

January 2026



WHITE PAPER

# Maintaining Reliability of Energy Systems with Natural Gas Infrastructure

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*Image Credit: USA Today*

## Acknowledgements

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*This report was prepared by GTI Energy as part of the Reliable Affordable Infrastructure for Secure Energy (RAISE) program. We thank RAISE's sponsors, the expert advisory committee members and other individuals that provided input and review into the report. A full list of RAISE sponsors and advisors can be found at <https://www.gti.energy/raise/>. The views and findings expressed in this report are those of GTI Energy and do not necessarily reflect the views of any RAISE sponsors or advisors.*

## Introduction

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Reliable energy systems provide affordable, efficient fuel delivery and storage network, and shape overall economic stability and growth. As global energy demand continues to grow, maintaining the reliability of these systems is critical. Among the various energy sources, natural gas plays a key role in ensuring reliable energy delivery due to its versatility, ability to balance the intermittency of renewables, and relatively low cost. Additionally, natural gas is essential for decarbonization efforts as it serves as a cost-effective energy source that reduces carbon emissions while supporting the integration of renewables and alternative fuels such as hydrogen. However, the projected demand growth, extreme weather events, and infrastructure constraints raise unique challenges and opportunities. This paper explores the role of natural gas in maintaining U.S. energy system reliability and examines demand trends, increased AI technologies considerations, trade-offs between domestic utilization and export priorities, and reliability risks posed by extreme weather events and technological challenges. While we only briefly acknowledge the trade-offs in reliability and the evolving role of natural gas, we emphasize that natural gas and its infrastructure remain essential to system reliability and decarbonization, with deeper analysis of these cost and technology dynamics reserved for future work.

## Role of Natural Gas in Energy Systems Reliability

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Natural gas infrastructure enhances future system reliability through its scale, resilience, and adaptability. With more than 3 million miles of pipelines and over 500 storage facilities, the U.S. natural gas system offers extensive geographic reach, multiple supply pathways, and built-in redundancy that reduces the risk of disruptions during regional events<sup>1</sup>. Natural gas storage capacity allows seasonal energy storage at a scale far greater than batteries can currently achieve, ensuring supply availability during winter cold snaps, summer heat waves, or periods of simultaneous heating and electricity demand surge. Because pipelines and storage assets are primarily underground, they are less vulnerable to storms, wildfires, and grid outages. Additionally, the existing network has the potential to accommodate blending of renewable natural gas (RNG), synthetic methane, and hydrogen, thereby supporting decarbonization goals without the need for entirely new infrastructure.

Natural gas accounts for approximately 30-50% of electricity generation throughout the year, surpassing all other generation sources<sup>2,3</sup>. It provides dispatchable power capable of operating continuously and ramping up or down in response to fluctuations in demand or renewable output. This flexibility reduces the likelihood of load shedding and helps maintain grid stability during extreme weather events or periods of low wind and solar generation. Furthermore, natural gas supports heating, high-temperature industrial processes, and petrochemical production, all of which are highly sensitive to disruptions. As such, the reliability of natural gas supply and infrastructure is critical to overall system stability.

## Natural Gas Demand

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### Demand Trends

The current domestic natural gas consumption is approximately 91.4 billion cubic feet per day (Bcf/d) (Figure 1)<sup>4</sup>. Projections indicate that U.S. consumption could reach 125 Bcf/d by 2030, due to electrification trends, liquefied natural gas (LNG) export growth, and the rapid expansion of energy-intensive sectors such as data centers<sup>5</sup>. As demand rises, winter reliability during extreme cold events becomes increasingly dependent on regional capacity adequacy, storage deliverability, and effective gas–electric coordination, since production disruptions and pipeline constraints can significantly increase reliance on storage withdrawals and firm transportation. With this projected growth, prices are expected to increase to an average of \$4.00/MMBtu, primarily due to the recent increase in demand for LNG exports<sup>6</sup>. This approximately represent an 82% increase from the 2024 average of \$2.19/MMBtu and a 17% increase from the current

2025 average of \$3.43/MMBtu (as of October 2025)<sup>7</sup>.

