Energy & Infrastructure Insight: Natural Gas

Voya Investment Management

Letter from the energy and infrastructure team

Voya underwrote its first infrastructure transaction in 1990 and, since then, the energy & infrastructure team has remained a core pillar of our investment grade private credit offering.

We manage a circa $13 billion portfolio that focuses on single or multi-asset secured financings through a traditional project finance structure, plus investments in corporations whose business models have infrastructure characteristics.

Since Voya began classifying deals into infrastructure, corporate, and ABF in 2002, the infrastructure team has maintained a zero credit loss rate—successfully preserving principal through commodity cycles, financial crashes, geopolitical shocks, and the pandemic, while also generating competitive returns.

The team has deep sector experience across the energy and infrastructure landscape developed over multiple decades of transaction underwriting. It is our pleasure to distill that expertise into this series of educational insights for our current and prospective clients.

As always, we are happy to answer any questions you might have.

Sincerely,

The Voya PCIG energy and infrastructure team

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Made in America

Decades ago, there was a joke told in Houston bars of a geologist who returned home from a trip abroad seeking oil. In the debrief with her boss, she explained that she had both bad news and good news—the bad news was that she failed to find oil, but the good news was that she failed to find natural gas. Times have changed drastically since then. Thanks to technological innovation and robust demand for cleaner sources of energy, natural gas has become a major portion of the global energy diet.

In this Energy & Infrastructure Insight, we will explore the natural gas industry's transformation from a series of localized markets limited by logistical constraints into a global trade that brings clean, affordable energy to the masses. We will provide a brief overview of the natural gas value chain, discuss how the proliferation of liquefaction technology enabled natural gas to become a global trade, and review how the shale revolution and other factors caused LNG to grow from a nascent commodity to a major portion of the global energy diet.

Background: the natural gas value chain

Before we dive into the history of gas markets and LNG, we think it is important to provide an overview of the historical natural gas value chain. By understanding the process by which natural gas is transformed from subterranean molecules to energy or feedstocks, we can better appreciate the immense value created by the liquefaction process.

Historically, the natural gas value chain consisted of five steps (Exhibit 1).

Exhibit 1: The traditional natural gas value chain

Source: Voya IM.

1. **Exploration and production:** In this step, upstream energy companies explore subterranean geologic formations to discover hydrocarbon resources. Once a discovery is made, upstream energy companies develop the formations to extract natural gas resources. Natural gas can be produced by itself—frequently called "dry gas"—or can be produced alongside oil, often referred to as "associated gas."
2. **Gathering and processing:** Once natural gas molecules accumulate at the wellhead, the gas is transported by a smaller, localized pipeline system to a gas processing center that services multiple wells. The gas processing center removes impurities, liquids and solids from the gas so that it meets specifications for transportation along a longer-haul transmission pipeline.
3. **Natural gas transmission:** After the gas has been processed, it is injected into a longer-haul transmission pipeline that connects gas supply basins to gas demand centers. The pipelines function in much the same way as the interstate road system in the United States, allowing large volumes to be transported over long distances between two major points.

Historically, transport and storage difficulties caused natural gas trading to remain regional.

4. **Natural gas distribution:** Once the gas reaches a demand market, it exits the transmission pipeline and is placed into an interconnecting natural gas distribution system. The natural gas distribution systems function much like state highways and surface streets, allowing the gas to reach its ultimate destination.

5. **End use:** When the gas has reached its destination, it is used for a variety of purposes, including heating, cooking, electric power generation, and as a feedstock for manufacturing the chemicals and fertilizers that make modern agriculture possible. The just-in-time nature of gas delivery allows many of the processes that underpin developed societies to take place reliably and safely.

While the planet has abundant natural gas resources, they are distributed unequally from a geographic perspective and not all resources are legally or economically accessible. Gasses also occupy more space than solids or liquids of a comparable energy content under normal atmospheric conditions and temperatures. As such, the trans-oceanic shipment of natural gas would be rendered uneconomic if natural gas were loaded onto vessels in its gaseous form. Similarly, the construction of long distance, sub-sea pipelines is prohibitively expensive.

