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Natural Gas Reliability: Issues for Congress

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The reliability of the U.S. natural gas system is of growing policy interest in Congress. Until recently, natural gas shortages were relatively rare. However, key stakeholders, especially in the electricity sector, have begun to lose confidence in natural gas reliability, even as the role of natural gas in the nation's energy mix grows and evolves. In response, policymakers have called for greater attention to natural gas supplies and federal initiatives to ensure natural gas reliability.

In 2023, U.S. natural gas production exceeded 41 trillion cubic feet (Tcf), making the United States the world's largest producer. The U.S. market is also the world's most competitive, with thousands of producers and wholesale consumers, over 3 million miles of pipeline, more than 500 storage facilities, and eight active liquefied natural gas (LNG) marine terminals. Electricity is the largest gas consuming sector, accounting for 12.9 Tcf, or 40% of domestic demand, and natural gas is the largest energy source for electricity generation (43%). As a result, the respective reliabilities of the natural gas and electric power systems have become interdependent.

Recent natural gas supply emergencies in New York, Rhode Island, Texas, and other states have revealed new risks to natural gas supply reliability. These events have been attributed to long-term infrastructure constraints, severe storm damage, and cyberattacks—or a combination of these factors. Other emergent trends, such as an increase in electricity generation from wind and solar, which may strain gas supplies at certain times, and a national strategy to promote hydrogen as an alternative fuel, may pose future challenges to natural gas system reliability.

No federal agency has explicit authority to regulate natural gas system reliability, but agencies have authority over aspects of production, infrastructure development, and operations that influence reliability. Key agencies include the Bureau of Land Management (gas production and pipeline siting on federal lands), the Federal Energy Regulatory Commission (FERC; pipeline and LNG terminal siting, pipeline rates), the Pipeline and Hazardous Materials Safety Administration (pipeline safety), the Transportation Security Administration (pipeline physical and cybersecurity), the Cybersecurity and Infrastructure Security Agency (cybersecurity reporting), and the Department of Energy's Office of Cybersecurity, Energy Security, and Emergency Response (cybersecurity awareness and emergency response). Because intrastate transmission pipelines and gas distribution systems are not under federal jurisdiction, state regulators also play a key role in reliability.

Federal agency officials and energy sector stakeholders, many from the electricity sector, have called for greater federal regulation, often referring to FERC's regulation of electric power system reliability as a model. European and Australian natural gas reliability standards demonstrate that other approaches may also be possible. However, many in the natural gas industry question the need for such regulation. Pipeline operators, in particular, argue that their systems are highly reliable and that recent gas supply emergencies resulted from factors outside their operational purview. They assert that proposals to create a new reliability regulator would risk duplication and conflict with existing federal and state authorities, and that a FERC-type electric reliability model would not be appropriate for natural gas because of differences between the sectors. They point to other policy options, such as facilitating infrastructure expansion, as having a greater potential impact.

The Fiscal Responsibility Act of 2023 (P.L. 118-5) effectively approved completion of the Mountain Valley Pipeline in order to "increase the reliability of natural gas supplies," among other reasons. Other legislative proposals—including the Spur Permitting of Underdeveloped Resources Act (S. 1456), the Grid Reliability and Resiliency Improvements Act (H.R. 2875), and the Energy Emergency Leadership Act (H.R. 3277)—would establish new federal authorities to regulate natural gas supply reliability among existing operators, or would mandate other federal initiatives related to gas system reliability.

Natural gas reliability involves many interrelated physical and operational factors—such as infrastructure capacity and weather—as well as various regulatory regimes and economic drivers. In light of these factors, evaluating whether to create a new federal reliability regulator may be challenging because there have been few detailed proposals to do so and because gas reliability has so many dimensions. As Congress examines gas reliability policies, issues that may warrant consideration include pipeline expansion (including environmental considerations), the natural gas share of the overall electricity fuel mix, and potential regulatory structures. If Congress concludes that the current federal structure is insufficient, it may consider options for expanding federal gas reliability authority. Exactly what that authority could be, and what agency (or agencies) could administer it, could raise complicated questions regarding existing agency authorities, functions, and capabilities. Whether or not it pursues reliability legislation or other options, Congress may expand its oversight to understand the collective implications of disparate energy and environmental policies on natural gas system reliability, and vice versa.

SUMMARY

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Introduction

Natural gas is an essential commodity in the U.S. economy—used as an industrial feedstock, a heating source for homes and businesses, and a fuel for electricity generation, among other uses. Consequently, ensuring the reliability of natural gas supplies is a priority for the natural gas industry and consumers alike. It is also the subject of growing policy interest in Congress and among various federal agencies.

Because nearly all natural gas is delivered via pipeline, the reliability of the nation's gas pipeline system is of paramount importance for using natural gas, but reliable production, storage, and market functions are also essential. Since the 1950s, when the nation's interstate natural gas system first began to take shape, through the last decade, that system has had a strong record of delivering gas where needed to meet critical demands. As the Government Accountability Office (GAO) concluded in 2020, "interruptions of service to customers of interstate transmission pipelines are relatively infrequent, and industry, state, and federal stakeholders view the transportation of natural gas as reliable."[1]

Over the last several years, however, pipeline cyberattacks, natural gas system emergencies, and other energy supply failures have raised concerns about natural gas supply reliability. A 2019 natural gas pipeline shutdown due to a ransomware attack and a 2021 natural gas shortage in Texas due to extreme weather demonstrated the vulnerability of domestic pipeline systems to unexpected disruption. Other developments, such as plans to close a liquefied natural gas (LNG) import terminal in Massachusetts, have put a focus on critical constraints in regional pipeline capacity.

Natural gas reliability issues are also emerging due to the increased use of wind and solar energy for electricity generation, which may lead to greater reliance on natural gas-fired power plants and their pipeline gas suppliers when wind and solar resources are limited. Further, the use of natural gas pipelines in the production or transportation of hydrogen could impact natural gas reliability; the presence of hydrogen in natural gas pipelines could reduce their effective capacity and also potentially damage them.

Natural gas reliability concerns have been raised across economic sectors, but are particularly significant in the electricity sector due to the growing interdependence of the nation's electricity and natural gas infrastructure.

In response to natural gas system disruptions, policymakers have called for a greater focus on natural gas supplies and federal initiatives to ensure natural gas system reliability.[2] Some have called for establishing mandatory federal reliability standards for natural gas transmission pipelines, akin to the framework Congress has established for electricity transmission. Others focus on expanded federal requirements for pipeline security, changes to natural gas market rules, and measures to facilitate the expansion of natural gas infrastructure. Such proposals are the subject of ongoing debate within and outside the federal government. Some stakeholders—

[1] Government Accountability Office (GAO), *Gas Transmission Pipelines: Interstate Transportation of Natural Gas Is Generally Reliable, but FERC Should Better Identify and Assess Emerging Risks*, GAO-20-658, September 2020 (hereinafter GAO September 2020), p. 22.

[2] See, for example, Rep. Ann Kuster, remarks before the House Committee on Energy and Commerce, Subcommittee on Energy, Climate, and Grid Security, *Fueling America's Economy: Legislation to Improve Safety and Expand U.S. Pipeline Infrastructure*, hearing, January 18, 2024: "I believe we must have a more holistic conversation about the reliability of our natural gas system."

especially in the electricity sector—support proposals for broad-based natural gas reliability standards, while many in the natural gas sector oppose them.

This report examines the U.S. interstate natural gas system and associated markets for wholesale natural gas supply. The report outlines the role of the pipeline system supplying natural gas to key economic sectors, highlighting ties to the electricity sector. It summarizes current federal authorities and agency oversight of siting, safety, security, and reliability for natural gas pipelines and related infrastructure. It reviews recent high-profile natural gas supply disruptions and emerging challenges to natural gas system reliability. It reviews the natural gas pipeline industry's efforts to ensure reliability. It discusses recent gas reliability-related studies, proposals, regulations, and congressional actions—including new statutory and regulatory proposals. The report concludes with a discussion of key considerations for Congress.

U.S. Natural Gas Market Structure

The U.S. market for natural gas is the largest and most competitive in the world, consisting of numerous private natural gas producers and independent consumers linked by an expansive network of pipelines, storage facilities, and related infrastructure. The pipeline network also links to seven large LNG marine terminals that are used primarily for export overseas; one major LNG import terminal; and numerous other LNG and underground storage facilities. Electric power is the largest consuming sector for domestic natural gas, so pipeline connections to numerous power plants are another important characteristic of this infrastructure. Natural gas producers and consumers employ a variety of contractual and financial arrangements for commodity supply and pipeline transportation services.

Natural Gas Commodity Market

In 2023, marketed production of U.S. natural gas exceeded 41 trillion cubic feet (Tcf), making the United States the world's largest gas producer.[3] The United States has proven natural gas reserves sufficient to last more than 80 years at current levels of annual production and consumption, and these reserves continue to grow due to new discoveries and the application of new production technology.[4] Consequently, scarcity of domestic natural gas resources is not a limiting factor in U.S. natural gas supply the way it is in Europe, Japan, and other international markets.

Supply and demand are the principal determinants of the U.S. natural gas commodity price, with regional differences in gas production and pipeline capacity driving regional differences in prices. While the federal government regulates certain aspects of the sector, including interstate transmission pipeline rates and natural gas production on federal lands (discussed below), wholesale gas commodity prices are generally unregulated.

The existence of numerous and diverse participants in the U.S. gas market contributes to its competitiveness. For example, thousands of gas-producing companies operate in the United States; these range from supermajors, with billions of cubic feet of production per day, to small, independent companies with a few thousand cubic feet of daily production.[5] A key feature of the

[3] Energy Information Administration (EIA), *Monthly Energy Review*, DOE/EIA-0035(2024/3), March 2024 (hereinafter EIA March 2024), Table 4.1.

[4] EIA, "Frequently Asked Questions (FAQS): How Much Natural Gas Does the United States Have, and How Long Will It Last?," web page, last updated April 29, 2024, https://www.eia.gov/tools/faqs/faq.php?id=58&t=34#:~:text=Assuming%20the%20same%20annual%20rate,gas%20TRR%20in%20future%20years.

[5] Natural Gas Supply Association, *Representing America's Natural Gas Suppliers*, 2023, https://www.ngsa.org/wp-content/uploads/sites/3/2023/09/NGSA-Who-We-Are-9.23.pdf.

sector is that many producers are able to sell their natural gas to a wide range of customers—including marketers, large consumers, and local natural gas distribution companies—across a widespread and interconnected pipeline network. These interconnections facilitate the physical movement of natural gas from many different sources to many different destinations. Likewise, the ability of wholesale natural gas consumers to choose among a wide range of producers enables highly competitive commodity pricing.[6]

U.S. Pipeline Network

The U.S. natural gas pipeline system provides vital links between natural gas producers and consumers—such as natural gas distribution utilities, power plants, and industrial facilities. The network consists of over 400,000 miles of gathering lines, which run from natural gas production wells, and over 300,000 miles of large diameter transmission pipelines.[7] The latter connect directly to large wholesale customers and some 1,500 local distribution utilities, which operate around 2.3 million miles of distribution pipeline mains serving over 70 million retail customers.[8]

Natural gas pipelines are widespread, running alternately through remote and densely populated regions, delivering gas from sources of production to consumer markets—domestically and to Canada and Mexico—and to export facilities (**Figure 1**). These pipelines also connect to 171 LNG facilities—used for seasonal storage, import, and export—and over 400 underground storage facilities.[9] The underground storage facilities can store volumes equivalent to about 10% of annual U.S. natural gas consumption and are essential for daily and seasonal balancing of supply and demand. Within the U.S. pipeline network, at dozens of locations ("hubs"), physical interconnections enable the transfer of natural gas from one pipeline to another.[10] Such pipeline junctures, most notably Henry Hub on the Gulf Coast of Louisiana (the largest hub), are vital points for natural gas delivery and pricing.

[6] For additional discussion of U.S. natural gas markets and prices, see CRS Report R45988, *U.S. Natural Gas: Becoming Dominant*, by Michael Ratner.

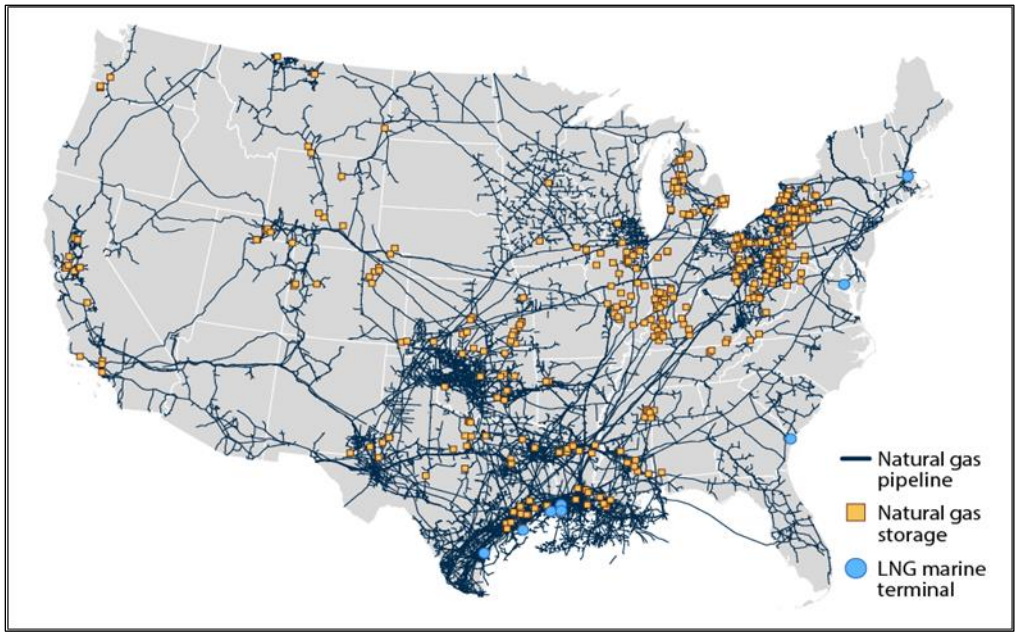
[7] Pipeline and Hazardous Materials Safety Administration (PHMSA), "Annual Report Mileage Summary Statistics," data tables, July 1, 2024, https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-summary-statistics; PHMSA, "Annual Report Mileage for Gas Distribution Systems," July 1, 2024, https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-gas-distribution-systems.

[8] PHMSA, July 1, 2024. Distribution mains bring natural gas from transmission pipelines to individual retail gas service lines.

[9] EIA, "Underground Natural Gas Storage Capacity," online database, "Total Number of Existing Fields" data series, June 28, 2024, https://www.eia.gov/dnav/ng/ng_stor_cap_a_EPG0_SAD_Count_a.htm.

[10] Federal Energy Regulatory Commission (FERC), *Energy Primer: A Handbook of Energy Market Basics*, staff report, April 2020 (hereinafter FERC April 2020), p. 22, https://www.ferc.gov/sites/default/files/2020-06/energy-primer-2020_0.pdf.

Figure 1. Contiguous U.S. Natural Gas Infrastructure



Source: Created by CRS using data from the U.S. Energy Information Administration and ESRI.

Notes: Map shows interstate and intrastate natural gas transmission pipelines, underground natural gas storage facilities, and major LNG import/export facilities (marine terminals). Map does not show distribution pipelines, gathering pipelines, or smaller LNG seasonal storage facilities.

Natural Gas Purchasing

Wholesale natural gas consumers seeking natural gas supplies must typically secure both the natural gas commodity and pipeline capacity through separate purchasing arrangements with producers and pipeline operators, respectively, or through marketers acting as intermediaries and aggregators.

Commodity Supplies

Two markets exist for wholesale natural gas—a physical market and a financial market. The physical market primarily involves the physical delivery of natural gas and is essential for gas supply reliability. In the physical market, customers may purchase natural gas under a variety of contractual arrangements of varying duration and with various pricing mechanisms (e.g., fixed, indexed). The two main types of purchasing contract are for "firm" supplies (obligating the receipt or delivery of the specified gas volumes) or for "interruptible" supplies (with no volume obligations).[11]

Much of the physical market involves daily trade on the day-ahead spot markets at various trading points, such as Henry Hub. The spot markets supply natural gas needed within days, allowing natural gas distribution companies, electricity generators, and other buyers to respond to weather or other short-term market changes—but not committing them to long-term purchases

[11] NaturalGas.org, "Marketing," web page, September 20, 2013, http://naturalgas.org/naturalgas/marketing/.

they may not need.[12] Spot market prices can be highly volatile due to fluctuating supply and demand balances.