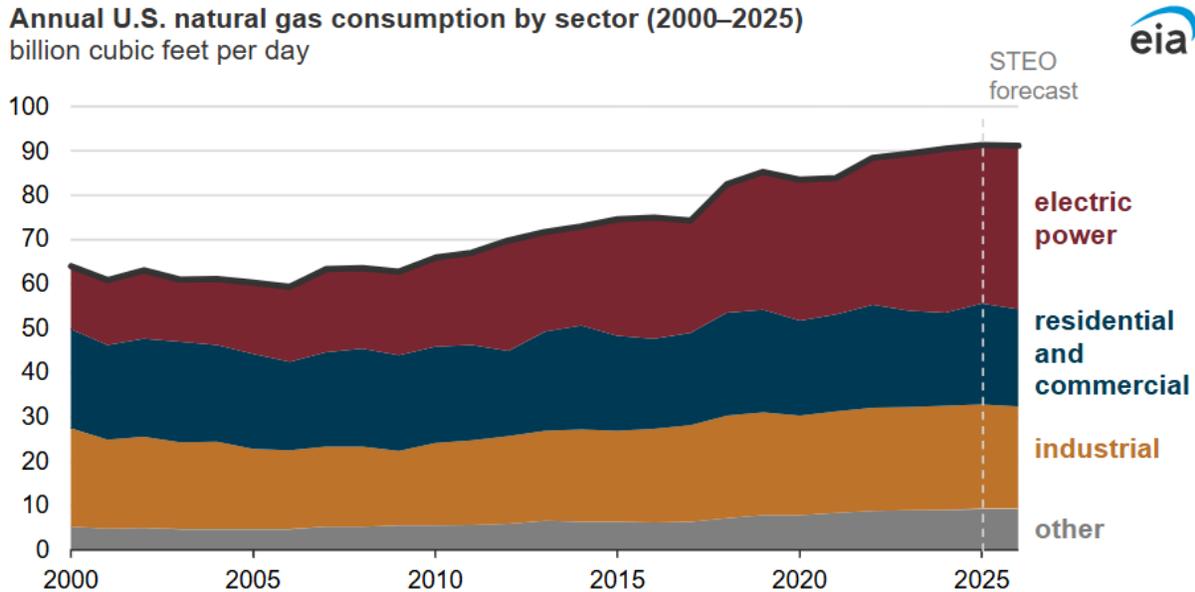


Figure 1: U.S. Energy Information Administration (EIA) annual U.S. natural gas consumption in billion cubic feet per day (2000-2025)

Electricity production is responsible for the largest proportion of natural gas consumption (Figure 1). Natural gas currently provides 450 GW of electricity, with an additional 20 GW of combined cycle power plant projects in development<sup>8</sup>. While natural gas remains indispensable for grid reliability, EIA forecasts a gradual decline in its share of electric power generation as renewable capacity expands. However, this reduction is offset by rising consumption in residential, commercial, and industrial sectors<sup>6</sup>.

Natural gas demand in the U.S. varies throughout the year due to seasonal and regional fluctuations, mostly driven by weather patterns, infrastructure constraints, and consumption profiles. The winter months typically see peak demand due to heating needs in the residential and commercial sectors, while summer demand rises in regions that rely on gas-fired power plants for cooling loads. Regionally, the Northeast faces heightened winter demand and pipeline capacity challenges, whereas the Gulf Coast maintains relatively stable consumption due to industrial and LNG export activity.

### Export vs. Domestic Utilization

The global energy demand is expected to grow by 18% in 2025 with natural gas demand growing by 32% (approximately 190,000 Bcf)<sup>8</sup>. The Middle East, North America, and Russia are projected to remain the main sources of natural gas (70-80% of global supply) to meet rising demands through LNG exports. In 2022, the U.S. exported an average of 10.6 Bcf/d, with Europe being the primary destination, followed by Asia (Figure 2)<sup>9</sup>. In 2024, U.S. exports increased to an average of 11.9 Bcf/d, and continued growth is expected in 2025 and 2026 with six major operating terminals, and three additional terminals under construction expected to come online or reach full operation by 2026<sup>10</sup>.

