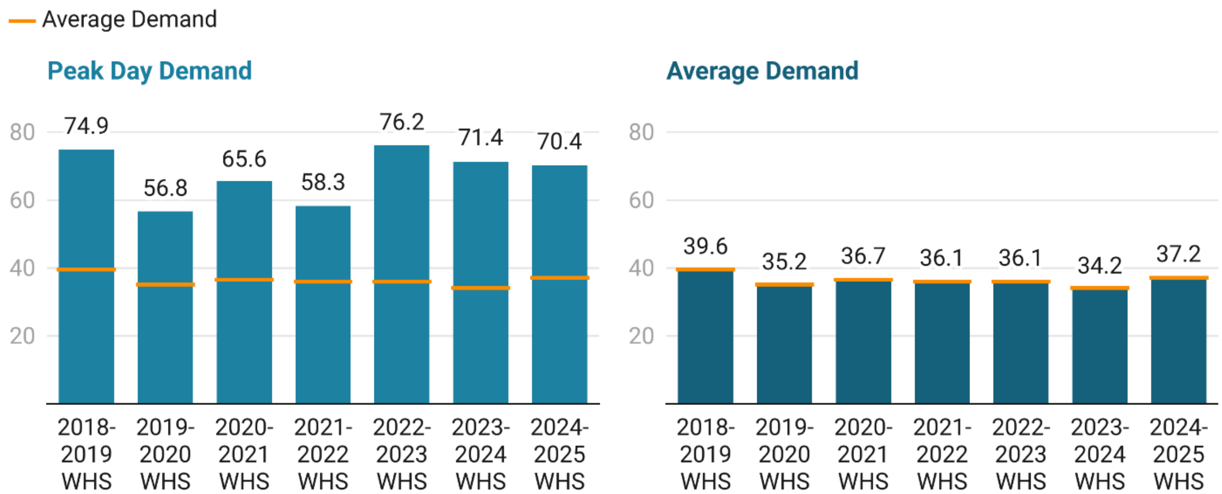
Role in Winter Heating Season Preparation

As with the refill season analysis discussed previously, peak day natural gas demand exceeds average demand during the withdrawal season. Between the 2018-2019 and 2024-2025 winter heating seasons, peak day demand in the residential and commercial sectors was, on average, nearly two times larger than average demand. The spread between average and peak natural gas demands during the heating season was significantly larger than the spread in electric power demand during the cooling season. Figure 17 shows that during this time, peak day demand averaged 67.7 Bcf per day while seasonal average demand averaged 36.4 Bcf per day. However, since 2018, peak day and average demand have fallen by approximately 6 percent each.

Figure 17

Winter Heating Season Residential and Commercial Natural Gas Demand

Billion cubic feet per day (Bcf/d)



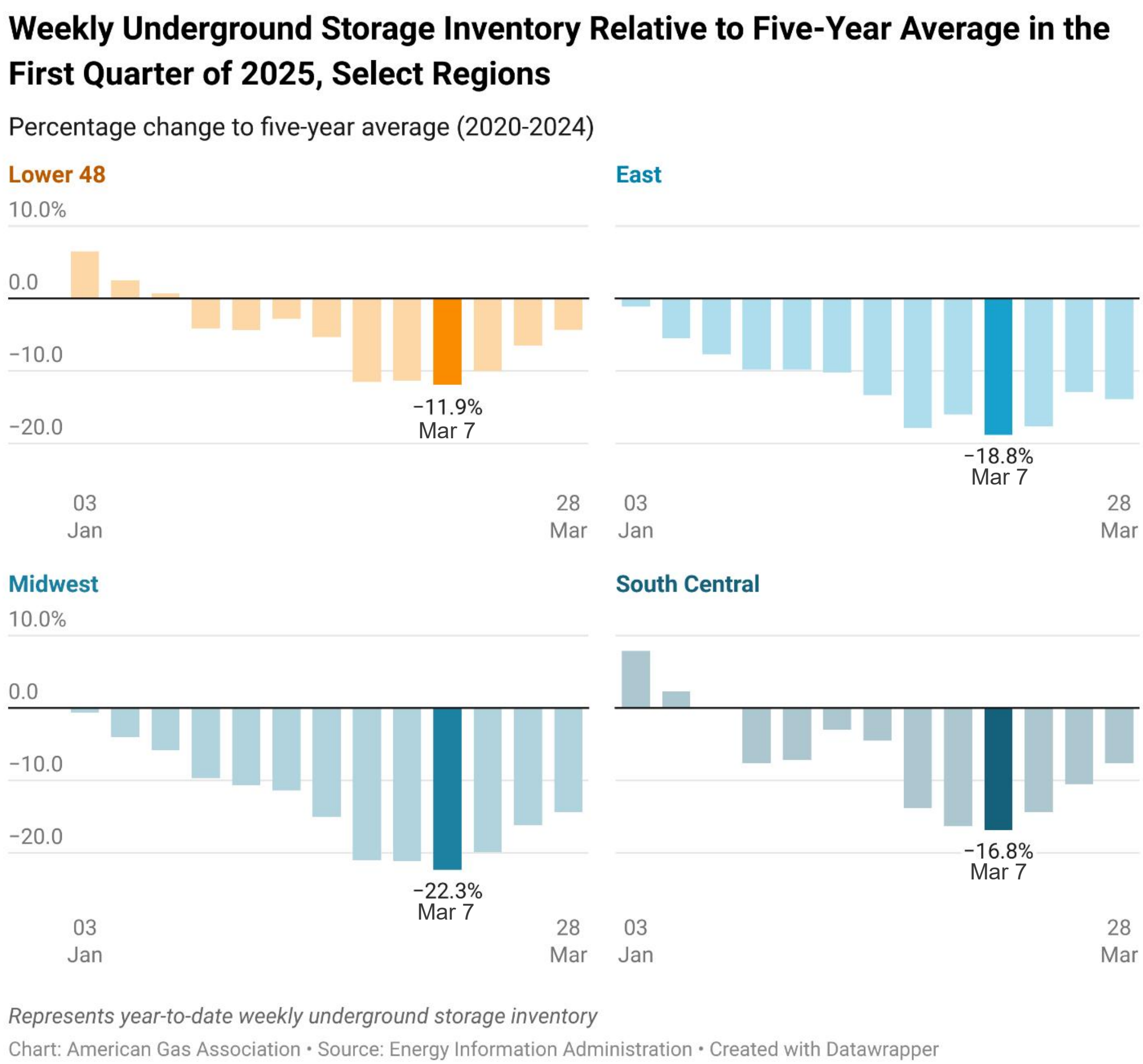
Date ranges reflect November 1 through March 31 of each year.

Chart: American Gas Association • Source: S&P Global Commodity Insights © 2025 by S&P Global, Inc. • Created with Datawrapper

While demand changes over very short periods of time, particularly when temperatures rise and fall abruptly, natural gas producers require planning to ramp up production. Thus, production is usually not immediately responsive to demand signals, meaning that storage is essential to meet short-term fluctuations in winter demand. For example, during the extreme winter weather of early 2025, Winter Storms Blair and Cora unleashed back-to-back snow and freezing conditions between January 4 to 11 from Utah to the East Coast and the western Gulf of Mexico to the Deep South. A week later, an Arctic blast moved through the U.S. from January 19 to 24, bringing freezing temperatures to most states. Between January 20 and 22, Winter Storm Enzo impacted states along the Gulf Coast and Southeast.

In response to the increased need for natural gas to provide essential heat for households and businesses and increased demand in the power sector to generate electricity, underground storage inventory in key regions was heavily utilized. As a result, national inventory levels declined, falling below the five-year average in the first quarter of 2025. Weekly storage data from the EIA showed the decline to be particularly marked in the East and Midwest regions. In certain weeks, inventories in these regions dropped below the minimum of the corresponding five-year inventory range as well. In the South Central region and the lower 48, inventories dipped below the five-year average for the week ending January 24 but remained above five-year minimum inventory levels. Through March 2025, the Midwest experienced the largest deviation in storage inventory relative to the five-year average of more than 22 percent for the week ending March 7. Figure 18 provides a graphical representation of these trends.

Figure 18



To ensure reliable and safe service during these yearly demand spikes, natural gas LDCs develop strategic plans, building carefully crafted supply portfolios using a mix of historic data and modeled forecasts of expected demand loads. Storage is a critical tool in this planning process. According to the AGA's 2022-2023 Winter Heating Season Performance Survey, 97 percent of respondents (36 of 37) used underground storage for a portion of their gas supply during the winter heating season. On average, these 36 LDCs stored 23 percent of their total winter supply portfolio in underground storage.

Additionally, at the aggregate level, LDCs reported using storage for a greater portion of their supply during their peak winter day than during the rest of the winter heating season, when compared to other supply tools. For example, during the peak day, the aggregate volume of gas supply acquired through pipeline or other storage represented 24 percent of the total reported supply, an 11 percentage point increase over the reported share utilized during the rest of the winter heating season. Supply categories, including on-system underground storage and LNG, propane-air (also referred to as liquid propane or LPG), and synthetic natural gas (SNG), also saw an increased use on the peak day in the 1.5 to 3 percent range. Outside of these storage tools, citygate purchases for sale customers increased by 5.4 percentage points, and other supply sources (including linepack and transporter imbalances) increased by 0.2 percentage points. All other supply tools were utilized less during the peak day than during the rest of the winter heating season, indicating the importance of storage assets for service reliability during peak [82]demand events.[83]

System Reliability

The ability to efficiently and quickly draw from natural gas inventories is a cornerstone of energy market reliability and stability. As discussed previously, reliability is an energy system's ability to deliver energy consistently to meet demand requirements and is characterized by low-impact, high-probability events. In fact, "the U.S. energy system manages reliability daily—in the standard fluctuations in energy supply and demand."[84] From normal conditions to severe weather events, withdrawals from storage facilities can compensate for reduced production or increased demand, thereby preventing widespread supply shortages. Such operational flexibility not only bolsters system reliability but also reduces the risk of price spikes.

In addition to providing a buffer against disruptions, storage enables market operators to optimize the timing of gas injections and withdrawals for operational or commercial benefits. Adequate availability of stored natural gas paired with adjacent pipeline delivery infrastructure can help meet demand requirements and reduce price risk for consumers.

Resiliency: Fallback and End-Use Potential

Resilience is characterized by high-impact, low-frequency events. Natural gas storage contributes to a resilient energy system as a fallback option during inclement weather events, such as winter storms, when typical supply routes may be impacted. During extremely cold conditions, natural gas production can experience freeze-offs, a temporary condition when liquids in unprocessed natural gas freeze in equipment at the wellhead, preventing normal flowing production. Freeze-offs can contribute to short-term reductions in dry gas production available to the market. These conditions can be challenging for some consumers, such as electric power plants, that are generally more reliant on spot gas purchases and non-firm transportation services.

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[82] Transporter imbalances refer to differences between the amount of natural gas a shipper schedules and the amount delivered or used in a pipeline system.

[83] Disclaimer: The aggregated data presented are not to be interpreted as standards or leading practices for gas supply management but instead represent a snapshot of the aggregated practices of those companies that participated in AGA's 2022-2023 survey. The need for and timing of any of the described practices will vary with each operator based on several factors, including unique regulatory, geographic, and operational characteristics. To learn more about AGA's Winter Heating Season Performance Survey, please visit: https://www.aga.org/research-policy/resource-library/2022-2023-winter-heating-season-performance-survey-overview/.

[84] American Gas Foundation. (2021). *Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience.* https://gasfoundation.org/wp-content/uploads/2021/01/Building-a-Resilient-Energy-Future-Full-Report_FINAL_1.13.21.pdf

Storage can prove critical during freeze-offs. For example, if a power plant is co-located with natural gas storage, the power plant can harness that reserve supply during periods of supply constraints. Similarly, stored natural gas can cover supply gaps in the event of a pipeline operator calling on its interruptible customers to reduce demand or even during force majeure events where supply or transportation cannot be maintained.

Natural gas is very useful in a flexible fuel-switching environment when other fuel sources have limited availability and are experiencing their own price spikes. In instances of supply disruptions, natural gas peaker plants with co-located gas storage can play a critical role in promoting energy resilience.

Recent research illustrates the value of natural gas storage for energy system resilience. A 2022 American Gas Foundation (AGF) study found that upstream and downstream investment in both storage facilities and storage distribution infrastructure contributes to natural gas AND electric system resilience.[85] Natural gas storage infrastructure—both above and below ground—has proven invaluable during supply disruptions and demand peaks. As the AGF study shows, it is imperative that adequate pipeline infrastructure be available to interconnect the natural gas system from the storage facility to end-use customers.

