WHITE PAPER

The State of Play in U.S. Energy and Ensuring Future Energy Leadership

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Key Takeaways:

The United States is the world's energy leader, driven by its vast resources, technological innovation, and policy support. It leads in oil, natural gas, and refining while also pioneering advancements in carbon capture, direct air capture, geothermal energy, and advanced nuclear. This strength has ensured energy security, affordability, and global market competitiveness.

However, the nation's energy infrastructure faces escalating pressure from rapidly rising electricity demand driven by the explosive growth of data centers, artificial intelligence applications, electrification, and industrial reshoring. The past decade has seen a reduction in firm power generation capacity, which has strained the U.S. energy grid's ability to meet rising demand. Without clear action, American consumers and businesses may face significant risks, including power outages, escalating energy costs, and diminished industrial competitiveness. Additionally, the resilience of energy infrastructure risks being compromised, increasing vulnerability to cybersecurity threats, severe weather events, and geopolitical disruptions.

The current juncture demands attention, given that delaying solutions risks eroding America's technological and economic advantage, ceding ground to international competitors investing in their energy infrastructure. Addressing these issues requires an integrated approach that aligns government policy, industry investment, and civil society. To sustain U.S. energy leadership, stakeholders should focus on five key priorities:

1. **Dismantle barriers in permitting and regulatory approvals** by modernizing and streamlining approval processes to accelerate the deployment of critical energy infrastructure across power generation, transmission, and fuel transport.

2. **Accelerate firm dispatchable generation capacity growth** and improve gas-electric market coordination by aligning policies and market structures that ensure natural gas infrastructure supports power system reliability amid increasing reliance on intermittent renewable energy.

3. **Unleash infrastructure investment** by implementing policies that reduce financial barriers, enabling private capital to accelerate the buildout of energy transport, storage, and processing infrastructure.

4. **Establish durable, technology-agnostic market mechanisms** with long-term policies that follow an "all of the above" approach to drive adoption of emerging energy technologies and create investment certainty beyond short-term subsidies.

5. **Strengthen resilience measures** by developing a comprehensive national strategy that safeguards energy systems from cybersecurity threats, extreme weather events, and geopolitical disruptions.

Introduction

This white paper assesses the current state of play in U.S. energy, highlighting the nation's leadership in oil, natural gas, refining capabilities, and low-carbon solutions, as well as its recent achievements in emissions reduction. It then identifies critical challenges and risks facing the energy sector, including rapidly rising electricity demand, declining firm power generation capacity, regulatory and permitting barriers, supply chain vulnerabilities, and cybersecurity threats. Finally, the paper outlines strategic priorities and practical resolutions aimed at sustaining and enhancing U.S. energy leadership.

Chapter 1: The current situation in U.S. energy

The United States has established itself as a global leader in energy, maintaining a strong position in oil and natural gas production and exports while driving innovation in renewable energy. Through groundbreaking technological developments, strategic infrastructure investments, and forward-thinking policy initiatives, the U.S. has become more self-sufficient in meeting its energy needs, improved its trade balance, strengthened energy security, maintained globally competitive prices, and reduced emissions intensity.

EXHIBIT 1

The United States is the leader in multiple energy and petrochemical sectors while China is gaining ground and leading in some emerging technologies

Rank[1]	Nuclear	Geothermal	Crude Oil	Natural Gas	Refining	Carbon capture	Petrochemicals	Solar	Wind
1	US	US	US	US	US	US	China	China	China
2	China	Indonesia	Saudi	Russia	China	Brazil	US	US	US
3	France	Philippines	Russia	China	Russia	Canada	Saudi	India	Germany

1. Ranking is based on amount of annual energy or product produced, 2023 reference year
Source: NEI, EIA, IEA, BCG Analysis

Leadership in Oil, Gas and Petrochemicals

The United States is the global leader in crude oil production, reaching 13 million bpd in 2024. This growth is driven by shale production, especially from the Permian Basin, where efficiency gains and strong initial production rates continue to boost output. The U.S.'s light sweet crude grades are in high demand globally for their lower refining costs and higher yield of gasoline and distillates. As a result, U.S. crude oil exports averaged more than 4 million bpd in 2024.

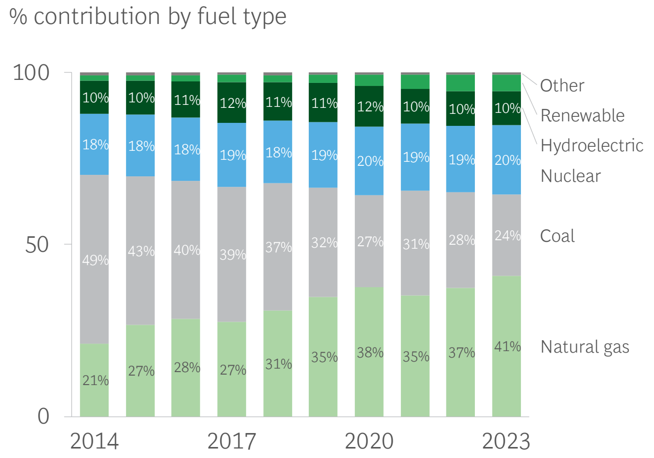
Complementing its strength in crude oil, the U.S. operates the most sophisticated refining systems globally. With an operable capacity of 18.4 million barrels per day (bpd) as of 2024[1], and a Nelson complexity index of 11 (a measure that compares secondary conversion capacity to primary capacity) American refiners have outpaced all competitors in scale and complexity, including China[2]. While China has recently matched U.S. capacity on paper, American refineries have prioritized efficiency and modernization, consistently operating at over 90% utilization, far exceeding China's 75%[3], resulting in higher refined fuel output. As a result, the U.S. has not only met domestic demand but also became the world's top exporter of refined products, including 900,000 bpd of gasoline exports in 2024. The U.S. industry's scale, adaptability, and high utilization ensure it remains the global refining leader, supplying critical fuel markets worldwide.