The confluence of these factors historically made natural gas trading a regional market, unlike oil, which has been shipped internationally at a large scale since the late nineteenth century.

A tale of two cities

Much as the introduction to Charles Dickens' *A Tale of Two Cities* paints a picture of stark contrasts, natural gas markets have historically been bifurcated into markets of oversupply and markets of undersupply. Markets with a surplus of natural gas enjoyed cleaner power generation, reliable heating sources, and an abundance of cooking fuel. Markets with deficits were forced to use other (often dirtier) sources of energy, including fuel oil and coal, to accomplish the same tasks.

Even in markets with abundant natural gas resources, natural gas was typically delivered just-in-time, given that it requires more space to store than coal or fuel oil. Despite both fuel oil and coal being dirtier than natural gas, their storability made them relatively attractive.

In the same way that the commercialization of jetliner travel more easily connected distant parts of the world, the commercialization of gas liquefaction technology connected regions boasting abundant natural gas resources with markets lacking domestic gas supply. Liquefaction also significantly improved natural gas's storability.

Natural gas liquefaction is not a new process. In the 1600s, Robert Boyle and Edme Mariotte conducted experiments on the relationship between the pressure and volume of gases. In the late 1800s, notable British scientists Michael Faraday, James Joule and William Thompson (Lord Kelvin) were some of the first to experiment with temperature's impact on the liquefaction of natural gases.

The breakthrough for LNG came in 1886 when Karol Olszewski became the first person to liquefy methane, the main component of natural gas. Olszewski discovered that cooling natural gas to -260 degrees Fahrenheit would cause the gas to become a liquid, reducing

Cooling natural gas to liquid form drastically reduced its volume, rendering transport and storage economical.

its volume at atmospheric conditions to 1/600th of its gaseous form. In 1873, German engineer Carl von Linde built the first compression refrigeration machine, which provided for a replicable process.

As with most innovations, LNG's road from discovery to commercialization was a long one. In 1941, the East Ohio Gas Company built the first full-scale commercial LNG plant in Cleveland, Ohio. The plant had an equivalent capacity of 100 million cubic feet (mmcf) of gas. The plant was small by modern standards, at roughly 3.7% the size of the Rio Grande LNG facility that recently began construction in South Texas. The project enabled East Ohio Gas to efficiently store gas to meet peak day demands, a use case that would be shared by other early LNG projects.

East Ohio Gas's Cleveland facility operated safely for a few years, but in 1944 a ruptured storage tank caused a series of explosions that killed 131 people. The severity of the accident caused interest in LNG facilities to wane, as many judged them too dangerous. Over the next fifteen years, the development of special alloys and better insulation materials eliminated the risks that led to the Cleveland accident.

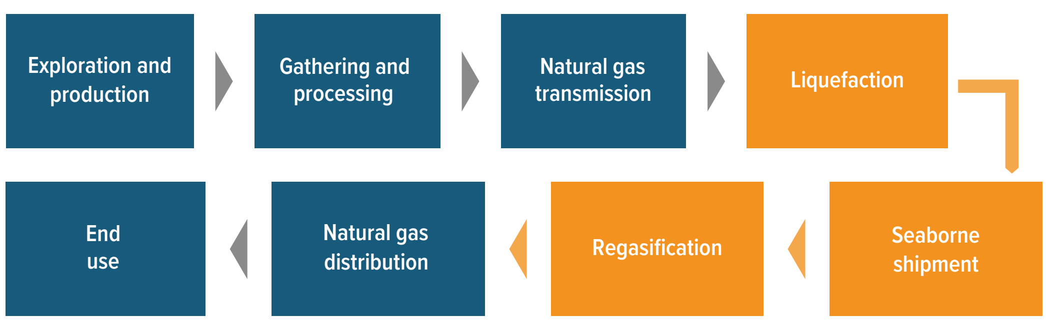
In June 1964, the world's first purpose-built LNG carrier entered service.

These improvements led to the first LNG cargo being shipped from the Louisiana Gulf Coast to gas-starved Great Britain on a repurposed Liberty Ship, the *Methane Pioneer.* In June 1964, the world's first purpose-built LNG carrier, the *Methane Princess,* entered service and began providing contracted LNG shipments from Algeria to Great Britain.