Natural Gas Storage Resilience: A Case Study

The following case study is intended to expand on the earlier discussion of the role natural gas storage played during the winter storms and Arctic blast in early 2025, specifically with respect to other extreme weather events, such as wildfires, hurricanes, and winter storms over the last decade.

Much of the U.S. experienced colder-than-normal temperatures in mid-February 2021, when Winter Storm Uri impacted much of the Southwest. Uri affected natural gas production in Texas and nearby areas due to freeze-offs, contributing to production losses of nearly 45 percent in Texas and 21 percent for the U.S. as a whole from the week ending February 13 to February 17.[86] The EIA reported that Uri contributed to production declines of nearly 5 Bcf per day from the Permian region and more than 2 Bcf per day from the Haynesville region.[87] [88] Stored natural gas proved to be a crucial resource during this time. For the week ending February 19, 2021, net withdrawals from underground storage reached nearly 340 Bcf, the second largest reported withdrawal from natural gas storage in the U.S., with a record withdrawal of 156 Bcf occurring in the South Central region that week.[89]

Additionally, supply constraints at this time contributed to rising natural gas prices. The Tuscan LNG Plant in Southern Arizona vaporized and injected more than 10,000 dekatherms of stored gas into the distribution system during Uri, saving Southwest Gas customers $1.5 million over two days.[90] Absent the availability of

85 American Gas Foundation. (2022). *Enhancing and Maintaining Energy System Resilience: Areas of Focus and Change*. https://gasfoundation.org/wp-content/uploads/2022/10/AGF-Enhancing-and-Maintaining-Gas-and-Energy-System-Resiliency-Report-NOV.pdf

86 https://www.eia.gov/todayinenergy/detail.php?id=46896

87 By comparison, Winter Storms Elliott and Heather, which occurred in December 2022 and January 2024, respectively, are estimated to have reduced natural gas production in the Permian Basin by approximately 3 Bcf per day, while Elliott reduced production in the Northeast by more than 6 Bcf per day. *See*: https://www.eia.gov/todayinenergy/detail.php?id=61563

88 https://www.eia.gov/todayinenergy/detail.php?id=61563

89 https://www.eia.gov/todayinenergy/detail.php?id=46916

90 https://www.matrixservicecompany.com/wp-content/uploads/2023/03/LNGIndustry-March2023.pdf

natural gas storage inventory, service outages would have been more widespread, and Southwest Gas customer bills would have been higher.

Winter Storm Elliott affected the Eastern interconnection in late December 2022, impacting the energy system with winter peak loads that caused unplanned outages of 90,500 MW.[91] Additionally, Elliott severely impacted Consolidated Edison Company of New York's (ConEd) natural gas operations during this time. ConEd, the natural gas LDC for Manhattan, the Bronx, and parts of Queens and Westchester County, experienced supply disruptions when the utility's pipeline servicers lost pressure. By preemptively planning for the storm, curtailing supply to interruptible customers, and activating its LNG facility, ConEd was able to maintain its distribution system pressure and was able to serve all homes during the height of the cold weather event. Of note, the LNG facility was dispatched on the afternoon of December 24 and returned to stand-by status the following morning when pipeline pressures began to improve, to preserve inventory.

The Polar Vortex that affected Oregon in February 2014 relied heavily on natural gas storage to maintain service. According to one report, nearly half of the Northwest Natural system peak that occurred on February 6, 2014, was met by storage inventory, "highlight[ing] the critical role that natural gas storage plays in meeting demand during extreme weather events."[92]

While not specific to the Polar Vortex, the winter of 2013-2014 represented the largest drawdown[93] from U.S. natural gas storage to date. By the end of the 2013-2014 winter heating season, storage levels in the lower 48 fell to 822 Bcf for the week ending March 28, 2014, nearly 49 percent below the five-year minimum.[94]

Natural gas storage contributes to system resiliency during hurricanes, droughts, and wildfires as well. In August 2020, Hurricane Isaias affected the energy system along the Atlantic coast from North Carolina to New England. In New Jersey in particular, New Jersey Natural Gas experienced a 60 percent demand increase on its system as residential and commercial customers used natural gas-fueled backup generators during power outages. The Company was able to manage the increased demand via built-in natural gas storage inventory and system flexibility.[95] In California, Southern California Gas Company used its natural gas storage to continue service in August 2020 despite increased cooling demand due to high temperatures and reduced renewable energy generation as a result of wildfires.[96]

Without adequate inventories of underground and LNG storage at these times of critical need, service to power plants, businesses, and homes would have been critically endangered.

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91 FERC & North American Electric Reliability Corporation (NERC). (2023). *Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliot: FERC, NERC, and Regional Entity Staff Report.* https://www.ferc.gov/media/winter-storm-elliott-report-inquiry-bulk-power-system-operations-during-december-2022

92 American Gas Foundation. (2021). *Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience.* https://gasfoundation.org/wp-content/uploads/2021/01/Building-a-Resilient-Energy-Future-Full-Report_FINAL_1.13.21.pdf

93 https://www.eia.gov/todayinenergy/detail.php?id=15391

94 https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2014/04_03/

95 American Gas Foundation. (2021). *Building a Resilient Energy Future: How the Gas System Contributes to US Energy System Resilience.* https://gasfoundation.org/wp-content/uploads/2021/01/Building-a-Resilient-Energy-Future-Full-Report_FINAL_1.13.21.pdf

96 *Id.*

Supporting a More Dynamic Energy Landscape

As the energy system evolves and becomes increasingly reliant on natural gas and renewable energy sources, the role of natural gas storage must be considered in the context of broader system needs. This includes not only seasonal balancing and emergency response but also the ability to support increasingly dynamic, flexible operations across the value chain. One of the most pressing structural changes in today's energy mix is the rising share of renewable generation,[97] particularly wind and solar, driven by policy goals, technology advancements, and market evolution. While renewable resources are a necessary tool in an increasingly cleaner grid, the inherent variability and weather dependence of these energy sources place added pressure on the rest of the energy system to remain reliable and responsive, particularly when renewable energy is unable to come online quickly.

Natural gas is uniquely positioned to serve as a balancing tool in this energy environment since it can respond quickly to declines in renewable output and can be stored in LNG tanks near generating facilities. The scope and size of natural gas storage facilities make natural gas storage an unmatched buffer for extreme seasonal peaks and emergency events. Notwithstanding recent significant advances and investment into battery technology, natural gas storage remains a critical enabler of real-time system flexibility.

Table 4 illustrates the estimated daily stored electricity output of both pumped hydro and battery storage compared to natural gas storage. Pumped hydro and battery storage have a combined nameplate capacity of 50 gigawatts (GW) with an estimated combined output of 146.5 gigawatt hours (GWh) per day. On average, current pumped hydro capacity can provide an estimated four hours of electric output per day, while battery storage can provide an estimated two hours of electric output per day. By comparison, actual peak day[98] natural gas output on January 21, 2025, the second-highest daily withdrawal to date, equates to nearly 21,100 GWh per day, 144 times the combined output from all currently existing battery and pumped hydro facilities in the US.

[97] For example, between 2020 to 2024, the portion of electric generation derived from renewable energy sources rose 3.3 percentage points from 19.5 percent to 22.8 percent according to EIA data. By comparison, the portion of generation derived from natural gas remained relatively flat, falling 0.5 percentage points from 39.1 percent to 38.6 percent.

[98] The largest single-day withdrawal occurred on January 1, 2018, and was slightly larger than January 21, 2025.

Table 4

U.S. Energy Storage Capacity and Daily Deliverability by Resource

Based on Maximum Nameplate and Monthly Capacity Factor through January 2025

Resource	Nameplate Capacity (GW)	Avg Hours/Day	GWh/Day
Pumped Hydro	23	4	93.1
Battery	27	2	53.4
Total	50		146.5
Natural Gas Storage		**Bcf/Day**	**GWh/Day**
Peak* Day Output on 1/21/2025		69.4	21,087.70

** Peak day output on January 21, 2025, is the second highest storage withdrawal reported by S&P Global. Subject to revision.*

Table: American Gas Association • Source: Energy Information Administration, S&P Global Commodity Insights © 2025 by S&P Global, Inc. • Created with Datawrapper

Reinforcing the Broader Value of Storage

As discussed earlier, natural gas storage delivers measurable value across the supply chain during both routine and extraordinary conditions. Its ability to reinforce reliability, stabilize markets, and absorb shocks has long been recognized. However, in a system increasingly shaped by variable generation and shifting consumption patterns, storage must also be recognized as a flexible asset that complements the use of renewables and helps bridge the gap between generation and demand.

Viewed through this lens, storage is a critical component of a resilient, adaptable energy system. It supports reliability not only in the face of seasonal or weather-driven challenges, but also as a daily operational tool in a modern, decarbonizing energy landscape. These flexibility attributes represent another layer of strategic value that natural gas storage provides to both natural gas industry and power sector stakeholders by completing the broader picture of storage as a foundational component of system reliability and resilience. Section 5 builds on this discussion of the value of natural gas storage by considering the economic valuation of storage for gas owners. This section discusses both intrinsic and extrinsic market valuation frameworks and describes the regulatory value derived through cost of service regulation.

5. Value of Storing Natural Gas

Natural gas storage facilities require substantial investment, often involving millions of dollars in construction costs and ongoing expenses for system maintenance and operation. To attract capital, storage facility developers must offer investors incentives that outweigh the actual and opportunity costs of the investment. One of the primary incentives for investors is the *value* that natural gas storage brings to the energy market. Thus, the cost-effectiveness of a project hinges on:

- The developer's ability to show that the value the project brings to the market is greater than its cost, and
- Its ability to show that the project's cost-effectiveness is at least as high as the cost-effectiveness of other potential projects with similar risk profiles.

Estimating the value of a project can be a complex task. For a storage facility that charges market-based rates, the valuation of gas storage is generally understood by its *intrinsic* and *extrinsic* values.[99] [100] Intrinsic and extrinsic valuations of gas storage can be modeled, calculated, and analyzed in several ways, but this report offers a generalized discussion of market valuation. For regulated storage facilities, such as those owned and operated by LDCs, valuation is based on a cost-of-service model which will also be discussed in this report.

Market-Based Valuation

Intrinsic Value

Intrinsic value refers to the inherent benefits of a project or contract resulting from the seasonal spread in natural gas prices. The intrinsic value of underground storage can be calculated by evaluating the seasonal spread between summer (injection) and winter (withdrawal) prices.[101] This value can be directly observed and hedged against current forward market prices and allows the opportunity to estimate a storage valuation at the time of injection or withdrawal that is independent of shifting market conditions.[102]

Seasonal price spread refers to differences in natural gas prices between seasons, which tend to follow a predictable yearly pattern. During the refill season, natural gas prices tend to be lower due to higher temperatures and lower demand. Conversely, during the withdrawal season, natural gas prices tend to be higher as colder temperatures drive increased energy demand.[103] The owners of gas in storage capitalize on

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[99] Facilities that charge market-based rates are authorized by FERC pursuant to the 2005 Energy Policy Act. *See* Section 3, Jurisdictional Considerations.
[100] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook.* https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pdf
[101] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook.* https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pd
[102] https://www.lacimagroup.com/wp-content/uploads/2020/08/Gas-storage-overview-static-valuation.pdf
[103] Withdrawal season also aligns with the winter heating season months.

seasonal spreads by optimizing the timing of gas storage injections and withdrawals to maximize profit. The larger the seasonal spread, the higher the intrinsic value of storage, as owners can withdraw and sell gas at a premium (a price higher than the price of gas when it was injected).[104]

In the past, large seasonal spreads equated to high intrinsic value for underground storage. However, since the late 2000s, shrinking seasonal spread in the U.S. has diminished the inherent value of gas storage units.[105] The increased use of natural gas for export and during the summer months for electric generation has increased base load demand and reduced seasonal spreads. The shale gas revolution has enabled the shift by greatly increasing domestic natural gas supply since 2000.[106]

FERC's 2011 *State of the Markets* report highlighted factors contributing to declining seasonal spread, stating,

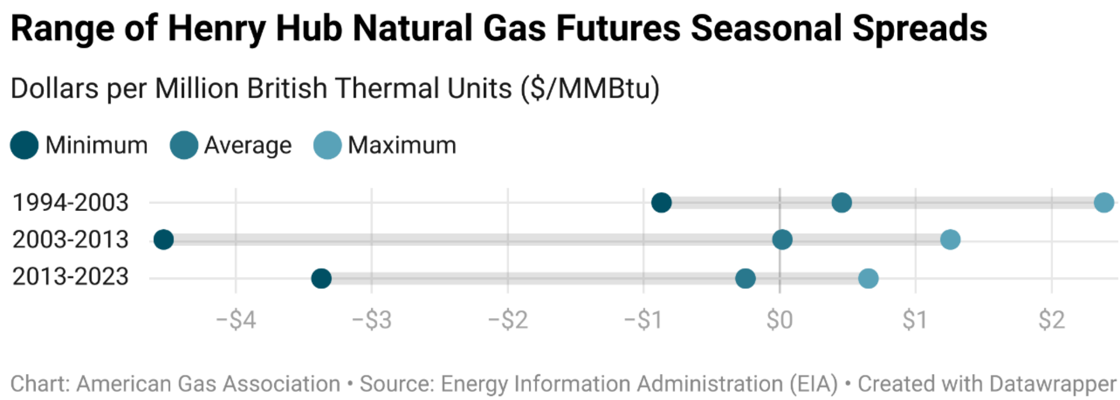
> "[f]alling seasonal spreads reflect increased production and storage capacity, as well as greater year-round use of natural gas by power generators. … [W]e expect this trend to continue."[107]

Since 2011, production and the use of natural gas for electricity generation have continued to climb, while underground storage development has slowed significantly.[108] Despite this sluggish capacity growth, seasonal price spreads have continued to shrink over the last decade. Figure 19 illustrates this trend.