The financial market involves primarily trading in Henry Hub natural gas futures, which are contracts obligating a party to buy a specific quantity of natural gas at a specific future date (typically, the 15th day of a future month) at a specific price. As is the case with other commodities, trading in natural gas futures rarely involves the actual physical exchange of natural gas. Participants in the futures market typically meet their contract obligations by pairing contracts to buy with offsetting contracts to sell, or by making cash payments. Thus, futures trading is primarily used as a financial risk management tool by buyers and sellers.[13] Henry Hub natural gas futures are traded on the New York Mercantile Exchange (NYMEX).[14]

Pipeline Transportation Services

Wholesale natural gas customers must purchase pipeline transportation service, also referred to as *pipeline capacity*, from pipeline operators. This service allows customers to ship natural gas from where it is produced (or stored) to the point of delivery—such as a factory, power plant, or distribution company "city gate."[15]

As with commodity contracts, pipeline capacity also is generally available on a firm or interruptible basis. Contracts for firm transportation service give customers the right to ship gas in quantities up to the contracted portion of a pipeline's capacity with priority over other shippers not holding firm transportation contracts.[16] Because firm pipeline capacity is guaranteed, this is the most expensive type of transportation service. Alternatively, customers may contract for interruptible transportation service, which provides natural gas shipment if pipeline capacity is available. Because interruptible capacity is not guaranteed and may not be available during times of peak demand, interruptible transportation costs less than firm transportation.[17] There is also a secondary market for pipeline transportation services where customers holding pipeline capacity rights can sell (release) capacity to other shippers.

The terms of commercial service of natural gas pipelines may include provisions for access to pipeline capacity, rates for transportation service, requirements for commodity quality, and other commercial requirements. Natural gas transmission pipelines typically are "contract carriers," serving only a specific group of shippers, usually under long-term pipeline capacity agreements, but also subject to rate regulation.[18] Customers seeking to ship natural gas on a given pipeline with which they have a contract must request the use of ("nominate") the desired capacity on a day-ahead basis, with opportunities to make intraday adjustments on the day of delivery. The pipeline operator assembles and verifies all such nominations to coordinate daily natural gas

[12] American Gas Association (AGA), "Natural Gas Prices," web page, accessed July 1, 2024, https://www.aga.org/research-policy/resource-library/natural-gas-prices/.

[13] Ibid.

[14] CME Group, *NYMEX Rulebook*, chapter 220, "Henry Hub Natural Gas Futures," 2009, https://www.cmegroup.com/content/dam/cmegroup/rulebook/NYMEX/2/220.pdf.

[15] A *city gate* is the physical point of receipt for a natural gas distribution company beyond which the natural gas is transported on distribution system pipelines for delivery to retail customers.

[16] FERC April 2020, p. 23.

[17] Ibid.

[18] For further discussion of contract carriage, see William A. Mogel and John P. Gregg, "Appropriateness of Imposing Common Carrier Status on Interstate Natural Gas Pipelines," *Energy Law Journal*, vol. 4, no. 2, 1983, pp. 155-187. Being subject to rate regulation is often a requirement to be granted eminent domain authority by a state or federal agency for pipeline construction.

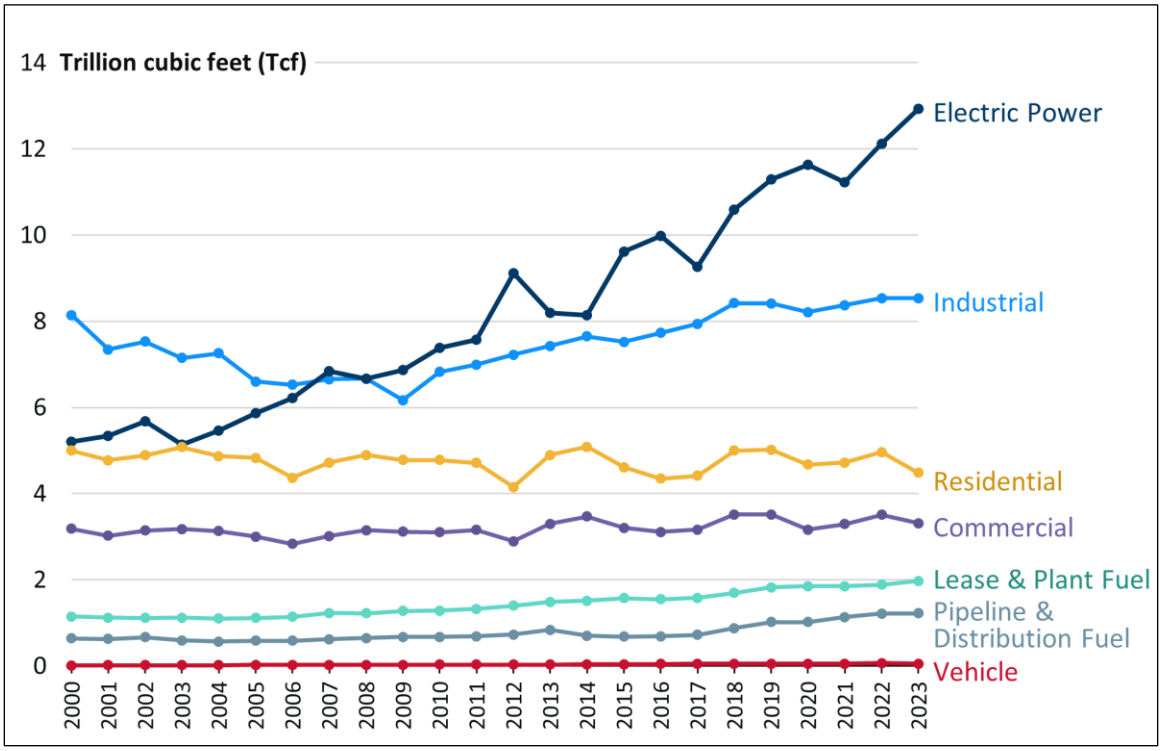
shipments—prioritizing firm capacity—and to determine how much capacity remains available for interruptible shipments.[19] The rates and terms of interstate natural gas transportation services are regulated by the Federal Energy Regulatory Commission (FERC), discussed below.

Gas-Electric Interdependency

While natural gas producers supply various types of buyers across the economy, the electricity sector represents the largest share of buyers. In 2023, U.S. pipelines carried 32.5 Tcf of natural gas for domestic consumption (and an additional 7.6 Tcf for export).[20] Electricity was the largest domestic consuming sector, accounting for 12.9 Tcf, 40% of domestic demand, followed by the industrial (32%), residential (14%), and commercial (10%) sectors.[21] The market share for electric power has nearly doubled since 2000, when it accounted for only 22% of domestic consumption (**Figure 2**).

Figure 2. Annual U.S. Natural Gas Consumption by Sector, 2000-2023

Figure is interactive in the HTML version of this report.



Source: Energy Information Administration, Monthly Energy Review, DOE/EIA-0035(2024/5), May 2024, Table 4.3, p. 108.

Notes: Excludes exports. "Lease and plant fuel" is natural gas used in well, field, and lease operations (e.g., drilling and field compressors) and as fuel in gas processing plants. "Pipeline and distribution fuel" is natural gas consumed in pipeline operations.

[19] Interstate Natural Gas Association of America (INGAA), "Interstate Gas Pipeline Fundamentals," slide presentation to the PJM Electric Gas Coordination Senior Task Force, December 16, 2021, https://www.pjm.com/-/media/committees-groups/task-forces/egcstf/2021/20211216/20211216-item-02-ingaa-presentation.ashx.

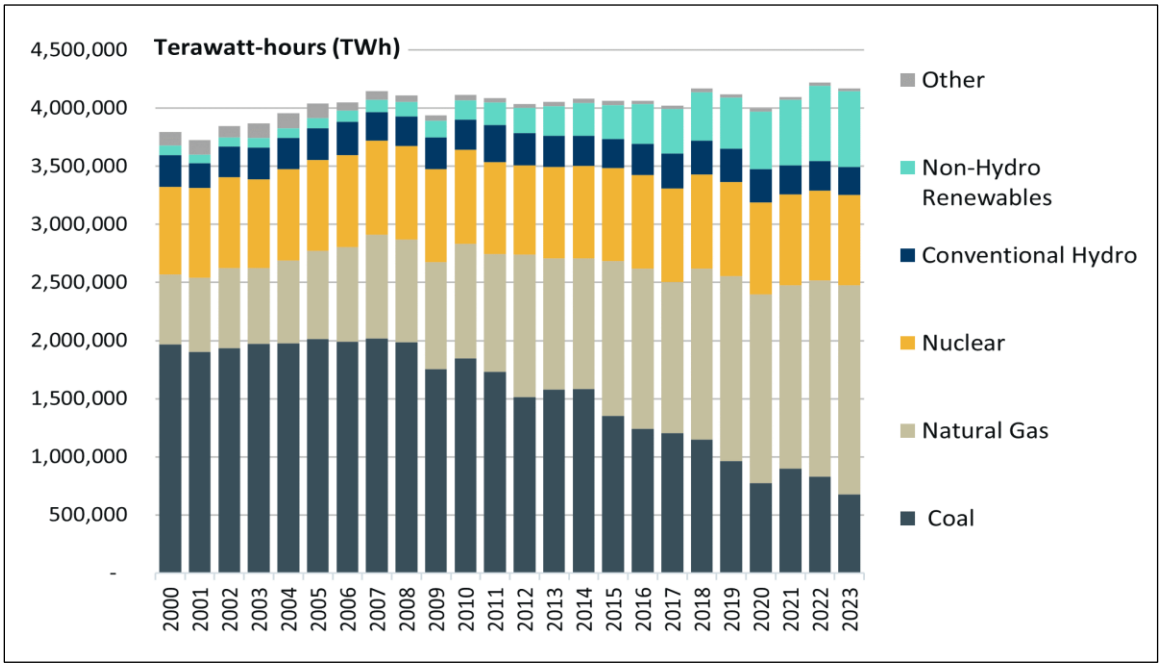
[20] EIA, May 2024, Table 4.1.

[21] Ibid., Table 4.3.

The rise in natural gas demand from the electric power sector corresponds to declining prices for natural gas, which, among other factors, made natural gas more cost competitive as a fuel for electricity generation beginning around the late 2000s.[22] Total U.S. electricity demand has been relatively flat for the last decade, so the share of electricity generation from natural gas has grown, primarily replacing coal in the generation fuel mix. Since 2015, natural gas has been the single largest energy source for electricity generation in the United States, accounting for 43% of total generation in 2023 (**Figure 3**).

Figure 3. Annual U.S. Electricity Generation by Energy Source, 2000-2023

Figure is interactive in the HTML version of this report.



Source: Energy Information Administration (EIA), *Electric Power Annual 2010*, November 2011, Table 2.1.A; and EIA, *Monthly Energy Review*, May 2024, Table 7.2a and Table 10.6.

Notes: "Other" includes petroleum liquids, petroleum coke, pumped storage, blast furnace gas and other manufactured and waste gases derived from fossil fuels, nonbiogenic municipal solid waste, batteries, hydrogen, purchased steam, sulfur, tire-derived fuel, and other miscellaneous sources. Nonhydro renewables include wood, black liquor, other wood waste, biogenic municipal solid waste, landfill gas, sludge waste, agricultural byproducts, other biomass, geothermal, solar thermal, solar photovoltaic, and wind. EIA began reporting net generation from small-scale solar photovoltaic facilities in 2014. These values are included in nonhydro renewables for the years in which they are available.

As the electricity sector has risen to become the largest source of domestic natural gas demand, and as natural gas has concurrently risen to become the largest source of fuel for electricity generation, the nation's natural gas and electricity systems have become increasingly interdependent—both economically and operationally. This interdependence is especially significant during times when demand for electricity or natural gas (or both) is high. Annual demand for electricity typically peaks during summer afternoons because of air conditioning use.

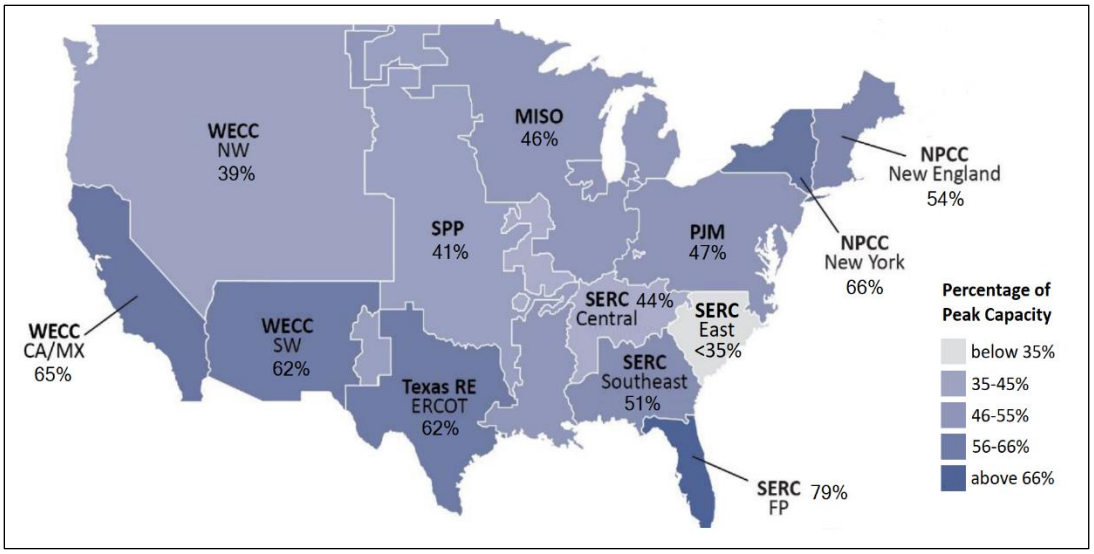
[22] For additional discussion of the changing role of natural gas in the electric power sector, see CRS Report R47521, *Electricity: Overview and Issues for Congress*, by Ashley J. Lawson.

A secondary peak typically occurs during winter nights because of electric heating uses. Winter electricity peak demand periods often coincide with peak demand for natural gas for heating.[23]

Installed natural gas-fired electricity generation capacity varies by region, with some parts of the country more dependent upon natural gas than others, particularly during the winter season (**Figure 4**). In regions of the country with high reliance on natural gas for both electricity and heating needs, such as the Northeast, natural gas supply constraints and disruptions during winter peak demand periods may be especially impactful.

Figure 4. Contiguous U.S. Natural Gas-Fired Winter Peak Generating Capacity, 2023-2024

Gas-Fired Capacity as a Percentage of Total Winter Peak Capacity by NERC Assessment Area



Source: Adapted by CRS from North American Electric Reliability Corporation (NERC), *2023–2024 Winter Reliability Assessment*, November 2023, p. 9.

Notes: MISO = Midcontinent Independent System Operator, NPCC = Northeast Power Coordinating Council, SERC = SERC Reliability Corporation, SPP = Southwest Power Pool, Texas RE = Texas Reliability Entity, and WECC = Western Electricity Coordinating Council. PJM is not an abbreviation.

Interdependent Reliability

The relationship between natural gas reliability and electric power reliability has long been a focus of key stakeholders in the electricity sector. The North American Electric Reliability Corporation (NERC), for example, began to highlight the reliability implications of increased natural gas-fired generation over 30 years ago: "[T]he reliability concern is the continuity of gas supply to this growing segment of generating capacity."[24]

Since the 1990s, NERC has carried out a series of proceedings examining the gas-electric reliability relationship. Among these was its 2017 *Special Reliability Assessment*, which stated

[23] Nationwide, as of 2020, 51% of homes used natural gas for space heating, 34% used electricity, 4% used propane, and 4% used kerosene or other fuel. However, states vary significantly in the prevalence of different heating fuels, so the interdependency of electricity and natural gas systems during winter peak demand periods varies as well. For estimates of the shares of space heating fuels by state and for the United States overall, see EIA, "Highlights for Space Heating Fuel in U.S. Homes by State, 2020," https://www.eia.gov/consumption/residential/data/2020/state/pdf/State%20Space%20Heating%20Fuels.pdf.