With liquefaction facilities now safer and purpose-built vessels emerging, commercial seaborne LNG cargoes would provide a much-needed bridge between large, remote natural gas resources and major population centers.

The commercialization of LNG led to an enhanced version of the natural gas value chain that included an additional three steps (Exhibit 2).

Exhibit 2: The natural gas value chain with LNG



Source: Voya IM.

1. **Liquefaction:** Natural gas transmission pipelines terminate at large liquefaction facilities along the coast. The natural gas is treated to remove impurities that would otherwise harm the facility's equipment. The gas is then cooled to -260 degrees Fahrenheit, at which point it becomes a liquid occupying 1/600th the space of its gaseous form. The LNG is stored in tanks that maintain its temperature until it is loaded onto insulated vessels and shipped to its destination.

Gas liquefaction has enhanced net importers' energy security while reducing their emissions intensity.

2. **Seaborne shipment:** The LNG is shipped from its origin to its destination via specialized insulated tankers. The tankers are refrigerated so that the necessary temperature can be maintained for the duration of the journey. In many cases, boil-off gas—gas which evaporates during the voyage—is used to power the vessel, ensuring that waste is minimal.
3. **Regasification:** Once the LNG reaches its destination, it is regasified under a controlled process. (The liquid is pumped into a vaporizer, where it is reheated to its gaseous form.) The gas is then injected into the domestic gas infrastructure, where it is used for power generation, heating, cooking and other functions.

The commercialization of LNG is the culmination of decades of research and billions of dollars of investment. The process is carefully choreographed to ensure that it is safe, replicable and economical. Gas liquefaction has helped to alleviate energy inequality, while also enhancing the energy security and reducing the emissions intensity of importing countries.

Gradually and then suddenly

To understand the large-scale adoption of LNG, one must appreciate the concepts of energy security and energy independence. While hydrocarbon resources occur in abundance throughout the world, their distribution is unequal. Some countries, such as Saudi Arabia, have more hydrocarbon resources than they can possibly consume, making them energy independent. Other countries, such as Japan, face severe hydrocarbon shortages, making them energy dependent. However, Japan can still achieve energy security by maintaining trade relationships that ensure a stable supply of energy. One of the chief aims of a nation's energy policy is to achieve diversification of both supplier and energy source, because when energy dependence is combined with energy insecurity, energy crises can occur.

LNG was on the precipice of exponential growth that would transform it from a niche commodity to a major part of the global energy diet.

Japan and much of the Western world received a sharp reminder of the importance of energy security in October 1973, when Saudi Arabia led OPEC on an oil embargo against nations that supported Israel in the Yom Kippur War. In under six months, the price of oil increased by more than 300% as the same number of buyers competed for substantially fewer barrels of oil. Prior to this, Japan and others had relied on OPEC oil to generate power and fuel transportation domestically.

To reduce reliance on foreign oil supplies, Japan and other net energy importers began aggressively pursuing nuclear and LNG as alternative sources of supply. In the decade following the oil crisis, the global LNG trade grew more than fivefold, from 6.04 million tonnes per annum (mtpa) in 1973 to 30.83 mtpa in 1983, with much of that growth coming from Japanese imports.