Between 2013 and 2023, the average seasonal spread of natural gas in underground storage was -$0.26 per MMBtu, indicating that futures contract prices during the winter heating season were lower on average than those during the preceding refill season over this period. In comparison, the average price of gas during the refill season was lower than the price of gas during the winter heating season in the two decades prior, providing an average value of $0.02 per MMBtu between 2003 and 2013 and an average value of $0.46 per MMBtu between 1994 and 2003.[109]

[104] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook*. https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pdf
[105] Hénaff, P., Laachir, I., & Russo, F. (2018). Gas Storage Valuation and Hedging: A Quantification of Model Risk. *International Journal of Financial Studies, 6*(1), 27. https://doi.org/10.3390/ijfs6010027
[106] https://thebreakthrough.org/issues/energy/history-of-the-shale-gas-revolution
[107] https://www.ferc.gov/sites/default/files/2020-05/som-rpt-2011.pdf
[108] See Section 3, Figure 6.
[109] https://www.eia.gov/dnav/ng/ng_pri_fut_s1_m.htm. Note: Values are calculated using Henry Hub monthly natural gas futures contract prices. As of 3/5/2025 available data reflects prices between December 1994 to April 2024.

Figure 19



While the intrinsic value of natural gas is a useful tool in assessing the cost-effectiveness of storage projects, it fails to capture short-term market changes effectively. [110] To account for that deficiency, analysts also look at the extrinsic value of storage.

Extrinsic Value

Extrinsic refers to the option value outside of intrinsic value that can be derived from the flexibility storage assets provide in response to market changes. However, unlike intrinsic value, extrinsic value cannot be observed or hedged at the time of valuation.[111] At its most basic level, extrinsic value is determined by the ability of storage owners and operators to profit from the optionality inherent in storage and the ability to respond to price movements, uncertainty, and volatility.[112] [113] Thus, extrinsic value can be calculated as the incremental value that storage owners can earn by re-optimizing withdrawals and injections according to spot and forward price movements.[114]

Over time, as the shrinking seasonal spread has diminished the intrinsic value of storage, the extrinsic valuation has become increasingly important to facility owners. Storage owners and operators may have a greater opportunity to realize increased extrinsic value when there is high price volatility by selling stored gas into the market when prices rise and injecting gas into storage when prices drop.[115] Figure 20 shows a measure of historical price volatility at Henry Hub equal to the day-to-day percent change in price.[116]

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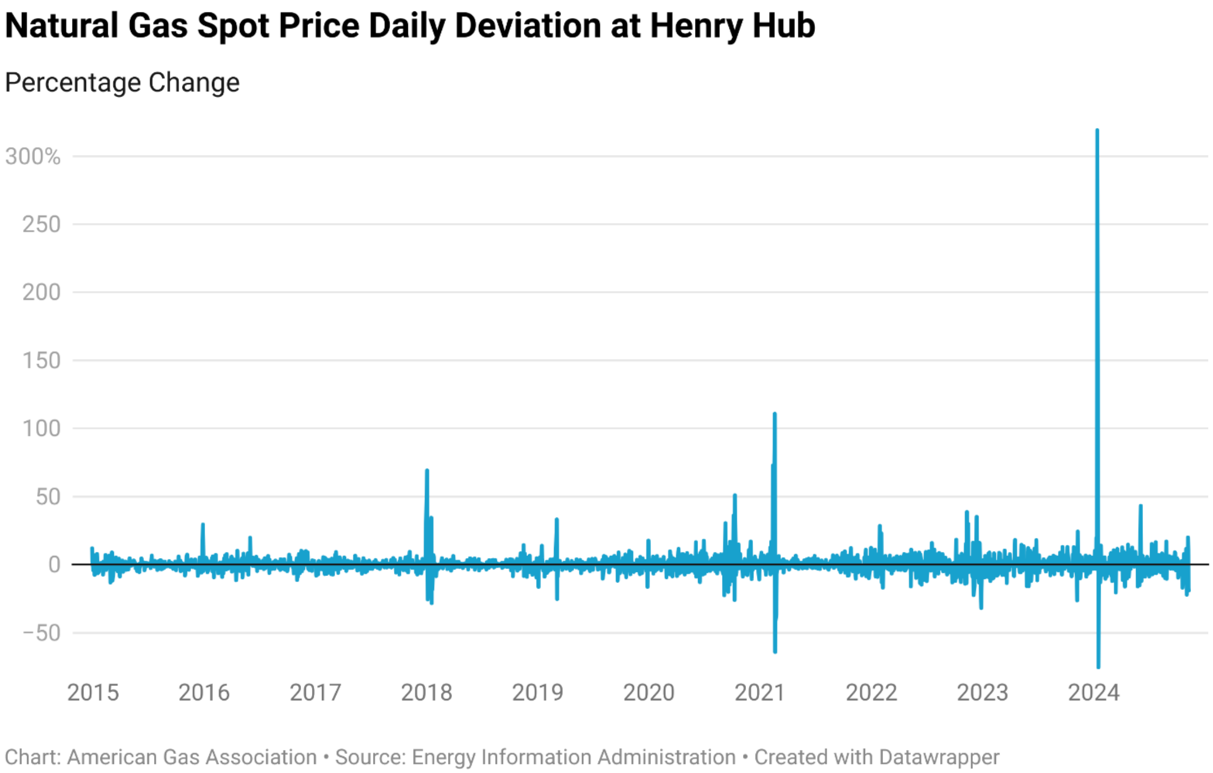
[110] https://www.gie.eu/wp-content/uploads/filr/2747/GIE_Brochure_The_Value_of_Gas_Storage_May2015.pdf
[111] https://timera-energy.com/blog/a-practical-view-of-the-flexibility-value-of-gas-and-power-assets/
[112] See Section 3, Table 3
[113] https://search.lsu.edu/ces/presentations/2009/DISMUKES_GAS_STORAGE_ENV_PERMIT_1.pdf
[114] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook.* https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pdf
[115] *Id*.
[116] The EIA defines price volatility by the day-to-day percentage difference in the commodity's price. The degree of variation, not the level of prices, defines a volatile market. *See*: https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2003/10_23/volatility%2010-22-03.htm

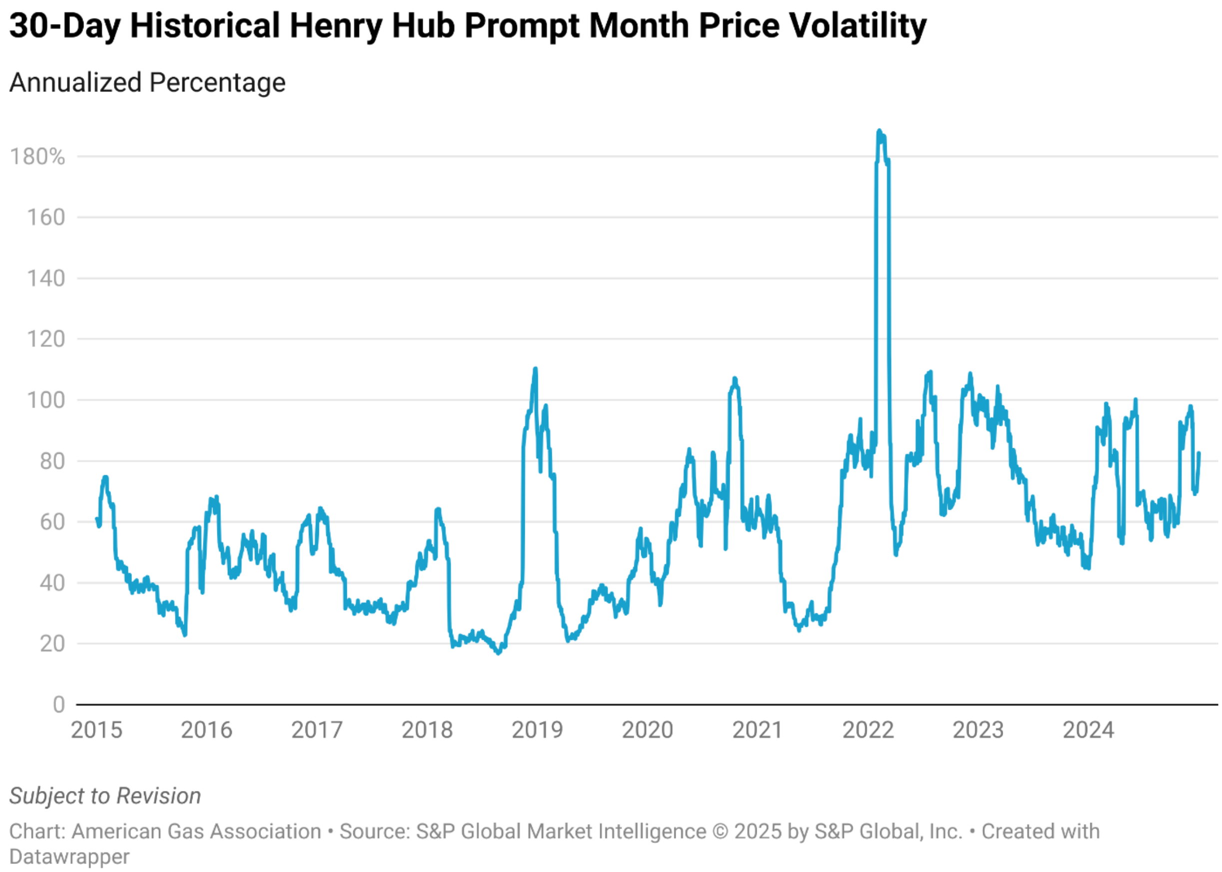
Figure 20



Looking at prompt month prices at Henry Hub in Figure 21, historical volatility has increased between 2015 and 2024. The average annualized percentage between 2015 and 2019 was 43 percent.[117] This measure of price volatility increased over the following five-year period, averaging 71 percent between 2020 and 2024. According to the EIA, price volatility is influenced by increased uncertainty about market conditions that affect natural gas supply and demand (*e.g.* production freeze-offs, storms, changes in inventory levels). In quarter one of 2022, price volatility reached an average of 128 percent due to declining production levels in January and February, weather-driven fluctuations in natural gas demand, record U.S. LNG exports to Europe to help reduce supplies from Russia, and declines in working gas inventories in the lower 48.[118]

[117] Annualized percentage is a widely used trading measure of price volatility. It is calculated by taking the standard deviation for the previous 30 days of daily changes in the Henry Hub front-month futures price multiplied by the square root of 252 (number of trading days in a year) multiplied by 100. Percentages are averages for that period. See: https://www.eia.gov/todayinenergy/detail.php?id=62203
[118] https://www.eia.gov/todayinenergy/detail.php?id=53579

Figure 21



LNG Storage

The same market valuation framework can be applied to LNG storage, although it is not well discussed in academic literature. Since LNG storage assets do not interact with the seasonality of demand in the same way that underground storage does, the intrinsic valuation may not be applicable. However, merchant-owned LNG storage facilities that are authorized to charge market-based rates can be valued extrinsically.