The United States is the world's largest exporter of natural gas, supplying global markets with competitively priced energy. This was particularly evident over the last couple years where U.S. exports have surged to 13 Bcf/d[4] — surpassing Qatar's and Australia's 10 Bcf/d[5] — and reaching 41 countries. Additionally, the nation generates more electricity from natural gas than any other country, accounting for nearly 30% of the global total, further cementing the fuel's role as a linchpin of energy security both foreign and domestic.

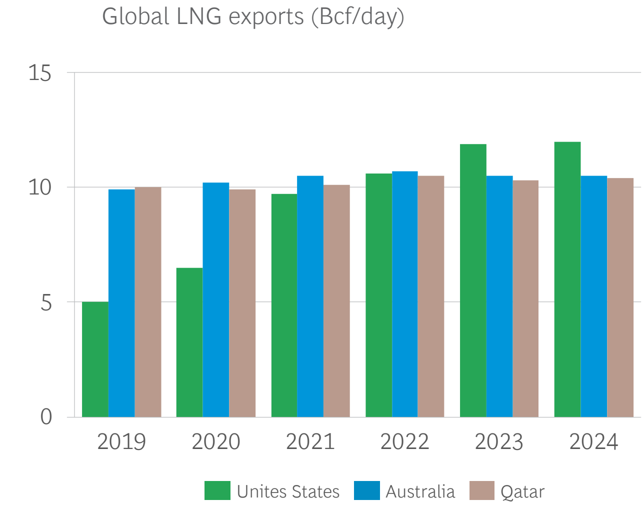
EXHIBIT 2

Natural gas is a critical resource for electricity supply, with a growing share in the power mix and global energy exports

Natural gas-fired power's share has risen by 20 percentage points in the last decade



While exports have become the largest globally



Source: EIA, BCG analysis

1. EIA
2. Refinery of the future, Worley
3. Wood Mackenzie
4. https://www.eia.gov/todayinenergy/detail.php?id=63244
5. https://www.eia.gov/todayinenergy/detail.php?id=62464

U.S. consumers have a distinct price advantage compared to other global centers, largely due to its large low-cost resource base. Since 2022, Henry Hub prices have averaged around $3.8/MMBtu, while European Dutch TTF prices averaged $21/MMBtu, and the Asian Japan Korea Marker (JKM) averaged $20/MMBtu. This stark price advantage has strengthened U.S. industrial competitiveness, reduced domestic energy costs, and enabled the nation's LNG export industry. As a result, the U.S. has created a trade surplus of $30-50B during this period, which represents 4-5% of the total trade deficit[6].

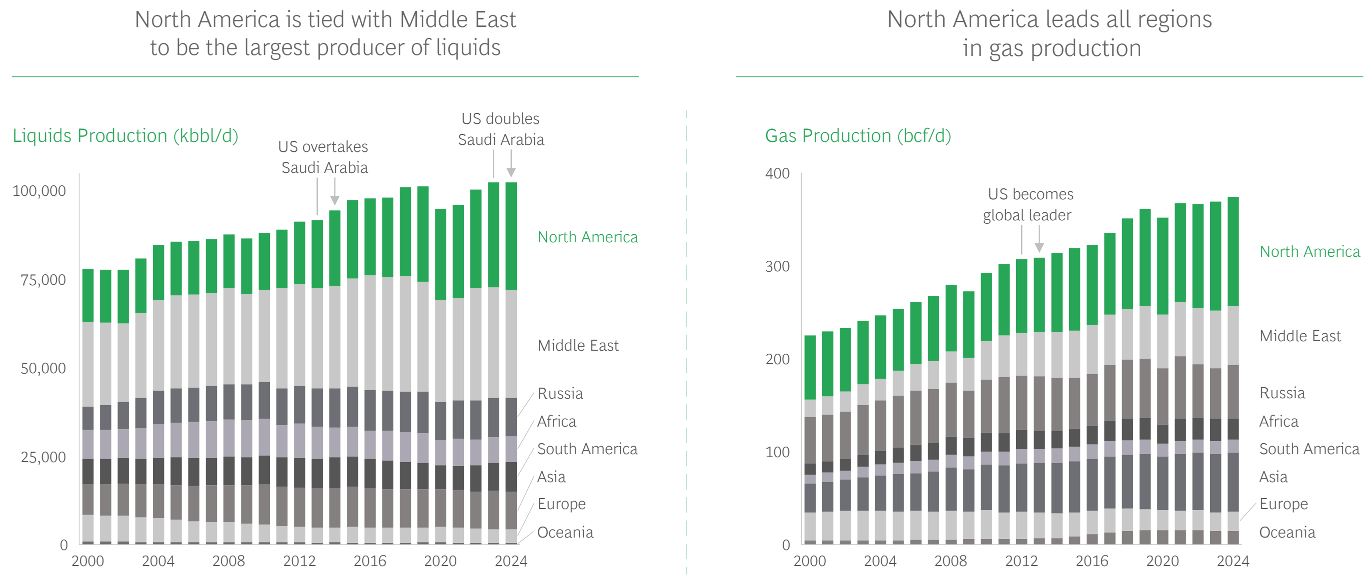
Lower natural gas prices have fueled growth in energy-intensive manufacturing sectors that rely on natural gas and byproducts as a feedstock and/or an energy source. A prime example is the petrochemical industry, where ethylene capacity surged nearly 50% between 2013 and 2020, reaching 40 Mtpa, and driving polyethylene (PE) exports from 3 million tons in 2010 to over 13 Mt in 2023 – a 21% jump from 2022 alone[7 8]. Since 2010, over $200 billion has been invested in petrochemical infrastructure, solidifying the U.S. as the leading exporter of ethylene-derived products[9]. Despite China's rapid expansion, U.S. producers increased exports, reaching a record 2.5 Mt of PE exported to China in 2023.