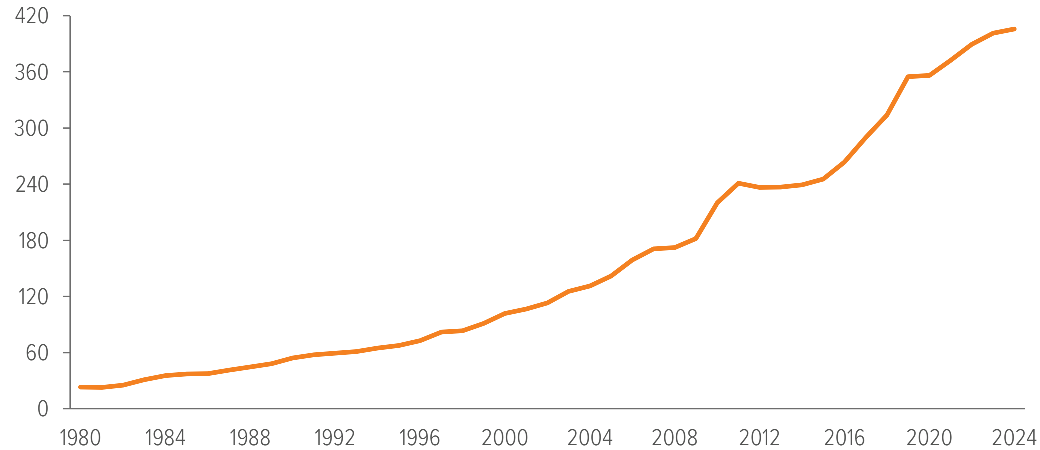
While the LNG industry's expansion in this period seems dramatic, its best days were still ahead of it. Much like Ernest Hemingway's description of going broke, energy transitions occur "gradually and then suddenly." LNG was on the precipice of exponential growth that would transform it from a niche commodity to a major part of the global energy diet (Exhibit 3).

This growth would be driven by:

- Emergence of the Asian tigers and China
- Global focus on climate change and emission reduction
- Development of substantial shale hydrocarbon resources

Exhibit 3: LNG demand climbed to 17x its 1980 level by 2024

Million metric tonnes consumed per year, 1980–2024



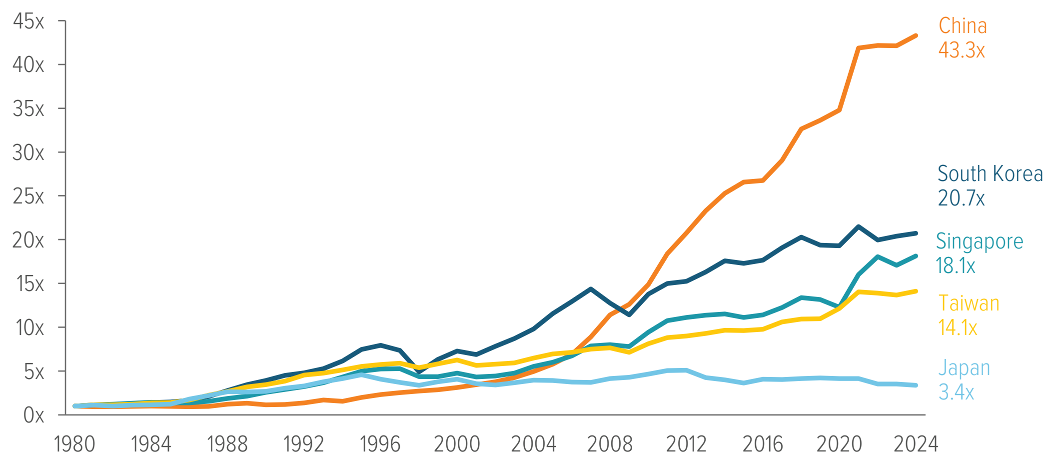
As of 05/20/25. Source: International Group of Liquefied Natural Gas Importers.

Asia shakes the world

When Napoleon Bonaparte said, "Let China sleep, for when she wakes, she will shake the world," he likely wasn't envisioning the largest commodity supercycle in history. Beginning in the late 1970s and continuing into the 21st century, China and the four Asian tigers—Japan, South Korea, Singapore and Taiwan—saw unprecedented GDP growth (Exhibit 4).