[24] North American Electric Reliability Council (NERC), *Reliability Assessment 1992-2001*, September 1992, p. 27.

that "growing interdependence of the natural gas and electric infrastructure has resulted in new operational and planning reliability challenges."[25] More recently, NERC's *2022 State of Reliability* report concluded that "interdependencies between the electricity and natural gas industries are a major new reliability risk that must be explicitly managed."[26] NERC's *2023 State of Reliability Technical Assessment* report asserted that the electric power system "has never been more dependent upon the round-the-clock continuity of just in time natural gas delivery."[27] Echoing this conclusion, a FERC official testified in 2023 that "natural gas system reliability is fundamentally crucial to electric reliability and it has only grown more so."[28]

Although most attention on natural gas-electric interdependency has focused on the electricity sector's dependence upon natural gas, analysts have also shown that reliable electricity supplies can be essential for operating certain critical natural gas infrastructure. A 2023 academic study, for example, found that "approximately 10% of U.S. interstate pipeline compressor stations depend on electricity, with several large pipelines quite vulnerable to electric outages."[29] A 2024 joint paper from four grid operators also highlights natural gas-electric "co-dependency" due to gas compressor station electrification and "natural gas infrastructure being dependent on the availability of electricity."[30] Key compressor stations may have on-site backup electricity generation, but prolonged power grid outages may still pose a natural gas reliability challenge.

Natural Gas-Electric Market Coordination

Just as the natural gas and electricity sectors are physically interconnected, their wholesale markets are also interconnected, although the U.S. electricity market has a distinctive structure (see "Wholesale Electricity Commodity Markets" text box below). Operators of natural gas-fired power plants must procure fuel and pipeline capacity in the competitive markets like any other commercial or industrial buyer. Typically, power plants don't have natural gas storage facilities on-site, so they procure fuel as needed (i.e., for real-time delivery). Electricity demand is constantly changing and power plants change their output in response, often requiring rapid changes in natural gas flows to power plants. Both the natural gas and electric power sectors seek to coordinate their respective wholesale markets, but market misalignment has been an issue, as discussed below.

[25] NERC, *Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System*, November 2017, p. viii.

[26] NERC, *2022 State of Reliability*, July 2022, p. vi.

[27] NERC, *2023 State of Reliability Technical Assessment*, June 2023, p. 37. Just-in-time delivery refers to natural gas being pulled from the pipeline as needed, rather than being stored on-site.

[28] David S. Ortiz, Director, FERC, Office of Electric Reliability, testimony before the House Energy and Commerce Committee, Energy, Climate and Grid Security Subcommittee, *Keeping the Lights On: Enhancing Reliability and Efficiency to Power American Homes*," hearing, September 13, 2023.

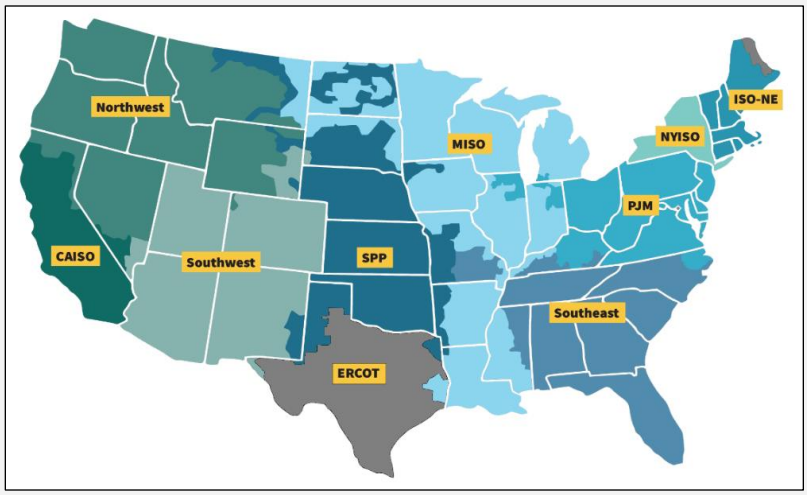
[29] Sean Smillie, M. Granger Morgan, and Jay Apt, "How Vulnerable Are US Natural Gas Pipelines to Electric Outages?," *The Electricity Journal*, vol. 36, issues 2-3 (March-April 2023), 107251, p. 7.

[30] ISO New England, Midcontinent Independent System Operator, PJM, and Southwest Power Pool (Joint RTOs), "Strategies for Enhanced Gas-Electric Coordination: A Blueprint for National Progress," position paper, February 21, 2024 (hereinafter Joint RTOs 2024), p. 10, https://pjm.com/-/media/library/reports-notices/special-reports/2024/20240221-strategies-for-enhanced-gas-electric-coordination-paper.ashx.

Wholesale Electricity Commodity Markets

In some regions of the country, wholesale electricity is bought and sold primarily through organized markets operated by independent entities. The seven U.S. wholesale electricity market regions are CAISO, ERCOT, ISO-NE, MISO, NYISO, PJM, and SPP (**Figure 5**). Within these regions, power plants compete to sell power, as described below. Wholesale markets do not exist in the Northwest, Southeast, Southwest, Alaska, or Hawaii. Within these regions, power plants are primarily owned by monopoly utilities selling wholesale power at regulated rates, and competition is relatively limited.

Figure 5. U.S. Wholesale Electric Market Regions



Source: Federal Energy Regulatory Commission, "RTOs and ISOs," web page, https://www.ferc.gov/power-sales-and-markets/rtos-and-isos.

Notes: CAISO = California Independent System Operator, ERCOT = Electric Reliability Council of Texas, ISO-NE = ISO New England, MISO = Midcontinent Independent System Operator, NYISO = New York Independent System Operator, and SPP = Southwest Power Pool. PJM is not an abbreviation.

The wholesale electricity markets are operated by regional transmission organizations (RTOs) or independent system operators (ISOs). These entities hold auctions over different timescales, such as hourly or daily. In an auction, power plants offer to sell electricity at their marginal cost, and the market operator determines demand based largely on bids from distribution utilities and the operators' own analysis. The market operator determines the market clearing price based upon the available supply (i.e., power plant offers) and demand. Power plants that clear the market (i.e., have an offer price less than or equal to the clearing price) sell electricity at the market clearing price during the time period specified by the auction.

Organized markets involved in electricity trade "at wholesale in interstate commerce" are subject to the Federal Energy Regulatory Commission's (FERC's) economic regulatory authority (16 U.S.C. §824). FERC uses this authority to ensure that the market rules are designed to result in just and reasonable electricity rates that are not unduly discriminatory (i.e., do not favor some power plants over others). Because the ERCOT market operates entirely within a single state (Texas), FERC does not have jurisdiction over ERCOT's market rules. Nonetheless, ERCOT operates similarly to other markets.

Some regions operate markets for products other than electricity generation. One such product is ancillary services. (*Ancillary services* is an umbrella term for operations needed for grid reliability.) Additionally, some regions operate forward capacity markets to procure electricity supply several years into the future.

Natural Gas Reliability Challenges

For most of its existence, the nation's natural gas system was viewed by market participants as having inherent physical characteristics that ensured reliable service. However, major reliability incidents in recent years have led some policymakers to question this view and have revealed

potential new risks to natural gas supply reliability. These events have been attributed to long-term infrastructure constraints, severe storm damage, and cyberattacks—or a combination of these factors. Other emergent trends, such as a shift to wind and solar power generation, and a national strategy to promote hydrogen as an alternative fuel, may pose future challenges to natural gas system reliability.

Constrained Natural Gas Infrastructure

Growth in U.S. natural gas production to meet growing natural gas demand has been driving efforts to expand the natural gas pipeline system, especially to consuming markets with constrained infrastructure—where natural gas prices tend to be highest. Over the last decade, however, proposals for new interstate natural gas pipelines and related infrastructure have become increasingly controversial. Major projects have faced development barriers, in many cases due to public opposition, protracted permit review, and related litigation.[31] Project opponents have expressed skepticism about the need for new pipelines and associated LNG facilities. Opponents have also raised concerns about potential environmental impacts, potential safety risks (especially to minority and low-income communities), and, more recently, misalignment with Biden Administration commitments to reduce greenhouse gases.[32]

Permitting issues at the federal, state, and local levels have led to the cancellation of several proposed pipeline projects in recent years. These include the Constitution Pipeline (Pennsylvania, New York), the PennEast Pipeline (Pennsylvania, New Jersey), the Northeast Supply Enhancement Project (Pennsylvania, New York, New Jersey), and the Atlantic Coast Pipeline (West Virginia, Virginia, North Carolina).[33] Other projects have faced years of delay beyond initially anticipated development timelines. For example, final approval of the highly controversial Mountain Valley Pipeline (West Virginia, Virginia)—which was ultimately approved by an act of Congress[34]—was granted in 2023, more than seven years after its initial permit application to FERC.[35]

Certain parts of the country face particularly constrained natural gas supplies due to historical limits in regional infrastructure development. The Southwest and Northeast are two regions where natural gas pipeline constraints have contributed to recent supply emergencies during periods of high natural gas demand, or have given rise to specific concerns about future gas shortages.

- **Newport, RI, Gas Distribution Outage.** In January 2019, the operator of the natural gas distribution system serving the Newport, RI, area was forced to interrupt service to over 7,400 customers for approximately seven days due to low system pressure. The outage was the combined result of three precipitating factors: gas demand above contractual limits due to extremely cold temperatures,

[31] For additional background, see CRS Report R45239, *Interstate Natural Gas Pipeline Siting: FERC Policy and Issues for Congress*, by Paul W. Parfomak.

[32] White House, "FACT SHEET: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies," press release, April 22, 2021.

[33] Niina H. Farah, Miranda Willson, and Carlos Anchondo, "How FERC, Courts May Change Pipeline Industry in 2022," *E&E News*, January 20, 2022; Carlos Anchondo, "Pipeline Company Cancels Northeast Gas Project," *E&E News*, May 8, 2024.

[34] Fiscal Responsibility Act of 2023 (P.L. 118-5 §324).

[35] FERC, "Order Issuing Certificates and Granting Abandonment Authority," 161 FERC ¶ 61,043, Docket Nos. CP16-10-000, CP16-13-000, October 13, 2017.

the unplanned shutdown of a regional LNG storage facility due to a power system failure, and the malfunction of a transmission pipeline valve.[36] Due to the outage, the governor of Rhode Island declared a state of emergency in the affected county and called up the National Guard to assist residents without natural gas service.[37]

- **Winter Storm Elliott Gas Shortages.** On December 24, 2022, during Winter Storm Elliott, Consolidated Edison declared a natural gas emergency and called for immediate conservation measures. New York City's gas distribution system was experiencing rapidly falling natural gas pipeline pressure because of frigid temperatures, which were driving up heating demand, and interstate pipeline constraints. According to the company's announcement, natural gas pipeline owners "reported that equipment problems caused by the cold weather and the heavy demand for natural gas [were] challenging their ability to provide adequate amounts of gas throughout the Northeast."[38] A subsequent FERC/NERC report on the storm's causes and impacts concluded that the utility had narrowly avoided a catastrophic natural gas supply failure. The report noted "had pipeline pressures not recovered, Con Edison could have faced an unprecedented loss of its entire system that, in this worst-case scenario, would have taken months to restore."[39] The natural gas supply shortage was also a key factor in the unavailability of significant regional electricity generation capacity during the storm.[40]
- **Pacific Northwest Storage Failure.** On January 13, 2024, the operator of the Northwest Pipeline reported an operational emergency and requested "all customers to take IMMEDIATE action to reduce loads." An outage at the Jackson Prairie Underground Natural Gas Storage Facility was causing a "rapid" loss in natural gas volume.[41] The outage was reportedly due to a failure of the fiber-optic network supporting the facility's control systems.[42] Constraints in regional gas infrastructure limited pipeline operators' ability to bring in alternative supplies of natural gas during the loss of this critical storage facility. Utilities in the Pacific Northwest subsequently asked customers to curtail natural

[36] State of Rhode Island, Division of Public Utilities & Carriers, *Summary Investigation into the Aquidneck Island Gas Service Interruption of January 21, 2019*, investigation report, October 30, 2019.

[37] PHMSA, *Events Contributing to Natural Gas Outages on National Grid's Distribution System in Newport, Rhode Island*, accident report, August 13, 2019, p. 2, https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/regulatory-compliance/pipeline/accident-investigation-division/72801/rhode-island-natural-gas-outages-summary-report-web.pdf.

[38] Con Edison Media Relations, "Con Edison Urges Customers to Conserve Energy Due to Heavy Demand on Interstate Gas Pipelines," press release, December 24, 2022.

[39] FERC, NERC, and Regional Entities, *Inquiry into Bulk-Power System Operations During December 2022 Winter Storm Elliott*, staff report, October 2023 (hereinafter FERC/NERC October 2023), p. 21.

[40] According to FERC/NERC October 2023, "At the worst point of the Event, there were 90,500 MW of coincident unplanned generating unit outages, derates and failures to start…. Including generation that was already out of service, a total of over 127,000 MW of generation was unavailable, representing 18 percent of the U.S. portion of the anticipated resources in the Eastern Interconnection."

[41] Northwest Pipeline LLC, "Operational Emergency – JP: Puget Sound Energy's Jackson Prairie Storage facility has suffered a complete outage," screenshot of notice posted on X by @mumm49, January 13, 2024, https://x.com/mumm49/status/1746297896579039267.

[42] Daniel Beekman, "PSE Asks Customers to Conserve Amid Cold Snap, Gas Storage Facility Outage," *Seattle Times*, January 13, 2024.

gas and electricity use.[43] Although the facility was brought back online under manual control at reduced capacity, the outage threatened natural gas supplies for both heating and electricity generation during a period of record demand due to extremely cold weather.[44]

- **Everett LNG Retirement.** In August 2020, the owner of an LNG import terminal in Everett, MA, stated that it was considering closing down the terminal after a nearby power plant—its principal LNG customer, the Mystic Generating Station—was slated for a 2024 closure.[45] The announcement prompted statements of concern from regional natural gas distribution utilities and the regional grid operator about the reliability impacts of such a closure, given long-standing natural gas supply constraints in New England.[46] The potential closure of the Everett facility was the principal topic of a June 2023 FERC Commissioner-led forum "to discuss solutions to the electric and gas challenges facing the New England region."[47] On November 6, 2023, FERC Chairman Willie Phillips and NERC Chief Executive Officer James Robb issued a joint statement that they remained "concerned about the potential loss of the Everett Marine Terminal … and the consequences that it might have for the reliability and affordability of the region's energy supplies."[48] In May 2024, Massachusetts regulators approved LNG purchase agreements between local natural gas utilities and the Everett terminal owner to keep the facility operational into 2030, but concerns remain about its future status.[49]

While the Southwest and Northeast have experienced significant natural gas supply disruptions, gas consumers in other regions are also concerned about future supply constraints. For example, due to uncertainties about future pipeline capacity, electric generating companies are reportedly proposing to add on-site LNG storage to serve existing power plants in Virginia and South Dakota.[50]

[43] NW Natural, "Customer Notice," press release, January 14, 2024, https://www.nwnatural.com/about-us/the-company/newsroom/2024-conserve-gas.

[44] Kyra Buckley, "NW Natural Lifts Request for Customers to Reduce Gas Use," *OPB*, January 13, 2024.

[45] Kevin Clark, "Exelon: Massachusetts' Gas and Oil-Fired Mystic Power Units to Close in 2021 and 2024," *Power Engineering*, August 25, 2020.

[46] See, for example, Gordon van Welie, Chief Executive Officer, ISO New England, "ISO New England Letter to Energy Secretary Granholm, Including Draft Problem Statement on Importance of LNG," August 29, 2022, https://www.iso-ne.com/static-assets/documents/2022/08/isone_energy_security_letter_to_us_doe_and_statement_for_ferc_winter_forum_2022_08_29.pdf.

[47] FERC, 2023 New England Winter Gas-Electric Forum, South Portland, ME, June 20, 2023, https://www.ferc.gov/news-events/events/2023-new-england-winter-gas-electric-forum-06202023.

[48] FERC and NERC, "Joint Statement of FERC, NERC on Reliability," November 6, 2023, https://www.ferc.gov/news-events/news/joint-statement-ferc-nerc-reliability#:~:text=Comments%20of%20Chairman%20Willie%20L,of%20the%20region's%20energy%20supplies.

[49] Massachusetts Dept. of Public Utilities, "Petition of Boston Gas Company d/b/a National Grid for Approval of a Gas Supply Agreement with Constellation LNG, LLC, pursuant to G.L. c. 164, § 94A" and other petitions, Final Order, D.P.U. 24-25-B; D.P.U. 24-26-B; D.P.U. 24-27-B; D.P.U. 24-28-B, May 17, 2024, https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/19075280.

[50] Robert Zullo, "Utilities Plan Onsite Gas Storage to Improve Reliability; Critics Warn of Costs, Safety Concerns," *Wisconsin Examiner*, January 23, 2024, https://wisconsinexaminer.com/2024/01/23/utilities-plan-onsite-gas-storage-to-improve-reliability-critics-warn-of-costs-safety-concerns/.