The foundation of this leadership in the energy industry is the technological revolution that transformed U.S. shale production. This transformation was driven largely by the technological innovations of American companies, but U.S. players benefited from a unique advantage. National laboratories provided vital support to accelerate the development of key technologies and helped scale groundbreaking technologies including drilling & fracturing technologies, 3D seismic imaging & microseismic monitoring, and reservoir mapping & real-time monitoring. National labs remain a unique asset that can be leveraged for advancing future innovations across the ever-changing energy sector.

EXHIBIT 3

North America is now the largest producer of oil and gas globally

In 2024, US produced more liquids than any other country globally

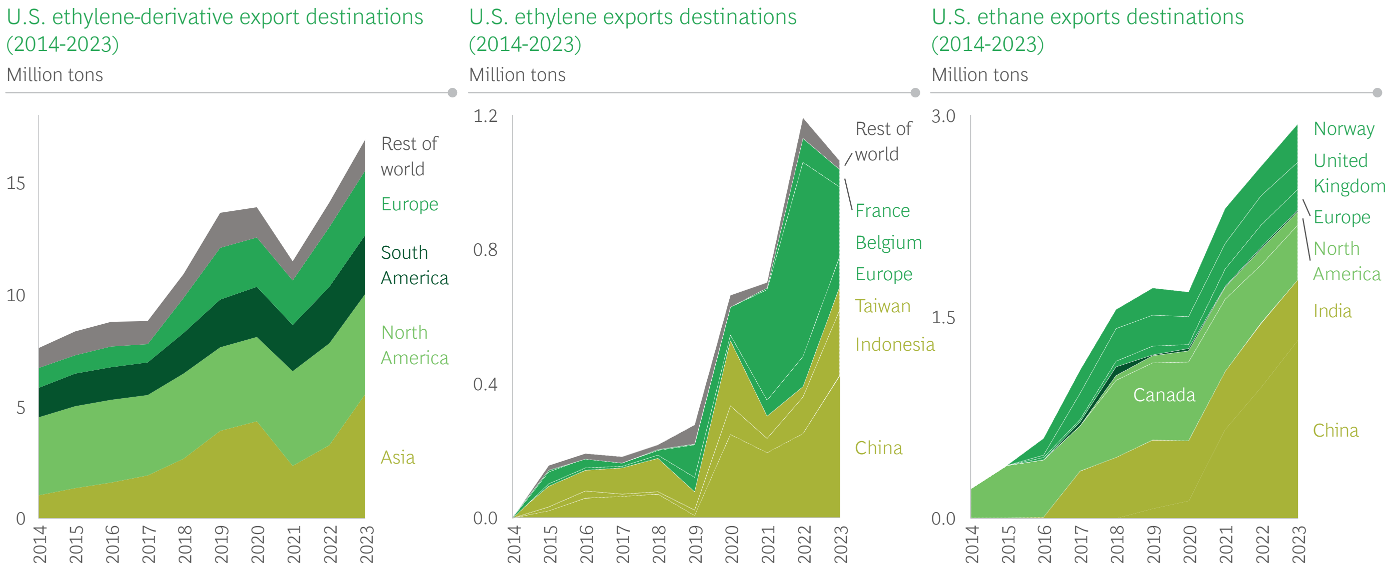


Note: Liquids include crude oil, condensate, NGL, and other liquids
Source: Rystad Energy; BCG Analysis

6. World Bank, https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2021/tradeflow/Exports/partner/WLD/product/271111
7. EIA
8. EIA
9. ACC, "Mid-year outlook: Declining US chemical industry output with potential rebound in 2021"

EXHIBIT 4

US ethane-based petrochemicals reached 22 Mt in 2023, increasing by over 130% since 2014



Source: EIA

This transformation of the energy industry was also enabled by over $240 billion in infrastructure investments between 2010 and 2024, ensuring the efficient transport and processing of natural gas. These investments span the entire supply chain, including $50 billion in processing facilities, $92 billion in pipelines, $99 billion in LNG liquefaction facilities, and $3 billion in storage, reinforcing the U.S.'s role as a key player in global energy markets.

Leadership in Low Carbon Technologies

A diverse range of advanced energy technologies—including carbon capture and storage (CCS), direct air capture (DAC), and geothermal energy—will be essential for strengthening energy security, enhancing industrial competitiveness, and expanding low carbon power generation. The U.S. leads globally in carbon capture and storage (CCS) initiatives, with over 30 CCS projects either operating or under construction—the highest number of any country. This expansive portfolio reflects the nation's commitment to scaling carbon removal technologies to meet emissions reduction goals. Additionally, the U.S. is also the first country to fund large-scale Direct Air Capture (DAC) hubs as part of its broader carbon management strategy. Notably, the U.S. is constructing the world's largest DAC project, which will scale DAC technology by nearly 15 times its current capacity.

Geothermal energy has been a key component of the U.S. renewable energy portfolio, positioning the country as a global leader in this sector. As of 2021, the United States led the world in cumulative installed geothermal capacity with ~4GW – almost 25% of the global online capacity. Additionally, the U.S. holds the world's largest technical enhanced geothermal capacity potential, estimated at over 70 terawatts (TW), accounting for nearly one-eighth of the global total. At a depth of 5 km, the country's technical potential exceeds 7 TW—seven times greater than its total installed power capacity today. This leadership is attributed to the country's vast geothermal resources, particularly in the Western states, and a series of energy policy decisions aimed at expanding geothermal energy use. Legislative acts such as the Geothermal Steam Act of 1970, the Energy Policy Act of 2005, and the Advanced Geothermal Research and Development Act of 2007 have been instrumental in fostering growth and innovation within the sector.

Progress in Nuclear, Hydrogen, Solar, and Wind Energy

The U.S. continues to make significant strides in non-fossil energy technologies including nuclear, solar, hydrogen, and wind energy, strengthening its position as a key player in this portion of the energy landscape. In 2024, nuclear power generation rose to 781 billion kWh, the largest annual increase since 2016[10]. The anticipated restart of the Palisades plant in late 2025 will further add to the nation's nuclear capacity. The U.S. also has the world's largest operational portfolio of blue hydrogen with 1.4Mt in operation and an expected capacity of 7 Mt by 2030[11]. Solar power generation is projected to surge by 75% from 163 billion kWh in 2023 to 286 billion kWh in 2025, driven by new project developments. Wind power generation is expected to climb by 11%, from 430 billion kWh in 2023 to 476 billion kWh in 2025. These advancements reflect the nation's commitment to diversifying its energy portfolio, enhancing grid resilience, and ensuring long-term affordability for consumers and industries alike.