Exhibit 4: Asian tigers' GDP skyrockets

Multiple of 1980 GDP per capita, 1980–2024



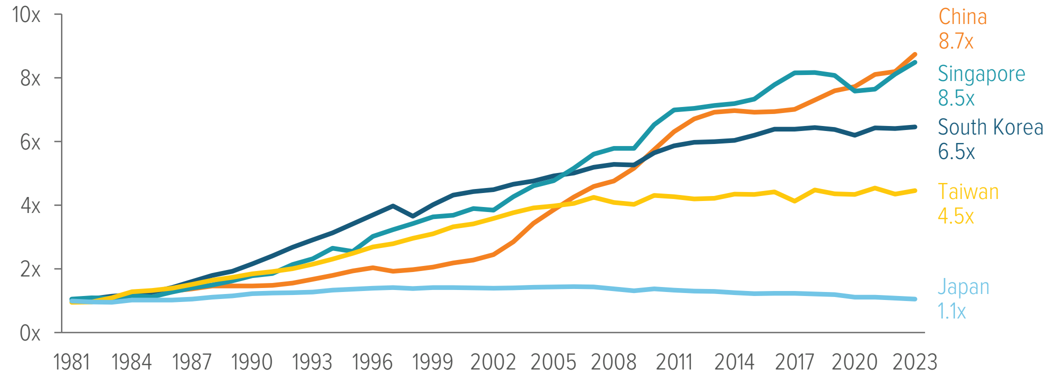
As of 04/15/25. Source: International Monetary Fund.

LNG is forecast to benefit as China and others seek to replace coal-fired power generation with gas-powered generation.

Asia was one of the primary beneficiaries of a new buzzword in the late-20th-century corporate lexicon: globalization. Its growth was the result of a buildout in manufacturing capabilities to support international—and subsequently domestic—demand for finished goods and products. As with any society's development, Asia's entailed a supercharged appetite for energy and commodity consumption (Exhibit 5).

Exhibit 5: Asian tigers' economic growth fueled energy usage

Multiple of 1980 primary energy usage, 1980–2023



As of 05/30/25. Source: Energy Information Administration.

At first, the growth in energy consumption was driven by manufacturing plants that used energy as a key input to produce finished goods. Later, as the upper and middle classes grew larger, energy usage shifted towards quality-of-life improvements such as heating, cooling, power generation and transportation.

Given that the Asian economies lack ample domestic energy resources, their development required the importation of vast quantities of coal, oil and LNG. While coal demand has remained strong in Asia due to its low costs of production and transportation, LNG is forecast to benefit as China and others seek to replace coal-fired power generation with gas-powered generation.

An inconvenient truth

Around the same time that China and the Asian tigers were undertaking their rapid industrialization, the scientific community began to develop concerns about rising temperatures on our planet. They concluded that fossil fuel usage could contribute to rising carbon dioxide levels in the earth's atmosphere, which could cause the earth's surface to warm. The warming, if left unabated, could cause more volatile weather patterns and make life more arduous for large swaths of humanity.

Natural gas is around 50% less carbon intensive than coal and 25% less carbon intensive than diesel.

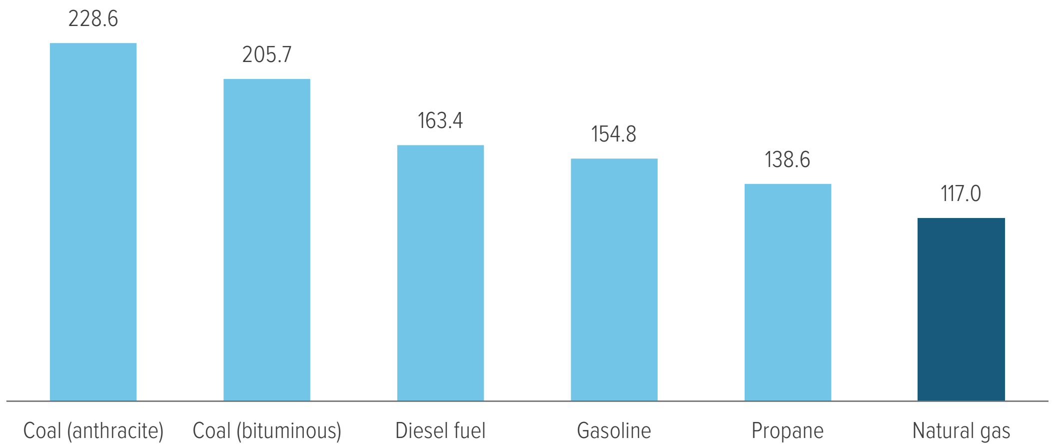
The classic energy trilemma of ***abundance, affordability,*** and ***accessibility*** was now augmented by a need for the energy to be ***clean***.

