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Natural Gas Markets Going Global: Changes in Consumption

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The future of natural gas as a fuel for the global economy depends on many factors, including supply, consumption, prices, transportation, and policies. In 2020, natural gas made up approximately 25% of the world's primary energy mix. Unlike other fuels, natural gas is used in multiple ways: as a heating fuel for homes, business, and industrial processes, to produce electricity, as a feedstock for petrochemicals and fertilizers, and in other less prominent ways. The market for natural gas is evolving and it is likely that natural gas will remain a key component of the world's energy mix for decades to come. As demands for natural gas have changed so has the natural gas market.

The 2022 Russian war against Ukraine has brought to the front the geopolitical dimensions of natural gas. Russia is the world's largest exporter of natural gas, primarily by pipelines to Europe. Europe is also Russia's biggest natural gas market. Some EU member states and companies had been reluctant prior to the 2022 war to shift significantly away from the status quo. Some of Europe's larger natural gas companies have major financial interests in maintaining Russian supplies and were thus reliant on Russia. A major test for the EU in developing a more coherent energy policy could be how to balance these views with those of member states that are highly dependent on Russian energy and are concerned by the leverage Russia could exert on parts of Europe if no alternatives are found to alleviate at least some of that dependence.

The rise of the U.S. natural gas sector at the beginning of the 21st century changed the course of natural gas a global fuel. The emergence of the United States as an exporter of liquefied natural gas (LNG) has caused significant changes to natural gas markets. The U.S. natural gas market is one of the few that does not link its price of natural gas to oil, and this has carried over into LNG contracts from U.S. companies. Therefore, some buyers view U.S. LNG exports as a hedge against oil prices. Unlike oil, natural gas is not necessarily priced in U.S. dollars. Further, unlike others, U.S. exporters do not require destination clauses. All these changes have moved natural gas toward becoming a more global commodity.

Going forward, China represents a major question mark for the natural gas industry. China is the fourth-largest natural gas producer in the world, with its production rising since 2000. Its natural gas resource base is large, and its shale gas endowment is estimated to be nearly double that of the United States. China's production is less than 20% that of the United States, and China's consumption makes up 8% of its primary energy consumption. China is also a growing natural gas importer, with pipelines from Central Asia, Russia, and Burma in addition to its LNG import terminals.

There are certain limitations in the use, trade, and particularly the transport and storage of natural gas. Unlike oil, which can be easily purchased on the spot market and transported via pipeline, rail, truck, or ship, natural gas is relatively expensive in world markets, technologically challenging to move to markets, and not as easily traded. The natural gas market is becoming more global, especially with more LNG available and the rise of the LNG portfolio companies (companies without a specific destination for any particular LNG cargo), but additional changes would need to happen for it to reach the same level of market dynamism as the oil market. The ease of trading oil has contributed to oil's greater insulation from geopolitical tensions and other challenges. As has been seen in 2022 with the Russian invasion of Ukraine, natural gas cannot easily be replaced nor the availability rapidly increased. More flexibility in the natural gas market would be needed in order to insulate both consumers and producers.

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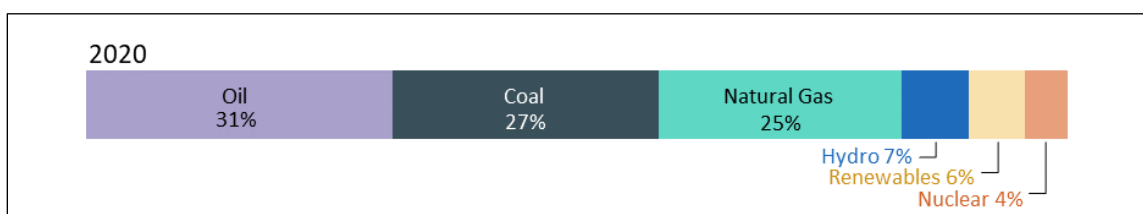
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Introduction¹

The future of natural gas use in the global energy mix is uncertain and depends on many factors, including supply, demand, prices, transportation and other costs, and government policies related to energy and the environment. The ways in which the natural gas market is evolving will have implications for the global energy mix over at least the next 20-30 years. New production of natural gas is caught between a need for more supplies in the near term and a future driven by a goal of decarbonization. This dichotomy adds volatility to the market. In considering the future of natural gas, there are important differences between natural gas and other fuels. Natural gas has multiple uses and a distinct set of key producers and consumers that differ from those of other fuels. It is bought and sold in different ways with varying contract terms and conditions, and it is viewed both positively and negatively by environmental groups, among other considerations. As shown in **Figure 1**, natural gas supplied a quarter of the world's energy in 2020, ranking third behind oil and coal.

Figure 1. World Primary Energy Mix, 2020



Source: BP, *Statistical Review of World Energy, 2021*, at <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.

Notes: Primary energy comprises commercially traded fuels, including modern renewables (does not include traditional biomass such as wood and peat) used to generate electricity.

Many base-case or business-as-usual scenarios by government agencies, academia, industry, and other groups feature natural gas as a prominent fuel in the global energy mix over the next 20-30 years. In scenarios that restrict greenhouse gas emissions, natural gas tends to stay in the energy mix, but at lower levels depending on the restrictions. However, the varied uses of natural gas make it difficult to eliminate natural gas from the energy mix. This report will examine how natural gas markets are changing for a variety of reasons, and what this may mean for the United States both from a strategic and geopolitical perspective.

The countries of the world, for the most part, are undertaking an energy transformation to varying degrees and in different ways, and natural gas plays a bigger or smaller role depending on how a country attempts to achieve its goals. Certain benefits and limitations of natural gas are important to its future use as a fuel. The International Energy Agency (IEA), in its annual *World Energy Outlook (WEO)*, shows how projections can change under different policy assumptions (see **Figure 2**). In the figure, the dotted trend line shows how historical natural gas demand may increase according to an econometric progression. The upper line plots the 2019 WEO's Current Policies scenario, which projects what may happen "if the world continues along its present path (at the time), without any additional changes in policy."² This provides an upper bound to the

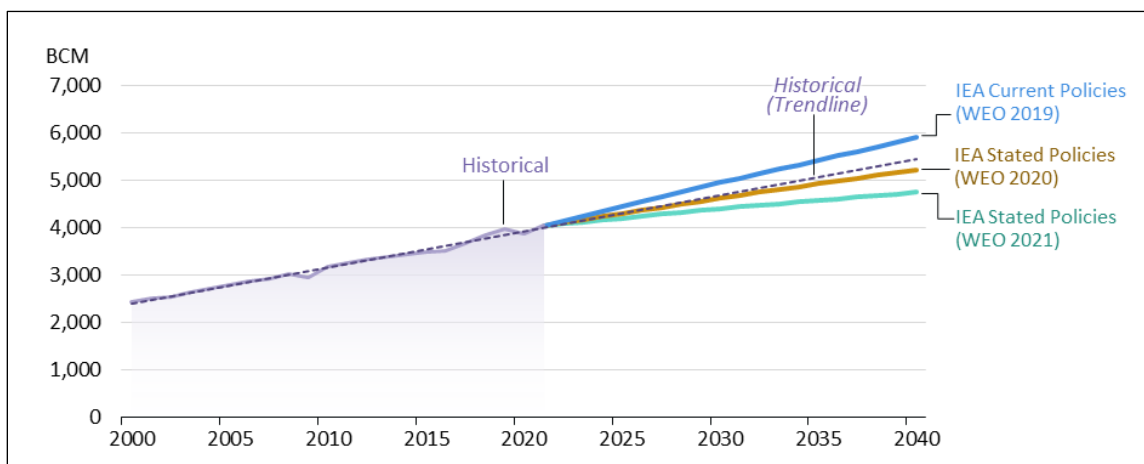
¹ For consistency and completeness, most of the data used in this report are for 2020. Not all data for 2021 have been released across the issues covered in this report. In some instances, 2021 data have been added, in part to show the status of the industry coming out of the effects of COVID-19.

² International Energy Agency, *World Energy Outlook 2019*, November 2019, p. 23.

natural gas industry’s trajectory without any changes in policy to curb emissions. By 2030, natural gas consumption would increase by 22% over 2021. The projection closest to the trend line is from the 2020 WEO Stated Policies Scenario, which “reflects all of today’s announced policy intentions and targets, insofar as they are backed up by detailed measures for their realization.”³ This scenario shows a 14% rise in natural gas demand between 2021 and 2030. In 2040, the two scenarios of natural gas demand differ by 11%. The 2021 WEO Stated Policies Scenario,⁴ by 2040, shows an additional 9% drop in natural gas demand from the 2020 Stated Policies case, and a 20% decline from the WEO 2019 projection.

Figure 2 shows that in all the IEA’s least climate-aggressive forecasts, natural gas demand will be increasing in absolute terms.⁵ The slower rise forecast in the later scenarios is primarily a result of an assumed greater penetration of renewable electricity, especially solar. The assumptions include, in some cases, the anticipated results of proposed policies. Nevertheless, the future role of natural gas depends in part on it reaching more markets, particularly as liquefied natural gas (LNG), and providing a competitive price.

Figure 2. IEA Projections of Natural Gas Demand
2019, 2020, and 2021



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, for historical data, and the IEA’s 2019, 2020, and 2021 WEOs.

Notes: Natural gas demand increases in all scenarios presented on the chart. There are other IEA scenarios that show different demands for natural gas. The trend line was provided by using Excel’s built-in program. Units = billion cubic meters (BCM). The United States tends to report natural gas data in cubic feet. One cubic meter is equal to 35.31 cubic feet.

³ International Energy Agency, *World Energy Outlook 2020*, October 2020, p. 17. “Ordinarily, the Current Policies Scenario provides a baseline for our scenario analysis by outlining a future in which no new policies are added to those already in place. It is difficult to imagine this ‘business-as-usual’ approach prevailing in today’s circumstances, so we have not included the Current Policies Scenario in the overall scenario design for the WEO 2020. That said, we would warn against taking the STEPS [Stated Policies] as a baseline or reference case. Achieving stated policies should not be taken for granted, especially in countries and sectors where they are ambitious and far reaching” (pp. 76-77).

⁴ In the International Energy Agency, *World Energy Outlook 2021*, October 2021, the Stated Policies Scenario incorporates policies that have been put into place by countries as well as policy initiatives that are under development (p. 16).

⁵ In addition to the Stated Policies scenario, the IEA WEO also includes more aggressive, emission-cutting scenarios—Net Zero Emissions (NZE) and Announced Pledges Scenario (APS). In both these scenarios, natural gas use drops by 2050, but initially the APS shows a rise in natural gas consumption out to 2030.

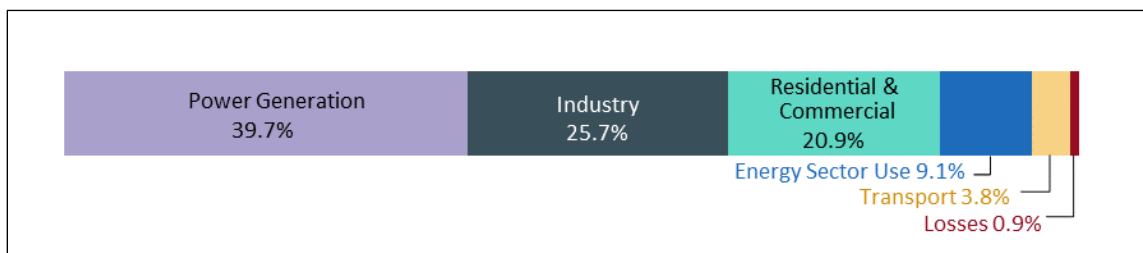
Natural gas has some unique characteristics that make it hard to compare with other fuels. When burned, natural gas emits fewer greenhouse gases (GHGs) than other fossil fuels; however, methane, the main component of natural gas, is itself a potent GHG when released into the atmosphere. Unlike most other fuel sources, natural gas is used in multiple ways: to generate electricity; for cooking; to provide heat for homes, businesses, and industrial processes; as a feedstock for fertilizers, plastics, and petrochemicals; as a source for natural gas liquids; and currently as the primary source of hydrogen.

Some natural gas is produced with oil extraction, known as associated gas. If there is no local market for the gas or transportation to a market, the associated gas will likely be flared (combusted) or vented (released into the atmosphere), in either case essentially wasted.

