Rethinking US Natural Gas Exports and Climate-Change Benefits

Thomas N. Russo

Conventional wisdom today is that US natural gas exports, especially liquefied natural gas (LNG), can be used in other countries to reduce what might otherwise be rising carbon dioxide emissions. Natural gas is currently considered a bridge fuel to a more renewable energy future. How long natural gas will continue to serve as a bridge fuel is open to debate, along with how long it will take for battery storage to effectively compete with natural gas.

Legislators, regulators, and companies relying solely on the industry narrative of coal-to-gas switching and the ability of gas-fired power plants to provide capacity during evening ramp hours have not internalized all of the costs and risks associated with this play. Similarly, renewable energy advocates can oversimplify the benefits and environmental risks, including the idea that wind and solar power are clean and have no significant impacts on the environment. The large footprints and operational characteristics of wind and solar farms and their documented adverse impacts on bird and bat populations are widely documented. The full life-cycle impacts and costs associated with manufacturing, delivering, and ultimately disposing of solar and wind equipment at expiration of useful life is also not well-understood.

This column addresses pros and cons of natural gas use in developing countries and concludes there are no silver bullets for addressing climate change. Economic growth in various countries and regions will often dictate how significant natural gas exports and renewable energy technologies are in combating climate change. While LNG exports can help reduce CO_2 emissions in the global power sector through coal-to-gas and liquid fuels–to-gas switching, the benefits may be far less than expected unless gas flaring and methane leaks are reduced. I'll first cover global temperature and CO_2 emissions along with country and regional performance, then discuss opportunities and risks that affect how successful LNG exports might be in reducing CO_2 emissions.

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GLOBAL TEMPERATURE AND CO_2 EMISSIONS

Despite one's political position on climate change, the data on temperature anomalies are hard to ignore when compared to average temperatures over the 1951–1980 period. In 2018, the latest annual average anomaly was 0.8°C, or 1.44°F, warmer than the long-term average (**Figure 1**). Eighteen of the 19 warmest years have all occurred since 2001, except for 1998, with 2016 ranking as the warmest year on record. This research is broadly consistent with similar constructions prepared by the

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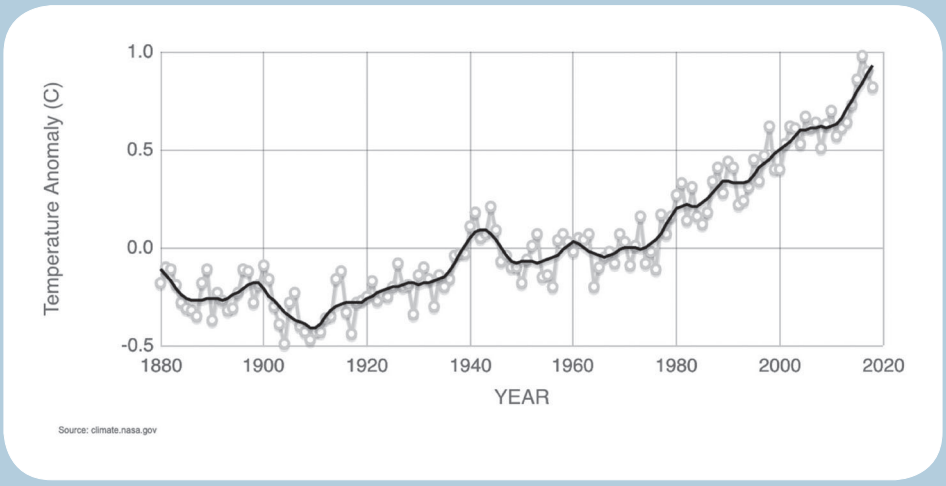
Figure 1. Global Land-Ocean Temperature Index and Global Temperature Anomalies



Climatic Research Unit and the National Oceanic and Atmospheric Administration.

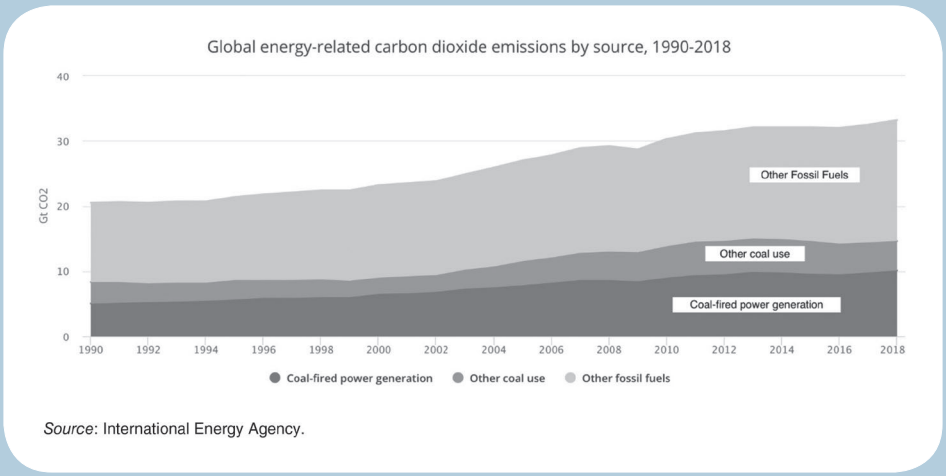
Despite the Paris Agreement and coverage by popular media of the need to combat climate change, CO_2 emissions in 2016 and 2017 have grown. Even coal-fired power generation, which has been under economic pressure from natural gas, increased globally (**Figure 2**).