Gas-Electric Market Misalignment

One issue complicating natural gas infrastructure development is misalignment between the natural gas and electricity markets. Examining gas-electric coordination, a 2019 report prepared for the National Petroleum Council (NPC) concluded,

> Due to incompatibility within the markets, the largest end-user of natural gas pipelines, natural gas-fired power generators, faces impediments to entering into contracts necessary for pipeline capacity expansion. Power plant takes from pipelines are highly variable; yet the market currently lacks an efficient and transparent pricing structure for the intraday volumetric variability upon which they rely. Conversely, the design of the competitive wholesale electricity markets does not provide competitive generators with sufficient incentives to commit capital needed for expansion to meet their requirements for gas transportation services.[51]

Gas-electricity contract issues have been a limiting factor for some proposed pipeline expansions. For example, in 2016, Massachusetts regulators attempted to allow electric distribution utilities to sign long-term contracts with pipeline developers to provide fuel for electricity generation; however, the state's Supreme Judicial Court ruled that the regulators lacked this authority.[52] This ruling contributed to the cancellation of the proposed Northeast Energy Direct and Access Northeast pipeline projects in New England in 2016 and 2017, respectively.[53] In a 2023 response to questions from the House Energy and Commerce Committee, then-FERC Commissioner James Danly stated that "gas-fired generators operating in RTOs and ISOs are effectively prohibited from procuring their gas through firm fuel contracts or signing precedent agreements necessary for pipelines to construct additional pipeline capacity."[54]

Market misalignment can also pose reliability challenges related to short-term gas commodity supply. For example, operating days start at different times in the wholesale gas market (10 a.m.) versus the wholesale electricity market (12 a.m.). This difference in scheduling has required generators to "straddle two consecutive gas operating days to cover one electric operating day, thus complicating gas procurement for [electricity] generation."[55] Some electric generators also face challenges with "multiday trading requirements of natural gas over weekends and holidays that significantly strain natural gas/power coordination and dispatch."[56] In 2014, the grid operator PJM established its Gas-Electric Coordination Team "to increase collaboration with the natural gas industry to improve operational awareness and be better prepared in the event of gas supply disruptions."[57] The team's efforts have led to changes in both the gas and electricity markets'

[51] N. Jonathan Peress, Environmental Defense Fund, "Gas/Electric Coordination and Natural Gas Pipeline Deployment," prepared for the National Petroleum Council Study on Oil and Natural Gas Transportation Infrastructure, Topic Paper 3-3, October 1, 2019 (hereinafter Peress October 2019), p. 1, https://www.energy.gov/sites/default/files/2022-10/Infra_Topic_Paper_3-3_FINAL.pdf.

[52] Commonwealth of Massachusetts, Office of the Attorney General, "AG Healey Applauds Today's SJC Decision in ENGIE Gas & LNG V. DPU, CLF V. DPU," press release, August 17, 2016.

[53] Jon Chesto, "Kinder Morgan Shelves $3 Billion Pipeline Project," *Boston Globe*, April 21, 2016; Robert Walton, "Enbridge Halts $3.2B Access Northeast Natural Gas Pipeline for Now," *Utility Dive*, June 30, 2017.

[54] FERC Commissioner James Danly, "Responses to Questions for the Record for June 13, 2023 House Energy & Commerce Oversight Hearing," August 9, 2023, p. 17, https://www.ferc.gov/news-events/news/responses-questions-record-june-13-2023-house-energy-commerce-oversight-hearing.

[55] PJM, *PJM Promotes Gas/Electricity Industry Coordination*, fact sheet, January 3, 2024, https://www.pjm.com/-/media/about-pjm/newsroom/fact-sheets/gas-electric-coordination-fact-sheet.ashx.

[56] Joint RTOs 2024, p. 3.

[57] PJM, "How Is PJM Addressing Gas-Electric Concerns?," web page, https://learn.pjm.com/three-priorities/keeping-the-lights-on/gas-electric-industry/how-is-pjm-addressing-gas-electric-concerns#:~:text=The%20Gas%2FElectric%20Team,which%20could%20impact%20grid%20reliability.

daily operations to improve transparency and scheduling, but certain market misalignments remain.

Weather-Related Physical Disruptions

Natural gas production and transportation infrastructure is vulnerable to physical disruption from weather-related events, such as freezing, flooding, weather-induced earth movement (e.g., mudslides), and other weather impacts. Resulting infrastructure outages can, in turn, unexpectedly limit available natural gas supplies to critical consumers even in regions with relatively unconstrained infrastructure under normal operating conditions. Additionally, storms can damage electricity infrastructure, potentially disrupting power supplies to natural gas equipment (e.g., compressor stations). In 2011, an arctic storm led New Mexico Gas Company to widely curtail service to its customers, drawing increased attention to growing natural gas supply risks due to severe storms. In 2021, two distinct events in the Southeast—Winter Storm Uri and Hurricane Ida—focused renewed attention on weather-related risks.

- **2011 Southwest Arctic Storm.** In February 2011, an arctic air mass situated for several days over the Southwest caused extremely low temperatures throughout the region.[58] In New Mexico, freezing-related issues led to a 20% reduction in wholesale natural gas supplies at a time of record natural gas demand for heating.[59] When initial voluntary and involuntary curtailments were insufficient to maintain pipeline system pressure, New Mexico Gas Company was forced to curtail service to 28,000 customers throughout the state "in order to avoid catastrophic system failure."[60] All told, natural gas supply shortages forced gas companies to curtail service to over 50,000 gas distribution customers across Arizona, Texas, and New Mexico.[61]
- **Winter Storm Uri.** In February 2021, an extreme cold weather event—Winter Storm Uri—caused widespread and extended blackouts in Texas and other South Central states. A subsequent investigation by FERC and NERC concluded that "natural gas fuel supply issues" due to freezing infrastructure and loss of power were responsible for over 27% of all electricity generator outages, decreases in generating capacity, and failures to start during the storm in the affected region.[62] The fuel supply issues included "declines in natural gas production, the terms and conditions of natural gas commodity and transportation contracts, low pipeline pressure and other issues."[63] Among other social and economic impacts, the storm caused 246 confirmed storm-related deaths in Texas, many attributed to

[58] Mike Hardiman, "Intense Cold Wave of February 2011," National Weather Service, media release, March 31, 2011, https://www.weather.gov/media/epz/Storm_Reports/Cold11/Feb2011ColdWx.pdf.

[59] New Mexico Gas Company, "Arctic Storm of February 2011," slide presentation, p. 7, https://www.nmlegis.gov/handouts/STTC%20080714%20Item%204%20Gas%20Pipeline%20Issues.pdf.

[60] Ibid., pp. 9-10.

[61] FERC and NERC, *Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1-5, 2011*, staff report, August 2011, p. 10.

[62] FERC, NERC, and Regional Entities, *The February 2021 Cold Weather Outages in Texas and the South Central United States*, staff report, November 2021 (hereinafter FERC/NERC November 2021), p. 16.

[63] Ibid., p. 172.

"the loss of electricity and resulting loss of regular heating sources" and "loss of power while on electricity dependent equipment required to sustain life."[64]

- **Hurricane Ida Disruptions.** On August 29, 2021, Hurricane Ida made landfall in Southeast Louisiana as a Category 4 storm. The hurricane caused catastrophic damage from storm surge exceeding 10 feet and wind speeds exceeding 150 miles per hour.[65] Hurricane Ida caused widespread and prolonged disruption of natural gas production and pipeline infrastructure in the Gulf of Mexico.[66] The Energy Information Administration (EIA) reported that some Gulf gas production continued to be shut-in 60 days after Hurricane Ida made landfall. According to the agency, "the hurricane caused more natural gas production shut-ins than any other hurricane in the past ten years."[67]

Climate Change Impacts

Federal agency analysts and other researchers have identified climate change as potentially making severe weather events more frequent and severe, which could increase near-term weather-related risk to natural gas infrastructure due to such storms.[68] Some officials also point to risks that could arise from longer-term climate change phenomena, such as rising sea levels. For example, a May 2023 Pipeline and Hazardous Materials Safety Administration (PHMSA) notice in the *Federal Register* states,

> Pipeline infrastructure is … vulnerable to the impacts of climate change. For example, well-documented threats to pipeline infrastructure from natural force damage (which includes incidents caused by acts of nature such as flooding, land movement, and lightning) are likely to be exacerbated by climate change.[69]

The notice further states that PHMSA has "documented serious pipeline integrity threats from hurricanes" and "expects more severe and frequent hurricanes will amplify the risk of damage to pipeline facilities, to the detriment of … the reliability of the U.S. oil and gas industry."[70] Similarly, the U.S. Global Change Research Program's *Fifth National Climate Assessment*, published in November 2023, states,

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[64] Texas Department of State Health Services, "February 2021 Winter Storm-Related Deaths – Texas," press release, December 31, 2021, p. 3.

[65] National Weather Service, "Catastrophic Hurricane Ida Strikes Southeast Louisiana August 29, 2021," https://www.weather.gov/lix/hurricaneida2021#:~:text=Hurricane%20Ida%20made%20landfall%20as,morning%20of%20August%2029%2C%202021.

[66] EIA, "Natural Gas Weekly Update," October 28, 2021, https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2021/10_28/. "For the 28 days during which [the Bureau of Safety and Environmental Enforcement] reported shut-in natural gas volumes as a result of Hurricane Ida, impaired natural gas production totaled 38.4 [billion cubic feet] or 56.0% of total U.S. offshore natural gas production in a month … and 1.2% of total U.S. natural gas production (when compared with the monthly production total in January of the same year)."

[67] Ibid.

[68] See, for example, National Oceanic and Atmospheric Administration, *Atlantic Hurricanes and Climate Change*, fact sheet, May 2023, https://sciencecouncil.noaa.gov/wp-content/uploads/2023/05/1.1_SOS_Atlantic_Hurricanes_Climate.pdf. "Concerning event attribution, model simulations of current and preindustrial conditions and observed records of extreme rainfall in general have been used to attribute extreme rainfall amounts in several recent tropical cyclone events partly to anthropogenic forcing such as increased greenhouse gases." For further discussion of this topic, see CRS Report R47583, *Is That Climate Change? The Science of Extreme Event Attribution*, by Jonathan D. Haskett.

[69] 88 *Federal Register* 96, May 18, 2023, p. 31897.

[70] Ibid.

> Climate change threats, including increases in extreme precipitation, extreme temperatures, sea level rise, and more intense storms, droughts, and wildfires, are damaging infrastructure and operations…. Without mitigation and adaptation, projected increases in the frequency, intensity, duration, and variability of extreme events will amplify effects on energy systems.[71]

The assessment identifies several risks specific to pipelines, including flooding, freezing, and land subsidence—which can impact pipelines on land—as well as stronger hurricanes, increasing wave heights, and sea level rise—which can impact underwater pipelines.[72] A May 2024 EIA analysis stated that "the potential for a stronger hurricane season suggests heightened risk for weather-related production outages in the U.S. oil and natural gas industry," although "recent hurricanes have had a much smaller impact on total U.S. natural gas supply" due to declining Gulf of Mexico production in recent years.[73]

Cybersecurity and Physical Security Threats

Federal security officials and industry analysts have long identified pipelines in the United States as potential targets for intentional disruption of physical or cyber systems.[74] Over the last decade, the degree of security threat, particularly from cyberattacks, has been growing.

Cybersecurity Incidents

In 2019, the then-Director of National Intelligence singled out pipelines as critical infrastructure vulnerable to cyberattacks that could cause shutdowns "for days to weeks."[75] The Transportation Security Administration's (TSA's) *2023 Biennial National Strategy for Transportation Security* identifies pipelines, among other transportation infrastructure, as "accessible targets for domestic threat actors" and continuing targets for international terrorist groups.[76]

Growing warnings about pipeline security threats have paralleled public reports about significant cybersecurity incidents specifically directed at U.S. natural gas pipelines. Examples include the following:

- In April 2018, several major U.S. natural gas pipeline companies reported information technology (IT) system cyberattacks on the third-party data interchange systems used to communicate with customers.[77]

[71] Craig D. Zamuda et al., *Fifth National Climate Assessment*, U.S. Global Change Research Program, November 14, 2023, chapter 5.1, "Climate Change Threatens Energy Systems," https://nca2023.globalchange.gov/chapter/5/#key-message-1.

[72] Ibid., chapters 5.1 and 10.2.

[73] EIA, "Forecast Strong Hurricane Season Presents Risk for U.S. Oil and Natural Gas Industry," *Today in Energy*, May 22, 2024, https://www.eia.gov/todayinenergy/detail.php?id=62104.

[74] "Already Hard at Work on Security, Pipelines Told of Terrorist Threat," *Inside FERC*, McGraw-Hill Companies, January 3, 2002; Jennifer Alvey, "Cyber Security: A 'Virtual' Reality," *Public Utilities Fortnightly*, September 15, 2003.

[75] Daniel R. Coats, Director of National Intelligence, *Worldwide Threat Assessment of the U.S. Intelligence Community*, Statement for the Record before the Senate Select Committee on Intelligence, January 29, 2019, p. 5.

[76] Transportation Security Administration, *2023 Biennial National Strategy for Transportation Security*, April 18, 2023, p. 3.

[77] R. Collins, N. S. Malik, and M. Vamburkar, "Cyberattack Pings Data Systems of at Least Four Gas Networks," *Bloomberg*, April 4, 2018.

- In December 2019, a ransomware attack affecting the control and communication network of a natural gas transmission pipeline compressor station led to a two-day pipeline shutdown.[78]
- In July 2021, the Cybersecurity and Infrastructure Security Agency (CISA) and the Federal Bureau of Investigation (FBI) jointly attributed a series of cyber intrusions among U.S. natural gas pipeline operators a decade earlier to Chinese state-sponsored actors seeking "to help China develop cyberattack capabilities against U.S. pipelines to physically damage pipelines or disrupt pipeline operations."[79]
- In May 2021, a ransomware attack on a refined products pipeline owned by the Colonial Pipeline Company disrupted supplies of gasoline throughout the East Coast for several days.[80]

The Colonial Pipeline disruption drew particular attention to pipeline vulnerability to cyberattacks. In subsequent testimony before the Senate, the Deputy Secretary of Transportation stated that pipelines "face persistent and increasingly sophisticated cyber attacks" and "as we saw with the Colonial Pipeline, cybersecurity can and does affect safe and reliable operations."[81] A 2023 threat assessment from the Office of the Director of National Intelligence states, "China almost certainly is capable of launching cyber attacks that could disrupt critical infrastructure services within the United States, including against oil and gas pipelines."[82] In 2024, the FBI Director testified that Chinese government "hackers are targeting our critical infrastructure," including "our oil and natural gas pipelines."[83]

Physical Security Incidents

While cybersecurity has been a somewhat greater focus in the natural gas sector, physical security, especially of the pipeline system, has also been a long-standing concern. A 2011 federal threat assessment stated that "domestic extremists," including "environmental activists," were responsible for pipeline "tampering and vandalism" and "likely also pose threats to pipeline networks."[84] Such an incident occurred in 2016 when climate activists temporarily disrupted five pipelines transporting oil from Canada to the United States by closing manual safety valves.[85] A subsequent GAO report stated that "threats to the nation's pipeline systems have evolved to

[78] Dragos, Inc., "Assessment of Ransomware Event at U.S. Pipeline Operator," *Dragos Blog*, February 19, 2020, https://www.dragos.com/blog/industry-news/assessment-of-ransomware-event-at-u-s-pipeline-operator/; Cybersecurity and Infrastructure Security Agency (CISA), "Ransomware Impacting Pipeline Operations," Alert (AA20-049A), February 18, 2020. The location of the affected pipeline system was not disclosed for security reasons.

[79] CISA and Federal Bureau of Investigation, "Chinese Gas Pipeline Intrusion Campaign, 2011 to 2013," Joint Cybersecurity Advisory, Product ID: AA21-201A, July 20, 2021.

[80] Colonial Pipeline, "Media Statement Update: Colonial Pipeline System Disruption," May 17, 2021, https://www.colpipe.com/news/press-releases/media-statement-colonial-pipeline-system-disruption.

[81] Polly Trottenberg, Deputy Secretary of Transportation, testimony before the Senate Committee on Commerce, Science, and Transportation, *Pipeline Cybersecurity: Protecting Critical Infrastructure*, hearing, July 27, 2021.

[82] Office of the Director of National Intelligence, *Annual Threat Assessment of the U.S. Intelligence Community*, February 26, 2023, p. 10.

[83] Hon. Christopher Wray, Director, Federal Bureau of Investigation, testimony before the House Select Committee on the Chinese Communist Party, *The CCP Cyber Threat to the American Homeland and National Security*, hearing, January 31, 2024.