In electricity generation, natural gas-fired generation is highly efficient (combined cycle), and in single-cycle (or simple-cycle) facilities can be ramped up and down quickly.⁶ This allows for managing the intermittency of renewables like solar and wind on the electric grid, which may be vital to maintaining a stable electric grid as more electricity comes from renewables.⁷

Figure 3. Global Natural Gas Consumption by Sector, 2021

Total Natural Gas Consumption = 4,103 BCM



Source: International Energy Agency (IEA).

Notes: Losses may include natural gas lost during transformation, consumption, transportation, and processing. Units = billion cubic meters (BCM).

The breakdown of natural gas consumption in **Figure 3** reinforces that natural gas is used in different parts of the economy and is somewhat evenly distributed among sectors. Natural gas demand was not affected as much as oil by the COVID-19 pandemic, in part because of its different uses. Natural gas consumption declined in the early months of 2020 but rebounded by year’s end in conjunction with increasing economic activity and temperature-related factors. Although power generation is responsible for the largest share of natural gas consumption, the rise in 2021 is attributed to industrial uses, which vary by country and may include chemical manufacturing, metals, and agriculture, among other areas.⁸ Natural gas for heating rose globally, as the winter in the northern hemisphere of 2020-2021 was cold. In the United States, less than 1% of natural gas is used for transport; the share is much higher in other countries (e.g., Iran and Pakistan).

⁶ According to U.S. Energy Information Administration, a simple-cycle facility uses natural gas in a single conversion system, such as a combustion turbine or boiler with a steam turbine, to produce electricity. In a combined-cycle system the exhaust heat from a gas turbine is used to heat water and generate electricity from a steam turbine. U.S. Energy Information Administration, at <https://www.eia.gov/todayinenergy/detail.php?id=52158>.

⁷ Currently, battery technology and other technologies are not sufficiently developed to fulfill this need.

⁸ International Energy Agency, *Gas Market Report, Q3-2022*, July 2022, p. 26, at <https://iea.blob.core.windows.net/assets/c7e74868-30fd-440c-a616-488215894356/GasMarketReport%2CQ3-2022.pdf>.

A key determinant of the future of natural gas as a global fuel is the ability to transport it at a reasonable cost, by pipeline or LNG. (See **Figure A-1** for an overview of the natural gas development lifecycle.) Cooling natural gas to negative 260°F to produce LNG—and maintaining it at that temperature during a 1,000+-mile voyage on a specialized and heavily insulated ship—is expensive. Being able to move natural gas to more markets is essential to it remaining an important part of the global energy mix. In 2021, 19 countries exported natural gas by LNG and 44 countries were capable of importing it.⁹ This is augmented by the growing use of floating storage and regasification units (FSRUs) that allow for countries to build the infrastructure to import LNG more quickly and for a lower cost.¹⁰ For example, in the wake of Russia’s war against Ukraine, German companies have leased five FSRUs to mitigate the uncertainty of Russian natural gas imports. The first two facilities should be operational by the end of 2022,¹¹ less than 10 months after the war started, compared to an onshore terminal that may take 24-36 months to construct and longer to permit. Moving natural gas by pipeline is less technically challenging and expensive than transporting LNG, but still requires natural gas to be put under pressure to reach markets. Europe’s attempts to supplant Russian natural gas with LNG from the United States and elsewhere having reached existing capacity.¹² To meet its short-term need for fuel, Europe has also increased the use of coal, while aiming to increase efficiency and reduce overall energy demand.

More generally, FSRUs have been essential in enabling more countries to import natural gas. In addition to helping facilities to become operational faster, FSRUs are less expensive and—because of their mobility—have allowed countries and companies without investment-grade credit ratings to import natural gas (e.g., Bangladesh, Croatia, Ghana, and Pakistan). Historically, LNG export projects had to have investment-grade counterparties in contracts in order to receive financing.

As LNG trade has increased and new producers and purchasers have entered the market, trade flows have changed. As elaborated below, the United States is a growing exporter of LNG, sending cargos to over 40 countries since 2016.¹³ A fire in June 2022 at the Freeport LNG export terminal in Texas highlights some constraints of the global LNG market. Although the fire lasted approximately 40 minutes, the damage inflicted is expected to keep the facility offline for months, leaving the global market in a tenuous position. Additional liquefaction capacity would be needed to give the market enough spare capacity to avoid a significant impact on prices and consumption in the event that a facility goes offline. By contrast, the attack against Saudi Arabia’s Abqaiq oil processing facility in 2019 only raised oil prices for a short period of time; the oil market has spare capacity and was able to respond to dampen the effect. About a decade ago, it was assumed that a successful attack against Abqaiq would have caused oil prices to skyrocket, but that did not happen.

Despite natural gas’s role as a major fuel in the world economy, natural gas formations tend not to be the focus of international exploration for hydrocarbons. Crude oil remains the focus of

⁹ GIIGNL, *GIIGNL Annual Report 2022*, Neuilly-sur-Seine, France, May 5, 2022, p. 4, at https://giignl.org/wp-content/uploads/2022/05/GIIGNL2022_Annual_Report_May5.pdf.

¹⁰ For additional information on FSRUs, see CRS Insight IN11956, *LNG Exports to Europe: What Are Floating Storage Regasification Units (FSRUs)?*, by Paul W. Parfomak and John Frittelli.

¹¹ Daniel Stemier, “RWE, Uniper Snap Up Four FSRUs for German Government,” *Energy Intelligence*, May 5, 2022.

¹² Benjamin Storrow and Sara Schonhardt, “First War, Then Fire: The Global LNG Outlook Is Volatile,” *EnergyWire*, June 14, 2022, at <https://subscriber.politicopro.com/article/eenews/2022/06/14/first-war-then-fire-the-global-lng-outlook-is-volatile-ew-00039304>.

¹³ U.S. Department of Energy, *LNG Monthly*, Washington, DC, May 2022, at https://www.energy.gov/sites/default/files/2022-05/LNG%20Monthly%20March%202022_0.pdf.

international oil companies, as their name implies. In the United States, this changed somewhat because of the advent of shale gas in the mid-2000s, but as the industry's ability to extract oil from tight formations advanced, the focus returned to oil. Geologic formations like the Bakken in North Dakota and the Eagle Ford and Permian Basin in Texas produce a lot of associated natural gas (natural gas that is produced with oil), but oil is the main focus of production. The Marcellus shale formation in Pennsylvania is the leading natural gas formation in the United States.

U.S. Natural Gas Interests

The introduction of shale gas over a decade ago transformed the United States from a growing net importer of natural gas to a growing net exporter. As production increased, U.S. natural gas prices declined and consumption increased. During this time, interest in natural gas by multiple administrations, Congress, companies, and the public grew. Companies, in particular, offered new ways to use natural gas. Electric utilities shifted from coal- to natural gas-fired power generation as natural gas prices fell. The transportation sector, particularly long-haul trucking, rail, and shipping, also became an area of interest for possible conversion to natural gas.¹⁴ When oil prices declined in 2014, interest in using natural gas for trucking and rail waned. Because of regulations in the shipping industry to cut emissions, however, natural gas as a bunker fuel for ships remained. Another area of growth was the export of LNG from the lower-48 states, which started in February 2016.

The United States has the fifth-most natural gas reserves in the world and ranks first in both natural gas production and consumption.¹⁵ In 2020, the United States exported the second-most natural gas behind Russia, and was third for both LNG exports and exports by pipeline separately. In 2022, the United States is poised to become the largest LNG exporter, surpassing Qatar and Australia, and it may likely continue to expand its capacity.¹⁶ Although a net natural gas exporter, the United States also imports natural gas, mainly from Canada by pipeline and from Trinidad and Tobago into the Boston area (Everett Terminal) as LNG.¹⁷ Certain infrastructure constraints within the United States make imports more efficient to meet demand in some places. In addition to its natural gas reserves, the United States also has a massive infrastructure of natural gas pipelines and storage facilities, which gives it the ability to move natural gas around the country to almost everywhere it is needed.

Perhaps the biggest impact on global markets of the United States becoming an exporter happened even before any natural gas molecules left the country. U.S. natural gas exporting companies developed more market-oriented contract terms than companies from other countries. Contract terms including no destination clauses, which limit where exports can go, and no link to oil prices, helped move natural gas towards being a global commodity. Such changes also have put the United States at the center of the natural gas world, decreasing the prominence of other

¹⁴ In these three sectors, the use of LNG, with its greater energy density, was the proposed delivery system for many of the conversions.

¹⁵ In the oil and natural gas industry, for a resource to be counted as a reserve, there must be a 90% likelihood that the oil and natural gas can be produced with existing technologies, under current market conditions, and be able to reach a market.

¹⁶ Scott Disavino, "U.S. to Be World's Biggest LNG Exporter in 2022," *Reuters*, December 21, 2021, at <https://www.reuters.com/business/energy/us-be-worlds-biggest-lng-exporter-2022-2021-12-21/>.

¹⁷ U.S. law, the Merchant Marine Act of 1920 (commonly referred to as the Jones Act), restricts vessels that may carry domestic shipments, including LNG, from one U.S. port to another, requiring that they be U.S.-built, -owned and -crewed. Currently, there are no large, transoceanic Jones Act-qualified LNG tankers (only smaller barges designed for refueling ships in port), and the United States has not built one in over 40 years. For more information see CRS Report R45725, *Shipping Under the Jones Act: Legislative and Regulatory Background*, by John Frittelli.

exporting countries, including Russia. The United States has been a major oil producer for decades and regained the top spot about 10 years ago, but it does not have the same influence in the gas sector due to constraints in the natural gas market. Consequently, a shift towards natural gas in the U.S. energy mix may enhance U.S. energy and national security by decreasing its dependency on other countries for other fuels. Additionally, increased use of natural gas globally may enhance U.S. influence with certain countries as a reliable market-driven supplier.

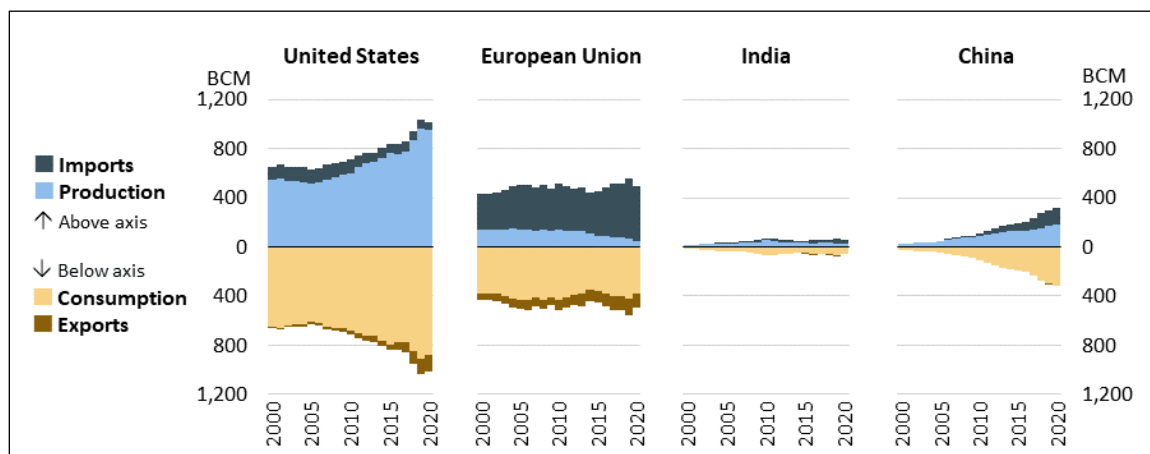
For most observers, energy security for the United States has fundamentally concerned oil. As the world's largest producer and consumer of natural gas, the United States is not as concerned about the natural gas market. However, as has been shown in 2022, natural gas plays a major geopolitical role because of constraints in how it is bought and sold. The United States has an opportunity to play a bigger role in the global natural gas market than in the oil market. In addition, any shift in consumption towards natural gas from oil would likely increase the influence of the United States in the natural gas sector, while improving U.S. energy security. The global natural gas industry also has consumers and producers differing from those for oil, which gives the United States an opportunity to engage the natural gas-oriented countries from a better vantage point.

Consumers: Changes Ahead?