According to the International Energy Agency (IEA),[1] global energy-related CO_2 emissions rose 1.7 percent to a historic high of 33.1 gigatons (Gt) of CO_2. The power generation sector accounted for nearly two-thirds of emissions growth. Coal use in electricity power generation alone surpassed 10 Gt of CO_2, mostly in Asia. China, India, and the United States accounted for 85 percent of the net increase in emissions, while emissions declined for Germany, Japan, Mexico, France, and the United Kingdom.

The primary cause of the increase in CO_2 emissions was a robust global economy in 2018, which drove energy consumption higher (**Figure 3**). Extreme weather events in Europe, Asia, and the United States increased demand for heating and cooling but played a minor role in the rise of CO_2 emissions. Even as the global economy continued to expand, emissions stagnated between

[1] International Energy Agency. (2018). *Global energy & CO_2 status report 2018.* Retrieved from https://www.iea.org/geco/emissions/.

Figure 2. Global Energy-Related CO_2 Emissions by Source, 1990–2018



Source: International Energy Agency.

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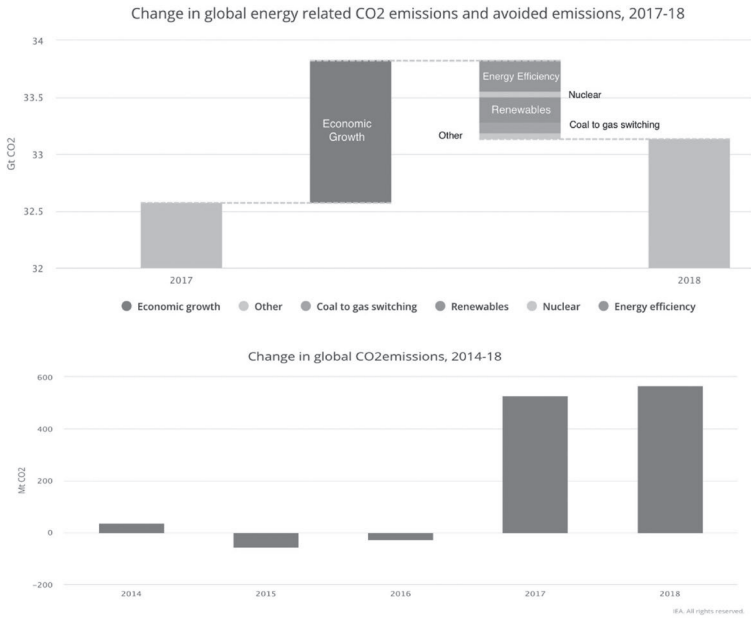
Figure 3. Factors That Contributed to Change in Global Energy-Related CO_2 Emissions and Avoided Emissions and CO_2 Emissions 2014–2018



Source: International Energy Agency.

2014 and 2016 due to substantial energy efficiency improvements, government policies mandating widespread deployment of renewable energy resources and fuel switching in China, and retirement of coal-fired power plants with gas-fired power-generating units in the United States. The dynamics changed in 2017 and 2018 with changes in government policies that allowed a resurgence in coal-fired power generation in China. Wind and solar generation were not scaled up fast enough to meet the increase in energy demand, and China abruptly announced its high feed-in tariffs for solar generation would be phased out. As a result, growth in China's solar industry decreased, while other government policies allowed coal-power production to increase.

CO_2 emissions increased by nearly 0.5 percent for every 1 percent gain in global economic output compared with an increase of 0.3 percent on average since 2010. Nevertheless, IEA data shows that renewables and nuclear energy have contributed to a slowing of CO_2 emissions growth, with emissions increasing 25 percent slower than energy demand in 2018.