[84] Transportation Security Administration, Office of Intelligence, Pipeline Threat Assessment, MTA-83259-2011-01-18, January 18, 2011, pp. 3, 5. This report is marked "Unclassified/For Official Use Only."

[85] Common Dreams, "To Avert Climate Catastrophe, Activists Shut Down 5 Pipelines Bringing Tar Sands Oil into the U.S.," press release, October, 11 2016.

include sabotage by environmental activists."[86] A 2018 white paper for PJM warned that "[d]epending on the configuration of specific gas systems, physical attacks against crucial … system components could also produce long-term disruptions to fuel supplies."[87]

More recent developments, including the 2022 bombing of the Nord Stream natural gas pipelines in Europe, have drawn renewed attention to pipeline physical security.[88] In May 2023, a NATO intelligence official reportedly warned that Russia was "actively mapping allied critical infrastructure," including pipelines, and there was a "significant risk" Russia could target this infrastructure in Europe and North America in response to allied support for Ukraine.[89] An April 4, 2023, Kansas City Regional Fusion Center security bulletin stated that the film *How to Blow Up a Pipeline*, which depicts domestic climate activists plotting to bomb an oil pipeline, "could potentially inspire similar attacks."[90]

Increased Electricity Generation from Wind and Solar

The share of wind and solar in the U.S. electricity generation mix increased from 1% in 2008 (the first year in which this share was at least 1%) to 15% in 2023.[91] If current trends continue, the share of wind and solar will likely continue growing for the foreseeable future. For example, 71% of planned electric-generating capacity additions in 2024 use wind or solar energy. An additional 23% of planned additions are for battery storage, which is frequently built alongside wind or solar facilities.[92] Looking farther ahead, many experts expect wind and solar development to proceed at a faster pace than it has to date.[93]

Wind and solar energy have variable (intermittent) supply because the wind does not always blow and the sun does not always shine in a given location.[94] Some natural gas-fired generators can quickly increase or decrease their output in response to changing wind and solar supply, a behavior known as *balancing*.[95] Some observers suggest that an increased need for balancing by natural gas-fired generators could stress the natural gas system during unfavorable conditions for

[86] GAO, *Critical Infrastructure Protection: Actions Needed to Address Significant Weaknesses in TSA's Pipeline Security Program Management*, GAO-19-48, December 2018, p. 1.

[87] Paul Stockton, Sonecon LLC, "Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions," June 8, 2018, p. 6, https://pjm.com/-/media/committees-groups/committees/mrc/20180628-special/20180628-exelon-dr-stockton-memo.ashx?la=en.

[88] For more background on the Nord Stream pipelines, see CRS In Focus IF11138, *Russia's Nord Stream 2 Natural Gas Pipeline to Germany Halted*, by Paul Belkin, Michael Ratner, and Cory Welt.

[89] Natalia Drozdiak, "NATO Warns That Russia Is Mapping EU, US Critical Assets," *Bloomberg*, May 3, 2023.

[90] Kansas City Regional Fusion Center, "Security Threats to Pipeline Infrastructure," Situational Awareness Bulletin 23-21, April 4, 2023.

[91] CRS analysis of EIA, "Short-Term Energy Outlook Data Browser," https://www.eia.gov/outlooks/steo/data/browser/. Totals are for utility-scale facilities only, defined by EIA as facilities with a capacity of at least 1 megawatt. Additional generation comes from smaller facilities such as rooftop solar panels, but this amount is not reflected in the above value.

[92] EIA, "Solar and Battery Storage to Make Up 81% of New U.S. Electric-Generating Capacity in 2024," February 15, 2024, https://www.eia.gov/todayinenergy/detail.php?id=61424.

[93] See, for example, a multimodel analysis through 2035 in John Bistline et al., "Emissions and Energy Impacts of the Inflation Reduction Act," *Science*, vol. 380, no. 6652 (June 29, 2023), pp. 1324-1327.

[94] For additional discussion of variable renewable energy and balancing options, see CRS In Focus IF11257, *Variable Renewable Energy: An Introduction*, by Ashley J. Lawson, and CRS Report R45764, *Maintaining Electric Reliability with Wind and Solar Sources: Background and Issues for Congress*, by Ashley J. Lawson.

[95] Not all natural gas-fired generators are designed for balancing. In addition, options exist for balancing other than natural gas-fired generators. Examples include hydropower facilities, energy storage facilities, demand response programs, and expanded transmission networks.

wind and solar generation. For example, a 2023 natural gas and electricity joint trade group paper states,

> The challenges to meeting Real-Time Market dispatches largely occur during extreme weather, but we expect these challenges to become more common as [Regional Transmission Organizations/Independent System Operators] increasingly rely on natural gas-fired generators to dispatch on short notice in response to reduced wind and solar generation…. [I]t is important to assess whether this country has sufficient natural gas infrastructure to support the level of real-time flexibility that electric system operators need to respond quickly to intermittent resource fluctuations, such as wind and solar.[96]

Likewise, in 2020, GAO reported that "[o]fficials from three Western states told us that growth in the use of renewable energy, such as solar energy, to fuel electric power generators could add stress to natural gas transmission pipelines."[97] The 2019 NPC report concluded that "issues posed by the current misalignment between the natural gas and electricity markets will become more pronounced and problematic as more renewables are integrated into the electric grid."[98]

Hydrogen Production and Transportation

The federal government is promoting hydrogen as an environmentally superior alternative to conventional fossil fuels for vehicles, power generation, and many other applications.[99] The Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58 §40313) authorized an $8 billion program of Regional Clean Hydrogen Hubs, which would be centers of activity involving hydrogen production, delivery, and end use. Some of the hub proposals selected for federal funding would produce hydrogen by methane steam reformation, which uses natural gas as a feedstock.[100] Supplying hydrogen from sources such as regional hubs for delivery to power plants, industrial facilities, and vehicular fuel distribution centers could require the development of an expansive hydrogen pipeline network.[101] Accordingly, the IIJA also directs the Secretary of Energy to advance the safe and efficient delivery of hydrogen or hydrogen blends in pipelines, including by retrofitting existing natural gas pipelines (§40313(a)(5)).

If, over the long term, steam reformation becomes widely adopted to produce large volumes of commercial hydrogen, it could divert natural gas commodity supplies (for feedstock) and pipeline capacity (for hydrogen transportation) historically available for conventional uses. To facilitate the pipeline transportation of hydrogen in the near term, some in Congress, in the pipeline industry, and in the executive branch have proposed blending significant hydrogen volumes with

[96] Natural Gas Supply Association, Interstate Natural Gas Association of America, and Electric Power Supply Association, "Exploring Real-Life Challenges with Ensuring Natural Gas Availability for Power and Joint Industry Suggested Mitigation Strategies," joint paper submitted for FERC's 2023 Annual Reliability Technical Conference, Docket No. AD23-9-000, October 31, 2023, https://epsa.org/wp-content/uploads/2023/11/Reliability-Alliance-Gas-Electric-Consensu-Paper-Fall-2023-AD23-9-000.pdf.

[97] GAO September 2020, p. 20.

[98] Peress October 2019, p. 5.

[99] DOE, *Hydrogen Strategy: Enabling a Low-Carbon Economy*, July 2020.

[100] White House, "Biden-Harris Administration Announces Regional Clean Hydrogen Hubs to Drive Clean Manufacturing and Jobs," press release, October 13, 2023; DOE, "Hydrogen Production: Natural Gas Reforming," web page, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming#:~:text=Most%20hydrogen%20produced%20today%20in,source%2C%20such%20as%20natural%20gas.

[101] Currently, there are approximately 1,600 miles of active hydrogen pipeline in the United States, located primarily along the Gulf Coast to serve regional oil refineries. For further details, see CRS Report R46700, *Pipeline Transportation of Hydrogen: Regulation, Research, and Policy*, by Paul W. Parfomak.

methane in existing natural gas pipelines.[102] Because of hydrogen's chemical properties, introducing hydrogen-methane blends into existing natural gas pipelines could reduce their effective capacity. As a study from the National Renewable Energy Laboratory concluded,

> The energy density of hydrogen also presents energy transmission challenges. At a fixed pressure drop along a length of pipeline, hydrogen's lower energy per unit volume than natural gas reduces a pipeline's capacity to transport energy and may not sufficiently service end-user energy demands.[103]

Thus, in some localities with constrained natural gas infrastructure, hydrogen growth could effectively reduce pipeline transportation capacity and thus have a negative impact on natural gas supply reliability.

Introducing hydrogen-methane blends into existing natural gas pipeline systems also could pose new operational risks to the infrastructure itself. Transporting hydrogen by pipeline poses safety challenges due to hydrogen's physical characteristics. Hydrogen molecules are the smallest of all molecules and are therefore more prone than methane to leak through joints, microscopic cracks, and seals in pipelines and associated infrastructure.[104] The presence of hydrogen can deteriorate steel pipe, pipe welds, valves, and fittings through a variety of mechanisms, particularly embrittlement.[105]

In 2022, a safety advocacy group published a report on hydrogen blending that "identifies serious concerns about the pursuit of hydrogen blending options for existing gas transmission or gas distribution pipelines" due to the potential for pipeline leaks and failures and the greater flammability of hydrogen compared with methane.[106] However, a pipeline industry trade group disagreed with these findings, pointing to operator experience safely transporting hydrogen blends.[107]

Federal Authorities and Oversight

No federal agency has explicit authority to regulate natural gas system reliability. However, under various statutes, federal agencies have regulatory authority over aspects of natural gas production, infrastructure development, and operations that influence reliability.

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[102] See, for example, Sen. Joseph Manchin, opening remarks before the U.S. Senate Committee on Energy and Natural Resources, *Opportunities and Challenges in Using Clean Hydrogen in the Transportation, Utility, Industrial, Commercial, and Residential Sectors*, hearing, February 10, 2022; Kavya Balaraman, "SoCalGas, SDG&E Outline Plan for Hydrogen Blending Demonstration Projects in California," *Utility Dive*, September 20, 2022, https://www.utilitydive.com/news/socalgas-sdge-hydrogen-blending-cpuc/632201/.

[103] Natasha Nguyen, "Hydrogen Blending as a Pathway Toward U.S. Decarbonization," National Renewable Energy Laboratory, January 24, 2023, https://www.nrel.gov/news/program/2023/hydrogen-blending-as-a-pathway-toward-u.s.-decarbonization.html.

[104] The kinetic diameters of molecular hydrogen and methane, respectively, are 289 and 380 picometers.

[105] Peter Adam et al., "Hydrogen Infrastructure—the Pillar of Energy Transition: The Practical Conversion of Long-Distance Gas Networks to Hydrogen Operation," white paper, Siemens Energy, September 15, 2020, pp. 14-15, https://assets.siemens-energy.com/siemens/assets/api/uuid:3d4339dc-434e-4692-81a0-a55adbcaa92e/200915-whitepaper-h2-infrastructure-en.pdf.

[106] Richard B. Kuprewicz, President, Accufacts Inc., *Safety of Hydrogen Transportation by Gas Pipelines*, prepared for the Pipeline Safety Trust, November 28, 2022, p. 1, https://pstrust.org/wp-content/uploads/2022/11/11-28-22-Final-Accufacts-Hydrogen-Pipeline-Report.pdf.

[107] American Gas Association and American Public Gas Association, joint letter to Bill Caram, Executive Director, Pipeline Safety Trust, and Richard Kuprewicz, President, Accufacts Inc., December 15, 2022, https://pstrust.org/wp-content/uploads/2023/01/AGA-letter-to-PST-on-H-Report.pdf.

Natural Gas Production

Direct federal authority over natural gas supplies is limited primarily to production on federal lands, which accounts for only a fraction of U.S. natural gas production. In 2022, approximately 9% of U.S. natural gas production came from the federal mineral estate.[108] Under the Federal Land Policy and Management Act of 1976 (FLPMA; P.L. 94-579) and other statutes, the Bureau of Land Management (BLM), within the Department of the Interior (DOI), manages natural gas production from federal subsurface lands, including lands whose surface is managed by other agencies, or *split estate lands*.[109] Natural gas production from offshore lands in federal waters on the U.S. outer continental shelf is managed by DOI's Bureau of Ocean Energy Management (BOEM).

DOI's mission includes issuing leases to private companies to develop and produce natural gas from federally owned natural gas reserves, although it does not control how much gas is produced. The federal government does not similarly manage natural gas reserves on private lands, although the operations of all natural gas producers must comply with federal requirements under the Clean Air Act, the Clean Water Act, and other federal statutes. Thus, apart from management of the federal mineral estate, federal agencies play a limited role in overall U.S. natural gas production.[110]

Natural Gas Facility Siting

As an independent agency established within DOE, FERC carries out one of DOE's statutory purposes, "to promote the interests of consumers through the provision of an adequate and reliable supply of energy at the lowest reasonable cost" (42 U.S.C. §7112(9)).[111] In the context of natural gas system reliability, one of FERC's principal roles is approving expansions of interstate natural gas pipeline capacity for natural gas transmission and authorizing the cost recovery of such expansions through regulated rates. Under Section 7(c) of the Natural Gas Act of 1938 (NGA), FERC is authorized to issue certificates of "public convenience and necessity" for "the construction or extension of any facilities ... for the transportation in interstate commerce of natural gas," including pipelines and LNG facilities (15 U.S.C. §717f(c)).[112] Siting regulation of intrastate natural gas infrastructure is under the jurisdiction of the states.

FERC's policy statement *Certification of New Interstate Natural Gas Pipeline Facilities*, in force since 1999, states,

> The Commission also has certificated projects that would serve no new market, but would provide some demonstrated system-benefit. Examples include projects intended to provide improved system reliability….[113]

[108] Bureau of Land Management (BLM), "About the BLM Oil and Gas Program," web page, https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/about.

[109] If surface lands over the federal mineral estate are not federally owned (i.e., are split estate lands), BLM works with private surface owners to manage the federal mineral estate.

[110] For further details about federal land management, see CRS Report R43429, *Federal Lands and Related Resources: Overview and Selected Issues for the 118th Congress*, coordinated by Katie Hoover.

[111] GAO September 2020, p. 10.

[112] Under Section 3(e) of the NGA and the Energy Policy Act of 2005 (P.L. 109-58), FERC is also authorized to approve the siting, construction, expansion, and operation of LNG import or export terminals onshore and in state waters (15 U.S.C. §717b(e)(1)).

[113] 88 FERC ¶ 61,227, p. 15.

> Projects designed to improve existing service for existing customers, by replacing existing capacity, improving reliability or providing flexibility, are for the benefit of existing customers. Increasing the rates of the existing customers to pay for these improvements is not a subsidy.[114]

The policy statement also explicitly includes "increasing electric reliability" among the types of public benefits FERC considers in evaluating pipeline certificate applications.[115] Such considerations may be incorporated within the commission's environmental review in compliance with the National Environmental Policy Act (NEPA).[116]

FERC is in the process of reconsidering its policy statements for the review of interstate natural gas pipeline siting applications. In February 2022, FERC issued two statements updating its policies for the certification of natural gas pipelines. The first established a new policy "to provide a more comprehensive analytical framework" for how FERC would evaluate certificate applications.[117] Under this policy statement, the commission would specifically evaluate the consumer benefits of proposed projects that would "support reliability by increasing the volumes of natural gas available to customers."[118]

The second policy statement established FERC's interim policy for evaluating the greenhouse gas impacts of proposed pipelines and described how FERC would "integrate climate considerations into its public interest determinations."[119] In March 2022, facing criticism of these new policies within and outside Congress, FERC redesignated both policy statements as unenforceable drafts and invited additional comments.[120] The docket for FERC's pipeline policy statement review remains open, but the commission has not publicly indicated if or when it would issue updated statements.

Other federal agencies may have permitting authority over parts of an interstate natural gas pipeline project, storage facility, or LNG facility, depending on the configuration of the project. For example, the U.S. Army Corps of Engineers (Corps) must authorize activities that may affect federally regulated waters and wetlands, such as water crossings, as well as activities that cross or may affect Corps-managed lands and Corps water resource projects. The U.S. Coast Guard assesses waterway suitability for LNG marine terminals. Federal land management agencies, such as the BLM, must authorize pipeline rights-of-way on federal lands.

While these agencies operate under independent statutory authority, they generally cooperate with FERC in its review of natural gas certificate applications. The siting of facilities not under federal jurisdiction—which includes intrastate transmission pipelines, distribution pipelines, gas processing facilities, and certain "peak-shaving" LNG and underground storage facilities—is regulated by state agencies.

In addition to its siting authorities, FERC requires natural gas pipeline companies to report damage to jurisdictional facilities other than LNG facilities "caused by a hurricane, earthquake or other natural disaster or terrorist activity that results in a loss of or reduction in pipeline throughput or storage deliverability" or other damage that "in the natural gas company's

[114] Ibid., p. 19.