The comparisons in **Figure 4** highlight some important changes in natural gas markets, particularly among consuming countries. Although the focus of changes in the United States has mostly been on the dramatic rise in production since the advent of shale gas just over a decade ago, there have also been large increases in U.S. consumption. **Figure 4** also shows the scale of the natural gas markets in these key consuming countries and regions.

The figure focuses on countries and regions going through changes with respect to natural gas markets. (Some major LNG importers and natural gas consumers such as Japan and South Korea are not shown in the figure because they tend to be consistent buyers.) The EU and the United States are going through changes, particularly related to production and environmental policies, which affect consumption and imports of natural gas. China and India are growing LNG importers; however, coal continues to play the biggest role in those two countries' energy mix. In addition to constraints imposed by domestic politics, infrastructure constraints for natural gas, and relatively low production, China and India, as well as other potential natural gas importers, need reasonably priced, abundant, accessible, and available natural gas resources. As noted above, a key component to expanding natural gas markets is the use of FSRUs. As discussed further below, FSRUs decrease the cost associated with import terminals, can be put into operation much more quickly, and can be used either long-term or on a temporary basis.

Figure 4. Select Market Supplies and Disposition
2000-2020



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

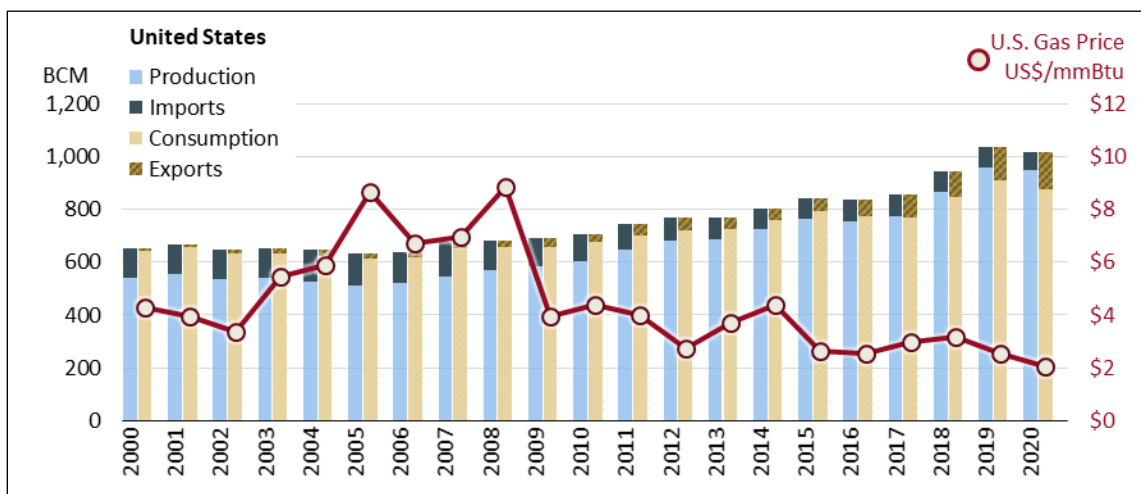
Notes: Units = billion cubic meters (BCM).

The United States: Gas Consumer, Producer, and Exporter

The rise of the U.S. natural gas sector in the beginning of the 21st century changed the course of natural gas as a global fuel. Prior to 2008, natural gas prices (see **Figure 5**) were generally increasing and the United States was viewed as a growing natural gas importer. Multiple LNG import terminals were built in the United States, while existing ones were recommissioned and expanded. Additionally, export terminals were built around the world, with the United States as the target market. However, the market conditions also drove U.S. domestic producers to innovate. As average U.S. prices peaked in 2008, domestic shale gas production was brought to market. Improvements in technologies such as hydraulic fracturing and horizontal drilling made the development of unconventional natural gas resources, such as shale and other lower-permeability rock formations economically possible. Improved efficiency lowered production costs, making shale gas production competitive at almost any price. The large amount of natural gas brought to market enabled large-scale exports from the United States.

As it improved, shale technology shifted from natural gas to natural gas liquids (NGLs) and to oil. This shift in technological capabilities raised U.S. production of NGLs and crude oil to new heights. The value of these commodities improved the economics of production and fostered additional drilling and production of natural gas. It also expanded the production regions where the technology could be used. The migration of shale technologies to places like the Bakken in North Dakota, and the Permian Basin and Eagle Ford in Texas, which are primarily crude oil formations, enabled natural gas production through associated volumes to continue to grow despite a decline in natural gas prices. The crude oil found in these formations contain a high percentage of dissolved natural gas. As most new U.S. crude production was from these three areas, the percentage of associated natural gas produced in the United States began to rise. However, when oil prices decline, production tends to slow, and in these regions then so does natural gas production.

Figure 5. U.S. Natural Gas Supply, Disposition, and Price
2000-2020



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

Notes: Prices are annual spot prices for the Henry Hub, the main natural gas pricing point for U.S. natural gas, at <https://www.eia.gov/dnav/ng/hist/rngwhhda.htm>. Spot natural gas prices change many times a day. The prices used here are an annual average of daily prices. Thus, the range of prices may be greater than the prices shown on this chart. Volume units = billion cubic meters (BCM) and price units = U.S. dollars per million British thermal unit (US\$/mmBtu).

As U.S. natural gas production increased and prices fell, U.S. consumption of natural gas grew (see **Figure 5**). The rise in consumption did not keep pace with production, so companies turned to exports of natural gas, first by pipeline to Mexico and then as LNG to other parts of the world. The United States started exporting LNG from the lower-48 states in February 2016 and in 2022 is projected to become the largest LNG exporter globally.

The prospect of the entrance of the United States as an exporter of LNG caused significant changes to global natural gas markets. The U.S. natural gas market is one of the few that does not link its price of natural gas to oil, and this has carried over into LNG contracts from U.S. companies. Therefore, some buyers view U.S. LNG exports as a hedge against oil prices. Unlike oil, natural gas is not necessarily priced in U.S. dollars. U.S. exporters do not require destination clauses, although the final destination of U.S. LNG exports must be reported to the U.S. Department of Energy by statute. U.S. exporters have been more open to shorter-term contracts than the traditional 25-30 year contracts. The relatively low price of U.S. natural gas has also helped consumers in other regions negotiate better prices for imports from non-U.S. sources.

The United States has quickly risen in the export rankings and continues to add to its LNG export capacity. According to projections by the U.S. Energy Information Administration (EIA), U.S. natural gas production, consumption, and exports will continue to grow for decades to come, while U.S. prices are projected to stay relatively stable and low.¹⁸ One aspect of EIA projections, however, is a status quo assumption when it comes to technology, laws and regulations, and markets, among other things. As the development of shale gas has shown, significant changes to the industry may happen quickly.

¹⁸ U.S. Energy Information Administration, *Annual Energy Outlook 2022*, Washington, DC, March 2022, at https://www.eia.gov/outlooks/aeo/pdf/AEO2022_Narrative.pdf.

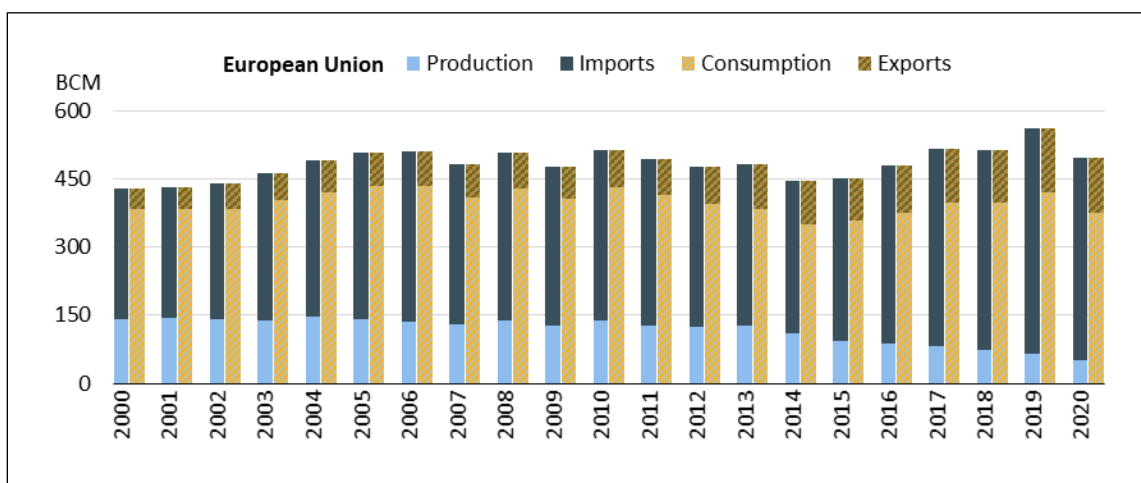
Europe: Declining Gas Production, Import Challenges, Rising Renewables

As a major energy consuming region, Europe faces a number of challenges in addressing its current and future energy needs. For the 27 member states of the European Union (EU),¹⁹ challenges include declining internal natural gas production, rapidly rising global demand and competition for energy resources from countries such as China and India, heightened tensions with Russia, efforts to integrate the EU’s internal energy markets, and a growing need to shift fuels in keeping with the EU’s climate change policy goals. As a result, energy supply security has become a key concern for the EU. European energy security is also of significant interest to the United States.

While energy policy in the EU has long been a strongly guarded competence of individual national governments, the EU’s role in energy policy has expanded over the last few decades. An important element of the EU’s energy supply strategy has been to shift to a greater use of natural gas and renewables and to move away from coal. The view toward nuclear power has varied by member, but since Russia’s 2022 war against Ukraine more member countries have softened their view toward nuclear power as energy supplies have been affected. In July 2022, the European Parliament endorsed EU rules labelling investments in natural gas and nuclear power plants as climate friendly, paving the way for the proposal to become law, which may occur by the end of 2022.²⁰

EU natural gas consumption has increased since 2014 (see **Figure 6**), after declining for several years.

Figure 6. EU’s Natural Gas Supply and Disposition
2000-2020



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

¹⁹ Current EU members are Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

²⁰ Kate Abnett, “EU Parliament Backs Labelling Gas and Nuclear Investments as Green,” *Reuters*, July 6, 2022, at <https://www.reuters.com/business/sustainable-business/eu-parliament-vote-green-gas-nuclear-rules-2022-07-06/>, online edition.

Notes: The data in the chart are for current EU members regardless of when they joined the EU. Since 2000, the following countries have joined the EU: in 2004, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia; in 2007, Bulgaria and Romania; and in 2013 Croatia. The United Kingdom left the EU in 2020 and is not included in this chart for any years. Exports and imports are a summation of individual member states regardless of where they came from or where they went, including from within the EU. The total exports and imports for EU member countries is greater than exports and imports into and out of the EU as a whole because they do not include internal transfers. Units = billion cubic meters (BCM).

In 2020, natural gas made up almost 25% of the EU’s primary energy mix.²¹ Some observers expect EU member states to rely increasingly on natural gas, as those states strive to meet targets for reducing carbon dioxide and other greenhouse gas emissions.²² By 2035, some analysts estimate that natural gas may make up almost 30% of the EU’s primary energy mix, depending on market conditions, though it could decline in a “slow development scenario” where natural gas becomes less competitive.²³ However, this outcome is unlikely as it requires breakthroughs in other forms of energy and technology.

Most natural gas that EU member states consume comes from imports from countries outside the EU (78% of consumption in 2020).²⁴ EU dependence on natural gas imports is expected to rise over time, given declining natural gas production within the EU. Analysts note this decline has been propelled in part by policy decisions, such as Germany’s decision to phase out the use of nuclear energy (by 2022) and coal (by 2038), thus encouraging EU natural gas producers to speed up production to offset any shortfalls; and some EU member states’ decisions to not enact prohibitions on shale gas development.²⁵ The main source of natural gas imports for EU members has been Russia, which accounted for 47% (about 165 BCM) of non-EU natural gas imports in 2020 (44% of total EU natural gas consumption).²⁶ EU member states also import natural gas from non-EU members Norway (20%), Algeria (7%), Qatar (4%), and others.²⁷

EU member states have limited flexibility to change natural gas suppliers or supply routes. Most natural gas imports are transported via pipeline, unlike oil imports (90% of which arrive by sea). In addition, typically natural gas is bought and sold via long-term contracts, whereas oil is sold mainly on the spot market or short-term basis. The restrictions on the contracted natural gas make it difficult for counterparties to quickly unwind from agreements.