Reduction in Carbon Emissions

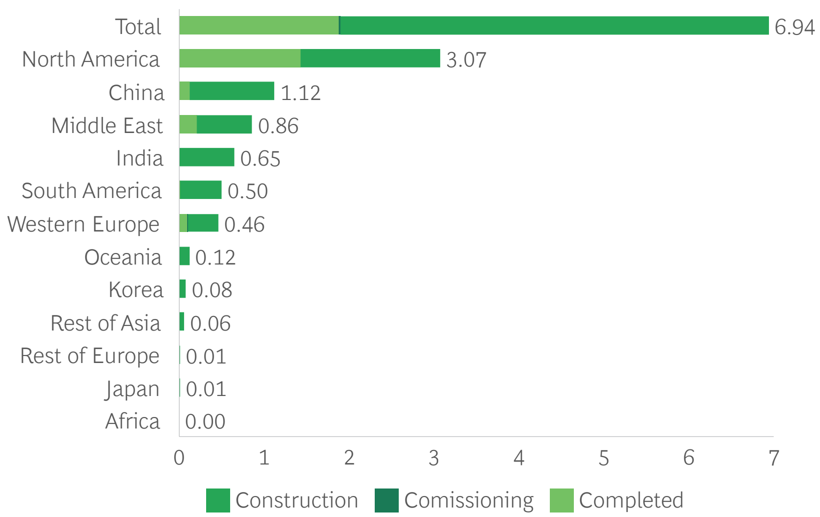
Over the past three decades, the United States has managed to reduce total greenhouse gas emissions by 3% despite a 36% increase in population and a 380% expansion in GDP[12]. This demonstrates that economic growth has outpaced emissions, with emissions per dollar of GDP declining by 80% since 1990. Key drivers of this reduction include improvements in fuel efficiency, a transition in power generation from coal to natural gas, the rapid deployment of wind and solar energy, and a 46% decline in the energy intensity of the economy. Notably, U.S. energy-related emissions peaked in 2007 and have since fallen by 21%, underscoring the nation's ability to achieve emissions reductions while sustaining economic expansion[13].

EXHIBIT 5

Largest operational blue H2 portfolio is in North America; China & North America lead in construction (~>1 Mtpa each), Globally 5.0 Mt in construction

Regional distribution of active and in construction prod. capacity

Mt of H2 equivalent including Hydrogen and derivatives, COD 2030



Insight

North America accounts for almost all current operational capacity

North America, China and India lead the portfolio in construction

Project pipeline in construction has grown in 0.6 Mtpa from Oct24 to Jan25

Active + Advanced stage: 15.4 Mtpa:

1.9 Mtpa in operation, it could be doubled at the end of 2025
5.0 Mtpa in construction (4.4 in Oct24)
8.5 Mtpa passes FID or advanced engineering

Source: GlobalData – January 2025; BCG analysis

10. Nuclear Energy Institute
11. GlobalData – January 2025
12. https://www.macrotrends.net/global-metrics/countries/usa/united-states/gdp-gross-domestic-product
13. EIA

Chapter 2: Challenges Facing U.S. Energy Leadership

Despite its position as a global energy leader, the United States now faces challenges that could hinder its continued leadership. These include rising electricity demand amid declining firm power generation capacity, regulatory and permitting hurdles for critical infrastructure, supply chain vulnerabilities, cybersecurity threats, and the lack of durable energy policies. The urgency of addressing these challenges is heightened by the rapid advancements made by global competitors like China, which is aggressively scaling its AI capabilities and investing in the energy infrastructure necessary to support its growing digital economy. Without decisive action, the U.S. risks falling behind not just in AI, but in the energy systems that power data centers, high-performance computing, and industrial innovation—critical elements for maintaining its global economic and technological leadership.

Scaling Power Supply and Grid Investment to Meet Load Growth

For over 15 years, electricity demand in the U.S. remained relatively flat, hovering between 3.9 and 4.1 million MWh annually. However, this long plateau is now over as the rapid expansion of data centers for cloud computing and artificial intelligence applications, as well as increased industrial activity and electric vehicle (EV) adoption is boosting electricity demand. At the same time, firm power generation capacity, much sought after by data centers and other consumers with a need for uninterrupted uptime, has declined by 6% over the past decade[14].

This growing risk is further exacerbated by the lack of real-time data and forecasting tools to track evolving energy needs across technologies, fuels, and regions. The challenge is not just about increasing supply—it's about timing. The deployment of new power generation varies widely, with nuclear, natural gas, and renewable projects requiring long lead times from capital formation to construction and operation. Delays in this process introduce uncertainty, with the longer the development timeframe the longer the potential delay. This dynamic is making it difficult to scale up generation capacity at the pace required to meet the rising demand- at least without significant price increases. Since 2020 average electricity prices for all end sectors have risen between 21 and 28%.

Compounding these challenges, rising temperatures and acute weather events across the U.S. are placing additional stress on the energy system, necessitating enhanced resilience planning. The number of heating degree days in the U.S. decreased from an average of 5,000 in the 1950s to 4,000 over the last decade, while cooling degree days have risen from 1,000 to 1,500 over the same period[15]. This shift has increased power demand, decreased power generation efficiency while placing increased pressure on natural gas distribution, and fuel supply chains. Utility providers are also increasingly concerned about the impact of more frequent and severe heatwaves on transmission systems and peak generation capacity[16].