[115] Ibid., p. 25.

[116] 42 U.S.C. §§4321 *et seq*.

[117] FERC, *Certification of New Interstate Natural Gas Facilities*, Docket No. PL18-1-000, February 18, 2022, p. 38.

[118] Ibid., p. 42.

[119] FERC, *Consideration of Greenhouse Gas Emissions in Natural Gas Infrastructure Project Reviews*, Docket No. PL21-3-000, p. 2, February 18, 2022.

[120] FERC, "FERC Seeks Comment on Draft Policy Statements on Pipeline Certification, GHG Emissions."

judgment … creates the potential for serious delivery problems on its own system or the pipeline grid" (18 C.F.R. §260.90(a)). Pipeline companies must also report any "interruptions of service to communities, major government installations and large industrial plants outside of communities or any other interruptions which are significant in the judgment of the pipeline company" and last longer than three hours (18 C.F.R. §260.90(a)). Although the commission collects these damage and service interruption reports, the information they contain is not made public.[121]

Pipeline Safety

The Natural Gas Pipeline Safety Act of 1968 (P.L. 90-481) is the principal statute establishing the federal role in natural gas pipeline safety. Under the act, the Department of Transportation (DOT) has primary authority to regulate key aspects of pipeline design, construction, operation and maintenance, and emergency response planning.[122] DOT exercises its regulatory authority through its Pipeline and Hazardous Materials Safety Administration, whose functions include promulgating and enforcing pipeline safety regulations, overseeing pipeline operators, supporting state pipeline safety agencies, and cooperating with other federal agencies that also have pipeline safety or security responsibilities.

Neither PHMSA's authorizing statutes, its current mission statement, nor its pipeline safety regulations explicitly refer to pipeline system "reliability."[123] However, the agency asserts that "safety is foundational to reliability" and has historically highlighted its reliability role.[124] In PHMSA's 2009-2010 biennial report to Congress, for example, the agency stated,

> DOT's hazmat mission is to protect people and the environment from the risks inherent in transportation of hazardous materials—by pipeline and other modes of transportation. In addition to fulfilling the Department's primary safety mission, the DOT modes play an important role in helping to ensure reliability throughout the transportation system that the American public depends on.[125]

Congress, at times, has also recognized PHMSA's role in reliability. For example, the Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 (P.L. 112-90), which reauthorized PHMSA's pipeline safety program, included among its primary purposes "to provide for enhanced reliability in the transportation of the Nation's energy products by pipeline." In the 116th Congress, the PIPES Act of 2020 (S. 2299), a PHMSA reauthorization bill, similarly stated that its primary purpose was "to enhance the safety and reliability of pipeline transportation," although the specific reference to "reliability" was ultimately not enacted.[126] In a 2024 House hearing on a subsequent PHMSA reauthorization bill, the subcommittee chairman stated that "provisions in the PIPES Act of 2023 [H.R.6494] will ensure the safety and reliability of the U.S. pipeline network and the transportation of our critical energy resources."[127]

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[121] "FERC Form No. 576 – Report of Service Interruptions," https://www.ferc.gov/industries-data/natural-gas/resources/industry-forms/form-no-576-report-service-interruptions; 89 *Federal Register* 40480.

[122] Pipeline safety regulations are covered in Title 49 of the *Code of Federal Regulations.*

[123] Pipeline and Hazardous Materials Safety Administration (PHMSA), "PHMSA's Mission," web page, https://www.phmsa.dot.gov/about-phmsa/phmsas-mission.

[124] Linda Daugherty, Deputy Associate Administrator, PHMSA, personal communication, December 14, 2023.

[125] PHMSA, *Transportation of Hazardous Materials 2009-2010: Biennial Report to Congress*, October 2011, p. 3.

[126] S. 2299 passed in the Senate but not in the House. This "reliability" language was not included in the PIPES Act of 2020 as enacted as Division R of P.L. 116-260, the Consolidated Appropriations Act, 2021.

[127] Rep. Troy Nehls, opening statement before the House Transportation and Infrastructure Committee, Railroads, Pipelines, and Hazardous Materials Subcommittee, *Ensuring Safety and Reliability: Examining the Reauthorization Needs of the Pipeline and Hazardous Materials Safety Administration*," hearing, May 7, 2024.

Pipeline Security and Emergency Response

Executive Order 13010, signed by President Clinton in 1996, includes natural gas storage and transportation among the U.S. critical infrastructures "so vital that their incapacity or destruction would have a debilitating impact on the defense or economic security of the United States."[128] Thus, pipeline security is considered an essential component of pipeline system reliability. Two federal agencies are primarily responsible for pipeline security; both are within the Department of Homeland Security. The Transportation Security Administration (TSA) has broad authorities for pipeline cybersecurity and physical security, while the Cybersecurity and Infrastructure Security Agency (CISA) has broad capabilities for managing cybersecurity risk across a variety of sectors and systems. DOE's Cybersecurity, Energy Security, and Emergency Response (CESER) office also plays a role in pipeline security and reliability.

The Implementing Recommendations of the 9/11 Commission Act of 2007 (P.L. 110-53) directed TSA to promulgate pipeline security regulations and carry out necessary inspection and enforcement if the agency determines that regulations are appropriate (§1557(d)). Thus, TSA has primary responsibility and regulatory authority for the security of natural gas pipelines in the United States. In 2021, following the Colonial Pipeline incident, TSA imposed mandatory requirements on pipeline companies' cybersecurity practices; it has since revised and renewed those requirements.[129] TSA has not similarly imposed mandatory requirements for pipeline physical security, relying instead on operator compliance with voluntary guidelines.[130]

In carrying out its cybersecurity functions, TSA works closely with CISA, which was created by an act of Congress in 2018 (P.L. 115-278). CISA's mission is to "lead the national effort to understand, manage, and reduce risk to our cyber and physical infrastructure."[131] The Cyber Incident Reporting for Critical Infrastructure Act of 2022 (P.L. 117-103, Division Y) mandates that CISA promulgate regulations requiring critical pipeline operators and other covered entities to report cyber incidents and ransomware payments.[132] The agency published its proposed reporting regulations, seeking public comments, on April 4, 2024.[133]

CESER's stated vision is "a secure, reliable, and resilient energy sector for the American people," and its stated mission is to "strengthen the security and resilience of the U.S. energy sector from cyber, physical, and climate-based risks and disruptions."[134] CESER's roles and responsibilities are established through various presidential policy directives, executive orders, legislative authorities, and agency rules, frameworks, and strategies.[135] Among its key activities, CESER funds research and development, deploys monitoring tools to better understand evolving energy

[128] Executive Order 13010, "Critical Infrastructure Protection," 61 *Federal Register* 138, July 17, 1996.

[129] Transportation Security Administration (TSA), "TSA Updates, Renews Cybersecurity Requirements for Pipeline Owners, Operators," press release, July 26, 2023.

[130] TSA, *Pipeline Security Guidelines: March 2018 (with Change 1 (April 2021))*, https://www.tsa.gov/sites/default/files/pipeline_security_guidelines.pdf.

[131] CISA, "About CISA," web page, accessed July 8, 2024, https://www.cisa.gov/about-cisa.

[132] The Cyber Incident Reporting for Critical Infrastructure Act of 2022 was enacted as part of the Consolidated Appropriations Act, 2022 (P.L. 117-103).

[133] 89 *Federal Register* 23644, April 4, 2024.

[134] Department of Energy (DOE), Office of Cybersecurity, Energy Security, and Emergency Response (CESER), "CESER Mission," web page, https://www.energy.gov/ceser/ceser-mission.

[135] For details, see CESER, "Authorities and Roles," web page, https://www.energy.gov/ceser/authorities-and-roles.

infrastructure risks, conducts exercises, and coordinates federal responses to energy sector incidents (a role CESER played after the Colonial Pipeline cyberattack).[136]

Pipeline Transportation Service

In addition to siting authority, Section 7(c) of the NGA vests in FERC extensive regulatory authority over the rates for interstate natural gas pipelines, mandating a "just and reasonable" standard for pipeline rates and terms of service (15 U.S.C. §717d(a)).[137] For most interstate natural gas pipelines, FERC uses a cost-of-service methodology, which allows for a reasonable rate of return on investment by the pipeline owner. FERC may set "initial" rates for newly certificated pipelines under Section 7 of the NGA. The commission may approve general rates and rate changes under Section 4 and may require prospective rate changes when rates are seen as no longer just and reasonable under Section 5.[138] Rates for intrastate natural gas transmission and distribution pipelines are under state jurisdiction.

In the past, FERC officials have highlighted the commission's economic regulation of interstate pipeline rates as contributing to supply reliability: "In a sense, even though FERC does not have direct jurisdiction over system reliability for interstate gas pipelines, it regulates and oversees pipeline tariffs and service agreements in a manner that promotes system reliability."[139]Among other provisions, FERC requires gas pipeline tariffs to incorporate business practice standards developed by the North American Energy Standards Board (NAESB), discussed further below.[140]

State Regulation of Gas Reliability

Because intrastate transmission pipelines and natural gas distribution systems are not under federal jurisdiction, state regulators can also play an important role in natural gas reliability. Some states have specific natural gas reliability or reliability-related regulations. California, for example, uses a winter cold day and an extreme peak day gas supply standard for system planning purposes for the state's two major natural gas utilities.[141] In 2022, in response to the gas supply shortages during Winter Storm Uri, Texas adopted its first weatherization regulations for natural gas facilities "to protect gas flow to power generators and ensure Texans have electricity

[136] Prior to the establishment of CESER, the former DOE Office of Electricity Delivery and Energy Reliability (now the Office of Electricity) performed some activities related to natural gas infrastructure "resiliency," which included cybersecurity and reliability components. However, the office's natural gas reliability functions were transferred to CESER when the latter was established in 2018. DOE, "Secretary of Energy Rick Perry Forms New Office of Cybersecurity, Energy Security, and Emergency Response," press release, February 14, 2018.

[137] "All rates and charges made, demanded, or received by any natural-gas company for or in connection with the transportation or sale of natural gas subject to the jurisdiction of the Commission, and all rules and regulations affecting or pertaining to such rates or charges, shall be just and reasonable" (15 U.S.C. §717c).

[138] FERC, "Cost-of-Service Rate Filings," web page, last updated August 14, 2020, https://www.ferc.gov/industries-data/natural-gas/overview/general-information/cost-service-rate-filings.

[139] Joseph McClelland, Director, FERC Office of Electric Reliability, response to questions for the record for the Senate Committee on Energy and Natural Resources, *Natural Gas Service Outages in New Mexico*, field hearing, S. Hrg. 112-7, Albuquerque, NM, February 21, 2011, p. 70. Pipeline operators incorporate their FERC-approved rates and other conditions for transportation in publicly posted "tariffs" available to prospective shippers. Tariff conditions may be related to the allocation of pipeline capacity to shippers, description of the pipeline services offered, financial and transactional requirements, and specification of commodity characteristics (quality).

[140] FERC, "Standards for Business Practices of Interstate Natural Gas Pipelines," 83 *Federal Register* 170, August 31, 2018.

[141] Anna Brockway, "Gas Planning and Reliability in California," white paper, California Public Utilities Commission, December 27, 2021, p. 11, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/natural-gas/long-term-gas-planning-oir/gasplanning_final_2021-12-27.pdf.

during weather emergencies."[142] These new weatherization standards are credited with the state avoiding blackouts during Winter Storm Heather in 2024.[143] Pennsylvania requires all jurisdictional utilities, including natural gas utilities, to have "written physical security, cyber security, emergency response and business continuity plans to protect this Commonwealth's infrastructure and ensure safe, continuous and reliable utility service."[144] Some state reliability regulations may complement or incorporate federal regulations, such as PHMSA's pipeline safety standards or TSA's cybersecurity requirements.

Natural Gas Reliability Debate

Following recent natural gas shortages in different parts of the country, some energy stakeholders and policymakers have been debating reliability risks to U.S. natural gas supplies and the potential role of the federal government in ensuring gas reliability. While some have proposed comprehensive federal reliability regulation, others have questioned the fundamental need for new federal regulation.

GAO Natural Gas Reliability Study

In 2020, at the request of a Member of Congress following the Newport gas system outage, GAO published a report about the reliability of the U.S. interstate natural gas system. GAO's study examined natural gas service interruption reports submitted to FERC between 2015 and 2019, conducted interviews with utility regulators in 42 states and representatives from 15 natural gas transmission pipeline operators, and surveyed 61 local distribution companies.[145]

GAO's analysis of FERC data found that interstate pipeline operators reported serious service interruptions to firm contract customers an average of 28 times per year during the study period, but that these interruptions "did not usually result in outages to large-volume customers that use natural gas."[146] However, GAO reported concerns about growing risks to gas reliability:

> While service interruptions to the customers of interstate transmission pipelines are generally infrequent and limited in scope, the risk of such interruptions may be increasing. Industry representatives and state officials told us that greater use of interstate transmission pipelines, primarily due to increased production of natural gas and increased use by electric power generators, could make service interruptions more likely.[147]

The agency also reported that "[o]fficials in 10 states said that improved federal oversight of the overall reliability of interstate transmission pipelines is needed."[148] GAO concluded that, at that time, FERC was not "using all available data to routinely identify and assess emerging risks to

[142] Railroad Commission of Texas, "RRC's Commissioners Approve Final Rule to Weatherize Natural Gas Supply for Emergencies," press release, August 30, 2022.

[143] Texas Oil & Gas Association, "Largely Supported by Natural Gas, the Texas Electric Grid Remains Resilient Amid Winter Storm Heather," press release, January 18, 2024.

[144] 52 Pa. Code §101.1–§101.7.

[145] GAO September 2020, pp. 3-4. GAO sent surveys to 152 randomly sampled distribution companies and received 61 responses.

[146] Ibid., pp. 12, 14. This figure does not include interruptions lasting less than three hours or on intrastate transmission pipelines, which are not reported to FERC.

[147] Ibid., p. 17.

[148] Ibid., p. 22.

the reliability of the natural gas pipeline system" and therefore was "not optimally positioned to anticipate and respond to these risks."[149]

Calls for Natural Gas Reliability Regulation

Agency officials and energy sector stakeholders, many from the electricity sector, have called for greater federal regulation of natural gas system reliability. Often such statements refer to FERC's regulation of electric reliability as a model for potential regulation of natural gas system reliability (see the "Mandatory Federal Standards for Electric Reliability" text box below). Because of the commission's role as a regulator of both electricity and interstate natural gas systems, FERC officials have been prominent voices in the gas reliability debate, but not the only ones. Calls for new legislation to establish federal authority over natural gas reliability have appeared in various forums in recent years, especially in the context of gas-electric interdependency. Examples include the following:

- A 2021 National Academies report, *The Future of Electric Power in the United States*, recommended that "Congress should build on the example it set in the electric power system … and authorize the Federal Energy Regulatory Commission (FERC) to designate a central entity to establish standards for and otherwise oversee the reliability of the nation's natural gas delivery system."[150]
- In January 2022, former FERC Chairman Richard Glick testified before Congress that "[l]egislation to establish and enforce reliability standards for the pipeline network will better secure the reliability of our Nation's energy infrastructure in the face of threats such as extreme weather and cyber-attacks."[151]
- In an October 2023 joint report on Winter Storm Elliot, staff from FERC, NERC, and other electric reliability regulators recommended "that Congress and state legislatures (or state regulatory entities that have jurisdiction over natural gas infrastructure reliability) take action to establish reliability rules for natural gas infrastructure necessary to support the grid and natural gas [local distribution companies]."[152]
- In a November 2023 press briefing, FERC Chairman Willie Phillips stated, "I continue to call on Congress and our congressional leaders to take action on this, and if they don't, I believe it's incumbent upon our gas utilities to act themselves and voluntarily stand up as an organization to address the reliability of our natural gas system."[153]

[149] Ibid., p. 22.

[150] National Academies of Sciences, Engineering, and Medicine, *The Future of Electric Power in the United States* (Washington, DC: National Academies Press, 2021), p. 7.

[151] Hon. Richard Glick, FERC Chairman, testimony before the House Energy and Commerce Committee, Energy Subcommittee, *Securing Our Energy Infrastructure: Legislation to Enhance Pipeline Reliability*, hearing, January 19, 2022.

[152] FERC/NERC October 2023, p. 20. Regional entities work alongside NERC to ensure that electric reliability standards are met within their regions. Additional information is available at NERC, "ERO Enterprise | Regional Entities," web page, https://www.nerc.com/AboutNERC/keyplayers/Pages/default.aspx.