Europe’s vulnerability to Russian natural gas imports is most acute during winter, especially unusually cold winters, when European natural gas imports are most needed. During the winter months, Europe needs all the natural gas imports by pipeline and LNG that it can receive. Any volumes that are curtailed, whether from Russia or others, affect European markets. The lack of an import cushion because of infrastructure constraints and suppliers leaves Europe vulnerable despite its efforts to mitigate the risks.

²¹ Primary energy comprises commercially traded fuels, including modern renewables used to generate electricity. Oil makes up about 38%; coal, 13%; nuclear, 11%; and renewables (including hydroelectric), 14%. *BP Statistical Review of World Energy 2019*, p. 9.

²² EU Commission, “2020 Climate & Energy Package,” at https://ec.europa.eu/clima/policies/strategies/2020_en.

²³ Eurogas, *Long-Term Outlook for Gas to 2035*, October 2013, p. 3.

²⁴ Based on data from Cedigaz, a subscription service statistical database, at <http://www.cedigaz.org>. Some of the natural gas imported in to the EU is then re-exported to non-EU members.

²⁵ Markus Wacket, “Germany to Phase Out Coal by 2038 in Move Away from Fossil Fuels,” *Reuters*, January 25, 2019.

²⁶ Gas imports from Russia peaked in 2008 at 226 BCM. Since 2008, imports have not risen above 200 BCM. BP, *Statistical Review of World Energy 2022*.

²⁷ Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

The EU's dependence on Russian natural gas imports has increased over time as production within the EU declined (see **Figure 6**). Prior to Russia's 2022 war on Ukraine, dependence on Russia as a supplier was deemed likely to continue and grow. However, the war has altered European views of Russia's reliability as an energy supplier.²⁸ The EU collective and many individual member states are exploring alternative sources for their natural gas needs. The cuts in supplies by Russia have prompted Europe to make alternative arrangements for their natural gas needs.

In the past, Russia has sought to protect its share of the EU natural gas market. It has attempted to stymie European-backed alternatives by proposing competing pipeline projects and attempting to increase its influence with European companies by offering them stakes in these and other projects. It remains unclear whether Russia's war on Ukraine will permanently end or significantly alter these natural gas relationships.

Successive U.S. Administrations and Congresses have viewed European energy security as a U.S. national interest. In recent years, promoting diversification of EU natural gas supplies has been a focal point of U.S. energy policy in Europe and Eurasia. This has also been a source of disagreement between the United States and the EU. Some EU members took the position that the United States was against the Nord Stream 2 natural gas pipeline from Russia to Germany, not because of security reasons, but because the United States wanted to export more LNG. This point of view was promoted by countries and companies, in part, that had vested interests in Nord Stream 2, e.g., Austria's OMV.²⁹

Although the United States and the EU have sought to promote the import of piped natural gas from the Caspian Sea region and LNG from the United States and other LNG producers, this is not being achieved in volumes sufficient to fully counter Russian imports to the region. Other regions such as North Africa and the Eastern Mediterranean have potential as alternative suppliers but are constrained in their ability to start or increase exports for varied reasons. In June 2022, driven in part by the uncertainty of supply caused by Russia's war against Ukraine, Egypt and Israel agreed to a provisional deal to supply natural gas to the EU, as part of a larger agreement.³⁰ In July 2022, the European Commission signed a memorandum of understanding with Azerbaijan to increase imports of Azerbaijani natural gas to at least 20 BCM per year by 2027.³¹ Norway has also agreed to increase natural gas exports to the EU.

Since 2006 at least, the EU and several member states have advocated for increased European energy supply diversification in order to mitigate the potential for cutoffs or curtailments of Russian natural gas supplies to Europe. Most Russian natural gas exports to the EU arrive via pipelines that pass through Ukraine and Belarus. Russian disputes with Ukraine have at least twice resulted in significant interruptions in the flow of natural gas to some EU members (in 2006 and 2009). Of note, since Russia's 2022 war on Ukraine, Russian natural gas supplies to Europe have steadily decreased, but have not ceased. As of October 2022, only one member of the EU, Hungary, is still receiving imports of Russian natural gas by pipeline.³² Additionally, some EU

²⁸ European Commission, at https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en.

²⁹ Meeting with Mr. Rainer Seele, the CEO of OMV, January 25, 2018.

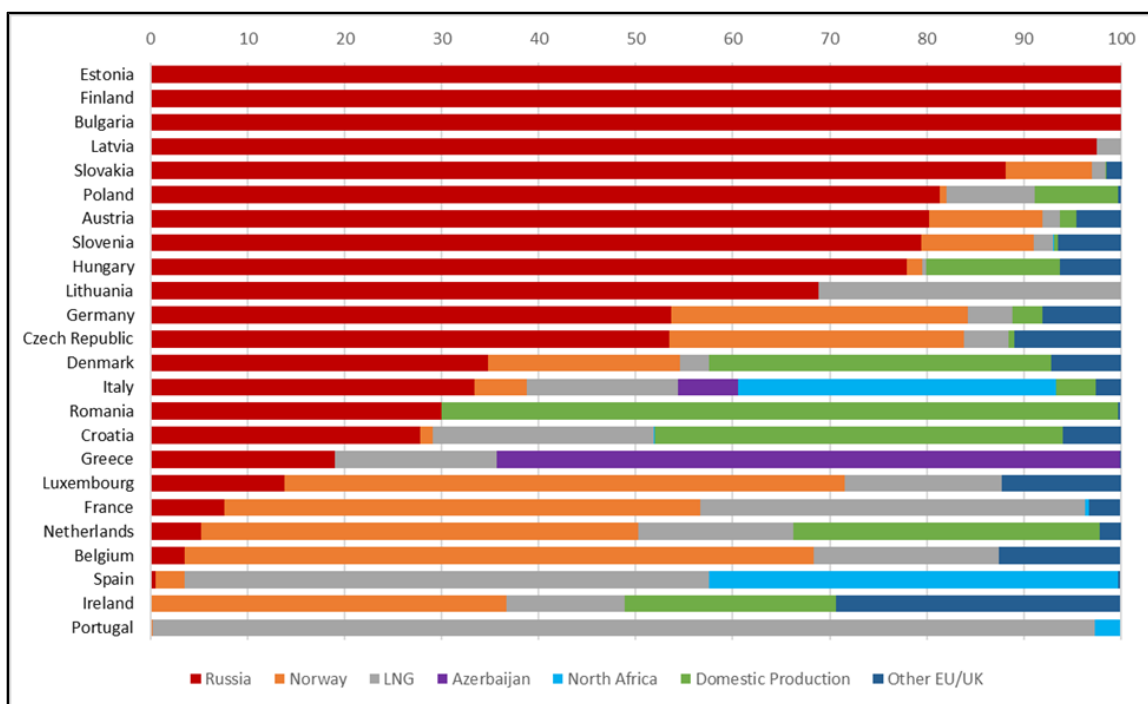
³⁰ James Shotter and Raya Jalabi, "EU Looks to Israel as It Battles Russian Energy 'Blackmail,'" *Financial Times*, June 14, 2022, online edition, at <https://www.ft.com/content/225cd02e-0764-4295-a1ed-f209c6c3fc09?desktop=true&segmentId=7c8f09b9-9b61-4fbb-9430-9208a9e233c8>.

³¹ "EU Signs Deal with Azerbaijan to Double Gas Imports by 2027," *Al Jazeera*, July 18, 2022, at <https://www.aljazeera.com/news/2022/7/18/eu-signs-deal-with-azerbaijan-to-double-gas-imports-by-2027>.

³² ZeroHedge, "Only One EU Member Is Still Receiving Russian Natural Gas," *Oil Price.com*, October 3, 2022, at <https://oilprice.com/Energy/Natural-Gas/Only-One-EU-Member-Is-Still-Receiving-Russian-Natural-Gas.html>, online.

members receive natural gas by LNG from Russia. Some member states in Central and Eastern Europe, as shown in **Figure 7**, rely entirely or almost entirely on Russian imports for their natural gas supplies and thus are especially vulnerable to such interruptions.

Figure 7. EU Natural Gas by Source
2021



Source: Based on figure from the Brussels-based research center Bruegel, which uses data from the European Network of Transmission System Operators for Gas (ENTSO-G) and Eurostat. See Bruegel, “Preparing for the First Winter Without Russian Gas,” February 28, 2022.

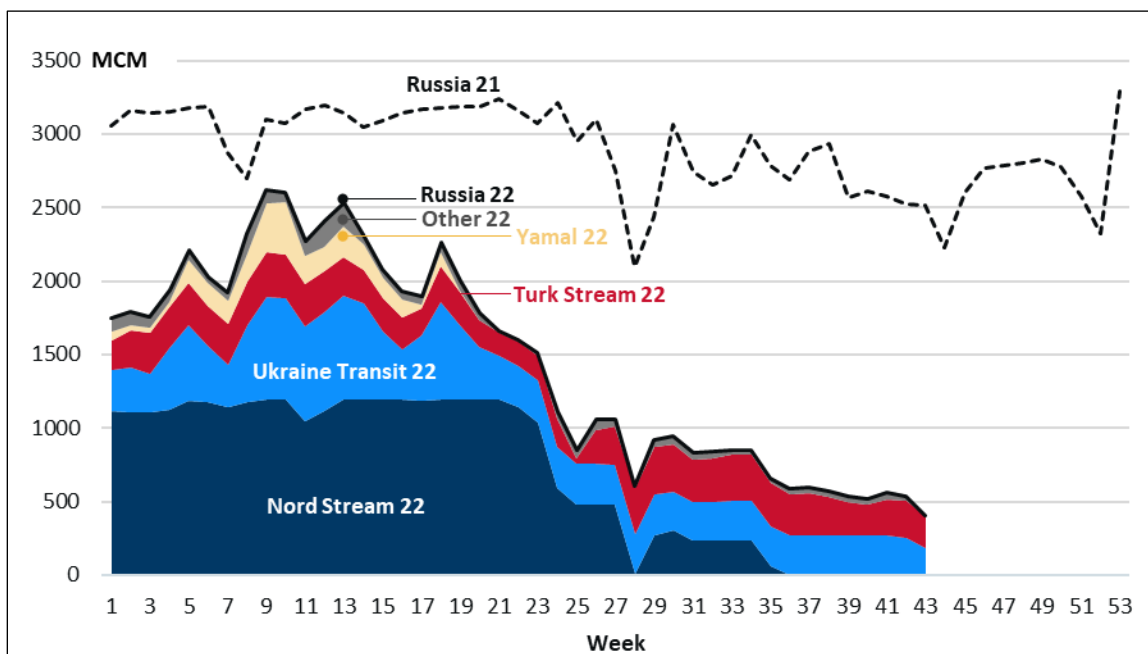
Notes: The graphic is organized by the countries that import the most natural gas from Russia to the least by percentage. LNG = liquefied natural gas; UK = United Kingdom. LNG imports could come from many different suppliers around the world. The EU’s interconnected gas networks make it challenging to account for both foreign imports and foreign-originating gas traded between EU member states. Bruegel’s breakdown seeks to account for gas flowing into the EU and subsequent trade within the EU market. Nevertheless, the figure should be considered suggestive rather than definitive.

Since 2014, Russian aggression in Ukraine has not resulted in a complete cutoff of natural gas supplies to the EU as a whole, but it has increased concerns about the reliability of Russia as a supplier, particularly since February 2022. This is a key point when looking at the future of natural gas over the next 20 or so years. Russia has the largest natural gas reserves in the world and has extensive infrastructure to bring that gas to markets domestically and internationally, especially to Europe.

Prior to 2022, to increase reliability, some EU member states had sought to strengthen their energy ties to Russia by developing new supply routes for Russian gas bypassing Ukraine that they viewed to be less vulnerable to potential cutoffs. Since 2012, an increasing share of Russian gas imports have transited directly from Russia to Germany (and on to other European countries, including Ukraine) via the Nord Stream 1 pipeline, a joint venture between Russia and several

European energy companies.³³ On September 26, 2022, an explosion damaged both Nord Stream 1 and 2, leaving them unable to transit natural gas.³⁴ Figure 8 shows natural gas exports to Europe through Russia’s main export pipelines since the beginning of 2022 through October compared with total exports to Europe from Russia in 2021.