Domestically, LNG storage owners and operators have the same opportunity as underground storage owners and operators to derive value from the flexibility of storage assets in response to market movements. A 2010 report published by Carnegie Mellon University approached “real option” storage valuation from the perspective of storing LNG at regasification facilities.[119] The study attempted to capture the flexibility and strategic value

[119] Real option in this context refers to the opportunity to make strategic decisions by managing physical assets, such as LNG stored at a downstream facility, in tandem with market uncertainty, such as price fluctuations.

LNG storage brings to the market by integrating different modeling techniques, capturing both price and shipping uncertainty.[120]

Regulatory Value

Regulated storage facilities, including underground and LNG, are valued by a cost-of-service model that is largely determined by prudently incurred costs rather than market conditions or the intrinsic/extrinsic framework discussed above.[121] However, it is important to note that certain market influences—such as inflation and interest rates—can affect both costs and the return expected by equity investors. Under this model, storage operators recover capital investments and operating costs through cost-of-service ratemaking. The value is driven by the allowed rate of return, as determined by the regulator, on the facility's rate base, which consists of capital investments, depreciation expenses, and ongoing operating, maintenance, and administrative expenses. Since these factors are determined through regulatory proceedings rather than market forces, the financial value of regulated storage tends to remain stable, supporting reliability and long-term infrastructure investment.

As an example of cost recovery, Virginia Electric and Power Company (VEPCO), a subsidiary of Dominion Energy, received approval from the Virginia State Corporation Commission (VA SCC) in February 2025 to construct and operate an LNG facility at the Brunswick and Greensville County Power Stations. VEPCO anticipates the project will be complete and in service during the fourth quarter of 2027 at an estimated cost of $547 million, which will be recovered in rates charged to customers. As part of its petition, VEPCO described the project as having an estimated 2 Bcf of LNG storage capacity, 15 million standard cubic feet per day (mmscfd) of liquefication capacity, and approximately 500 mmscfd of regasification capacity.[122]

According to the filing, VEPCO stated the facility would address a reliability need and provide value to more than 700,000 homes to mitigate against threats of severe weather, cyberattacks, natural disasters, or other interruptions. At full capacity, the facility could operate both stations at full load for approximately four days or a single station for approximately eight days. As part of its final order, the VA SCC found that the project "would improve reliability of electric service provided by [VEPCO],"[123] "is required by the public convenience and necessity…[in] that it is one way to 'guard[] against anomalous threats to reliability,'"[124] and "can be expected to have a meaningful term of service,"[125] underscoring the inherent value of the project for customers.

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[120] Lai, G., Wang, M. X., Kekre, S., Scheller-Wolf, A. & Secomandi, N. (2010). *Valuation of the Real Option to Store Liquefied Natural Gas at a Regasification Terminal.* https://kilthub.cmu.edu/articles/journal_contribution/Valuation_of_the_Real_Option_to_Store_Liquefied_Natural_Gas_at_a_Regasification_Terminal/6709037?file=12238235

[121] Fang, H., Ciatto, A., & Brock, F. (2016). *U.S. Natural Gas Storage Capacity and Utilization Outlook.* https://www.energy.gov/sites/prod/files/2017/01/f34/U.S.%20Natural%20Gas%20Storage%20Capacity%20and%20Utilization%20Outlook_0.pdf

[122] *See* Virginia Electric and Power Company, Order No. 250230124, Virginia State Corporation Commission. Ordered February 24, 2025. Case No. PUR-2024-00096. https://www.scc.virginia.gov/docketsearch/DOCS/83zm01!.PDF

[123] *Id*. at 11.

[124] *Id*. at 14.

[125] *Id*. at 14.

6. Constraints, Challenges, and Future Outlook

Market Constraints and Challenges

Under the current market landscape, underground and LNG storage assets are critical to maintaining market stability and energy security requirements. Storage owners and operators continuously navigate numerous challenges and constraints, including infrastructure costs, regulatory requirements, pipeline availability, capacity limitations, and consumer needs. As the natural gas industry has evolved and continues to grow, it has become increasingly critical for utilities and storage operators to address and adapt to market limitations and operational changes.

The first hurdle for storage operators is cost. Once a facility has been built, continuous infrastructure investment is required for safety, maintenance, and operation. For gas utility-owned and operated storage, storage infrastructure costs are ultimately passed through to end-use customers. In these instances, developers must ensure that storage investments are prudent and justified by operational needs. For gas utility-owned storage and merchant-owned storage, investment decisions are not limited to new infrastructure. Many underground storage facilities were developed decades ago and require significant ongoing capital investment to maintain and modernize wells and equipment.[126] Newer facilities also need regular maintenance and upgrades in monitoring systems for integrity purposes.

LNG storage facilities also require large capital investments. Operationally, LNG storage is expensive because it must be stored at extremely low temperatures that can only be achieved and sustained through specialized cryogenic technology.[127] In addition, advanced safety systems and continuous regulatory compliance are required to mitigate risk during storage and transport.

Regulatory requirements are an additional consideration for utilities and storage operators. Regulatory frameworks often vary by region and state, complicating the management of multi-state operations due to differences in permitting processes, safety standards, and environmental compliance requirements at the federal and state levels. As a result, LNG and underground storage projects frequently encounter prolonged approval processes that escalate expenses and extend timelines.

Pipeline location and capacity availability present additional challenges for storage users and operators. LNG and underground storage facilities are strategically located near major pipeline systems to facilitate efficient injection and withdrawal and to enable more flexibility through greater market access.[128] The facilities are either integrated into the pipeline system or available at the production or consumption end to help balance flow

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[126] U.S. Department of Energy. (2016). *Ensuring Safe and Reliable Underground Natural Gas Storage: Final Report of the Interagency Task Force on Natural Gas Storage Safety.* https://www.energy.gov/sites/prod/files/2016/10/f33/Ensuring%20Safe%20and%20Reliable%20Underground%20Natural%20Gas%20Storage%20-%20Final%20Report.pdf

[127] https://www.wartsila.com/insights/article/creating-optimal-lng-storage-solutions

[128] For more information, see Appendix C.

levels and increase daily pipeline utilization rates.[129] However, downstream pipeline bottlenecks can limit the full ability of storage to access markets and provide value. Bottlenecks occur when existing pipeline capacity is insufficient to transport the necessary natural gas efficiently, whether due to infrastructure limitations, regulatory barriers, geographic constraints, or seasonal congestion during periods of high demand. Pipeline bottlenecks can also lead to regional price spikes, particularly in regions where pipeline expansion and storage additions have not kept pace with demand and production growth.

Like pipeline capacity limitations, the capacity and daily withdrawal limits of natural gas storage facilities pose constraints for LDCs and storage operators that must be planned around and prepared for when building supply portfolios and meeting consumer demand. Assuming pipeline availability, there is a finite supply of natural gas in storage facilities, and only a portion of this gas can be withdrawn from underground storage or regasified from LNG storage in a given period.

Even with adequate storage capacity and deliverability, a lack of sufficient pipeline or delivery infrastructure can limit or prohibit access to storage assets or services. In these cases, regulated pipelines or utilities may struggle to deliver gas from storage when demand is high. This can result in operational challenges for regulated entities and reduced market liquidity for other participants seeking firm transportation or balancing services. In such cases, inadequate access to storage can exacerbate price volatility and limit effective hedging strategies. Therefore, both the physical availability of storage and the infrastructure needed to access it are critical components of system resilience and market efficiency.

Storage Capacity Analysis

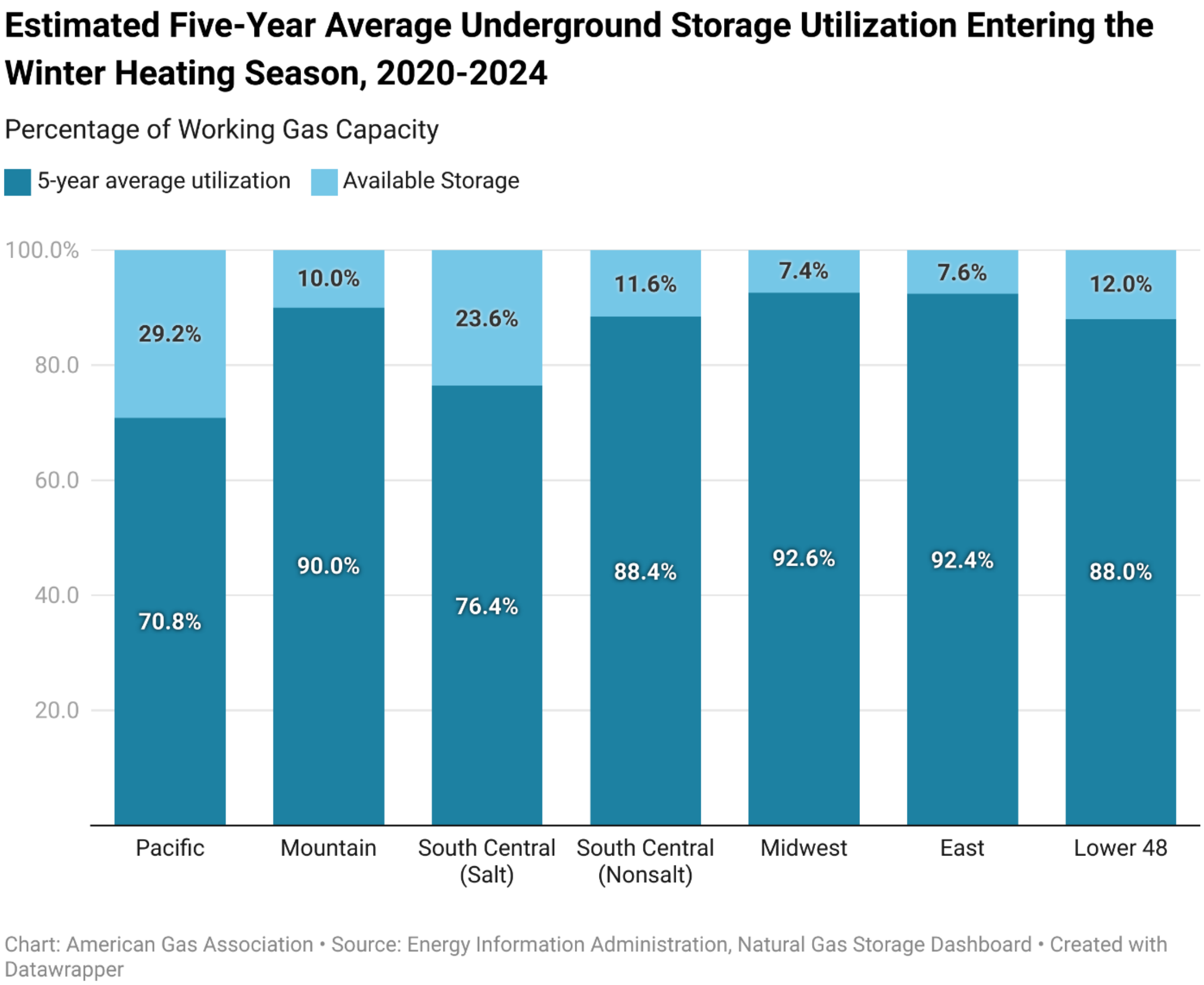
Assessing the need for more storage relies upon current capacity utilization and growth, as well as analyses of production, demand, and pipeline capacity at national and regional levels.[130] The decision to add more storage also depends upon the value additional assets may provide to market participants, whether extrinsic or through efficiency and reliability gains.

Figure 22 depicts the estimated five-year average underground storage capacity utilization in the lower 48 for the week entering the winter heating season each year. From 2020 to 2024, average storage capacity utilization was 88 percent. In the East, Midwest, and Mountain regions, average utilization was at least 90 percent, with yearly maximums ranging between 96 percent and 100 percent.

[129] https://www.eia.gov/naturalgas/archive/analysis_publications/ngpipeline/usage.html

[130] GTI Energy. (2025). *Underground Gas Storage in Natural Gas Infrastructure: Gulf Coast Insights.* https://sagticmsprod01.blob.core.windows.net/gti-cms-prod/2025-01/NZIP_%20UGS%20Report_011025.pdf

Figure 22



Data reflecting the utilization of LNG storage is not publicly available at the same level of detail. However, between 2019 and 2023, U.S. withdrawals averaged 45.4 Bcf per year, 4.2 Bcf lower than the average between 2014 and 2018. Figure 23 shows the five-year average regional withdrawals over the last decade in the lower 48. Between 2019 and 2023, average withdrawals in all regions but the Pacific and South Central were lower than in the previous five years.