[153] Hon. Willie Phillips, FERC Chairman, press briefing remarks, November 16, 2023, https://youtu.be/7AkhFN8MTyE.

Mandatory Federal Standards for Electric Reliability

The Energy Policy Act of 2005 (EPAct05; P.L. 109-58) authorized FERC and its certified electric reliability organization, the North American Electric Reliability Corporation (NERC), to develop and enforce mandatory reliability standards for the bulk power system. This step was prompted in part by the August 2003 blackout that affected approximately 50 million electricity customers in a region spanning from Ohio and Michigan to New York and Massachusetts. NERC had first formed to coordinate voluntary industry actions for reliability in the wake of a blackout in 1965 affecting 30 million electricity customers in the Northeast.

Since 2005, FERC has approved over 100 electric reliability standards covering topics such as critical infrastructure protection, emergency preparedness, facilities design, and transmission operations. In general, the goal of the standards is to prevent widespread, cascading failures like the 1965 and 2003 blackouts. Some power outages can—and do—occur even when electric sector participants are in full compliance with all reliability standards.

Congress set limitations on the scope of FERC's authority to enforce mandatory electric reliability standards. First, FERC's authority extends only to the bulk power system, defined in statute as "facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and electric energy from generation facilities needed to maintain transmission system reliability" (16 U.S.C. §824o(a)). Importantly, the electric distribution system is excluded from this definition, even though the great majority of power outages occur in distribution. Reliability of electric distribution is under state and local jurisdiction.

Second, FERC does not have authority to compel the enlargement or construction of electricity generation or transmission facilities, though FERC's economic regulation of the electricity sector (see the "Wholesale Electricity Commodity Markets" text box above) can indirectly affect investment decisions for new or enlarged facilities. As a result, the electricity reliability standards may have limited impact on some aspects of electric reliability, such as resource adequacy, which seeks to ensure that sufficient electricity supply will be available to meet future electricity demand. Finally, FERC's authority for electric reliability does not cover Alaska or Hawaii.

NAESB Reliability Forum Report

In July 2022, following a recommendation in their own joint staff report[154] on the 2021 winter outages, the Chairman of FERC and the President of NERC jointly requested that the North American Energy Standards Board convene an industry forum "to identify solutions to the reliability challenges facing the nation's natural gas system and bulk electric system."[155] NAESB is a private, independent "industry forum for the development and promotion of standards which will lead to a seamless marketplace for wholesale and retail natural gas and electricity."[156] NAESB standards for the natural gas sector cover primarily commercial communications and transactions. Many of these standards are incorporated by reference in FERC regulations.[157]

On July 28, 2023, in response to the joint request, the three co-chairs of the NAESB's Gas Electric Harmonization (GEH) Forum issued a report describing its activities between August 30, 2022, and July 20, 2023.[158] Participants in the forum consisted of representatives from the wholesale natural gas and wholesale electric industries. The NAESB forum considered 20

[154] FERC/NERC November 2021, pp. 18-19. Recommendation (7) states that "the Team recommends that FERC consider establishing a forum to identify concrete actions to improve the reliability of the natural gas infrastructure system necessary to support the [bulk electric system]."

[155] FERC, "FERC, NERC Encourage NAESB to Convene Gas-Electric Forum to Address Reliability Challenges," press release, July 29, 2022.

[156] North American Energy Standards Board (NAESB), "About NAESB," web page, https://www.naesb.org/aboutus.asp. The NAESB was preceded (until 2002) by the Gas Industry Standards Board, which focused exclusively on the natural gas sector.

[157] See, for example, 176 FERC ¶ 61,015, "Standards for Business Practices of Interstate Natural Gas Pipelines," Docket No. RM96-1-042; Order No. 587-Z, July 15, 2021.

[158] NAESB, *Gas Electric Harmonization Forum Report*, July 28, 2023, https://www.naesb.org/pdf4/geh_final_report_072823.pdf.

recommendations addressing a wide range of topics, including gas-electric commodity market alignment, natural gas and electricity demand response, natural gas system information posting, storm operations, and weatherization.[159]

The report stated that, although several proposed recommendations drew "strong support" from both the natural gas and electric power sectors, "on many critical recommendations, the natural gas and electric industries hold widely divergent opinions," which the co-chairs characterized as "profoundly disturbing."[160] Votes on specific recommendations indicated that electric power sector representatives were strongly in favor of additional reliability measures, whereas natural gas representatives were only moderately in favor of, or were moderately opposed to, the same measures. Among other findings, the forum co-chairs concluded "that the close interdependencies of the gas and electric industries and their importance to the nation's economy necessitate stronger reliability standards in the gas industry, along the lines of those that Congress determined (in 2005) were needed in the electric industry."[161]

NARUC Reliability Working Group

In November 2023, following NAESB's report, the National Association of Regulatory Utility Commissioners (NARUC) established the Gas-Electric Alignment for Reliability (GEAR) working group.[162] NARUC is composed of state utility regulators who, as noted above, have primary authority for many aspects of natural gas reliability and its potential impact on the electric power sector. GEAR has the stated goal of "develop[ing] solutions to better align the gas and electric industries to maintain and improve the reliability of the gas and electric energy systems on which our nation depends for power."[163] GEAR intends to focus on both operational challenges and infrastructure challenges, with a report of recommendations planned for February 2025.[164]

Natural Gas Industry Perspectives

While some policymakers have argued for federal regulation of natural gas system reliability, many in the natural gas industry question the need for such regulation. The pipeline industry, for example, maintains that it has long focused on reliability, alongside safety, of its own accord as a core operational priority. A 2015 report funded by the American Gas Foundation states that "the industry's major trade organizations have committed to improving pipeline safety and reliability by adopting best practices that exceed current legal requirements and developing new

[159] FERC defines electricity "demand response" as "the ability of customers to respond to either a reliability trigger or a price trigger from their utility system operator, load-serving entity, regional transmission organization/independent system operator (RTO/ISO), or other demand response provider by lowering their power consumption." The concept also applies to natural gas demand. FERC Staff, *National Action Plan on Demand Response,* Docket No. AD09-10, June 17, 2010, p. 3.

[160] NAESB, July 28, 2023, p. 2.

[161] NAESB, *Gas Electric Harmonization Forum Report*, July 28, 2023, p. 3, https://www.naesb.org/pdf4/geh_final_report_072823.pdf.

[162] National Association of Regulatory Utility Commissioners (NARUC), "Taskforce on Gas-Electric Alignment for Reliability (GEAR)," web page, https://maxxwww.naruc.org/forms/committee/CommitteeFormPublic/viewExecCommittee?id=13B6350000001C&multicolumns=1.

[163] NARUC, "Memorandum on the Creation of the Gas-Electric Alignment for Reliability (GEAR)," p. 1, https://pubs.naruc.org/pub/AA9B903D-D6CD-18AE-EA5B-DF611AB4C68C?_gl=1.

[164] Ibid., p. 2.

standards."[165] Pipeline operators, in particular, argue that the natural gas pipeline system continues to be highly reliable, and that recent gas supply emergencies such as the one in Texas resulted from factors outside the operational purview of the pipeline companies. The Interstate Natural Gas Association of America (INGAA), which represents the interstate gas pipeline industry, has asserted that "[i]nterstate natural gas pipelines maintain an exemplary reliability record" and that any natural gas supply shortages generally arise from constrained capacity and inadequate commercial arrangements rather than operational failures.[166]

Reacting to recent calls for legislation to regulate gas system reliability, pipeline industry trade associations jointly argued in 2021 that "proposals to create a new, additional pipeline reliability regulator fail to reflect pipelines' proven reliability record and risk duplicating and conflicting with existing federal and state agency regulatory authorities and programs."[167] They again asserted that "[p]ipelines by their design are inherently reliable infrastructure … and pipelines have a demonstrable history of performing well during emergencies."[168] They also argued that the gas regulatory models proposed, specifically the FERC/NERC electric reliability model, would not be appropriate for the natural gas sector because of "substantial differences in operations, markets, and regulations between pipeline systems and the electric grid."[169]

Key natural gas industry stakeholders have also taken issue with specific findings and recommendations in the NAESB forum report. INGAA opposed several NAESB forum recommendations on the grounds that they were vague; they might impose unjustifiable costs on the natural gas industry for benefits to the electricity industry; they encouraged FERC to operate outside its statutory jurisdiction; and they could promote new rules that would be unclear and unpredictable, among other objections.[170] The American Public Gas Association, which represents publicly owned natural gas distribution utilities, also expressed concern about regulatory jurisdictional issues (state vs. local) and called for greater emphasis on permitting reform for gas infrastructure and for encouraging the development of additional gas infrastructure to increase gas supplies.[171] The American Exploration and Production Council, which represents oil and natural gas producers, objected to several forum recommendations on the grounds that they were unnecessary—because the industry was already following the recommended practices (e.g., weatherization)—or would be of limited value.[172]

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[165] Van Ness Feldman, LLP, *Natural Gas Pipeline Safety and Reliability: An Assessment of Progress*, prepared for the American Gas Foundation, 2015, pp. 2-3, https://gasfoundation.org/wp-content/uploads/2019/10/pipelinesafety.pdf.

[166] Interstate Natural Gas Association of America (INGAA), "Comments of the Interstate Natural Gas Association of America Under AD22-9," FERC New England Winter Gas-Electric Forum, Docket No. AD22-9-000, filed November 7, 2022, p. 7; INGAA, "Reliability," web page, https://ingaa.org/issue/reliability/: "A survey of interstate pipeline operators conducted by INGAA found that from 2006-2016, pipelines delivered 99.79% of 'firm' contractual commitments."

[167] American Fuel & Petrochemical Manufacturers (AFPM) et al., letter to the Honorable Frank Pallone, Chairman, House Committee on Energy and Commerce, et al., December 7, 2021, p. 1, https://ingaa.org/wp-content/uploads/2022/01/39147.pdf.

[168] Ibid.

[169] Ibid., p. 3.

[170] INGAA, "Re: INGAA's Comments on the NAESB Gas-Electric Harmonization Forum Recommendations," letter to NAESB, July 20, 2023, https://www.naesb.org/misc/geh_sup_comments_INGAA_072023.pdf.

[171] American Public Gas Association, letter with comments to the NAESB GEH Forum, July 10, 2023, https://www.naesb.org/pdf4/geh071323w8.pdf.

[172] American Exploration and Production Council, "RE: Initial Comments of the American Exploration & Production Council on the NAESB GEH Forum Chairs' Strawman Recommendations," letter to NAESB, July 21, 2023, https://www.naesb.org/pdf4/geh071323w3.pdf.

Legislative Activity in Congress

Congress has had a long-standing interest in natural gas system reliability and the potential need for federal reliability regulation.[173] Until the 117th Congress, however, natural gas reliability had not been a primary legislative focus, although some legislation potentially affecting gas reliability had been proposed before. Recently enacted legislation specifically seeks to increase natural gas supply reliability in one region with new pipeline infrastructure. Other legislative proposals would establish new federal authorities to regulate natural gas supply reliability among existing operators, or would mandate other federal initiatives for natural gas system reliability. Selected legislative examples are summarized below.

118th Congress

In the 118th Congress, the Fiscal Responsibility Act of 2023 (P.L. 118-5) approved all federal requirements for completion of the Mountain Valley Pipeline project, a natural gas transmission pipeline from West Virginia to Virginia, in order to "increase the reliability of natural gas supplies" in the Eastern United States, among other reasons (§324(b)). The Spur Permitting of Underdeveloped Resources (SPUR) Act (S. 1456) would direct FERC to "adopt tariff provisions and rate treatments, and establish separately, by rule, additional reforms … necessary to protect the adequacy, affordability, reliability, and security of the supply and delivery of … natural gas by interstate natural gas pipelines (§3001(b))." The Grid Reliability and Resiliency Improvements Act (H.R. 2875) would direct NERC to submit to Congress a report examining, among other things, whether "increased natural gas transportation is essential to the reliability of the electric grid" (§2(7)). The Energy Emergency Leadership Act (H.R. 3277) would expand the responsibilities assigned to Assistant Secretaries of Energy to include energy "infrastructure, cybersecurity, emerging threats, supply, and emergency planning, coordination, response, and restoration" (§2(a)).

Prior Congresses

In the 117th Congress, the Infrastructure Investment and Jobs Act (P.L. 117-58) amended the scope of State Energy Security Plans under the Energy Policy and Conservation Act (P.L. 94-163) to include ensuring "reliable, secure, and resilient energy infrastructure" (§40108), such as natural gas infrastructure.[174] The proposed Energy Product Reliability Act (H.R. 6084) would have required FERC "to certify an Energy Product Reliability Organization," which would "develop and enforce energy product reliability standards," including standards for natural gas and hydrogen pipelines, subject to FERC review (§2(d)). The standards would address cybersecurity, physical security, and "coordination of delivery and availability of energy products to ensure reliable electricity generation" (§2(e)(3)). The Pipeline and LNG Facility Cybersecurity

[173] See, for example, Sen. Tom Udall, remarks before the Senate Committee on Energy and Natural Resources, *Natural Gas Service Outages in New Mexico*, hearing, S. Hrg. 112-7, February 21, 2011, p. 60: "Should there be new Federal reliability standards to cover the interdependency of electricity in the natural gas supply infrastructure?" See also Rep. Frank Pallone, opening statement before the House Energy and Commerce Committee, Energy, Climate, and Grid Security Subcommittee, *Powered Up: State Utility Regulators on Challenges to Reliable, Affordable Electricity*, hearing, February 14, 2024: "[E]ven though many electric systems base their reliability on the operation of the gas production, transmission, and generation systems, there are no mandatory reliability requirements for the gas system. So if we care about reliability, we can't allow this double standard to continue."

[174] State Energy Security Plans "shall address all energy sources and regulated and unregulated energy providers" (42 U.S.C. §6326 (c)(1)).

Preparedness Act (H.R. 3078) would have required DOE "to carry out a program relating to physical security and cybersecurity for pipelines and liquefied natural gas facilities."

In the 116th Congress, the Energy Infrastructure Demand Response Act of 2019 (S. 487) would have directed the Secretary of Energy to establish a pilot program for natural gas demand response "to increase reliability of the energy system," among other objectives.

In the 114th Congress, the PIPES Act of 2016 (P.L. 114-209), which reauthorized PHMSA's pipeline safety program, amended the agency's emergency order authority to include consideration of "the ability of owners and operators of pipeline facilities to maintain reliability and continuity of service to customers" (§16).

In the 107th Congress, the Pipeline Safety Improvement Act of 2002 (P.L. 107-355), which reauthorized the federal pipeline safety program under PHMSA's predecessor agency, established a research and development program for "pipeline integrity, safety, and reliability" to be jointly administered by DOT, DOE, and the National Institute of Standards and Technology (§12).[175] The statute mandated that DOE's responsibilities "reflect its expertise in system reliability" (§12(b)(2)).

Key Policy Issues in Natural Gas Reliability

As the previous discussion demonstrates, natural gas reliability involves many interrelated physical and operational factors—such as regional infrastructure capacity and weather—as well as various regulatory regimes and economic drivers. As Congress examines federal policies related to natural gas supply reliability, certain policy issues may warrant particular consideration: pipeline network expansion, the natural gas share of the overall electricity fuel mix, and potential regulatory structures for gas reliability.

Pipeline Network Expansion

One option often proposed to address natural gas reliability risks is expansion of the pipeline system to relieve capacity constraints and provide alternative paths for pipeline flows in the event of an emergency. While new gas transmission pipeline projects to expand regional capacity continue to be approved by FERC and state agencies, several major pipeline projects have been cancelled in recent years.[176] Some pipeline advocates argue that more such expansion should and would be occurring but for regulatory barriers and siting opposition.[177] As former FERC Chairman Danly testified in 2024, "the solution, of course is to remove the obstacles, primarily regulatory, to further expansion of the pipeline system."[178] Secretary of Energy Jennifer

[175] PHMSA's pipeline safety program was administered by DOT's Research and Special Programs Administration (RSPA) prior to reorganization in 2004 under the Norman Y. Mineta Research and Special Programs Improvement Act (P.L. 108-426).

[176] FERC, "Approved Major Pipeline Projects (1997-Present)," web page, last updated November 30, 2023, https://www.ferc.gov/industries-data/natural-gas/approved-major-pipeline-projects-1997-present.

[177] See, for example, H.Rept. 118-23. "There are numerous large natural gas pipelines that would have carried billions of cubic feet of natural gas per day and served tens of millions of customers that have been cancelled in recent years due to permitting challenges and delays."