**Annual U.S. liquefied natural gas exports by destination (2020–2022)**  
billion cubic feet per day

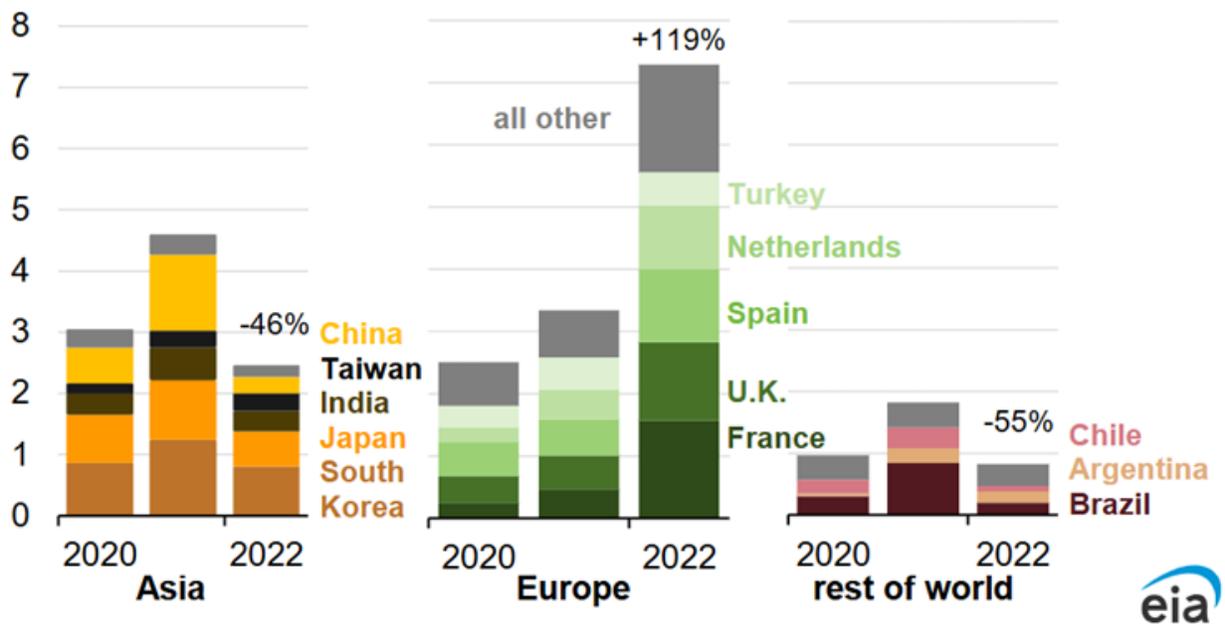


Figure 2: EIA 2020-2022 annual US LNG Exports by continent

With LNG exports accelerating against a backdrop of evolving U.S. energy policy, policymakers will need to navigate the challenge of balancing an affordable, reliable domestic natural gas supply with global market objectives. In 2025, the U.S. Department of Energy resumed reviews and approvals for non-FTA LNG export applications<sup>1</sup>, concluding that exports serve the public interest and that domestic supply is sufficient to support both domestic and export demand while generating economic and energy-

<sup>1</sup> <https://www.energy.gov/articles/secretary-wright-acts-unleash-golden-era-american-energy-dominance>

security benefits. Higher export volumes create substantial economic value, including production growth, job creation, and strengthened global energy security, but elevated exports can tighten domestic natural gas availability, potentially pressure prices, and complicate efforts to maintain an affordable and reliable onshore energy supply, particularly during peak demand periods. Balancing export growth with domestic reliability and storage adequacy should therefore be an explicit consideration as export authorizations expand.