Figure 23

Average Annual Withdrawals from LNG Storage, Lower-48

Billion cubic feet (Bcf)

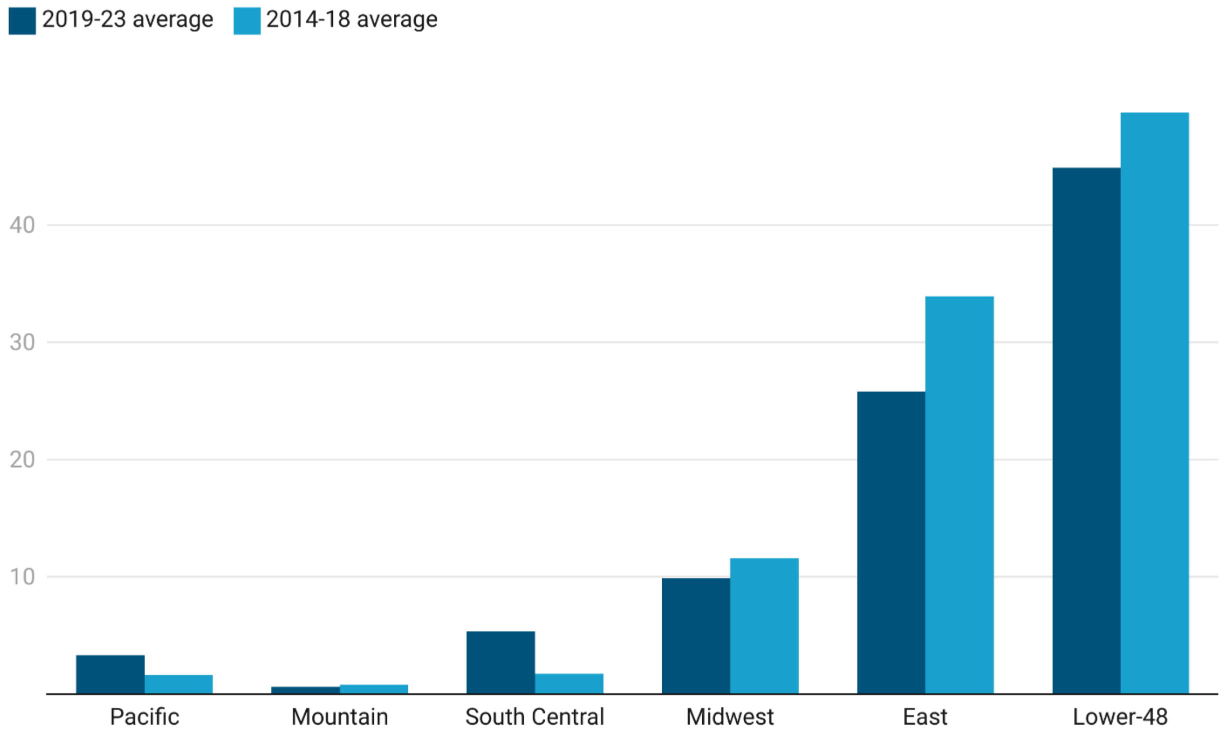


Chart: American Gas Association • Source: Energy Information Administration • Created with Datawrapper

In addition, Table 5 compares the compound annual growth rate of LNG and underground storage capacity with pipeline capacity additions and production and demand growth between 2013 and 2023.[131]

Table 5

Natural Gas Infrastructure and Market Expansion Rates

2013-2023 Compound Annual Growth Rate*

Region	LNG Storage Capacity	Underground Storage Capacity	Intrastate Pipeline Capacity	Interstate Pipeline Capacity	Production	Demand
East	18.3%	0.0%	3.6%	4.6%	11.4%	2.8%
Midwest	0.3%	0.1%	1.6%	6.4%	-3.3%	2.1%
Mountain	7.0%	0.2%	8.7%	1.1%	2.6%	2.4%
Pacific	0.6%	0.2%	0.8%	0.5%	-6.3%	-0.8%
South Central	0.0%	0.2%	6.8%	4.3%	3.0%	2.7%
Lower-48	10.5%	0.1%	5.8%	4.0%	5.0%	2.2%

**LNG Storage Capacity CAGR by region represents 2014-2023*

Table: American Gas Association • Source: Energy Information Administration, Pipeline and Hazardous Materials Safety Administration • Created with Datawrapper

At an aggregate level, dry gas production, demand, and pipeline capacity expansion have outpaced total underground capacity growth over the last decade.[132] This is a clear market signal that additional storage assets may be needed to keep pace with the growth of the market. High seasonal underground storage utilization across the lower 48 also indicates the potential need for expansion, particularly for regions reaching at least 90 percent utilization entering the winter heating season (*i.e.*, East, Midwest, and Mountain). In addition, LNG storage expansion may be necessary in regions where LNG storage capacity expansion has lagged other indicators and the average annual withdrawals from LNG storage have increased over the past five years (*i.e.,* South Central and Pacific). This analysis is not to say that the development and expansion of

[131] For information about the net changes between 2013 and 2023, see Appendix D.

[132] Dry gas is another term for consumer-grade natural gas. This is natural gas that remains after liquefiable hydrocarbons and volumes of nonhydrocarbon gases have been removed. The production of dry natural gas refers to the withdrawal of natural gas from reservoirs, which is reduced by volumes used at the lease site and by processing losses (to make the gas consumer-grade).

LNG and underground storage in other regions is unnecessary; rather, it illustrates where storage may be needed.

Similar to Figure 9 in Section 3, LNG storage capacity CAGRs represent PHMSA data from 2014 to 2023. As noted in Footnote 41, the data reported by PHMSA indicates a sharp decline in in-service LNG storage capacity from 2013 to 2014 despite an increase in the number of in-service facilities. In regions where LNG storage capacity growth has lagged demand and/or production growth, infrastructure expansion is necessary.

In addition to aggregate growth metrics, analyzing operational dynamics highlights the growing need for additional underground storage. Figure 24 compares peak daily demand with the maximum daily deliverability rate of underground storage for the U.S. over the last two decades. While peak demand has trended upward, deliverability rates have remained relatively flat since 2014, revealing a widening gap between demand and storage availability. In 2005, the difference between peak daily demand and maximum daily deliverability of underground storage assets was 21 Bcf. In 2022, this spread more than doubled to 51 Bcf. By 2025, this gap is expected to reach 60 Bcf, nearly three times the 2005 level.[133]

Since 2005, peak daily demand has increased at nearly twice the rate of maximum daily deliverability, with an average annual peak demand increase of 3.17 Bcf per day and an average annual increase in deliverability of 1.64 Bcf per day.[134] When analyzing the data since 2014, the flattening of the difference in deliverability versus peak demand growth becomes even more marked. Deliverability has been statistically flat over the last decade, while peak daily demand has grown at an annual rate of 3.16 Bcf per day.

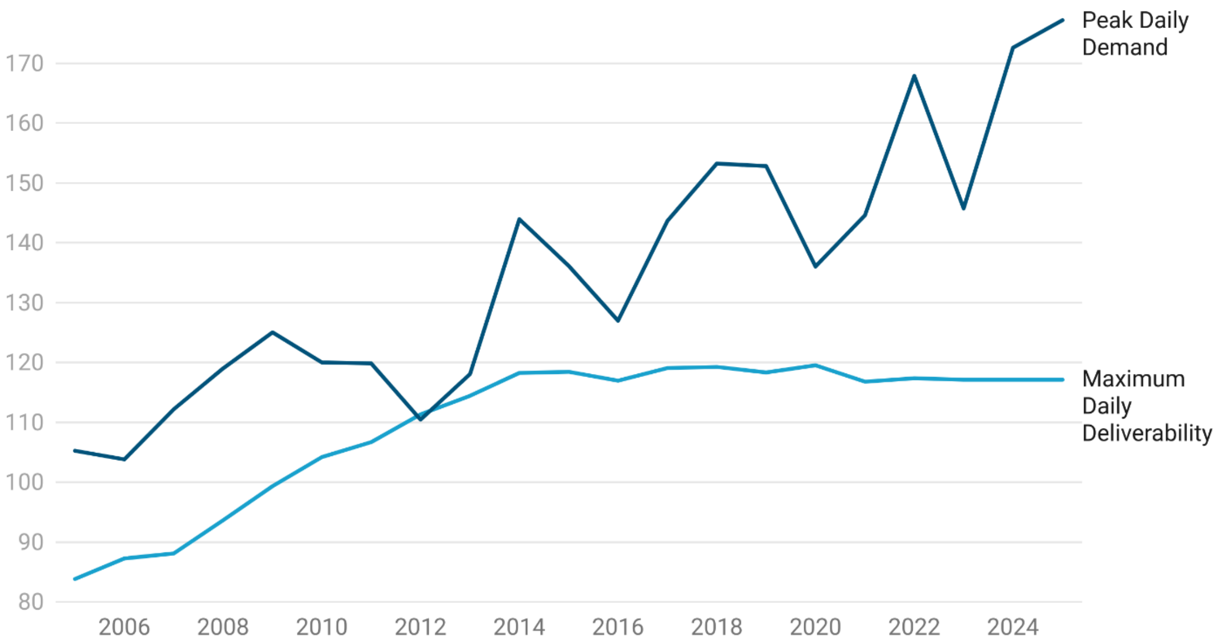
[133] Note: The maximum daily deliverability rates for 2024 and 2025 have not yet been published by the EIA's annual 191 report due publishing lags. For the purposes of Figure 24, the deliverability rates for 2024 and 2025 are the same as the most recent report, published for the 2023 year.

[134] Both of these results are statistically significant at the 99 percent confidence level.

Figure 24

Underground Storage Maximum Daily Deliverability vs. Peak Daily Demand

Billion Cubic Feet per Day (Bcf/d)



Subject to Revision

Source: Energy Information Administration, S&P Global Commodity Insights © 2025 by S&P Global, Inc. • Created with Datawrapper

Regional Analysis

East: Between 2013 and 2023, capacity additions to LNG storage have soared while underground storage capacity additions have remained stagnant. Currently, no new underground storage projects are planned or proposed in the Eastern region, while approximately 3 Bcf of additional LNG storage capacity is planned.[135] With soaring production levels and growing demand, expanding storage assets in the region will be necessary to meet consumer requirements and to help balance supply and demand.

Midwest: In the Midwest, demand growth outpaced LNG and underground storage between 2013 and 2023. While production levels fell over this period, underground storage utilization reached 96 percent entering the 2024-2025 winter heating season, and LNG storage withdrawals were 9.4 percent higher than in the previous decade. No additional storage assets are planned or proposed in the region as of March 2025, but more storage is needed.

[135] At least one LNG export terminal and one LNG peaker plant have been approved by FERC in the East region. The anticipated capacity represents an estimated volumetric conversion from cubic meters of LNG to Bcf of natural gas. LNG conversion factors may differ based on composition, source, and temperature, which can result in slight variations in the per-volume quantity.

It should also be noted that demand growth outpaced intrastate pipeline capacity additions in the Midwest between 2013 and 2023. Developing additional storage assets will rely on congruent pipeline availability and expansion for local storage utilization, particularly during peak periods.

Mountain: The Mountain region utilized all of its underground storage assets[136] entering the 2024-2025 winter heating season. With underground storage capacity experiencing little growth between 2013 and 2023, this signals the need for more underground storage in the region. Although LNG storage capacity increased over the same decade, growing demand, production, and interstate pipeline capacity levels may also indicate the need for storage expansion, including LNG storage assets. An additional 16 Bcf of underground storage working gas capacity is anticipated in the region by the end of 2025.[137] No LNG storage projects are planned or proposed at this time.

Pacific: Regional regulations have decreased natural gas demand and production in the Pacific region. Nevertheless, the five-year average for LNG storage withdrawals doubled from 2015-2018 to 2019-2023. LNG storage is an important asset for supporting electricity generation reliability in the region, with 90.7 percent of the total LNG storage capacity used for peak shaving. Underground storage also serves as an important backup energy resource in the region. While LNG and underground storage capacity experienced slight growth between 2013 and 2023, additional storage assets will be valuable for supporting grid reliability as electricity demand grows in the region.

South Central: Between 2013 and 2023, demand and dry gas production outpaced underground and LNG storage capacity growth in the South Central region, indicating the need for more storage. As of March 2025, at least 32 Bcf of underground storage working gas capacity has already been added to the South Central region, and 204.5 Bcf more is anticipated by 2031.[138] Additionally, an estimated 150 Bcf of LNG storage at export facilities is planned, proposed, or in construction.[139] Additional peak shaving facilities may also be valuable to help support domestic meet market expansion metrics.