Figure 8. Weekly Aggregated EU and UK Pipeline Imports of Russian Natural Gas 2021 and 2022



Source: Bruegel, European natural gas imports (bruegel.org).

Notes: Data for 2022 are only compiled through week 43. Units = million cubic meters (MCM). Russia’s war on Ukraine started in week 9 on the chart.

Although several member states supported Nord Stream 2 prior to 2022, others in the EU (and the U.S. government) have long opposed the pipeline project due to concerns about dependence on Russian natural gas. Just prior to the war, Germany halted the approval process for Nord Stream 2, not allowing it to go into service despite being completed. Inaugurated in January 2020, the TurkStream pipeline system sends natural gas across the Black Sea from Russia to Turkey to supply Turkey and southeastern Europe.

At the same time, other EU members have sought to bolster energy security by diversifying the sources of their natural gas imports. One such diversification effort involves the so-called Southern Gas Corridor to transport natural gas to the EU from Azerbaijan and, potentially, Central Asia via Turkey. The Trans-Anatolian natural gas pipeline (TANAP), which opened in 2018, connects to the Trans Adriatic Pipeline (TAP), which opened in 2020, to bring Azerbaijani natural gas into Italy and onward, via Greece and Albania, with planned regional interconnectors and spur lines to other markets. Russia’s TurkStream pipeline was the counter project to the Southern

³³ In addition to Russia’s Gazprom, the Nord Stream 1 consortium includes France’s Engie, Germany’s Uniper and Wintershall Dea, and Netherlands’ Gasunie.

³⁴ Merlyn Thomas, “Nord Stream Blast ‘Blew Away 50 Metres of Pipe,’” *BBC News*, October 18, 2022, pp. at <https://www.bbc.com/news/world-europe-63297085>, online.

Gas Corridor. LNG import projects in Croatia, Greece, Lithuania, Poland, and other planned terminals have helped diversify Europe's gas supplies.

In recent decades, the EU has sought to build an integrated internal energy market and improve network connectivity as part of a broader agenda of facilitating cross-border gas trade, improving consumer prices, and mitigating the impact of interruptions and overdependence on a single supplier. In response to potential supply instability from Russia, the EU has strengthened its internal energy regulations, diversified its suppliers and fuel mix, and invested in energy infrastructure, including gas storage.

Energy policy also is a key component of the EU's broader climate change agenda, as the production and use of energy accounts for approximately 75% of the EU's greenhouse gas emissions.³⁵ Under the EU's 2015 "Energy Union" initiative, member states committed to energy efficiency and renewable energy targets for 2020 and 2030. Additionally, the European Commission (the EU's executive) has proposed ambitious targets as part of the bloc's broad climate policy blueprint, the "European Green Deal," which aims to achieve net-zero emissions by 2050.³⁶ In this context, natural gas could play a critical, but potentially temporary, role in transitioning away from coal.

Since Russia's war on Ukraine, the EU and individual member states have sought to bolster short-term and longer-term energy security and rapidly reduce dependency on Russia. In particular, there has been an emphasis on decreasing natural gas use in the short term to increase supplies in storage for the winter.³⁷ There have also been incentives to reduce consumption and encourage fuel switching, especially to renewables.

Despite the EU's dependence on Russian natural gas, some analysts argue the EU is well positioned geographically to benefit from recent changes in global natural gas developments. Potential alternatives to Russian natural gas include increases in European production; new exports from the Eastern Mediterranean, which includes Israel and EU member Cyprus; imports from North Africa (primarily Algeria and Egypt) and the Caspian Sea region (Azerbaijan and Central Asia); and LNG, including from the United States, which has been limited thus far. Nonetheless, challenges to developing alternative sources of natural gas for Europe persist. Some potential alternatives present complications, such as political and geopolitical obstacles, corruption, technical limitations, environmental concerns, and financial constraints. There also are certain limitations in the use, trade, and transport of natural gas, such as the number of LNG tanker ships available and the shipyards to build them.

Russian involvement in the European energy sector goes beyond its role as an energy supplier. Russian energy companies and their subsidiaries have significant ownership stakes in European energy infrastructure, including pipelines, distribution, and storage facilities.³⁸ Russian-owned natural gas storage in Germany contributed to the run-up in European natural gas prices in winter 2021 because the Russian-owned facilities did not refill for the winter, which some analysts

³⁵ European Commission, *The European Green Deal: Clean Energy*, December 2019, at https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6723.

³⁶ European Commission, December 2019.

³⁷ European Commission, *Save Gas for a Safe Winter: Commission Proposes Gas Demand Reduction Plan to Prepare EI for Supply Cuts*, July 20, 2022, at https://ec.europa.eu/commission/presscorner/detail/en/IP_22_4608.

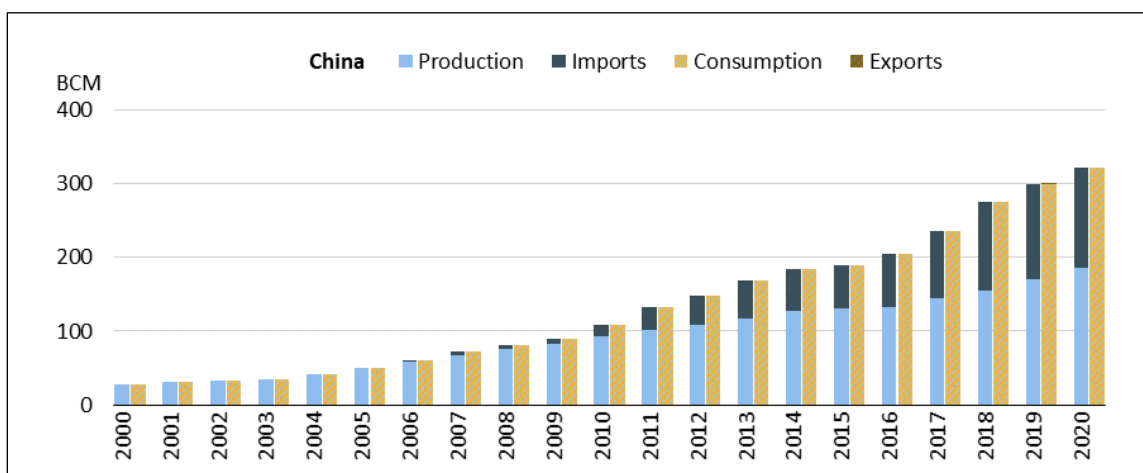
³⁸ See, for example, Deutsches Institut für Wirtschaftsforschung, *European Natural Gas Infrastructure: The Role of Gazprom in European Natural Gas Supplies*, Spring 2014.

believe was for geopolitical reasons.³⁹ Germany, since the war began, has essentially nationalized the storage facilities.⁴⁰

China: *Potential* Is the Key Word

When it comes to global supply and demand for natural gas, China is the main wildcard. China is the fourth-largest natural gas producer in the world, with its production rising every year and increasing almost seven-fold from 2000 to 2020 (see **Figure 9**). Its natural gas resource base is large, and its shale gas endowment is estimated to be nearly double that of the United States.⁴¹ China's production is currently less than 20% of U.S. natural gas production, partly due to its geology, regulatory regime, and a lack of technical skills, all of which make it difficult to bring natural gas to market, among other issues. Natural gas, 8% of China's primary energy, is dwarfed by coal as a primary energy source. China is the largest producer and consumer of coal in the world, producing eight times and consuming nine times as much as the United States. The interests of the coal industry play a significant role in Chinese energy policy at the national, provincial, and local levels of government. That said, China's natural gas consumption has increased every year at least since 2000.

Figure 9. China's Natural Gas Supply and Disposition
2000-2020



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

Notes: Units = billion cubic meters (BCM).

In 2020, China ranked second in global LNG imports behind Japan, and initial data show China surpassed Japan in 2021. China ranked fifth for pipeline imports. Central Asia, especially Turkmenistan, is China's main source of pipeline imports of natural gas. However, in 2019,

³⁹ David Sheppard, Mehreen Khan, and Guy Chazan, "Gazprom's Low Gas Storage Levels Fuel Questions over Russia's Supply to Europe," *Financial Times*, October 27, 2021, at <https://www.ft.com/content/576a96f7-e41d-4068-a61b-f74f2b2d3b81>, online.

⁴⁰ Nikolaus J. Kurmayer, "Berlin Inches Closer to Expropriating Gazprom Assets," *Euractiv*, May 12, 2022, at <https://www.euractiv.com/section/energy/news/berlin-inches-closer-to-expropriating-gazprom-assets/>, online.

⁴¹ Energy Information Administration, "World Shale Resource Assessments," September 24, 2015, at <https://www.eia.gov/analysis/studies/worldshalegas>.

Gazprom, Russia's national natural gas company, opened a pipeline (known as the Power of Siberia) to China.⁴² Early in 2022, a second natural gas pipeline was announced between the two countries. By 2026, China is projected to be the single largest importer of Russian natural gas, importing by both pipeline and LNG. China has built a large amount of LNG import capacity to add to its import pipelines. China's growing import dependency may prompt it to increase domestic production in a more concerted way. With major LNG export projects in Australia, Qatar, and the United States coming online by the end of the decade, China may be in a good position to take advantage of a potential oversupply of natural gas. If China can ramp up its natural gas production, especially its unconventional resources, foreign export projects targeting China's natural gas market may face a dilemma similar to that faced by those import projects constructed to supply the U.S. market prior to the advent of shale gas—displacement by domestic supplies. From an energy security and market perspective, additional natural gas resources provided by China would add positively to both. However, if China becomes a dominant producer, for which it has the resources but perhaps not the political will in the timeframe of this report, it may act aggressively with its resources, as has been seen with rare earth metals.

India's Natural Gas: A Small Part of Its Energy Mix

As India's economy grows, its energy needs, including for natural gas, will likely grow as well. India's economy is projected to account for about 15% of world GDP by 2050, up from about 10% in 2022.⁴³ Its population is expected to surpass China's as the world's largest by 2027, creating greater demand for energy.⁴⁴ In 2020, India accounted for 5.7% of global primary energy consumption, while China was the largest consumer with 26.1%.⁴⁵ Overall, India imports almost three-quarters of its energy needs, making it highly dependent on other countries. The Organization for Economic Co-operation and Development (OECD) believes India was the fastest-growing economy from 2014 to 2019, with a projected growth rate of almost 8%.⁴⁶ By 2050, India has the potential to overtake the United States as the world's second-largest economy in terms of purchasing power parity (PPP).⁴⁷

⁴² For additional information on the Power of Siberia, see CRS In Focus IF11514, *Power of Siberia: A Natural Gas Pipeline Brings Russia and China Closer*, by Michael Ratner and Heather L. Greenley. After many years of negotiations between Russia and China for the Power of Siberia, an agreement was reached shortly after Russia's invasion of Ukraine in 2014.

⁴³ John Hawksworth, Hannah Audino, and Rob Dlarry, *The Long View: How Will the Global Economic Order Change by 2050?*, Pricewaterhouse Coopers, February 2017, p. 20, at <https://www.pwc.com/gx/en/world-2050/assets/pwc-the-world-in-2050-full-report-feb-2017.pdf>.

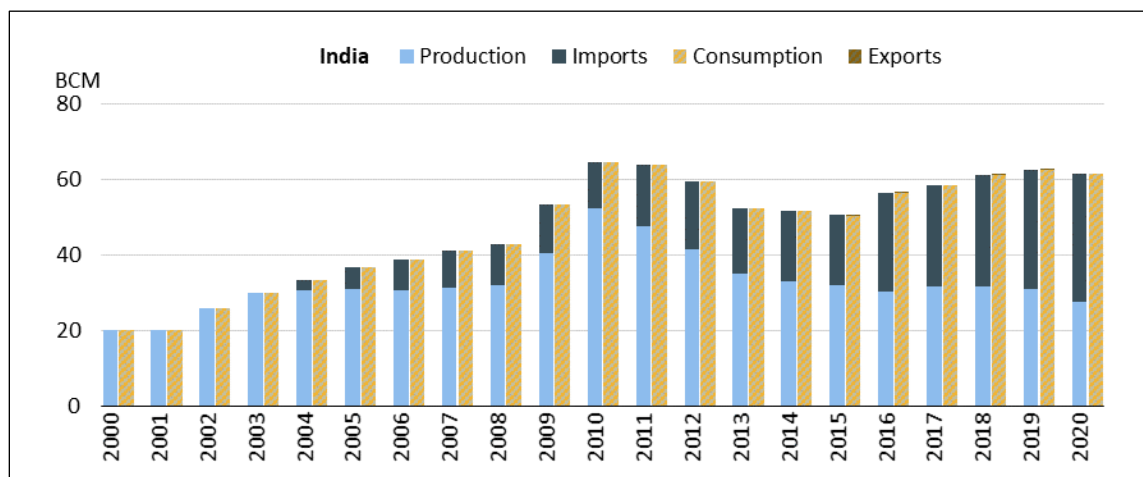
⁴⁴ United Nations: Population, *China and India: Most Populous Countries*, at <https://www.un.org/en/global-issues/population>.