Permitting and Infrastructure Development Constraints

Permitting processes in the U.S. are lengthy and complex. The time required to navigate these processes has doubled since the 1970s, now taking between 4 to 12 years for low carbon energy projects. In addition, interconnection queues have exceeded 3 years in many regions. While renewable energy dominates the interconnection queue, only 21% of projects that applied for interconnection prior to 2018 have been built[17]. For instance, queued solar capacity has surged 25x since 2014 making up almost 50% of the capacity in the queue[18]. Meanwhile, natural gas infrastructure, despite its critical role in ensuring reliability and affordability, faces growing challenges in securing approvals. In the Northeast, over the past 15 years, at least 6 major natural gas infrastructure projects have been delayed or cancelled, with some delays spanning over 10 years.

14. EIA
15. https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T01.12#/?f=A
16. Houston Chronicle. "Entergy will spend $137 Million upgrading power lines, poles to withstand extreme weather"
17. Berkeley Lab
18. Berkeley Lab

Recent trends indicate increasing regulatory and community resistance specifically toward natural gas plants, with numerous projects canceled or delayed in just the past several years. High-profile examples include the cancellation of the 650 MW Killingly Energy Center in Connecticut in 2022, and Montana's rejection of the 175 MW Sioux Falls' natural gas plant permit in 2023. New York denied permits for two major projects in 2021—the Astoria Replacement Project and Danskammer Energy—explicitly citing non-compliance with the state's stringent climate law. Additionally, grassroots opposition and regulatory scrutiny led to the abandonment of Virginia's 1,600 MW Chickahominy Power project in 2022, after over six years of permitting attempts. Collectively, these examples reflect a growing trend of permitting denials driven by environmental legislation, regulatory uncertainty, and community opposition, particularly in already stressed or lower income areas. These delays and cancellations highlight significant risks and barriers for future natural gas infrastructure investment.

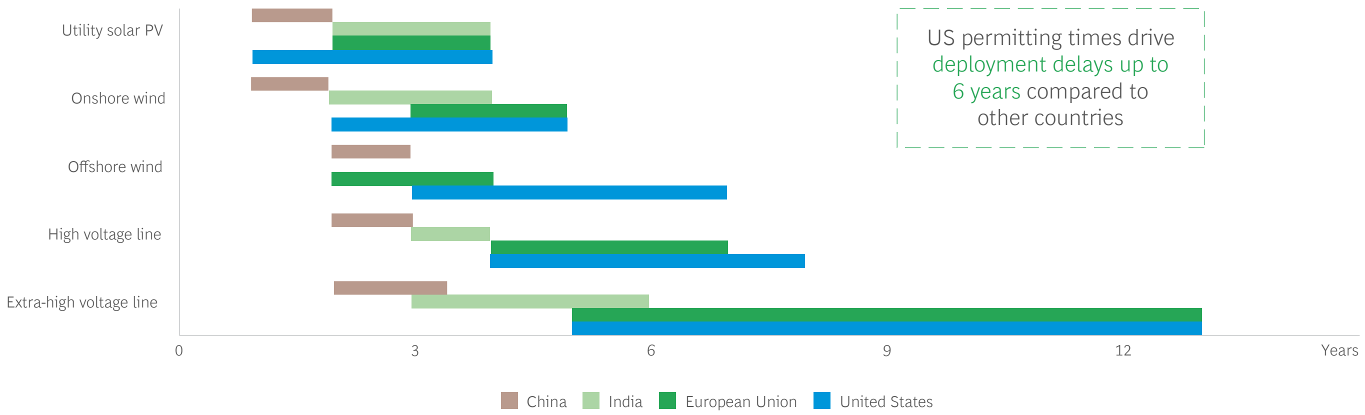
At the same time, natural gas demand is rising due to its critical role in electricity generation, industrial applications, and exports. However, infrastructure development has not kept pace, leading to transportation bottlenecks, exacerbating supply limitations and price volatility. While targeted projects, such as the recent Matterhorn pipeline, have helped alleviate some transportation constraints, ongoing permitting delays risk further constraining domestic supply. Mismatches between national energy priorities and local permitting regulations further complicate deployment, leading to stark regional disparities in energy access and pricing, particularly for projects that cross multiple jurisdictions.

EXHIBIT 6

Obstructive permitting | Permitting barriers are slowing deployment by several years and remain a major blocker for scaling technologies

U.S. permitting for energy projects lags other countries

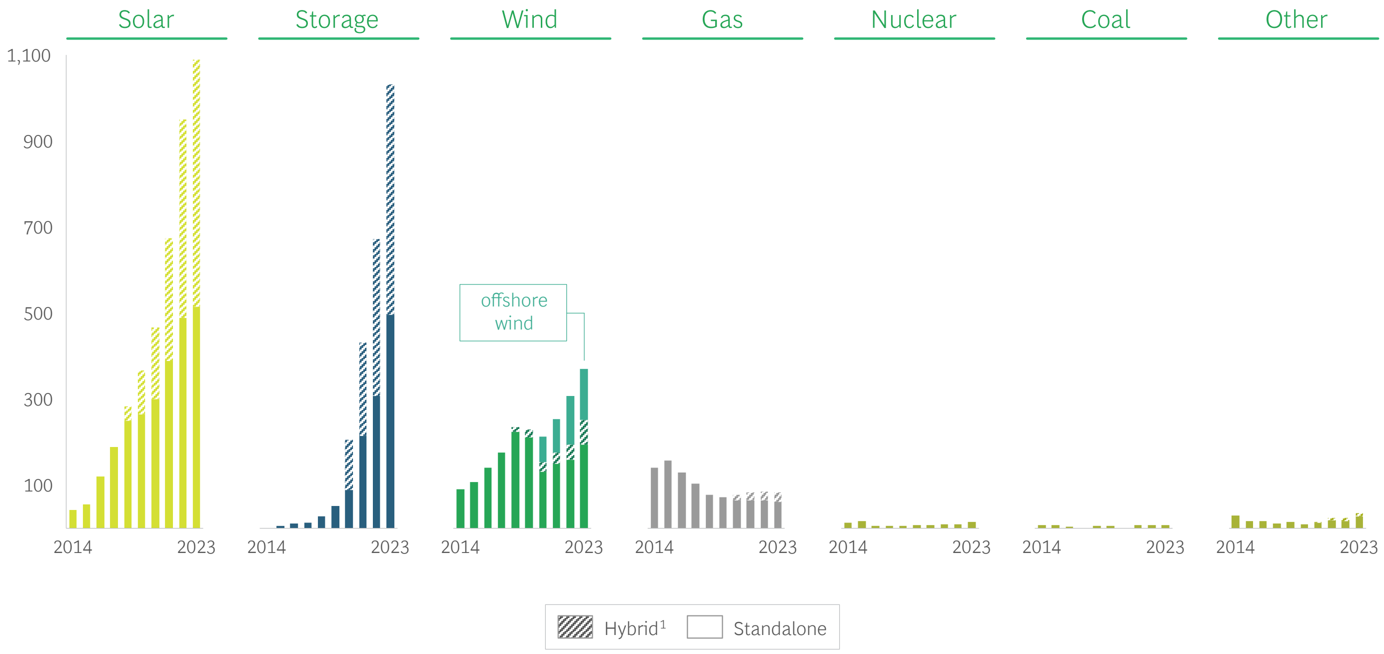
Typical deployment time for electricity grids, solar PV, and wind projects