Future Outlook

Market Fundamentals

In 2023, the U.S. natural gas market set new records for both production and consumption, and these trends are largely expected to continue in the near term. However, storage capacity—both underground and for LNG—has remained effectively static, a situation that could pose ongoing issues for supply-demand balances since, as described before, in the short term natural gas production lags demand. Natural gas storage growth may be needed as natural gas production and export technology continue to develop and improve.

[136] As defined by the EIA's peak demonstrated capacity as of November 2023. *See* Section 3, Figure 5.
[137] Data from S&P Global Commodity Insights. Anticipated additional storage in the Mountain region includes 10 Bcf in construction in Wyoming and 6 Bcf under regulatory application in Utah.
[138] Data from S&P Global Commodity Insights. The anticipated 2031 total represents storage projects that have been announced, are in construction, are in open season, are partially online, or are in the regulatory application process. Only 48 Bcf of additional storage capacity has been confirmed (*i.e.* in construction, announced, or partially online) in the South Central region.
[139] LNG conversion factors may differ based on composition, source, and temperature, which can result in slight variations in the per-volume quantity.

Recent natural gas demand growth has been attributed to increased requirements for gas-fired electric generation, industrial reshoring, and to meet residential and commercial customer additions (on average, more than one new natural gas consumer was added per minute in 2023).[140] Growing demand for natural gas in the power sector and rising LNG exports may lead to new market dynamics or operational realities by which natural gas storage can provide value. The expansion of artificial intelligence and cloud computing services is an additional driver of domestic demand growth.

Across the U.S., the EIA has attributed the recovery of electricity demand in the commercial sector following the pandemic to the acceleration of data center growth, as natural gas demand growth is concentrated among states where data centers are rapidly expanding. In Virginia, electricity demand grew by 14 billion kilowatt-hours between 2019 and 2023. Over the same time period, 94 new data centers were brought online.[141] Additionally, in the first half of 2024, more than 500 megawatts of new data centers were constructed in the U.S. and Canada, increasing inventory by 10 percent and surpassing last year by 23 percent.[142]

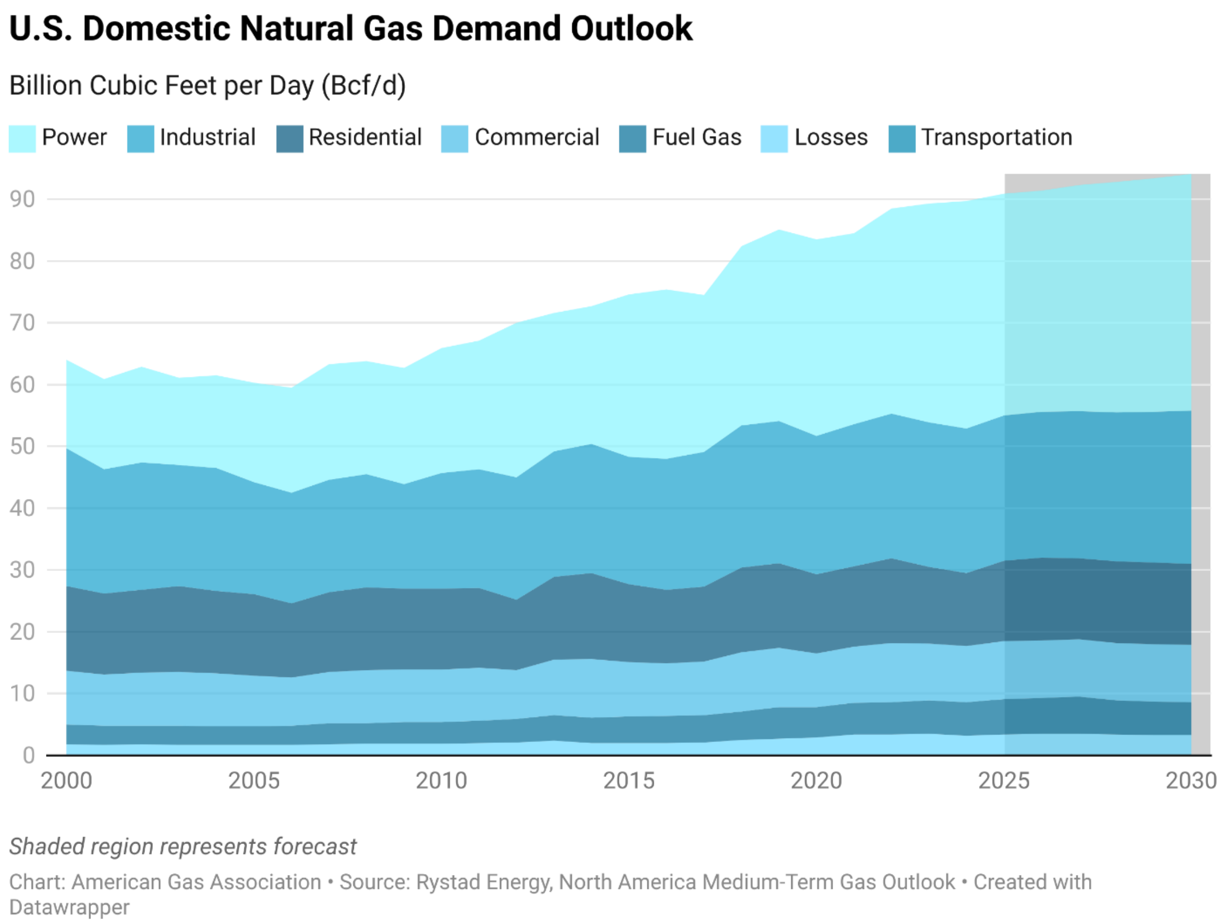
Global demand growth is also expected to influence U.S. LNG exports. In the near term, U.S. LNG exports to Europe are expected to increase after significant drawdowns in European inventories during the 2024-2025 winter. As of March 31, 2025, storage inventories in the European Union (EU) were 33.6 percent full, 11.6 percentage points below the five-year average.[143] By November 1, 2025, European Commission targets require EU gas storage inventories to be 90 percent full.[144] Analysts estimate that Europe may need more than 250 extra LNG cargos, estimated to cost at least $11 billion in total, to reach this requirement.[145]

The EIA projects that gross LNG exports will increase by nearly 38 percent through 2026 relative to 2024 levels, aided by the commissioning of new LNG export terminals.[146] The EIA forecasts that LNG export capacity for North America could more than double by 2028, with the bulk of that growth attributable to U.S. LNG export terminal projects.[147] In the U.S., these terminals would add an additional LNG storage capacity of approximately 45 Bcf. An additional 65 Bcf of LNG storage at export facilities in the lower 48 has also been approved by FERC, and approximately 42 Bcf more is proposed or have applications pending.[148] Additionally, gross pipeline exports are expected to increase more than 15 percent from 2024 to 2026 due to new transmission lines such as the Matterhorn Express Pipeline, which was designed to move natural gas produced in the Permian Basin.[149]

[140] https://playbook.aga.org/
[141] https://www.eia.gov/todayinenergy/detail.php?id=62409; https://s2.q4cdn.com/510812146/files/doc_financials/2024/q1/2024-05-02-DE-IR-1Q-2024-earnings-call-slides-vTC.pdf
[142] https://www.cbre.com/insights/reports/north-america-data-center-trends-h1-2024
[143] https://energiedashboard.admin.ch/gas/eu-gasspeicher
[144] The targets were set to help prevent supply shortages following Russia's invasion of Ukraine in 2022
[145] https://www.reuters.com/world/europe/europe-could-need-extra-11-billion-gas-refill-winter-stores-2025-04-01/
[146] According to the EIA's March 2025 Short-Term Energy Outlook.
[147] https://www.eia.gov/todayinenergy/detail.php?id=62984
[148] LNG conversion factors may differ based on composition, source, and temperature, which can result in slight variations in the per-volume quantity
[149] According to the EIA's March 2025 Short-Term Energy Outlook.

The trend of increased natural gas demand is expected to continue through at least 2030. Rystad Energy forecasts that total domestic natural gas consumption will increase by 4.5 Bcf per day, or 5 percent, from 2024 to 2030. Figure 25 graphs this demand forecast.

Figure 25



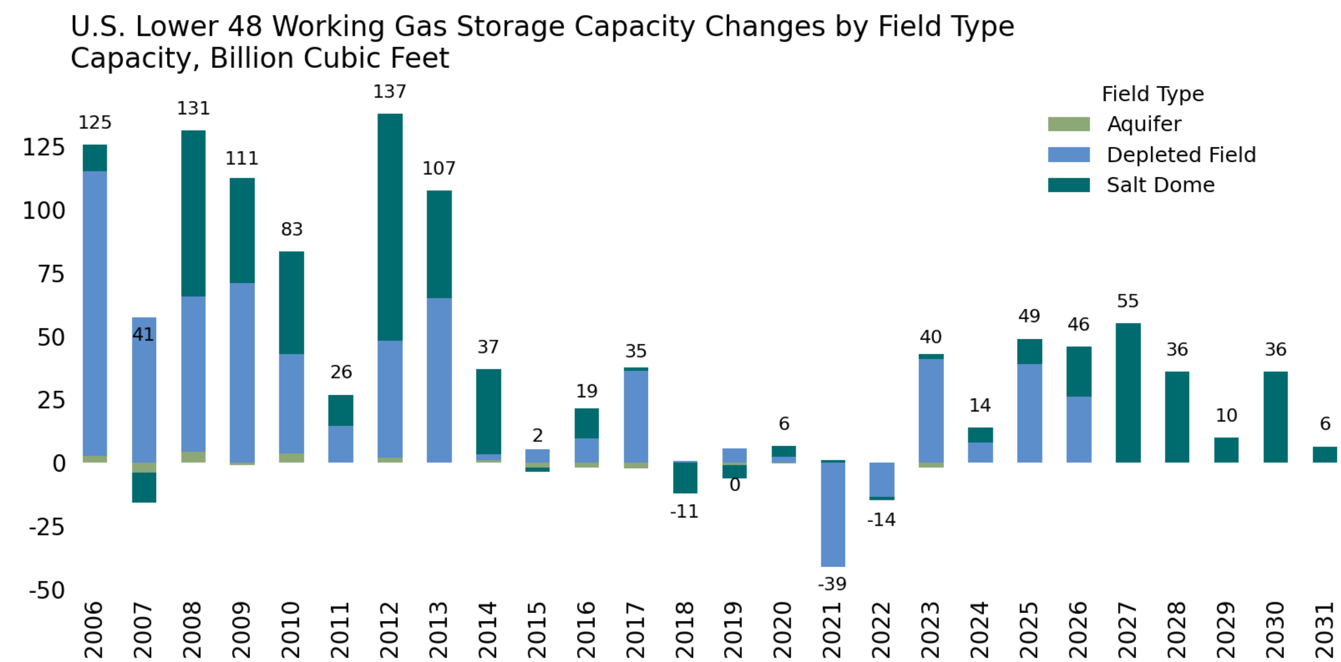
Natural gas is widely perceived to be a critical energy resource to meet data center energy load growth going forward. S&P Global Ratings estimates that by 2030, U.S. data centers will increase gas demand by between 3 and 6 Bcf per day. Increased demand could lead to supportive financial performance. S&P Global indicated that increased natural gas demand for data centers "should also generally support the [financial] performance of midstream companies focused on natural gas transportation and storage."[150] Similarly, the International Energy Agency said that "natural gas is set to continue to dominate the near-term data centre electricity supply in the United States," indicating growth of approximately 130 Terrawatt-hours per year of new natural gas-fired

[150] https://www.spglobal.com/ratings/en/research/articles/241022-data-centers-more-gas-will-be-needed-to-feed-u-s-growth-13290987

electricity generation to serve data centers between 2024 and 2030. This could translate into an additional 2.5 to 3.5 Bcf per day of natural gas demand.[151]

S&P currently tracks 253 Bcf[152] of additional underground storage capacity changes between 2024 and 2031, as shown in Figure 26.[153] Most of these are either depleted fields or salt dome facilities located along the Gulf Coast or Southeast, co-located with new pipeline capacity and production to serve growing LNG export demand. As mentioned in the previous subsection, there are currently no announced projects for new storage capacity additions in the East, Pacific, or Midwest regions.