While renewable energy sources such as wind, solar and hydroelectric have a vital role to play in the energy transition, the intermittency of renewables and the nascent state of battery technology limit them as a percentage of the energy diet. The need for reliable, dispatchable and affordable sources of energy means that we will continue to consume fossil fuels for the foreseeable future. Despite this, policymakers have sought to reduce emissions on the margins.

Fossil fuel emissions are not homogenous, as each fuel has unique components that lead to higher or lower energy density and emissions. Natural gas is around 50% less carbon intensive than coal and 25% less carbon intensive than diesel (Exhibit 6). Additionally, natural gas is free of both nitric oxide and sulfur dioxide, both of which are present in coal and can cause health problems in humans. The combination of lower carbon emissions and a lack of toxic particulate matter make LNG an ideal transition fuel.

Exhibit 6: Natural gas releases the least CO2 of all fossil fuels

Pounds of CO2 emitted per million BTU of energy produced



As of 01/15/25. Source: Environmental Protection Agency.

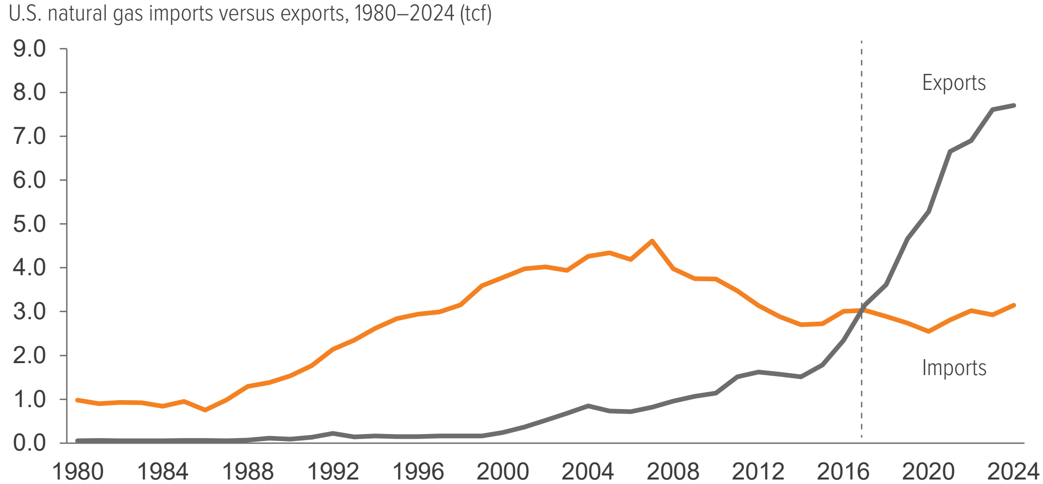
The American energy renaissance

As we discussed in our Insight focused on upstream energy, the shale revolution was a watershed moment for the U.S. energy industry. In the late 20th century, both bureaucrats and prominent Texas oilmen were forecasting the exhaustion of U.S. natural gas reserves.

At the time, the United States was one of the largest natural gas importers, with imports peaking at 4.6 trillion cubic feet (tcf) in 2007. By the end of the decade, the emergence of directional drilling and hydraulic fracturing made trillions of cubic feet of previously inaccessible domestic gas resources highly economical. As the shale revolution took off, the United States shifted from being a net importer of natural gas to being a net exporter (Exhibit 7).

Exhibit 7: Fracking took the U.S. from net importer to net exporter of LNG in 2016

U.S. natural gas imports versus exports, 1980–2024 (tcf)



As of 09/30/25. Source: Energy Information Administration.