Source: Permitting Dashboard (performance.gov); IEA WEO 2022, BCG analysis

EXHIBIT 7

Total Capacity in Queues (GW)



1. Hybrid storage capacity is estimated using storage to generator ratios where available, hybrid data was not estimated prior to 2020
Source: Lawrence Berkeley National Laboratory

Supply Chain, Security, and Policy Risks

The U.S. energy sector faces mounting security threats that could undermine stability and resilience. While the United States leads in oil and natural gas production, critical energy-related materials and technologies, including rare earth minerals, lithium, cobalt, and solar panel components, are heavily concentrated in a few countries, particularly China. For instance, China dominates the processing and refining of key minerals, handling 87% of rare earth, 65% of cobalt, and 58% of lithium refining. Additionally, China controls most of the low carbon tech manufacturing, producing 85% of photovoltaic cells, and 76% of battery cells globally. This concentration poses a risk to U.S. energy security, as any disruption in these supply chains—whether due to geopolitical tensions, trade restrictions, or logistical issues—could create bottlenecks, raise costs, and delay domestic energy projects.

The fragility of this reliance has already surfaced through a strained supply response to rising energy demands; for example, transformer lead times now average 2-3 years and an increase in price of 40-60% over the past 3 years[19] while turbine capacity has been booked through 2027 at some of the major manufacturers. Further compounding these challenges, domestics capacity for producing critical grain-oriented electrical steel – essential for transformer production – is limited to a single domestic supplier whose production capabilities are insufficient to meet escalating domestic demand. Moreover, sanctions on Russian steel producers coupled with soaring demand from EV manufacturing have intensified competition for these essential materials, exacerbating supply pressure and driving price increases of 60-80% since 2020[20].

19. Wood Mackenzie
20. Wood Mackenzie

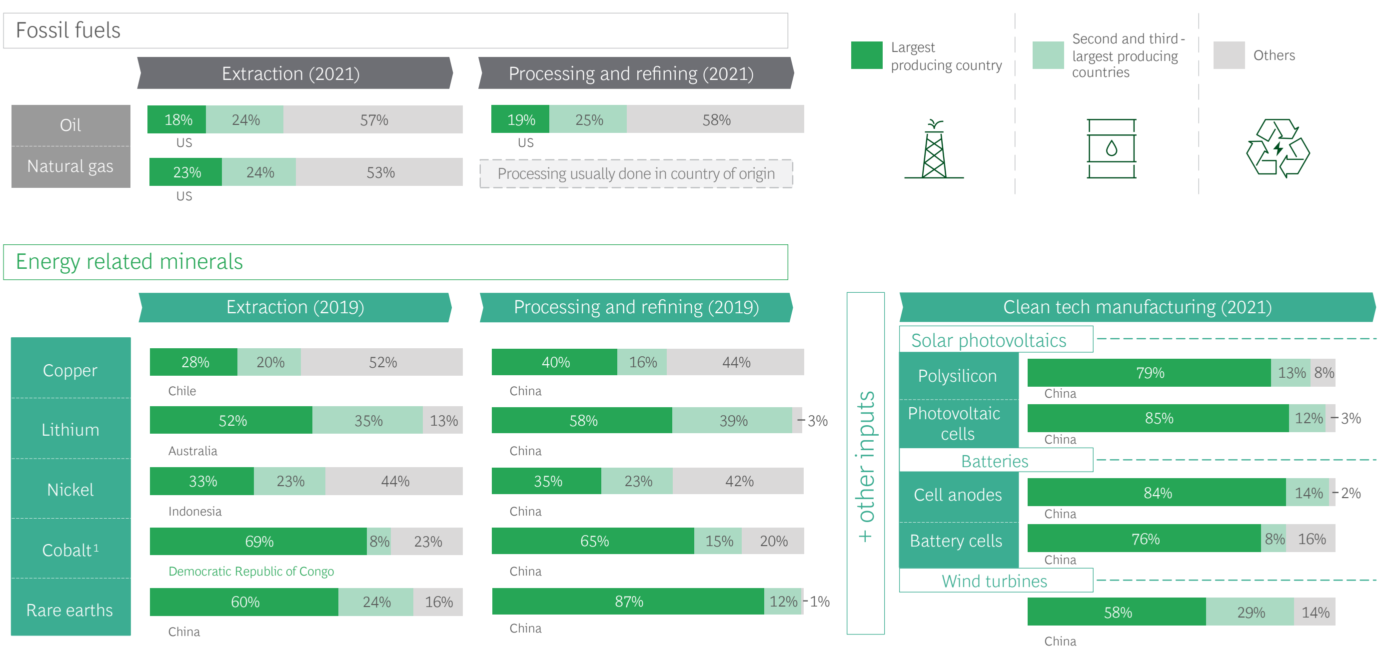
In the nuclear energy sector, the United States faces significant vulnerabilities due to its reliance on Russia for critical nuclear fuel supplies, with Russia providing 35% of total U.S[21]. nuclear fuel imports. Russia holds approximately 44% of the global uranium enrichment capacity, further amplifying its outsized influence on U.S. nuclear fuel procurement[22]. In 2023, uranium directly sourced from Russia accounted for 12% of total U.S. uranium imports, while Russian-enriched uranium represented an even larger share at 27%, underscoring America's substantial dependence on Russian nuclear processing capabilities[23]. This reliance highlights a strategic risk to U.S. energy security.