Figure 26



Source: S&P Global Commodity Insights, ©2025 by S&P Global Inc., Chart: American Gas Association, Data as of Apr 27, 2025, Subject to Revision

Geopolitical Shifts

Geopolitical factors will continue to shape the future of natural gas storage, particularly as the global energy landscape becomes more interconnected. Ongoing conflicts, such as the war in Ukraine, have accelerated the shift in global natural gas trade flows, with European countries seeking to diversify their supply sources and reduce dependence on Russian gas. In 2021, the year before Russia invaded Ukraine, Russian pipeline supply accounted for 31 percent of the gross European gas supply. Russian pipeline exports to Europe have fallen greatly since then, accounting for just 9 percent of the gross European gas supply in 2024.[154] U.S. LNG has

[151] *See* Section 2.5.3: https://iea.blob.core.windows.net/assets/dd7c2387-2f60-4b60-8c5f-6563b6aa1e4c/EnergyandAI.pdf
[152] Please note: total capacity changes may not foot due to rounding.
[153] Note: S&P indicates that 32 Bcf of this total capacity is online. The remaining 221 Bcf represents storage projects that have been announced, are in construction, are in open season, are partially online, or are in the regulatory application process.
[154] Sharples, J. (2025). *The End of Russian Gas Transit via Ukraine: Immediate Impact and Implications for the European Gas Market in 2025*. The Oxford Institute for Energy Studies. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/01/Insight-162-The-End-of-Russian-Gas-Transit-via-Ukraine.pdf

aided Europe in narrowing its energy gap, accounting for 45 percent of the continent's imports in 2023, more than any other country. Demand for U.S. LNG will likely continue to grow as the EU seeks to phase out all Russian gas imports by 2027.[155]

The ability to meet growing global LNG demand in the U.S. will be limited by LNG export capacity and, more specifically, the amount of LNG able to be loaded onto ships for export. Additional storage at LNG export facilities will be crucial to help meet this demand, promoting the continuous run of liquefaction trains while export ships load at the terminal or while the dock awaits empty cargo ships.

Regulatory Developments

Regulatory developments at the federal and state levels will also influence the trajectory of natural gas storage. FERC and the DOE are central to approving new storage and LNG infrastructure, and their policies can significantly impact project timelines. While the Biden Administration froze LNG export terminal permit approvals in 2024, the Trump Administration lifted the freeze in January 2025. The reversal allowed LNG export approvals to continue, as several projects have been approved by the DOE since the policy was rescinded. In April 2025, the DOE also lifted another Biden-era policy requiring authorized LNG exporters to meet strict criteria before being considered for LNG project timeline extension.[156]

Another regulatory consideration is the long timelines often required to permit, site, and construct natural gas storage facilities, sometimes involving multi-year approvals. Overlapping agency jurisdictions, public opposition, and complex environmental permitting processes can delay regulatory reviews. In today's rapidly shifting energy environment, this lag between planning and operational readiness can limit the system's ability to respond to emerging supply-demand pressures. These pressures must be balanced by other considerations, including public engagement and regulatory due diligence. However, to improve system flexibility and long-term resilience, there is a growing need for permitting reform that streamlines and accelerates the approval process for essential storage infrastructure. Reforms could include clearer permitting timelines, coordination between state and federal agencies, and expedited review of projects supporting reliability, grid stability, or critical export capacity. Addressing these challenges will be essential to help ensure that storage development can keep pace with rising demand.

Differences in state policy toward natural gas could lead to uneven treatment in storage infrastructure. Increased variable renewable electricity may lead to new requirements for flexible generation resources, including natural gas, as demonstrated in Table 4. However, states with aggressive decarbonization or renewable energy targets may also erect regulatory barriers to block or disincentivize the development of new natural gas storage, or even incentivize the removal of existing storage, even as those same policies put additional pressure on the natural gas system. Thus, regulatory barriers to natural gas storage can increase strains on energy system reliability and resiliency. By contrast, other states with high demand or production

[155] https://www.gisreportsonline.com/r/russian-gas/
[156] https://www.energy.gov/articles/energy-department-takes-action-remove-barriers-requests-lng-export-commencement-date

may continue to support storage expansion to meet growing requirements. This regulatory patchwork could further regional disparities in storage availability and market flexibility.

States and other jurisdictions with ambitious emissions reduction targets can also examine how natural gas storage can enable low-carbon pathways. By thinking of storage not simply as a buffer for gas supply, but as a multi-purpose flexibility tool that can unlock decarbonization pathways. Natural gas storage smooths out the variability of wind and solar by providing a firm, dispatchable backup when weather-dependent generation dips. Moreover, underground storage can be utilized for renewable natural gas storage derived from biogenic sources (landfill gas, agricultural digesters), which often have seasonal production peaks. In future scenarios, natural gas storage could possibly be repurposed for hydrogen-ready capabilities. Excess renewable electricity (e.g., midday solar or windy nights) can be converted via electrolysis into hydrogen or synthetic methane, then stored.

Pricing signals can spur new storage development, whether upgrades to existing facilities or new construction. However, several other barriers may slow market development, including permitting timelines, construction costs, and regulatory uncertainty. Addressing these burdens, along with adequate pricing signals from the market, could incentivize additional investment in storage in these areas.

7. Conclusions

Natural gas storage is a foundational component of the U.S. energy system, enabling reliability, flexibility, and resilience in the face of growing domestic demand and shifting global energy dynamics. As demonstrated throughout this report, storage plays a critical role in balancing seasonal supply and demand, enhancing grid reliability, and serving as a strategic buffer during high-impact events such as extreme weather or supply disruptions. Both underground and LNG storage systems serve complementary functions in supporting power generation, industrial processes, residential heating, and international trade.

Despite its indispensable value, natural gas storage faces significant challenges. Aging infrastructure, high capital costs, regulatory complexity, and pipeline bottlenecks continue to constrain expansion and optimization. Additionally, while the value of storage has evolved from a reliance on seasonal price spreads to increased dependence on market responsiveness, many regions in the U.S.—particularly the East, Midwest, and Mountain—are experiencing storage capacity constraints that have not kept pace with the rapid growth in production, demand, and pipeline infrastructure. As electrification accelerates and data center energy needs rise, these storage limitations could exacerbate volatility and reliability concerns.

Looking ahead, robust investment in both underground and LNG storage is essential to maintain system efficiency and meet future energy needs. Regulatory reform that streamlines permitting processes, coordinates agency oversight, and incentivizes strategic storage development will be key to addressing these limitations. Integrating storage with intermittent renewables can also bolster grid stability and support decarbonization efforts, positioning storage as a bridge to a cleaner, more resilient energy future.

Limitations and Opportunities for Further Exploration

While this report provides a comprehensive assessment of natural gas storage infrastructure, market dynamics, and policy frameworks, there are important limitations to note. Publicly available data on LNG storage capacity, utilization, and facility-level operations remain limited and inconsistent, complicating efforts to evaluate regional needs and investment potential. In addition, this report does not fully account for the potential impacts of decarbonization policies, emissions regulations, and carbon pricing mechanisms on future storage economics and system planning.

Regional and local market analyses can pinpoint where additional storage may deliver the greatest strategic value and reveal how market participants currently price existing assets. By comparing realized actual market indicators, such as injection/withdrawal behaviors or storage market rates, stakeholders can spot underserved markets, optimize capacity deployment, and sharpen commercial strategies. These insights also equip regulators and policymakers to target infrastructure investments and regulatory reforms that uphold reliability and advance other goals.

Future research could explore improved methods for valuing storage beyond traditional intrinsic and extrinsic frameworks, including environmental and social benefits. Further analysis is also needed to evaluate the optimal integration of natural gas storage with renewable energy sources, hydrogen blending, and carbon capture technologies. Storage can also be evaluated for its "resilience dividend," referring to the additional value storage provides during periods of extreme conditions or disruption. Stress-testing supply–demand balances against extreme cold snaps, pipeline outages, or rapid renewable ramp events shows how incremental storage capacity bolsters system reliability, unlocks deeper wind and solar integration, and lays the groundwork for low-carbon pathways. These findings are critical inputs to energy-policy design, market rules, and incentive frameworks that will sustain a flexible, resilient, and increasingly decarbonized energy system.

Final Thoughts

This paper has demonstrated the value of natural gas storage in the market, the vital role of storage in providing system reliability and resilience, and other market considerations. As the U.S. energy landscape evolves, with increased penetration of intermittent renewable energy sources and growing demand for energy security, the role of natural gas storage is expected to become even more significant. Investments in storage infrastructure and technology are critical for maintaining the reliability of natural gas supplies in an increasingly complex and dynamic market. Overall, natural gas storage remains an indispensable component of the nation's energy strategy, helping to safeguard consumers against disruptions and ensuring a resilient energy system.

Appendix A – Abbreviated Terms

AGA – American Gas Association

AGF – American Gas Foundation

Bcf – Billion cubic feet

CAISO – California Independent System Operator

CNG – compressed natural gas

DOE – Department of Energy

DOT – Department of Transportation

EIA – Energy Information Administration

FERC – Federal Energy Regulatory Commission

FSU – floating storage unit

LDC – local distribution company

LNG – liquified natural gas

MARAD – Maritime Administration

MMcf – Million cubic feet

PHMSA – Pipeline and Hazardous Materials Safety Administration

PUC – Public Utility Commission

USCG – United States Coast Guard

WHS – winter heating season

Appendix B – Glossary of Key Terms

Citygate – the point where natural gas is transferred from an interstate or intrastate pipeline to a local natural gas utility.

Co-location – the practice of placing natural gas storage facilities at or near generation facilities to serve as backup supply.

Compound annual growth rate (CAGR) – measures the average annual growth rate over a period of time under the assumption that growth happened at a steady, compounded rate each year.

Cushion gas – the gas that remains in the storage reservoir as a permanent inventory.

Demonstrated peak capacity – as used by the EIA, the sum of the largest volume of working natural gas reported for each individual storage field during the most recent five-year period, regardless of when the individual peaks occurred.

Depleted fields – refers to depleted oil or natural gas fields.

Design capacity – as used by the EIA, the sum of the reported working natural gas capacities of active storage fields in the lower 48 states as reported on Form EIA-191 as of the end of the most recent five-year review period. Sometimes referred to as nameplate capacity, design capacity is based on the physical characteristics of the reservoir, installed equipment, and operating procedures on the site.

Design day – the coldest hypothetical winter day when demand is expected to reach its highest peak. Natural gas utilities use the design day as a tool for system planning and winter heating season preparation.

Dry gas – another term for consumer-grade natural gas. This is the natural gas that remains after liquefiable hydrocarbons and volumes of nonhydrocarbon gases have been removed.

Dry gas production – the withdrawal of natural gas from reservoirs, which is reduced by volumes used at the lease site and by processing losses to make the gas consumer-grade.

Citygate – is generally the point where natural gas is transferred from an interstate or intrastate pipeline to a local natural gas utility.

EIA Form 191, *Monthly Underground Gas Storage Report* – provides data on the operations of all active underground storage facilities. Data are collected and mandated under Title 15 U.S.C. § 772(b).[157] The data appear in EIA publications such as the annual field-level storage report and the peak demonstrated capacity report.

Feedgas – the amount of natural gas delivered via pipeline to liquefaction facilities to be converted to LNG.

[157] https://www.eia.gov/survey/form/eia_191/instructions.pdf

Floating Storage Regasification Units (FSRUs) – FSUs that combine LNG storage with built-in regasification systems.

Floating Storage Units (FSUs) – ships and barges used as a form of LNG storage by the offshore industry and at LNG import and export terminals.

Injection rate – the rate at which gas is injected into a storage facility.

Injection season – the period of time from April 1 through October 31 of each year during which natural gas is generally injected into underground storage for future use.

Linepack – the amount of gas stored in the pipes of the gas transmission or distribution system.

Lower 48 – refers to the 48 contiguous states of the U.S., excluding Alaska and Hawaii.

Merchant operators – private companies or entities that own gas in storage for commercial, profit-driven purposes rather than for regulatory, utility, or system-balancing obligations.

Merchant Storage – refers to pipeline and independently owned facilities.

Peaker plant – a power plant that operates mainly during periods of high electricity demand, known as peak demand periods.

Peak shaving – a strategy that aims to reduce energy usage during periods of peak demand to promote energy system integrity and resilience. Peak shaving can take many forms, including demand response, energy efficiency, interruptible service, and, in the case of the electric grid, direct use natural gas service.

Pipeline capacity – the maximum amount of gas that can flow through a pipeline at one time.

Propane-air – also referred to as liquid propane or LPG, propane-air is a gas mixture that mimics the properties of natural gas, allowing it to be used as a direct replacement in burners and other combustion equipment without modifications.

Regasification – the process of converting LNG back to its gaseous form.