## **Data Centers and AI: A Rapidly Expanding Source of Energy Demand**

Data centers and artificial intelligence (AI)-driven applications are emerging as one of the fastest-growing energy consumers. The International Energy Agency (IEA) projections indicate that data center electricity demand could reach 945 terawatt-hours (TWh) by 2030, surpassing Japan's current total consumption<sup>11</sup>. In the U.S., data center consumption reached 176 TWh in 2023 (~4.4% of total electricity consumption)<sup>12</sup>. Forecasts suggest this share will rise to 9-12% by 2030, equivalent to 350-580 TWh annually<sup>12</sup>.

These facilities typically require hundreds of megawatts of continuous, high-reliability power per site, creating localized stress on transmission and interconnection infrastructure. In regions such as New York and Pennsylvania, this challenge is compounded by long transmission queue timelines, constrained interconnection capacity, and permitting and siting hurdles for new generation and transmission assets. As a result, the pace of load growth from data centers increasingly outstrips the ability of the grid to deliver new capacity on conventional timelines.

Natural gas-fired generation provides a critical reliability buffer by offering dispatchable power that complements intermittent renewables generation from the bulk grid or distributed resources, including virtual power plants. However, new gas-fired capacity development faces state-level siting and permitting headwinds, limiting near-term expansion options. Consequently, near-term system reliability in high-growth load pockets depends heavily on optimizing existing generation assets, enhancing storage deliverability, and securing firm fuel supply, rather than relying on new greenfield infrastructure. To address these constraints, developers and utilities are increasingly exploring co-location strategies, such as siting data centers adjacent to natural gas fired generation plants. This approach can mitigate grid interconnection delays, reduce

transmission bottlenecks, and secure firm, dispatchable power while longer-term grid upgrades and clean energy additions are developed. The exponential growth of data centers exemplifies the continued importance of strategic natural gas system planning and investments in natural gas system modernization.

## Decarbonization Considerations

Natural gas also plays a pivotal role in decarbonization strategies, acting as a cost-effective fuel that enables significant emissions reductions while supporting renewable integration. Since 2005, coal-to-gas switching has accounted for the largest share of U.S. power sector emissions reductions (over 500 million metric tons of CO<sub>2</sub>), surpassing the impact of renewables during the same period<sup>13,14</sup>. There is also growing consensus that natural gas will remain in the energy mix regardless of the pace of the energy transition, with global demand projected to increase in the next decade, even under the most aggressive decarbonization scenarios<sup>15</sup>. In parallel, industry guidance highlights practical pathways to integrate lower-carbon gas supplies such as RNG and hydrogen into existing systems without compromising safety or reliability. Together, these efforts demonstrate how emissions performance, operational resilience, and responsible sourcing can be advanced simultaneously, providing a pragmatic foundation for near-term reliability while longer-term energy system transitions are underway.

## Reliability Risks

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Assessments of the reliability of natural gas systems depend on the scale of analysis, as reliability challenges at the national level differ from those at regional levels. On a national scale, reliability is primarily driven by total supply availability, storage capacity, and interstate pipeline connectivity. In contrast, regional reliability is more directly affected by last-mile infrastructure constraints, compression capacity, and vulnerability to single-asset failures such as a pipeline segment or meter stations. This section addresses national climate and technology reliability concerns, which do not represent an exhaustive list of risks. Furthermore, accounting for regional variability is essential to effectively mitigate the full range of potential system vulnerabilities.

## Climate

During extreme cold events, natural gas supply reliability is impacted by freeze-offs in wells and gathering lines, which restrict production and pipeline flows<sup>16</sup>. Many of the

system failures during these events often stem from localized challenges rather than systemic issues across the entire gas network. During winter storms Uri, Elliot, and Heather, gas production declined by more than 15 Bcf/d<sup>16</sup>. These infrastructure constraints often coincide with heating demand surges (Figure 3). When demand outweighs production, system reliability and the ability to meet demand depend heavily on storage capacity. Insufficient storage and increased withdrawal rates have led to cascading reliability failures, forcing curtailments in industrial operations and power generation. During winter storm Uri in 2021, 4.5 million customers in Texas lost power, resulting in over 150 fatalities<sup>17-19</sup>. At the peak of winter storm Elliot in 2022, incremental unplanned generation outages reached 90,500 MW, with total unavailable generation exceeding 127,000 MW—approximately 18% of the eastern interconnection demand<sup>20</sup>.