Beyond supply chain, cybersecurity threats have become one of the most pressing risks facing the energy sector, ranking as the third most significant business risk and a top concern for industry leaders. As the grid becomes increasingly digital and interconnected, the number of vulnerable entry points in electrical networks has grown by roughly 60 each day resulting in 1,162 attacks on average in 2024 - a 70% jump compared to 2023[24]. This rising exposure was starkly illustrated in May 2021, when a cyberattack on Colonial Pipeline forced a complete shutdown, crippling fuel supplies along the U.S. East Coast and triggering widespread disruptions and shortages. Such incidents underscore the urgent need for stronger cybersecurity measures and resilience planning to protect the nation's energy infrastructure from future attacks.

Adding to these security risks is the environment of policy uncertainty, which continues to hinder the long-term stability of the U.S. energy sector, as existing policies often lack durability. Inconsistent regulations and shifting policy priorities across election cycles create an unpredictable environment for investors and industry stakeholders, leading to delays in infrastructure projects and increased costs. With clear, durable policies, the energy sector will develop a resilient and secure infrastructure capable of withstanding both external threats and market fluctuations.

EXHIBIT 8

Renewable energy sector depends on concentrated value chains; more diversification could lower security-of-supply risks



Sources: IEA; BP; BCG CEI analysis. Note: Because of rounding, not all bar segments add up to 100%.
1 Although 69% of the world's cobalt is extracted in the Democratic Republic of Congo, China owns a large portion of that country's cobalt extraction.

21. DOE
22. DOE
23. EIA
24. NERC, Check Point Research

Energy System Reliability Challenges and Gas-Electric Market Misalignment

The harmonization between natural gas and electricity markets is becoming increasingly critical as reliability concerns mount and energy infrastructure struggles to keep pace with demand compounded by the challenges discussed previously.

The increasing penetration of intermittent renewable energy sources presents challenges in balancing supply and demand, requiring additional firm, dispatchable power that can be quickly activated to ensure grid reliability. At the same time, industrial demand for natural gas continues to grow, driven by the reshoring of manufacturing, expansion of chemical production, and increased industrial heat applications. These factors necessitate significant investment in energy infrastructure to support both the integration of renewables and the growing demand for stable, on-demand power generation.

However, natural gas supply has been constrained by the failure of interstate pipelines and storage facilities to expand in line with growing demand. U.S. peak natural gas storage capacity has declined in five of the last seven years since hitting a peak of 4,362 Bcf in 2017, reflecting reduced investment in new storage fields and expansions. Had storage kept increasing at the same pace as natural gas production capacity, the U.S. would have had an additional 2,377 Bcf in storage capacity. The lack of policy durability combined with transmission and distribution bottlenecks has exacerbated these infrastructure constraints, leading to localized price spikes and raising reliability concerns.

Compounding these constraints, U.S. natural gas demand has undergone a structural shift from traditionally winter-peaking consumption to a dual-peaking system. This is driven primarily by heating needs, due to a shift in cooling degree days resulting in increased electricity demand in the summer. Gas-fired power generation reached record summer peaks of approximately 58 Bcf/d during recent heat waves[25], representing more than half of total U.S. daily production (~100 Bcf/d) and surpassing previous summer usage levels[26]. This shift is principally driven by escalating electricity consumption for air conditioning as summers become increasingly hotter, coupled with rising electric vehicle (EV) charging demand, which notably peaks during summer months characterized by increased road travel.

As pipeline utilization intensifies year-round, line pack— the volume of natural gas stored within a pipeline under pressure, providing short-term flexibility to balance supply and demand fluctuations—is increasingly depleted. Historically replenished during lower-demand summer periods, reduced line pack results in pipeline pressure drops and triggers emergency measures such as Operational Flow Orders (OFOs). For instance, during Winter Storm Elliott, the Christmas 2022 storm, pipelines rapidly depleted their line pack due to continuous power-sector draws, leading operators to issue critical notices requiring immediate gas balancing and resulting in power outages for millions of customers in the Eastern half of the country[27].

Lack of Market Pull For Low Carbon Solutions

Despite significant policy incentives for emerging low carbon solutions including hydrogen, carbon capture, and biofuels, the progress on investment and demand signals have been rather limited. Current incentives offer up to $3/kg for green hydrogen production, yet fewer than 10 projects have reached FID over the last 5 years[28]. Many industrial buyers, including steel, cement, and refining sectors, remain reluctant to pay a premium for low-carbon hydrogen, as existing incentives fail to bridge the cost gap between traditional and blue hydrogen. For example, green hydrogen production costs currently range between $5 and $7/kg—significantly higher than the $1.50/kg cost for conventional hydrogen produced via steam methane reforming (SMR)[29].

25. Wood Mackenzie
26. EIA
27. FERC
28. BCG Low Carbon H2 Projects Database, projects with electrolyzer capacity over 1MW
29. DOE Hydrogen Program Record

Similarly, biofuels including renewable diesel and sustainable aviation fuels (SAF) have benefitted from multiple federal and state incentives. The renewable diesel market, which expanded rapidly from 500 million gallons in 2019 to over 4 billion gallons in 2024, is now facing oversupply challenges, leading to refinery slowdowns and cancelled expansion plans. On the other hand, despite ambitious SAF targets – including a 3 billion gallon production goal – actual output in 2023 was 14 million gallons, representing less than 1% of total U.S. jet fuel demand.