Reliability – the ability of the energy system to deliver services in the quantity and with the quality demanded by end users. A reliable system responds adequately to high-probability, low-impact events and disruptions.

Resilience – the ability of the energy system to prevent, withstand, adapt, and recover from a system disruption. A resilient system responds effectively to low-probability, high-impact events.

Synthetic Natural Gas (SNG) – synthetic fuel created by mixing vaporized propane (*i.e.*, LPG) with air.

Transporter imbalances – differences between the amount of natural gas a shipper schedules and the amount delivered or used in a pipeline system.

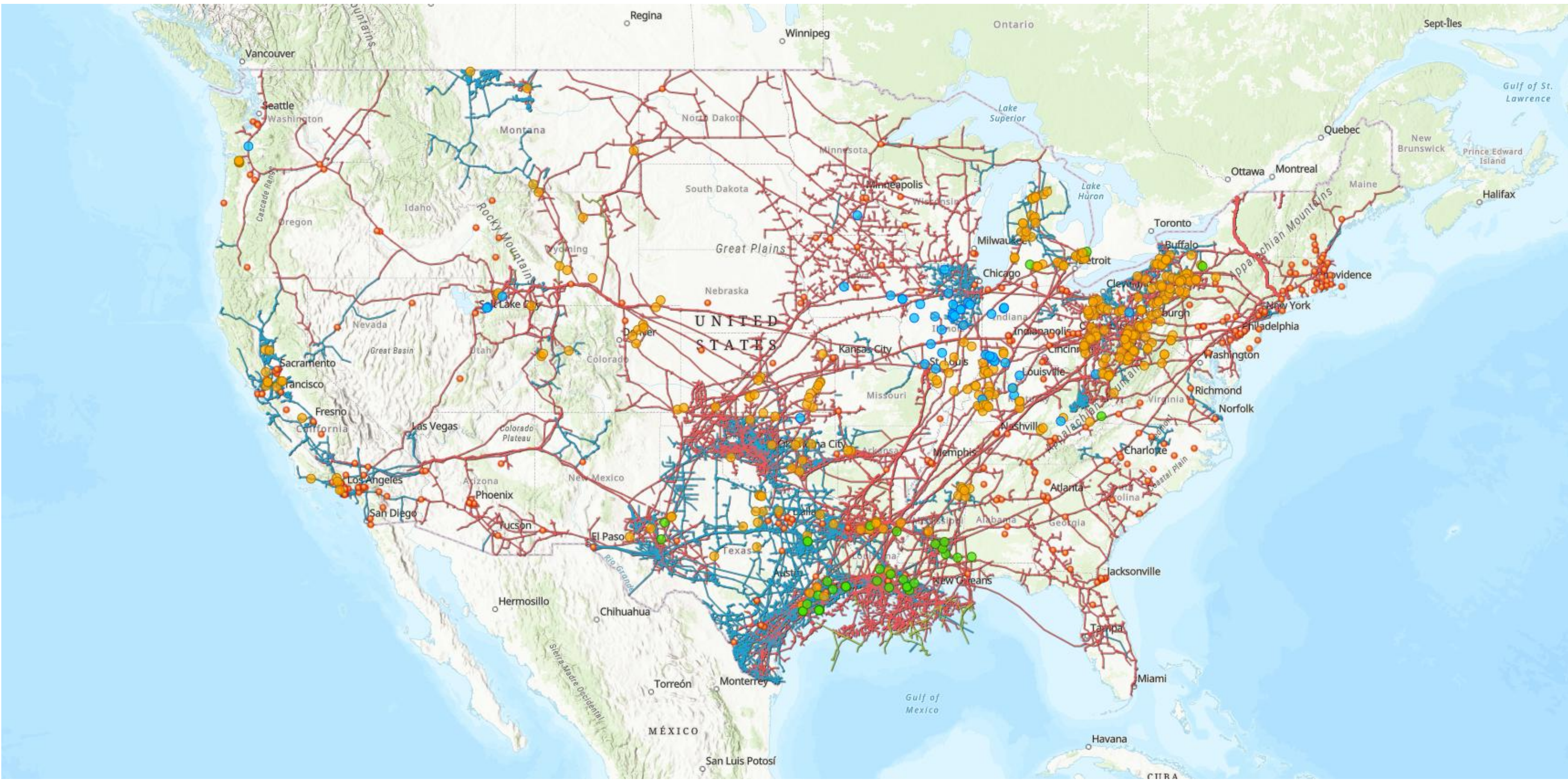
Vaporization – a step within the regasification process where a liquid physically changes to a gas.

Winter heating season – the period of time characterized by generally colder weather. Aligns with withdrawal season.

Withdrawal season – the period of time from November 1 through March 31 of each year during which natural gas is generally withdrawn from underground storage for use during the winter heating season.

Working gas – the volume of natural gas in underground storage that is available to be withdrawn to meet market demand.

Appendix C – Natural Gas Pipelines and Storage Assets Across the Lower 48



Source: ArcGIS Online

This map can be accessed via the following steps:

- Visit https://www.arcgis.com/home/webmap/viewer.html?webmap=your-map-id
- Map Layers:
    - Federal User Community. (2025, April). *Underground Natural Gas Storage* [Feature layer]. ArcGIS Online. https://www.arcgis.com/home/item.html?id=your-layer-id
    - Data source: U.S. Energy Information Administration
- HostedByHIFLD. (2025, April 8). *Above Ground Liquefied Natural Gas Storage Facilities* [Feature layer]. ArcGIS Online. https://www.arcgis.com/home/item.html?id=your-layer-id
    - Data source: Homeland Infrastructure Foundation-Level Data [HIFLD]
- Federal User Community. (2025, April 1). *Natural Gas Interstate and Intrastate Pipelines* [Feature layer]. ArcGIS Online. https://www.arcgis.com/home/item.html?id=your-layer-id
    - Data source: U.S. Energy Information Administration

Appendix D – Net Changes to Natural Gas Infrastructure Capacity and Market Indicators by State and Region

Natural Gas Market Expansion Metrics

2013-2023 Net Change*

Region	LNG Storage Capacity (Bcf)	Underground Storage Capacity (Bcf)	Intrastate Pipeline Capacity (Bcf/d)	Interstate Pipeline Capacity (Bcf/d)	Production (Bcf)	Demand (Bcf)
East	40.0	−8.5	1.1	24.5	8,353.4	2,618.0
Midwest	0.1	20.7	0.5	15.3	−63.8	1,044.1
Mountain	0.2	17.3	0.9	3.1	1,520.8	597.2
Pacific	0.0	11.2	0.3	0.4	−114.7	−226.6
South Central	0.0	64.6	23.4	35.2	4,454.8	2,328.7
Lower-48	**40.3**	**105.3**	**26.2**	**78.4**	**14,150.6**	**6,361.4**

**LNG Storage Capacity net changes represent 2014-2023*

Table: American Gas Association • Source: Energy Information Administration, Pipeline and Hazardous Materials Safety Administration • Created with Datawrapper

Natural Gas Infrastructure Capacity and Market Indicator Metrics

2013-2023* Net Change, Billion Cubic Feet (Bcf)

Region	LNG Capacity	Underground Storage Capacity	Intrastate Pipeline Capacity (Bcf/d)	Interstate Pipeline Capacity (Bcf/d)	Production	Demand
East	**40.0**	**-8.5**	**1.1**	**24.5**	**8353.4**	**2618.0**
Connecticut	0.1	-	-	0.1	-	57.8
Delaware	0.0	-	-	0.2	-	-13.8
Florida	0.0	-	0.4	2.2	0.1	418.4
Georgia	0.0	-	0.0	1.6	-	156.6
Maine	0.0	-	-	0.2	-	-6.7
Maryland	0.0	0.0	-	1.1	0.0	95.1
Massachusetts	-0.1	-	-	0.6	-	-43.7
New Hampshire	0.0	-	0.0	0.0	-	3.7
New Jersey	0.0	-	-	2.6	-	16.4
New York	0.1	-3.0	0.0	1.7	-15.2	45.7
North Carolina	0.3	-	0.0	0.3	-	216.5
Ohio	-	-2.8	0.1	3.6	1996.5	441.7
Pennsylvania	39.7	-11.0	0.7	2.6	4252.2	751.7
Rhode Island	0.0	-	-	0.0	-	12.0
South Carolina	0.0	-	0.0	0.2	-	109.6
Vermont	-	-	0.0	0.0	-	2.9
Virginia	0.0	-0.5	0.0	1.2	-56.0	210.9
West Virginia	-	8.8	-	6.3	2175.8	143.2
Midwest	**0.1**	**20.7**	**0.5**	**15.3**	**-63.8**	**1044.1**
Illinois	0.0	18.9	0.1	3.2	-0.3	18.6
Indiana	0.0	2.8	0.0	0.7	-4.1	202.4
Iowa	0.0	0.0	0.0	0.0	-	122.8
Kentucky	-	0.0	-	4.1	-3.6	118.3
Michigan	-	-3.4	0.2	5.5	-53.8	249.9
Minnesota	0.0	0.0	0.0	0.1	-	38.5
Missouri	-	0.0	0.0	1.2	0.0	33.8
Tennessee	0.0	2.4	0.2	0.1	-1.9	111.1
Wisconsin	0.1	-	0.0	0.3	-	148.7

Region	LNG Capacity	Underground Storage Capacity	Intrastate Pipeline Capacity (Bcf/d)	Interstate Pipeline Capacity (Bcf/d)	Production	Demand
Mountain	**0.2**	**17.3**	**0.9**	**3.2**	**1520.8**	**597.2**
Arizona	0.1	-	0.0	0.0	0.0	190.4
Colorado	-	19.3	0.2	1.9	99.9	37.2
Idaho	0.0	-	0.0	-	2.4	38.7
Montana	0.0	−0.1	0.0	0.0	−21.6	11.8
Nebraska	0.0	0.0	-	0.1	−0.8	28.8
Nevada	0.0	-	-	0.0	0.0	16.0
New Mexico	-	0.0	0.1	0.3	1805.6	76.6
North Dakota	-	-	0.6	0.5	697.1	122.8
South Dakota	-	-	-	-	−16.1	13.5
Utah	0.2	0.0	0.0	0.0	−180.8	38.8
Wyoming		−2.0	0.0	0.3	−864.9	22.6
Pacific	**0.0**	**11.2**	**0.3**	**0.4**	**−114.7**	**−226.6**
California	0.0	4.3	0.0	0.2	−114.0	−328.1
Oregon	0.0	6.9	0.1	0.2	−0.7	59.8
Washington	0.0	0.0	0.2	0.0	-	41.8
South Central	**0.0**	**64.6**	**23.4**	**35.2**	**4454.8**	**2328.7**
Alabama	0.0	8.2	0.0	3.5	−102.9	135.2
Arkansas	0.0	0.1	-	0.0	−749.8	101.4
Kansas	-	−1.0	-	−0.3	−153.4	21.2
Louisiana	0.0	7.2	3.1	18.5	1984.7	598.8
Mississippi	0.0	26.6	-	1.9	−31.6	200.0
Oklahoma		2.1	0.8	1.3	700.5	168.7
Texas	0.0	21.4	19.4	10.2	2807.3	1103.3
Lower-48	**40.3**	**105.3**	**26.2**	**78.5**	**14150.6**	**6361.4**
Alaska	0.0	0.0	0.0	-	29.4	121.6
Hawaii	-	-	-	-	-	0.1
U.S. Total	**40.3**	**105.3**	**26.2**	**78.5**	**14179.9**	**6483.2**

**LNG Storage Capacity net change represents 2014-2023, Please Note: Totals may not foot due to rounding.*

Table: American Gas Association • Source: Energy Information Administration, Pipeline and Hazardous Materials Safety Administration • Created with Datawrapper

Addendum: Version Control History

Version Date	*Summary of Revisions*
April 2025	Initial release of report
November 2025	Version revisions include: • **Updated seasonal spread analysis** to correct results (*i.e.*, −$0.26 per MMBtu for 2013–2023, +$0.02 for 2003–2013, + $0.46 for 1994–2003), clarify interpretation in narrative, and revise Figure 19. *See pp. 3, 43-44.* • **Corrected LNG storage data and terminology** for consistency with EIA's naming convention. Corrected values include a net addition of ~3.5 Bcf in 2022 and a net withdrawal of ~8 Bcf in 2023. *See pp. 6, 31.* • **Corrected unit for the power sector daily record** by adding "million" to "7.1 MWh" to correctly reference 7.1 million MWh. *See p. 33.* • **Minor typographical edit** to footnote 109. *See p. 43.*