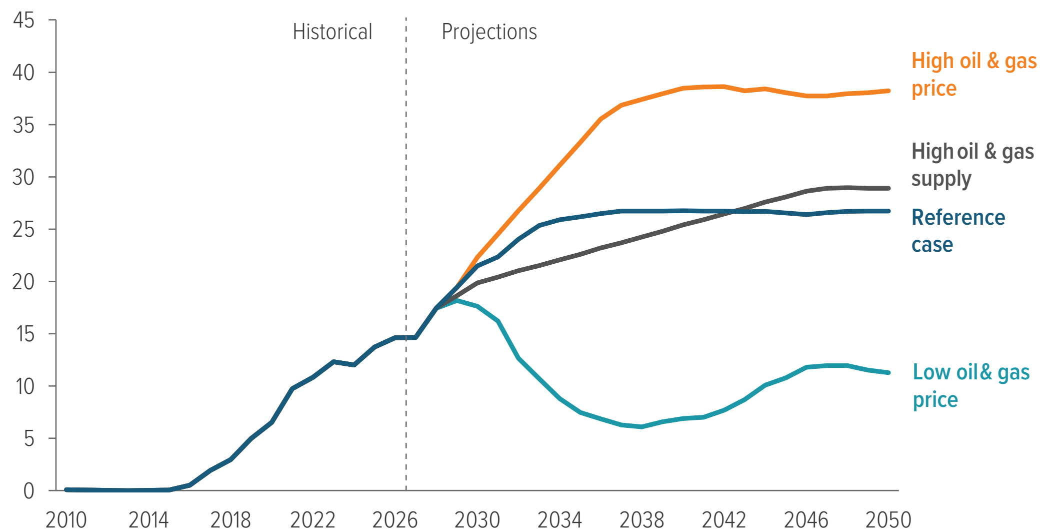
As domestic resources were exploited and the United States shifted from net importer to net exporter, LNG import facilities were reconfigured into LNG liquefaction facilities for export. The first retrofitted LNG export terminal, Cheniere's Sabine Pass, shipped its first cargo in February 2016. Under the U.S. Natural Gas Act of 1938, exports were allowed to countries with which the United States has free trade agreements, such as Mexico and Canada.

To make U.S. LNG cargoes more attractive in the global marketplace, the new export facilities sought U.S. Department of Energy approval for export to non-FTA countries. This enabled marketers to ship cargoes to any country not subject to sanctions by the U.S. government.

As a result of abundant resources and destination flexibility, the U.S. LNG export industry grew at a 65.7% CAGR from 2016 to 2022 (Exhibit 8). Almost overnight, the U.S. transitioned from net importer of natural gas to LNG export superpower.

Exhibit 8: The explosive growth in U.S. LNG exports is not over

U.S. LNG export growth 2010–2050 tcf



As of 07/11/25. Source: Energy Information Administration.

In the first half of 2023, the U.S. passed both Australia and Qatar to become the world's largest LNG exporter.

In the first half of 2023, the U.S. passed both Australia and Qatar to become the world's largest LNG exporter, a title it is expected to maintain for the foreseeable future. Currently, the United States has eight operational LNG export facilities with a combined nameplate liquefaction capacity of 17.1 billion cubic feet per day (bcf/d).

In addition to the currently in-service liquefaction facilities, there is another 15.8 bcf/d of additional export capacity that has received regulatory approval and is currently under construction. The commencement of operations at these upcoming LNG facilities will further solidify the U.S.'s position as the world's preeminent LNG exporter.

While U.S. domestic gas prices may experience volatility as new liquefaction projects come online, the growth in LNG exports is expected to benefit owners and creditors of natural gas infrastructure assets as producers seek to meet gas demand.

No free lunch

For the LNG export projects that will come online in the latter half of the decade, the path from inception to completion will be a grueling, multi-year process. Along the way, a project's management team must successfully navigate regulatory, financial and commercial hurdles to successfully reach a final investment decision. Once the final investment decision is made, the project's management team must then manage contractors to ensure that the project is delivered on time and within specification. Only after billions of dollars of investment and millions of man-hours of work will the first molecule of gas be liquefied.