Deployment and scaling of carbon capture technology to the level required for meaningful emissions reductions remains a challenge despite the $85/ton incentive. Estimates suggest that the 20 Mtpa capacity in operation and development will need to increase to at least 200 Mtpa in the coming decade to support emissions reduction goals across power generation and heavy industry. Infrastructure bottlenecks have also contributed to the slowed progress, with CO_2 pipeline permitting delays and local opposition leading to project cancellations, such as the 2023 withdrawal of Navigator pipeline.

While incentives have encouraged supply-side development of these technologies, demand-side adoption remains a critical barrier. A patchwork of federal and state incentives has created market uncertainty, leading to hesitation among investors and industrial buyers.

Chapter 3: Solutions to strengthen U.S. Energy

Maintaining U.S. leadership in the global energy sector requires a focus on durable, market-aligned policies that enable competition and innovation across all technologies.. A durable and pragmatic set of actions must focus on enabling competition, fostering private sector investment, and ensuring that incentives align with long-term economic and energy security goals. This means structuring policies that create stable market signals, allowing capital markets to efficiently allocate investment and drive innovation. However, industry faces an increasingly complex economic environment—shaped by rising interest rates, tariffs, labor constraints, and supply chain disruptions—that makes securing capital and scaling new technologies more challenging. Navigating these pressures requires making strategic trade-offs in policy – ensuring that regulatory decisions balance affordability, reliability and sustainability without stifling market forces. By reinforcing market-driven principles and focusing on policies that enhance competition and efficiency, the U.S. can sustain a resilient, innovative, and globally competitive energy system.

To navigate this dynamic landscape, stakeholders should focus on five key priorities:

Dismantle barriers in Permitting and Regulatory Approvals

Streamlining permitting approvals through better interagency coordination, standardized environmental reviews, and regulatory alignment will accelerate development. Regulatory consistency across federal and state levels is essential to avoid market fragmentation and ensure permitting reforms are effective. An example for improving the permitting process is the establishment of mechanisms that ensure timely decision-making, such as a "shot clock" system, where a coalition of federal and state actors commits to reviewing permit applications within a set timeframe to prevent perpetual delays. Such an approach would enforce accountability, improve predictability for investors, regulators and customers, in addition to ensuring that critical energy infrastructure projects advance in a timely manner. Reducing barriers for transmission infrastructure will help expand grid capacity, integrate new energy sources, and keep pace with rising demand while maintaining affordability and reliability. Another improvement is harmonizing natural gas export licenses in duration. Currently these licenses are issued with different duration depending on mode of export and type of contract. Harmonizing these to a longer length, 20+ years will improve the investment climate in LNG by providing assurance to investors and natural gas producers. The overall focus should be on reducing unneeded delays while maintaining necessary controls such as property rights and other oversight.

Accelerate firm dispatchable capacity growth

Improved market structures and incentives are required to ensure firm, dispatchable power remains available when needed. Expanding natural gas storage capacity through a strategic reserve, improving pipeline permitting, and increasing coordination between the operators and planners of both electricity and natural gas infrastructures will help prevent supply disruptions[30]. Initiatives like the North American Energy Standards Board (NAESB) Gas Electric Harmonization Forum and the Memorandum of Understanding between the DOE and the EPA on Interagency Communication and Consultation on Electric Reliability are critical as interdependency between gas and electric systems expands. [31]Additionally, modernizing capacity markets to properly value firm generation resources would support long-term system stability. For nuclear energy to scale beyond the current fleet, policy must provide long-duration price and regulatory certainty. Given the high capital intensity and extended development timelines of new nuclear builds, long-term contracts, credit mechanisms, or advanced market commitments will be essential to attract private investment and de-risk project development.

Unleash Infrastructure Investment

An "All of the above" approach is essential to overcoming constraints in transport, storage, and transmission thus ensuring that all energy sources can compete and contribute to a resilient system. Targeted financing mechanisms, loan guarantees, and streamlined approvals can accelerate deployment by reducing investment risk. Providing balance sheet support for first-of-a-kind (FOAK) technologies—while tying it to domestic supply chain requirements—can help scale innovation and drive costs down without distorting markets. Strategic support for FOAK technologies fosters early-stage development while allowing competitive forces to determine long-term viability. Addressing bottlenecks in energy transmission, storage, and transport will enable new energy sources to integrate more efficiently while maintaining system stability.

Establish Durable, Technology-Agnostic Market Mechanisms

Energy policy should create clear, long-term market signals that encourage private investment and drive commercial adoption of emerging energy technologies. Mechanisms should be technology-neutral to allow the most competitive solutions to thrive to reach overarching goals that meet energy security and other needs. At the same time, resolving the complex regulatory overlap that complicates efficient infrastructure deployment is critical—this means ensuring import tariff relief for strategic energy projects, providing certainty on export permits, and streamlining overlapping regulations that create unnecessary friction. Instead of relying solely on direct subsidies or incentives, establishing sector-specific emissions intensity standards would drive producers to lower GHG emissions per unit of output. This “all of the above” approach would enable the best technologies to compete based on cost efficiency and emission reduction potential while allowing industries to scale without being penalized for absolute emissions.

Strengthen Resilience Measures

A comprehensive energy resilience strategy must go beyond addressing cyberthreats and address the physical integrity, flexibility, and recoverability of energy systems. As infrastructure is exposed to high levels of physical risk, resilience planning must incorporate deliberate siting decisions, extreme weather adaptive engineering standards, and system designs that enable rapid recovery and reconfiguration. This includes hardening critical grid nodes, reinforcing fuel supply corridors, and ensuring redundancy in both generation and transmission. Public-private collaboration should extend to shared threat modeling, stress testing, and recovery protocols. Additionally, AI-driven analytics developed through National Laboratories can support predictive maintenance, real-time grid diagnostics, and adaptive demand response—enabling the system to anticipate and recover from disruptions more effectively. A next-generation approach to resilience should treat flexibility and speed of recovery as core design principles.

30. North American Reliability Corporation, Long Term Reliability Assessment
31. https://www.epa.gov/power-sector/electric-reliability-mou

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