[178] James P. Danly, testimony before the House Committee on Oversight and Accountability, Subcommittee on Economic Growth, Energy Policy, and Regulatory Affairs, *The Power Struggle: Examining the Reliability and Security of America's Electrical Grid*, hearing, March 12, 2024, https://oversight.house.gov/wp-content/uploads/2024/03/Danly-Testimony.pdf.

Granholm also testified in 2024 that, to maintain energy reliability, "in some places we will need to build new pipelines."[179]

The Biden Administration asserts that it "has taken aggressive action to accelerate project permitting and environmental reviews," including reviews for energy infrastructure projects such as gas pipelines.[180] Nonetheless, many in Congress have been seeking to advance "permitting reform" policies that could promote natural gas infrastructure development.[181] For example, the Fiscal Responsibility Act of 2023 (P.L. 118-5, Title III) amends the National Environmental Policy Act to

- require specific content in environmental impact statements (EISs) regarding reasonably foreseeable effects,
- clarify requirements for determining the appropriate level of environmental review,
- clarify agency roles,
- promote development of a single environmental document, and
- set page limits and deadlines for EISs and environmental assessments.

Additional proposals in the 118th Congress—such as those in the Building American Energy Security Act of 2023 (S. 1399), the RESTART Act (S. 1449), the SPUR Act (S. 1456), the REPAIR Act of 2023 (S. 3170), the Promoting Interagency Coordination for Review of Natural Gas Projects Act (S. 988), the Promoting Interagency Coordination for Review of Natural Gas Pipelines Act (H.R. 1115), and the Limit, Save, Grow Act of 2023 (H.R. 2811), among others—are intended to further facilitate the expansion of natural gas infrastructure.

As noted earlier, natural gas infrastructure expansion is often controversial for many reasons, including opposition to the use of fossil fuels; concerns about potential leaks and safety issues; concerns about environmental contamination; and local opposition. More detailed discussion of permitting reform is outside the scope of this report, as it involves environmental issues and energy sector considerations beyond natural gas reliability. However, legislative proposals such as those above may be consistent with policies promoting expanded gas infrastructure as a reliability solution.

The Changing Natural Gas Share in the Energy Mix

Although some stakeholders support infrastructure expansion to ensure natural gas supply reliability, others question the need for new infrastructure in light of environmental initiatives that may move the energy mix—especially in the electricity sector—away from natural gas. Experts

[179] Hon. Jennifer Granholm, Secretary of Energy, testimony before the House Committee on Energy and Commerce, Subcommittee on Energy, Climate, and Grid Security, *The Fiscal Year 2025 Department of Energy Budget*, hearing, May 1, 2024.

[180] White House, "FACT SHEET: Biden-Harris Administration Delivers on Permitting Progress to Build America's Infrastructure and Clean Energy Future Faster, Safer, and Cleaner," press release, April 30, 2024; White House, "Biden-Harris Administration Finalizes Reforms to Modernize Environmental Reviews, Accelerate America's Clean Energy Future, Simplify the Process to Rebuild Our Nation's Infrastructure, and Strengthen Public Engagement," press release, April 30, 2024.

[181] See, for example, Rep. Chrissy Houlahan et al., letter to House Speaker Mike Johnson and Minority Leader Hakeem Jeffries, November 8, 2023, https://garbarino.house.gov/sites/evo-subsites/garbarino.house.gov/files/evo-media-document/final-bipartisan-support-for-advancing-permitting-reform-11.7.2023.pdf: "Congress has long stated its intention to enact meaningful change within the permitting sector."

anticipate the share of electricity coming from fossil fuel sources (i.e., natural gas and coal) will decline in the coming years, in part because of federal climate initiatives.

Many relevant policies were included in legislation passed in the 117th Congress, namely the IIJA and P.L. 117-169, commonly known as the Inflation Reduction Act (IRA). These laws include multiple provisions aimed at promoting broader use of energy sources and technologies that compete with natural gas, such as renewable energy, hydrogen, and electric heat pumps.[182] The ultimate impact of these laws is unknown, but many analyses project a declining percentage share of natural gas in the overall energy mix. For example, one multimodel analysis of the impacts of the IRA shows that the expected share of fossil fuel sources used for electricity generation may decline from about 60% in 2021 to 11%-41% by 2035.[183] However, this wide range of possible outcomes indicates great uncertainty, and the total consumption of natural gas could still grow in absolute terms if overall energy demand grows.

Building new gas infrastructure in pipeline capacity-constrained regions to address natural gas reliability might not be necessary if the share of natural gas consumed for electricity generation declines. However, even in the face of declining overall demand for gas, the reliability of the electricity system could become even more dependent on natural gas in the future during times of peak demand if natural gas's continuing role is primarily for balancing intermittent energy sources such as wind and solar. Therefore, understanding gas-electric interdependency now and in the future must take account of not only *how much* natural gas is used for electricity generation, but also *when* natural gas is used and for what purpose.

An additional complication is that the electricity generation mix varies from state to state. Investment decisions for new power plants are affected by numerous state-specific factors, such as available natural resources, environmental policies, and risk tolerance for new technologies. These factors explain much of the state and regional variation in the generation mix today and are likely to lead to continued differences. The changing generation mix alters the degree to which the power sector is dependent upon natural gas and, consequentially, the relative value of infrastructure investments for natural gas reliability.

In addition to changes in regional electricity generation, some federal, state, and local policies seek to reduce natural gas consumption in other sectors. DOE, for example, is administering $8.8 billion in Inflation Reduction Act funding for consumer home energy rebate programs, including rebates for home energy efficiency and electrification, such as the installation of electric heat pumps.[184] DOE also recently promulgated new energy efficiency standards for residential gas

[182] Summaries of energy provisions in legislation enacted during the 117th Congress are in CRS Report R47034, *Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*, coordinated by Brent D. Yacobucci, and CRS Report R47262, *Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change*, coordinated by Jonathan L. Ramseur.

[183] John Bistline et al., "Emissions and Energy Impacts of the Inflation Reduction Act," *Science*, vol. 380, no. 6652 (June 29, 2023), Figure S13. Share of fossil fuel is for coal and natural gas absent carbon capture and storage technology. The paper does not provide a breakdown of the share of generation from natural gas and coal, but the authors note that "although all models suggest that gas-fired capacity will increase to provide firm capacity as load grows and coal retires, most models also suggest that natural gas generation will decline under IRA relative to today's levels." For context, natural gas and coal made up 43% and 16%, respectively, of U.S. electricity generation in 2023. EIA, "Frequently Asked Questions (FAQS): What Is U.S. Electricity Generation by Energy Source?," web page, last updated February 29, 2024, https://www.eia.gov/tools/faqs/faq.php?id=427&t=3.

[184] DOE, "Biden-Harris Administration Announces State and Tribe Allocations for Home Energy Rebate Program," press release, November 2, 2022. For further details, see CRS In Focus IF12258, *The Inflation Reduction Act: Financial Incentives for Residential Energy Efficiency and Electrification Projects*, by Martin C. Offutt.

furnaces and new energy conservation standards for domestic gas stoves.[185] Some localities and states (notably, New York) are pursuing policies to restrict or ban altogether the use of natural gas in new homes or certain commercial buildings.[186] Such gas hookup restrictions face legal challenges, and some have already been overturned by the courts, but they reflect a broader policy goal of reducing natural gas consumption to achieve climate policy objectives. To the extent such natural gas conservation or end-use electrification policies take effect, they could reduce overall demand for natural gas in the future. The effect on peak gas demand of residential fuel switching from natural gas furnaces to electric heat pumps is unclear.

Given the uncertainties about the future energy mix, some analysts express concern about the economic risks and justification for developing major new gas projects. Investments in new pipeline infrastructure come with high capital costs that are typically recovered over long time periods. Potential investors may hesitate to invest in pipeline infrastructure given the risk that their costs might not be recovered if, for example, demand for natural gas transportation services fell in future years because of a declining natural gas share in the energy mix. (This risk is sometimes referred to as a *stranded asset risk*.) As a 2024 study states, "there are growing concerns … about stranded [natural gas pipeline] investments and assets as the United States and other countries transition to net-zero economies."[187] Investors might choose, instead, to make alternative investments outside the natural gas sector, or to invest in natural gas infrastructure focused less on reliability and more on future alternative uses such as hydrogen. Alternatively, investors might seek to recover costs over shorter time periods, reducing their risk of stranded assets but potentially increasing costs for natural gas consumers in the near term.

Potential Legislative or Regulatory Approaches

As discussed above, some energy sector stakeholders, and some Members of Congress, have called for greater federal regulation of natural gas system reliability. In some cases, as in H.R. 6084 in the 117th Congress, legislative proposals specifically call for establishing a FERC/NERC-like regulatory structure, parallel to the system of reliability regulation in bulk electric power. Given that FERC already regulates electric reliability and key aspects of interstate natural gas infrastructure, there could be a rationale for adding gas reliability to FERC's existing regulatory purview.

However, critics of this approach point to the structural differences between electricity and natural gas, along with potential conflicts with existing reliability-relevant authorities among other agencies, to argue against it. For example, if cybersecurity were to be part of this new natural gas reliability authority, how this would be reconciled with TSA's existing statutory role in pipeline cybersecurity—which also covers liquids pipelines—could be an issue. Accounting for aspects of gas system reliability under state jurisdiction could also be a complication.

Evaluating whether to create a new federal regulator of natural gas reliability may be challenging because there have been few detailed proposals to do so and because gas reliability has so many dimensions. H.R. 6084 called for a FERC/NERC reliability model, but various regulatory

[185] DOE, "DOE Finalizes Energy Efficiency Standards for Residential Furnaces to Save Americans $1.5 Billion in Annual Utility Bills," press release, September 29, 2023; DOE, "DOE Finalizes Cost-Saving Efficiency Standards for New Cooking Products, Based on Recommendations from Manufacturers and Consumer Advocates," press release, January 29, 2024.

[186] Adam Burns, Kelly Lear Nordby, and Agustin Ros, "Natural Gas Restrictions in the U.S.: Examining the State of Play, Policy Objectives, Legal Developments, and Antitrust Implications," *JD Supra,* April 9, 2024, https://www.jdsupra.com/legalnews/natural-gas-restrictions-in-the-u-s-2571700/.

[187] EFI Foundation, *The Future of Natural Gas in a Low-Carbon World,* April 2024, p. 83.

approaches could be considered, potentially administered by a different entity or by multiple entities. As the FERC Chairman has stated, "it doesn't have to be FERC."[188]

The European Union, for example, has adopted a two-part standard for natural gas reliability—one addressing infrastructure and one addressing supply—based on performance measures or outcome measures rather than prescriptive measures (see the "Natural Gas Reliability Standards in Europe" text box below). Individual EU Member States are responsible for compliance within their borders. The Australian Energy Market Commission has mandatory reliability and supply adequacy standards for Australia's east coast gas system under its National Gas Rules, which include requirements for day-ahead status reports, supply risk reports, and other measures.[189] Europe's gas market is quite different from that of the United States, as it is heavily dependent on natural gas imports and has major pipeline connections to foreign suppliers (e.g., Russia). Australia is a natural gas producer and LNG exporter, but with a much smaller natural gas system than that in the United States. Nonetheless, the European and Australian standards demonstrate that other approaches to ensure natural gas reliability may be possible.

Natural Gas Reliability Standards in Europe

The European Union (EU) has implemented regulatory "measures to safeguard security of natural gas supply" since 2004.[190] These regulations were revised twice, in 2010 and 2017. The current regulation establishes two principal standards, one for infrastructure and one for supply.

- **Infrastructure Standard.** Requires EU Member States or their "competent authorities" to ensure natural gas systems would have the "technical capacity" to satisfy total gas demand on a "once in 20 years" peak demand day if there were "a disruption of the single largest gas infrastructure."
- **Gas Supply Standard.** Requires competent authorities to impose measures on the natural gas system to ensure natural gas supplies in case of (a) "once in 20 years" extreme temperatures for a 7-day peak period; (b) a "once in 20 years" 30-day period of "exceptionally high" demand; or (c) a 30-day period in which there is a "disruption of the single largest gas infrastructure under average winter conditions."

The EU regulations also require the establishment of "preventative action plans" for natural gas risk mitigation and "emergency plans" with measures to be taken in case of a supply disruption. Other provisions address crisis declaration, information exchange, confidentiality, cooperation, and regulatory oversight.

In 2022, following Russia's invasion of Ukraine and the resulting shortage of regional natural gas supplies, the EU amended its gas reliability regulations to include natural gas storage. The new regulations require Member States to ensure that their underground natural gas storage facilities "are filled to at least 90% of their capacity" by November 1 of each year, among other provisions.[191]

Concluding Observations

The U.S. natural gas system is currently essential to the U.S. economy, providing critical energy supplies for heating, industrial processes, and electric power generation. Federal and state

[188] FERC Chairman Willie Phillips, "Elliott Report: Complete Electricity Standards, Implement Gas Reliability Rules," press release, September 21, 2023.

[189] Australian Energy Market Commission, National Gas Rules, Version 76, Part 27, "East Coast Gas System Reliability and Supply Adequacy," 2024, https://energy-rules.aemc.gov.au/ngr/550/396981#27.

[190] The Council of the European Union, "Council Directive 2004/67/EC of 26 April 2004 Concerning Measures to Safeguard Security of Natural Gas Supply," *Official Journal of the European Union*, L 127, April 29, 2004, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32004L0067.

[191] The Council of the European Union, "Regulation (EU) 2022/1032 of the European Parliament and of the Council of 29 June 2022 Amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with Regard to Gas Storage," *Official Journal of the European Union*, L173/17, June 30, 2022, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32022R1032.

agencies, along with natural gas market participants, play various roles seeking to ensure access throughout the United States to low-cost and reliable natural gas. For many decades, this system seems to have worked reliably. Until a few years ago, natural gas shortages were relatively rare and natural gas reliability at the national level was not an issue of great concern inside or outside Congress.

However, recent natural gas supply failures and related developments have caused the situation to change. Key stakeholders, especially in the electricity sector, have begun to lose confidence in natural gas system reliability, even as the role of natural gas in the nation's energy mix continues to grow and evolve. As the Ranking Member of the House Energy and Commerce Committee remarked in 2023, "natural gas has serious reliability challenges."[192]

Several federal agencies and energy sector institutions already oversee aspects of the interstate natural gas system that affect reliability. They have been pursuing initiatives to address reliability issues that have come to light in recent gas supply emergencies. Notwithstanding such efforts, some in Congress have called for the federal government to do more to ensure natural gas system reliability. Several proposals in and outside Congress would seek to establish an overarching federal gas reliability regulator and mandate new natural gas reliability standards.

However, some stakeholders, especially in the natural gas sector, argue that existing regulatory oversight is adequate and that attempting to centralize and expand natural gas reliability regulation would be counterproductive. They point to other policy options, such as facilitating natural gas infrastructure expansion, as having a greater potential impact on reliability.

If Congress concludes that the current federal structure for overseeing the natural gas sector is insufficient to ensure natural gas supply reliability, it may consider legislative options to expand federal regulatory authority. Considering exactly what that authority could be, and what agency (or agencies) could administer it, could raise complicated questions regarding existing agency authorities, functions, and capabilities.

Whether or not it pursues reliability legislation, Congress may expand its oversight to understand the collective implications of disparate energy and environmental policies on natural gas system reliability, and vice versa. As noted above, several hearings have been held during the 118th and other recent Congresses on this subject. While gas reliability may be a factor considered by various federal agencies establishing new policies within their purviews, such as changes to FERC's pipeline permitting reviews or PHMSA's pipeline safety rules, it may not be considered in the same way across agencies. Furthermore, agencies may not be fully accounting for the relationship between natural gas reliability and electric reliability. As the 2024 joint RTO paper asserts, "permitting reforms for transmission vs. pipelines are being considered in separate silos, which largely ignore the interdependent nature of these two systems."[193] Bringing together the aggregate gas reliability implications of disparate agency policies may enable Congress to view gas reliability from a more holistic perspective and help inform future decisions.

Finally, Congress may seek a deeper understanding of evolving risks to natural gas reliability and developments in related areas that may affect those risks. New energy systems, changing state environmental policies, reconfigured generation portfolios, unpredictable climate conditions, and other factors create an ever-shifting risk landscape for natural gas system reliability. Identifying

[192] Rep. Frank Pallone, Jr., opening statement before the House Committee on Energy and Commerce, Subcommittee on Energy, Climate, and Grid Security, *Powering America's Economy, Security, and Our Way of Life: Examining the State of Grid Reliability*, hearing, September 28, 2023.

[193] Joint RTOs 2024, p. 13.

emerging risks and developing options to address them, both in the short and long term, may be an oversight challenge for Congress.

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