⁴⁵ BP, *Statistical Review of World Energy*, June 2021, p. 10, at <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.

⁴⁶ Isabelle Joumard and Christine de La Maisonnette, *OECD Economic Surveys: India*, Organization for Economic Cooperation and Development (OECD), December 2019, p. 16, at https://www.oecd-ilibrary.org/economics/oecd-economic-surveys-india-2019_554c1c22-en.

⁴⁷ PricewaterhouseCoopers LLP, *The World in 2050*, February 2015, p. 2, at <http://www.pwc.com/gx/en/issues/the-economy/assets/world-in-2050-february-2015.pdf>. Purchasing power parity (PPP) is an economic measure of a country's productivity and standard of living.

Figure 10. India's Natural Gas Supply and Disposition
2000-2020



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

Notes: Units = billion cubic meters (BCM).

Natural gas makes up 7% of India's total energy consumption, well behind coal and oil. Natural gas has held steady at around 7% of India's overall energy consumption, which has been rising over the last decade. With an eye on increasing the natural gas percentage, India instituted a number of policy initiatives related to natural gas production⁴⁸ and major infrastructure investments such as expanding domestic gas pipelines and LNG import terminals. If global natural gas prices return to relatively low levels, natural gas as a share of total energy consumption in India may likely grow in the coming decade. However, these changes require significant investment and commitment from the Indian government to reach fruition.

India's natural gas demand is expected to continue growing and the government has stated its goal of natural gas being 15% of the energy mix by 2030 (see **Figure 10** above).⁴⁹ India is continuing to build its energy infrastructure for natural gas, which had previously been almost exclusively configured for coal and oil. India's natural gas consumption has increased annually since dipping to a low in 2015.⁵⁰ In 2020, Indian consumption has almost returned to its peak of just over 60 BCM in 2010. Despite the modest rise in demand over the last few years, downward pressure on consumption is, in part, due to a steady decline in domestic production, reaching a decade low of under 24 BCM in 2020.⁵¹ The Government of India (GoI) has indicated it will change this in the short term, but the GoI's commitment and resources necessary for these changes are uncertain.

⁴⁸ Government of India, Ministry of Petroleum & Natural Resources, Directorate General of Hydrocarbons, June 8, 2022, at <http://dghindia.gov.in/>.

⁴⁹ International Energy Agency, *India Energy Outlook 2021*, February 2021, p. 37, at https://iea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fdd6283b22/India_Energy_Outlook_2021.pdf.

⁵⁰ BP, *Statistical Review of World Energy*, June 2021, p. 38, at <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.

⁵¹ BP, *Statistical Review of World Energy*, June 2021, p. 36, at <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.

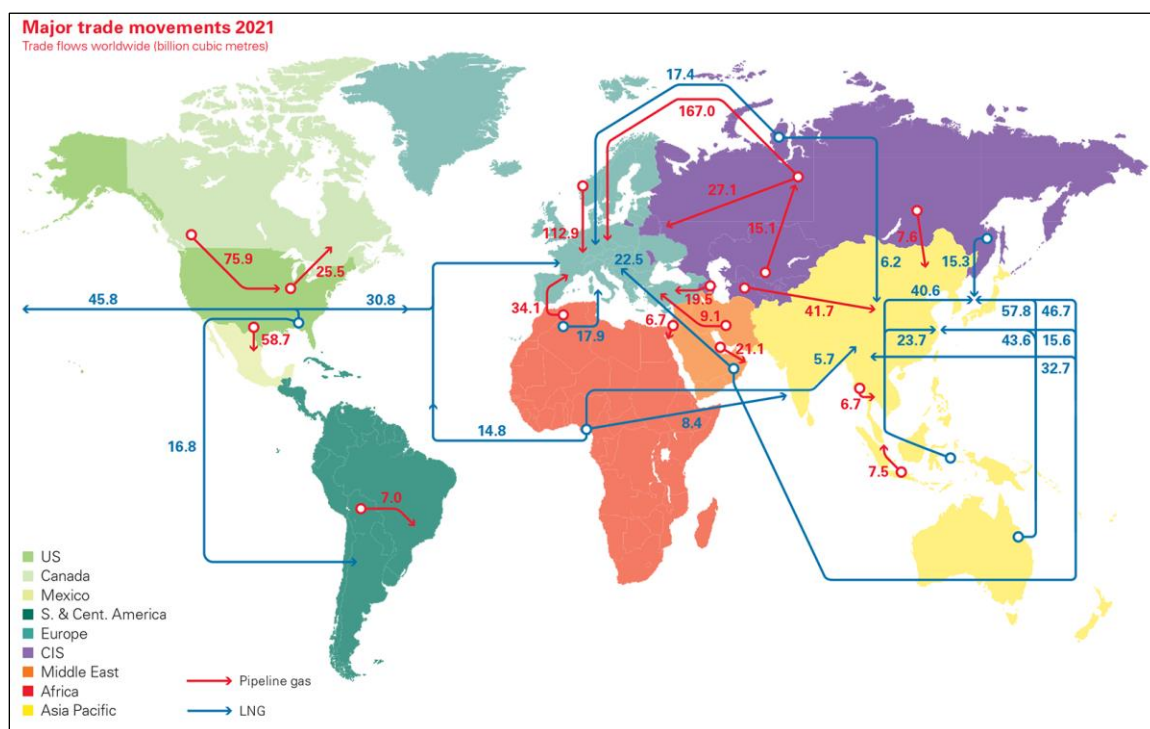
In 2020, Indian energy use was dominated by coal, which accounted for 55% of total primary energy consumption. This was followed by oil at 28%. In contrast, as mentioned above, natural gas accounted for 7% of India’s energy consumption. The GoI expected consumption of natural gas to grow from 71 BCM in 2011-2012 to 170 BCM in 2016-2017.⁵² Instead, India consumed just under 60 BCM in 2020. One likely explanation is the lack of growth in adequate infrastructure; the proliferation and integration of compressed natural gas into urban areas has not occurred as quickly as anticipated, and domestic production has declined significantly from 2010 to 2020, falling almost 50% in the time period.⁵³

Other Regions: Contributors to a Global Market

Although natural gas has been a global fuel for decades, its use is limited because of the expense and complexity of building LNG export and import terminals, in the absence of pipeline capacity. Additionally, LNG tanker ships are also expensive. As market dynamics have changed, including the entrance of the United States as a supplier and a more market-oriented perspective of U.S. companies, more countries have been able to start importing LNG. The role of the floating storage and regasification units has been essential to the expansion of natural gas globally. In particular, FSRUs have made it possible for economically challenged countries to import LNG, expanding the global market.

Figure 11. 2021 Major Natural Gas Trade Movements By Pipeline and LNG

1221 BCM Imported and Exported



Source: BP, *Statistical Review of World Energy*, 2022, p. 37.

⁵² Government of India, Economic Sectors, Planning Commission, *Twelfth Five Year Plan 2012-17*, New Delhi, 2012, p. 176, at http://planningcommission.gov.in/plans/planrel/12thplan/pdf/12fyp_vol2.pdf.

⁵³ BP, *Statistical Review of World Energy*, June 2021, p. 36, at <https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-full-report.pdf>.

Notes: CIS = Commonwealth of Independent States, which includes Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, and Uzbekistan. The dot for Qatar LNG exports is misplaced and appears to be in Oman.

In 2000, LNG played a relatively small role in natural gas trade. The majority of imports/exports were pipeline gas coming to the United States from Canada and leaving Russia for Europe. In 2000, the Middle East was a relatively small exporter of LNG, supporting the view that most of its natural gas production was being consumed domestically or regionally. Natural gas trade between 2000 and 2021 increased, particularly for LNG. Trade in LNG jumped two-and-a-half times during this time period. A key factor that enabled this increase was the rise in the number of LNG tankers, which rose from 75 ships in 2000 to about 700 ships in 2021. **Figure 11** above shows the current state of global trade of natural gas.

Central and South America and the Caribbean: Relatively Isolated

Central and South America constitutes the smallest natural gas market in the world, for both pipeline and LNG imports, of those countries that import natural gas. Brazil is the largest importer of natural gas in the region and the second largest consumer behind Argentina, which is the largest producer in the region. Bolivia is the main exporter within the region, while the United States is the largest exporter from outside of the region. Venezuela is the largest natural gas reserve holder, but because of sanctions and other sectoral issues has never developed its natural gas resources to their fullest extent. Natural gas ranks third, behind oil and hydropower, in the region's primary energy consumption. Seven countries—Argentina, Brazil, Chile, Colombia, Dominican Republic, Jamaica, and Panama—and Puerto Rico have LNG import capability. There is potential for the region to use more natural gas and for it to play a bigger role in the global market.

The Middle East: Mainly a Domestic Fuel

The Middle East is a major hydrocarbon center—with approximately 40% of the world's total natural gas reserves—but natural gas is primarily a regional commodity in the Middle East. Despite the large reserves, the Middle East produces less than 20% of the world's natural gas, and over 80% of its production is consumed within the region. The majority of imports into the region are by pipeline from other Middle East countries, with Qatar being the largest exporter by pipeline. LNG imports into the region are relatively small as Qatar is the supplier of about a third of the imports to its neighbors with the rest coming from elsewhere. Non-regional suppliers include Nigeria, Israel, Egypt, and the United States, among others. Iran and Saudi Arabia are the two largest consumers of natural gas in the region, in part because of government policies, with both countries being the source of almost all of their own supply. Iran has imported small amounts of natural gas from Azerbaijan and Turkmenistan, while Saudi Arabia consumes all of its production within the Kingdom.

Other Asia: A Strong Base

Japan and South Korea's role in the global natural gas market, particularly in terms of LNG imports, is significant: they had been the number one and two importers of LNG until China surpassed them in 2021. Both countries are resource poor and import almost all their energy resources, in contrast to China, which has a large endowment of energy resources, including natural gas. Additionally, post-Fukushima, Japan increased its LNG imports and the use of natural gas, as its nuclear fleet was shut down. As Japan restarts its nuclear energy facilities, its use and imports of natural gas are likely to decline. Taiwan is also a major importer of LNG. The region as a whole is the largest for LNG imports, some of which come from other parts of Asia,

particularly Australia and Malaysia, the Middle East (especially Qatar), and Africa, among other places, including the United States. It is likely that Asia will remain the largest market for LNG over the next 25 years or so. Given China's imports of LNG, the country may seek a bigger role in protecting sea lanes where its imports transit.