Figure 3: Natural Gas demand vs production during recent extreme winter events (2020-2025)<sup>21</sup>

Conversely, extreme heat events present a different set of reliability challenges. High temperatures drive spikes in electricity demand for cooling, which in turn increases reliance on natural gas-fired power plants. However, these power plants can experience

reduced output during heat waves due to hotter air intake and limitations of their cooling systems. During these extreme events, power generation often competes with residential and industrial loads for the limited pipeline capacity since pipeline efficiency can decline under thermal stress. This combination of soaring demand and constrained supply heightens reliability risks, particularly in regions with limited pipeline redundancy or high LNG export commitments, leaving less margin for emergency power generation.

Despite the complexity of climate challenges, the impact of these weather events can be alleviated by reinforcing existing infrastructure, especially at identified failure points, expanding pipeline and storage capacity, and integrating gas-electric planning. Recent FERC-NERC assessments show resilience improvements using such measures. During January 2025's Arctic cold snap, the system met record demand of 150 Bcf/day, with no manual load shed due to weatherization and proactive coordination<sup>22</sup>.

## **Infrastructure Modernization**

Some parts of the U.S. natural gas system are aging and require significant maintenance or replacement to ensure reliability. Older pipeline materials, such as cast and wrought iron and unprotected steel, are particularly vulnerable to premature corrosion, posing safety and operational risks. To address these issues, the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) launched initiatives to accelerate the replacement of cast iron and bare steel pipelines. These efforts have yielded substantial progress: from 2005 to 2022, the miles of cast and wrought iron gas distribution mains were reduced by more than 50%, and 24 states have completely eliminated cast iron pipes from their systems<sup>23-25</sup>. However, while replacement programs have outpaced expansions, the growing demand for natural gas will likely require new pipeline development to maintain system reliability and meet future energy requirements.

To address system failures, smart meters and advanced sensor networks are enabling near-real-time visibility into flows, pressure, and system performance. These improvements allow operators to identify anomalies before they escalate into service disruptions. Continuous pipeline monitoring technologies, including fiber-optic sensing, high-pressure smart gauge tool (HPSGT), magnetic flux, ultrasonic, and acoustic leak detection, as well as AI-driven anomaly detection, provide early warning capabilities that can significantly reduce outage duration and safety risks. As the industry collects more

data through these various monitoring and sensing techniques, it will also enhance demand prediction and improve gas-electric interconnectivity. By analyzing consumption patterns, weather impacts, and system constraints, operators can reduce inefficiencies and forecast energy needs with greater accuracy. This improved visibility in natural gas systems will strengthen coordination efforts with electric systems.

Furthermore, industry research and development efforts are increasingly focused on shortening response times to abnormal events through automated isolation systems, digital twins, and predictive maintenance platforms that anticipate failure based on operating conditions and asset health trends. As these technologies mature and become more widely deployed, they offer a pathway to improve operational reliability.

## Conclusion

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Rapid electrification, accelerating AI-driven energy demand and expanding data center developments are placing unprecedented stress on energy systems, elevating reliability and resilience as critical priorities. Meeting these challenges requires energy systems that balance security, affordability, and sustainability. In the near to medium term, natural gas remains the most reliable and scalable option for maintaining system stability, providing the flexibility required to support rising electricity demand while enabling the continued growth of renewables and alternative fuels.

As demand grows, expanding effective pipeline capacity, enhancing storage deliverability, and improving gas-electric coordination will be vital to prevent supply disruptions. Without these measures, simultaneous peak demand for heating and critical facilities could threaten energy stability. Extreme weather events further amplify these risks, reinforcing the need to strengthen infrastructure performance and reduce operational uncertainty. Additionally, policymakers will need to balance competing priorities, maximizing the economic and geopolitical advantages of LNG exports while preserving domestic energy reliability and affordability. Continued investment in system safety and modernization remains essential, particularly as natural gas continues to be one of the most cost-effective energy sources for consumers.

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