For investors in LNG liquefaction projects, the process is not any easier. Successful underwriting of an LNG liquefaction facility requires investors to utilize an interdisciplinary approach that includes:

1. **Regulatory analysis:** Investors need to ensure that management teams possess the necessary skills and resources to successfully navigate regulatory hurdles. Financeable projects will have received all regulatory and government approvals from national, state and local agencies. Most projects are located in marine environments, and management teams will need to have demonstrated both a willingness and an ability to successfully mitigate environmental impacts. Astute investors will stay abreast of the regulatory hurdles that a project needs to clear prior to reaching final investment decision.
2. **Contractual analysis:** Effective contracts are part and parcel to the success of an LNG liquefaction project. Relevant contracts include LNG offtake agreements, EPC agreements with contractors for construction of the facility, operations and maintenance agreements, and supply agreements with equipment manufacturers and power providers. Contracts that are inadequately structured can significantly affect project economics. Investable projects have ironclad contracts with blue-chip counterparties, which help to mitigate risks. Prudent investors will underwrite both the contracts and the counterparties.
3. **Market analysis:** While contracts help to insulate investors from changes in market conditions, supportive market fundamentals reduce the risk that counterparties will try to find contractual loopholes or renege on their agreements. Diligent investors examine both supply and demand markets. On the supply side, investors must ensure that sufficient feedgas can be obtained by the project throughout the life of the investment, and that the necessary infrastructure exists to deliver gas to the facility under multiple scenarios. On the demand side, investors will examine the markets where the gas is used as well as the offtakers. Historically, offtakers were primarily end users of natural gas, such as utilities. More recently, a burgeoning short-term and spot trade has emerged, whereby national and international oil companies act as "portfolio players" and seek to deliver LNG in a flexible fashion to the markets where it is most in demand.
4. **Financial analysis:** LNG export projects are multibillion-dollar assets, and their successful completion requires management teams to work with a wide range of financial market participants. Infrastructure private equity funds, international and national oil companies, and sovereign wealth funds provide the equity capital, while global banks and large infrastructure credit investors provide the debt financing. Investment grade projects feature amortizing debt with legal maturities inside of the projects' offtake agreements and robust debt service coverage ratios. Knowledgeable investors will ensure that a project's debt service coverage can withstand a variety of stress tests, including the most draconian scenarios. Investors should also analyze a project's ability to withstand delays in construction or prolonged outages at the facility. As with any investment, the existence of a margin of safety is a principal risk mitigant.

Opportunities abound

We believe that LNG will play a key role in helping the world achieve its energy security goals, while also supporting the transition to cleaner fuels.

Moving forward, we believe that investment in LNG infrastructure is one of the more interesting themes in the energy sector. As we write this newsletter, geopolitical uncertainty is at its highest level since the 9/11 terrorist attacks, wars are being waged in both Europe and the Middle East, and the world is burning more coal per annum than ever before.

While none of us can prognosticate future geopolitical events with any measure of certainty, we believe that LNG will play a key role in helping the world achieve its energy security goals, while also supporting the energy transition to cleaner fuels. Cargoes from OECD countries such as the U.S. and Australia will be more attractive than non-OECD cargoes, given the greater political stability associated with OECD countries. Incremental LNG cargoes will also help to replace coal by providing valuable dispatchable resources to augment renewable power generation in countries lacking indigenous gas resources.

The achievement of energy security and energy transition goals will require investments across the entire LNG value chain to:

- Develop additional gas reserves to provide feedgas
- Lay pipelines between producing basins and liquefaction facilities
- Build more liquefaction facilities
- Commission additional LNG vessels
- Construct new regasification facilities to import LNG
- Commission new power plants to generate electricity from imported gas

Cumulatively, this will cost tens of billions of dollars, much of which will be financed with long-term debt.

We expect that the U.S. private placement market will continue to be an attractive financing destination for many of the necessary LNG infrastructure projects, particularly ones in North America and Australia.

Taking an interdisciplinary approach, we plan to use our knowledge of the LNG value chain to make selective investments in durable assets at attractive prices and on fair terms. We invite you to join us in doing so.

A note about risk

The principal risks are generally those attributable to bond investing. Holdings are subject to market, issuer, credit, prepayment, extension and other risks, and their values may fluctuate. Market risk is the risk that securities may decline in value due to factors affecting the securities markets or particular industries. Issuer risk is the risk that the value of a security may decline for reasons specific to the issuer, such as changes in its financial condition.

IM4950345 • 222977 • 103125 • 2025-10-4816250

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