Natural Gas Market Changes

Floating Storage and Regasification Units (FSRUs)

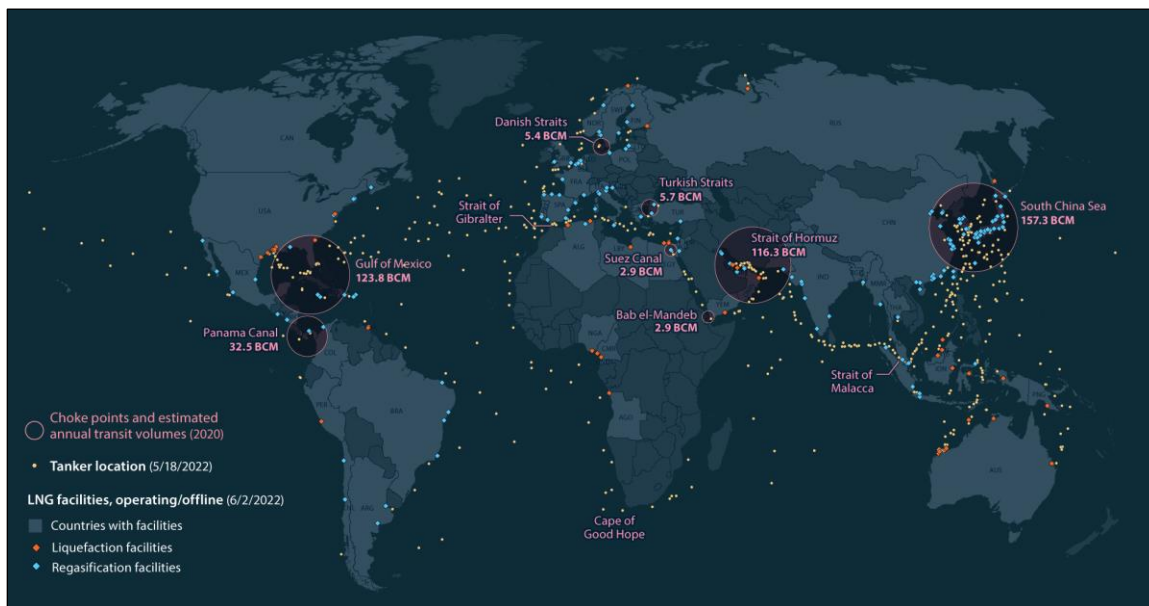
As discussed above, the role of the FSRU is essential to the development of LNG markets in the near term. FSRUs are specialized ships that allow for the import of natural gas, but their impact on the market has been even broader. FSRUs require some onshore infrastructure, usually at the port, but not nearly as much as a traditional onshore receiving terminal. Therefore, they are quicker and cheaper to install, which has led to greater imports and exports of LNG. The lower costs have also enabled countries with less than the highest credit ratings (e.g., Bangladesh, Pakistan, and Ghana) to import LNG. Traditionally, LNG export terminals were able to obtain financing once offtake contracts were signed with companies that had the highest credit ratings, like Japanese and South Korean utilities. This limited the import of LNG by certain countries. FSRUs helped change this aspect of the market. Continued use of FSRUs and expansion of the number of ships are important factors to the future use of natural gas. As of 2021, there were almost 50 FSRUs.⁵⁴ Most of the FSRUs were built or converted since 2010, primarily by Asian shipyards, especially in South Korea. The ships are deployed globally and may change markets based on conditions.

Figure 12 shows a snapshot of where LNG tankers were on May 18, 2022. The map also shows areas with significant LNG tanker congestion, some of which overlap with traditional choke points for oil shipping, like the Strait of Hormuz and Suez Canal. Note the South China Sea and how many tankers are coming to and from China, Japan, and South Korea, the three largest LNG importing countries in the world. For Japan in particular, having LNG come from the north from Russia could provide a certain amount of supply security vis-a-vis China. Additionally, as more ships come into service these natural gas choke points are likely to get more congested.

⁵⁴ International Group of Liquefied Natural Gas Importers (GIIGNL), *GIIGNL Annual Report 2022*, Paris, France, May 5, 2022, p. 20, at https://giignl.org/wp-content/uploads/2022/05/GIIGNL2022_Annual_Report_May24.pdf.

Figure 12. Shipping Snapshot of LNG Movements

Shipping date May 18, 2022



Source: Bloomberg and Energy Intelligence.

Notes: LNG flows through a particular area are estimates based on annual trade data from BP's *Statistical Review of World Energy, 2022*.

Storage: Another Key Market Component

Storage is an essential element for natural gas to become more of a global commodity. The main purpose of natural gas storage is to balance supply and demand in the market. During the winter months when natural gas consumption tends to peak, companies may not be able to import all the natural gas needed to meet demand and must draw from storage. This, for example, is part of the problem Europe faces. During the winter months, especially when temperatures are below average, Europe must use all of its production, imports of LNG and pipeline natural gas, and gas in storage. If one of these resources fails, Europe faces high prices from shortages, with potentially tragic consequences. Russia usually chooses this time of year to reduce natural gas supplies because Europe has not had an alternative. Although Europe has combined storage capacity nearly rivaling the United States and Russia (see **Table 1**), some of that capacity is owned by Russian companies, and it is not enough to offset the imports it receives from Russia. Additionally, European storage facilities are not necessarily placed evenly or strategically to maximize their effectiveness. Europe needs more interconnected natural gas infrastructure to most efficiently use the natural gas it has.

Table 1. Select Natural Gas Storage Data by Country, 2020

Country	Working Gas Capacity (BCM)	% World	Consumption (BCM)	WGC as % of Consumption
United States	135	27	878	15
Russia	120	24	423	28
China	37	7	322	12
Ukraine	31	6	36	87

Country	Working Gas Capacity (BCM)	% World	Consumption (BCM)	WGC as % of Consumption
Canada	28	6	114	25
Germany ^a	24	5	85	28
Italy ^a	20	4	69	29
Netherlands ^a	13	3	38	34
France ^a	12	2	40	29
Turkey	10	2	47	21
Other	79	16	1,803	4
TOTAL	510	100	3,855	13
Europe	109	21	431	25

Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>. The data in this table come from Cedigaz's underground natural gas storage database. It does not include above-ground storage or floating storage on LNG tankers.

Notes: The data included in this table are for storage facilities that are in operation or under construction. Working gas is the amount of natural gas in a storage facility that may be sold without degrading the facility's ability to function. A certain amount of natural gas must stay in the facility in order to maintain pressure and for other reasons. This is known as base gas. Europe includes members of the EU as well as non-members in the region. Europe does not include Turkey. Percentages may not add to 100% because of rounding. WGC = working gas capacity. Units = billion cubic meters (BCM).

a. Included as part of Europe.

Globally, natural gas in storage can meet 13% of the world's consumption. This is not enough to offset unexpected shortages of natural gas in the market. The United States has the most working gas capacity (WGC), natural gas that can be cycled in and out of storage, of any nation; it represents 15% of the country's consumption.⁵⁵ The United States also has a vast natural gas pipeline network, enabling companies to move gas to meet local demand.

Besides underground storage facilities, some natural gas is kept in above-ground facilities, particularly at LNG import terminals, and on ships (also known as floating storage). Above-ground storage is expensive, especially for gas left in liquid form. As shown in the previous section, there are a limited number of LNG tankers in the world, and using them for storage rather than to deliver natural gas may increase their cost. Additional underground storage is under construction around the world, representing about 10% of current global capacity, but it requires specific geological conditions and not every place is capable of storing natural gas.

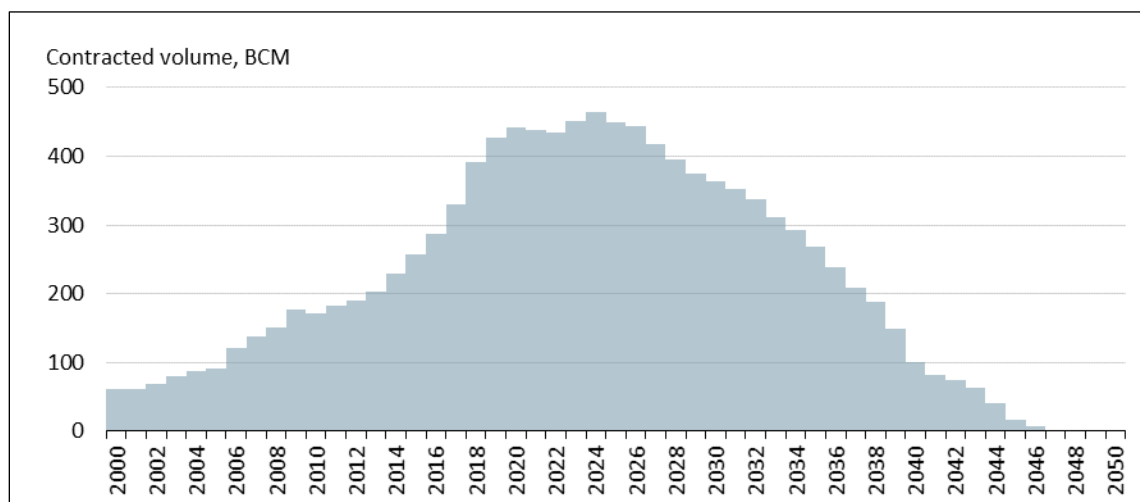
The Rise of the LNG Portfolio Player

As more natural gas exports are controlled by companies without a specific destination for any particular LNG cargo, market efficiency may be increased. (See **Appendix B** for a list of the top natural gas companies.) This may also foster increased use of financial tools to mitigate the risks involved in trading LNG. As shown in **Figure 13**, growing volumes of natural gas are part of contracts where at least one of the counterparts is a portfolio company, which is a company that is buying and/or selling natural gas without a defined supplier or consumer. The database used to create the chart shows that 2024 is expected to be the peak year for portfolio-related contracts.

⁵⁵ For natural gas storage facilities to operate, they require base gas, which is the amount that must remain in storage for the facility to operate. Working gas is the amount of natural gas that can be held in storage, but can be cycled out of the facility and then reinjected.

However, as more contracts are signed, the peak may be pushed out. Going forward, it is likely that more contracts will include a portfolio counterpart. The rise in portfolio companies does not mean that the stability of the natural gas market will increase or decrease. It also does not mean that volatility of natural gas prices will increase or decrease, but it may provide greater flexibility and resiliency.

Figure 13. LNG Export Contracts Held by Portfolio Companies



Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

Notes: A portfolio company enters into LNG contracts with other buyers and sellers in order to gain additional profits by arbitraging the most efficient positions in its portfolio. There is no predetermined destination for the LNG at the time the contract is signed, as is the case with traditional LNG contracts. The flexibility of the portfolio company is essential for the market to operate at a higher level of efficiency based on what markets are paying the highest price. For this chart, the data used require that either the buyer or the seller was deemed a portfolio company. As can be seen, some contracts started before the time period expressed on the chart. Additionally, some earlier contracts went beyond the time period of the chart. The Cedigaz database used for this chart should not be considered complete, nor exhaustive. Units = billion cubic meters (BCM).

Concluding Points

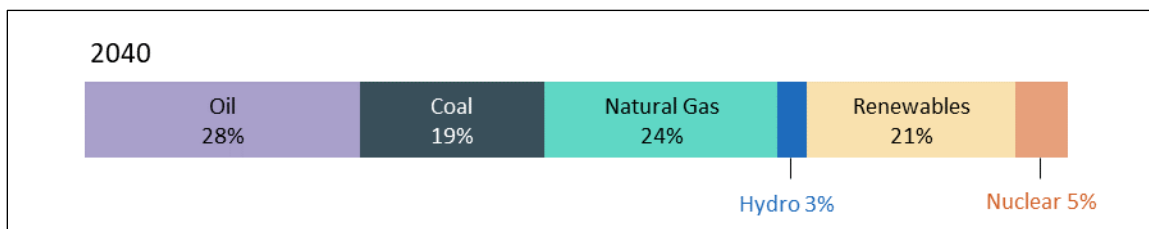
There are certain limitations in the use, trade, and particularly the transport and storage of natural gas. Unlike oil, which can be easily purchased on the spot market and transported via pipeline, rail, truck, or ship, natural gas is relatively expensive in world markets, technologically challenging to move to markets, and not as easily traded. The natural gas market is becoming more global, especially with more LNG available, the use of FSRUs, and the rise of the LNG portfolio companies, but additional changes need to happen for it to reach the same level of market dynamism as the oil market. The ease of trading oil has contributed to its greater insulation from geopolitical tensions and other challenges. As has been seen in 2022 with the Russian invasion of Ukraine, natural gas cannot easily be replaced nor the supply rapidly increased. More flexibility in the natural gas market would be needed in order to insulate both consumers and producers.

Natural gas, particularly since the advent of U.S. unconventional shale gas, has been seen by some as a bridge fuel between the use of hydrocarbons and renewables. After more than 10 years of shale gas, natural gas is still being viewed as a bridge fuel to a lower carbon world by some,

but as a required fuel by others, as the EU demonstrated by declaring natural gas and nuclear as sustainable fuels.

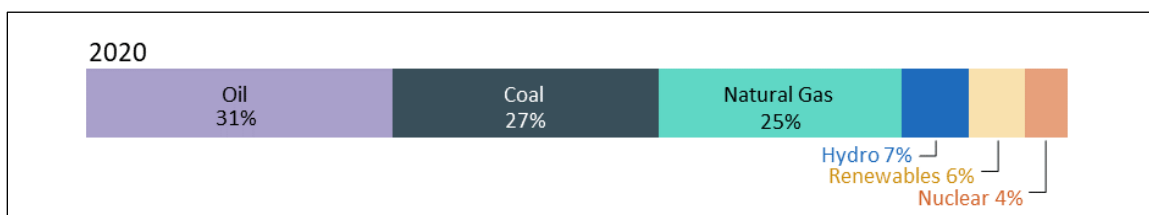
Figure 14 shows a projected scenario in which natural gas as a primary energy fuel does not change its market share, but oil and especially coal lose market share to renewables. This projection is based on the IEA’s Stated Policies Scenario, which “reflects all of today’s announced policy intentions and targets, insofar as they are backed up by detailed measures for their realization.”⁵⁶

Figure 14. World Primary Energy Mix, 2040 Projection



Source: IEA’s World Energy Outlook.

Figure 15., World Primary Energy Mix, 2020



Summary of Key Points

- The United States is the largest producer and consumer of natural gas, and approaching the top spot for exports.
- Uses of natural gas vary—electricity generation (including as a fill-in for renewables), hydrogen generation, industrial processes, and residential and commercial heating—allowing for fuel substitution in certain cases, but not all.
- Natural gas is expensive to transport, adding to its cost to consume.
- If natural gas is to grow, more natural gas storage would be needed throughout the world, especially close to natural gas consuming areas.
- Oil, not natural gas, tends to be the focus of exploration and production activities, which constrains the growth of natural gas.
- There is an important role for natural gas and oil companies in the energy transition. These companies have a vested interest in the continued use of fossil fuels, but are also transitioning their companies for the future. These companies

⁵⁶ International Energy Agency, *World Energy Outlook 2020*, October 2020, p. 17. “Ordinarily, the Current Policies Scenario provides a baseline for our scenario analysis by outlining a future in which no new policies are added to those already in place. It is difficult to imagine this ‘business-as-usual’ approach prevailing in today’s circumstances, so we have not included the Current Policies Scenario in the overall scenario design for the WEO 2020. That said, we would warn against taking the STEPS [Stated Policies] as a baseline or reference case. Achieving stated policies should not be taken for granted, especially in countries and sectors where they are ambitious and far reaching” (pp.76-77).

- have the financial resources and engineering prowess to contribute to energy transition regardless of which fuels make up the future energy mix.
- The natural gas market is shifting to be more like oil, including contract terms, pricing mechanisms, and buyers and sellers.
 - FSRUs are essential to expand the global reach of natural gas. The lower cost and temporary nature of FSRUs will increase worldwide natural gas consumption in the medium term, particularly as countries try to balance hydrocarbon use and climate change goals.
 - More LNG tankers and import terminals would be needed to expand the global natural gas market to more countries.
 - Investments in LNG export projects and other natural gas infrastructure that are commissioned today will likely still be in service in 2050, essentially locking in the use of natural gas in certain places.
 - Additional infrastructure would be needed to increase consumption of natural gas, especially in new markets.

Consumption: More About Environmental Questions

- **Environmental regulations.** Many projections of energy use assume a tightening of environmental regulations making the world use less hydrocarbons, including natural gas. However, the necessary regulations to curb emissions from fossil fuels, including natural gas, have not materialized, so far, to the extent needed to curb global emissions significantly.
- **Brazil, China, India consumption.** There is potential for a large increase in the consumption of natural gas by all three countries. Additionally, all three countries are significant emitters of carbon dioxide and natural gas is a small part of their energy mix. To meet the three countries' stated climate change goals, natural gas is likely to grow in their energy mix. Without natural gas, it is unlikely that these countries will meet their environmental targets. If they do not meet their climate change goals, it is unlikely that IEA's 2021 projections for natural gas demand (see **Figure 2**) will be met.
- **Fragmented markets.** Although the interconnections of natural gas markets are growing, their fragmented nature and the use of mainly pipelines for transport allows Russia to have more leverage in Europe. This situation is also exacerbated by the disparate energy markets within Europe. Russia's war against Ukraine has brought Europe together in a way it has not been before. With natural gas as a recognized key component of the discussion, Europe may be able to unite and permanently overcome Russia's control in this area.
- **Changes to the climate.** As changes to the climate occur there will be direct and indirect consequences for natural gas use. For example, if there are droughts in areas where hydroelectric power is prevalent (e.g., Brazil), more natural gas may be required to meet the shortfall. Droughts would also affect areas where fracking is used to produce natural gas. Certain parts of the world may require more natural gas to offset declines in other resources, while some producers may have to curtail natural gas production. Other countries, if capable, may increase production to meet the shortfall. At the same time, uncontrolled emissions of methane (e.g., venting of wells, pipeline leaks) present a significant contribution to global greenhouse gas emissions.

- **Consumption goes up before going down.** It is difficult to predict developments 25 years into the future. However, even in scenarios that show natural gas use declining in that time period, it is likely that consumption of natural gas will increase before it decreases. A shift to alternatives would likely require a rise in conventional fuels to meet the increase in resource demand in the near term. Additionally, overall energy consumption is likely to rise, especially as the world electrifies more sectors.

Other Short and Long Term Possible Changes

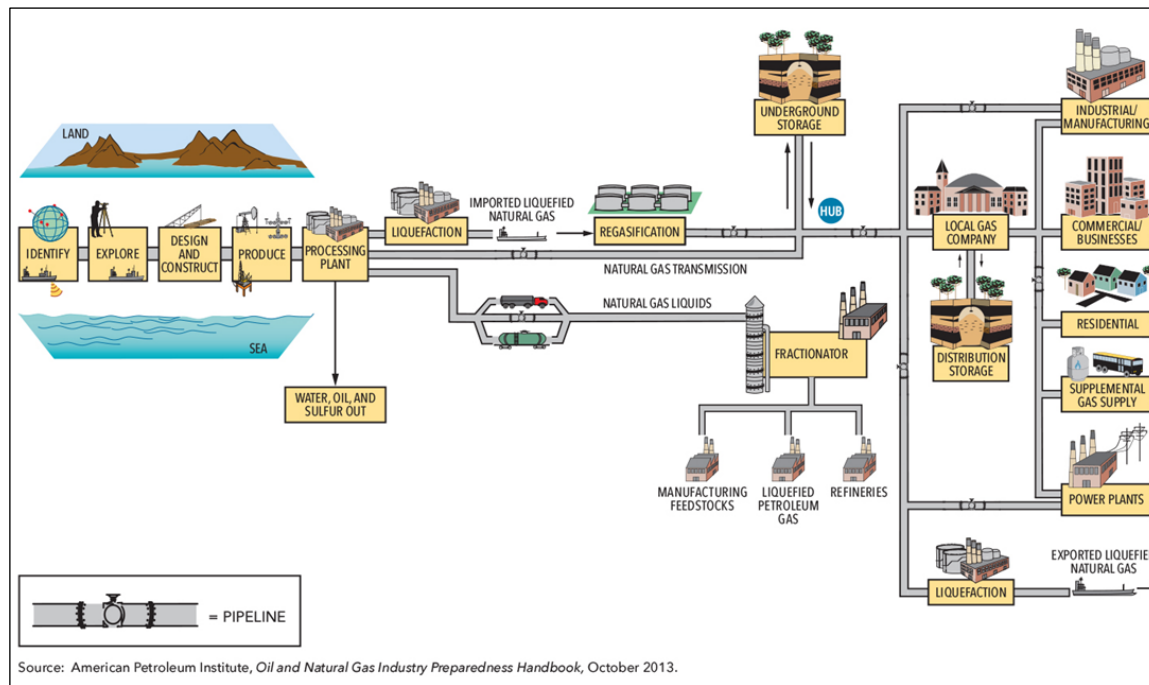
- **Technical advances and substitution.** As the development of shale gas has shown, there may still be game-changing breakthroughs to be found and they could move quickly. Additionally, natural gas has multiple uses and faces substitution in certain segments, which may decrease natural gas use in those segments in the future, should they come to fruition. For example, battery storage and fusion would both affect natural gas use in electricity generation. Improvements in the productivity of solar panels and wind turbines would also limit natural gas use. Increased weatherization and efficiency standards for buildings would curb the use of natural gas for home and commercial heating. Industrial consumption of natural gas for creating some chemicals and for use in oil refineries may not have immediate substitutes.
- **Prices.** As natural gas becomes more of a global commodity, prices will be driven more by market conditions—supply and demand—than contracted terms. This may add to the volatility of natural gas prices. As has been seen in 2022, as natural gas prices have risen to new heights in some regions, countries in those regions have quickly switched to other fuels, including coal.
- **Portfolio players.** As the natural gas market becomes more dynamic, the role of the portfolio player will likely become more important. The goal of some companies to maximize their portfolio of LNG import and export capacities by arbitraging market prices is a key factor in globalizing the natural gas market. By not being constrained by contract obligations, these companies are able to allocate their LNG resources in a market-efficient way. Leading the way in this area are international oil companies (e.g., Royal Dutch Shell, TotalEnergies, ExxonMobil, BP). These companies may likely try to expand the number of markets for LNG, which will lead to natural gas being a part of the global fuel mix in 2050.
- **Energy security.** The traditional definition of energy security essentially says that a fuel must be available, abundant, and reasonably priced. However, there is another dimension of energy security that has been borne out by Russia's war against Ukraine, which is that one's allies' energy security is part of domestic energy security. Although the United States is essentially natural gas independent, most U.S. allies are not. The current global situation for natural gas, especially prices, has put tremendous economic pressure on almost all governments. Europe, in particular, is paying the highest prices for natural gas, and has the ability to pay the higher prices. The higher prices in Europe are pulling cargos away from other countries, including U.S. allies, which pits U.S. allies against each other. Additionally, many poor countries are having their cargos redirected to other countries, which may lead to unrest in the poorer countries. These poorer countries tend to have larger populations and the lack of

energy may cause greater dislocations of people. The lack of energy may also cause economic decline as businesses that use natural gas may not be able to find viable alternatives.

- **Tankers.** More LNG tankers would be needed, especially in the short term, to meet growing demand for exports. An increase in tanker demand may initiate greater use of Chinese shipyards to produce the ships.
- **Russia/China natural gas relations.** Relations will likely grow closer as Europe shuns Russian natural gas exports. China's appetite for natural gas is likely to grow during the time period, and Russia presents a large resource. Tying these two countries together poses numerous strategic concerns.
- **Public Perception.** A single event, similar to Fukushima for nuclear power, may possibly disrupt the future of natural gas. Some conflagration at an import or export terminal or on a tanker that causes significant injury, loss of life, or environmental damage, could turn the public against the industry. In the United States, the use of hydraulic fracturing and perceived threats to ground water gave the industry pause when it came to the social license to operate. Additionally, there is already a move to ban the use of natural gas by some cities, mainly in Europe and the United States, because it is a fossil fuel.

Appendix A. The Natural Gas Sector: A Depiction

Figure A-1. Graphic Depiction of the Natural Gas Sector



Source: American Petroleum Institute (API), *Oil and Natural Gas Industry Preparedness Handbook*, October 2013.

Appendix B. Top Natural Gas Consuming Countries

Table B-1. Top Natural Gas Consuming Countries

Country	2020 Volume (BCM)	% World	2010 Volume (BCM)	% World	2000 Volume (BCM)	% World
United States	878	23	677	21	645	26
Russia	423	11	433	14	370	15
China	322	8	109	3	27	1
Iran	226	6	145	5	63	3
Canada	114	3	82	3	83	3
Japan	101	3	97	3	75	3
Saudi Arabia	93	2	60	2	50	2
Germany	85	2	91	3	92	4
Mexico	82	2	62	2	38	2
UAE	72	2	61	2	30	1
ROW	1,458	38	1,292	41	818	34

Source: Cedigaz, a subscription-based natural gas analytical, information, and data institution, at <http://www.cedigaz.org>.

Notes: Table includes the top 10 natural gas consuming countries as of 2020. These countries may not have been in the top 10 in 2010 or 2000. ROW = Rest of World. BCM = billion cubic meters (BCM).

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