The most significant source of increasing global temperatures appears to be coal combustion. Coal was responsible for more than 0.3°C of the 1°C increase in global average annual surface temperatures above preindustrial levels. The global yearly concentration of CO_2 in the atmosphere averaged 407.4 ppm in 2018, an increase of 2.4 ppm since 2017. This is a significant concentration increase from preindustrial levels, which ranged between 180 and 280 ppm.[2]

CO_2 SCOREBOARD IN 2018

China, India, Europe, United Kingdom, Mexico, and Japan are important markets for US natural gas exports, and all emit significant levels of CO_2. Any progress in significantly lowering CO_2 and global temperatures depends not only on LNG but on the importing country's primary energy generation mix and energy and environmental policies. A country's performance is not

[3] International Gas Union. (2018). *IGU world gas LNG report—2018 edition*. Retrieved from https://www.igu.org/sites/default/files/node-document-field_file/IGU_LNG_2018_0.pdf.

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Table 1. Regional and Country CO_2 Emission and Growth Rates in 2018

Total CO_2 emissions (Mt CO_2)		Growth Rate (%)
	2018	2017-2018
United States	4 888	3.1%
China	9 481	2.5%
India	2 299	4.8%
Europe	3 956	-1.3%
Rest of world	11 249	1.1%
World	33 143	1.7%

Source: International Energy Agency.

precisely related to whether or not it embraces the Paris Agreement.

As illustrated in **Table 1**, Europe has made progress in reducing CO_2 emission by 1.3 percent. While admirable, Europe's total CO_2 emission of 3.96 million tons (Mt) represents only 12 percent of total global emissions. China's CO_2 emissions comprised 29 percent of total global emissions and grew by 2.5 percent. Had economic growth not slowed in China, it is likely that China's CO_2 emissions may have increased more than 2.5 percent.

Despite withdrawing from the Paris Agreement, the United States has the most significant absolute decline in CO_2 emissions since 2000 among all countries who were signatories to the agreement, with the exception of 2018. Between 2017 and 2018, the United States saw an increase of 3.1 percent in CO_2 emissions. Despite this increase, US emissions remain around their 1990 levels, 14 percent and 800 Mt of CO_2 below their peak in 2000. Adverse weather conditions in the United States drove up cooling and heating needs, accounting for approximately 60 percent of increased emissions in 2018.

In China, CO_2 emissions grew by 2.5 percent, or 230 Mt, to 9.5 Gt. Coal-fired generation use outside of the electric power generation sector declined. However, electricity generation from coal-fired power stations increased more than 5 percent and drove up emissions by 250 Mt. The 80-Mt growth in emissions from gas combustion came predominantly from outside of the electric power generation sector, as natural gas was increasingly chosen as a replacement for coal-based heating.

India saw emissions rise by 4.8 percent, or 105 Mt, with the growth split evenly between the power, transportation, and industry sectors. Despite this growth, per capita emissions in India remain low at only 40 percent of the global average, due to the large number of India's citizens not having electricity. As efforts to bring electricity to all of India's citizens continue, CO_2 emissions are likely to increase unless all new electricity needs are met through renewable energy resources and storage.

Across Europe, emissions fell by 1.3 percent, or 50 Mt, driven by a 4.5 percent decrease in Germany as both oil and coal combustion fell sharply. The power generation sector used less coal, while generation from renewables reached a record high of 37 percent of the electricity generation mix. Renewable energy generation posted a record year in the United Kingdom, accounting for 35 percent of electricity generation, as the share of coal-fired generation fell to a record low of 5 percent. As a result, CO_2 emissions in the United Kingdom declined for a sixth straight year, hitting some of the lowest levels recorded since 1888. France also saw a significant drop in emissions, as electricity generation from hydroelectric and nuclear power stations resulted in lower utilization of coal- and natural gas–fired power plants in 2018 than in 2017.

Emissions declined in Japan for a fifth straight year with a decline across all fossil fuel–fired generation, due to continued improvements in

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energy efficiency and increased electricity generation from nuclear power stations as reactors came back online. In Mexico, CO_2 emissions declined again in 2018, continuing progress made in 2017 as Mexico used more natural gas in its power generation system. This follows a three-year rise in emissions within the power generation sector from 2014 to 2016. Whether or not CO_2 emissions continue to decline will depend on whether President Andrés Manuel López Obrador continues with the energy reforms of the previous administration. Current Mexican imports of US pipeline gas and LNG are continuing to rise.

OPPORTUNITIES FOR US LNG EXPORTS

Growth in the global economy can be expected to increase energy demand and CO_2 emissions in the power generation and transportation sectors. Oil-fired generation plays a minor role overall in the electric power generation sector, except in the Caribbean and Mexico.

As **Figure 4** illustrates, China and India are critical to combating climate change. Both countries' use of coal-fired power generation has increased; while at the same time, China and India are ranked among the top LNG importers in the last few years. Coal-to-gas switching for electric power generation using LNG is driven by government mandates to improve air quality, even though coal prices are lower than LNG. However, spot LNG prices are affected by weather and supply and demand. In 2018, China and India imported 78.1 Mt of LNG, or 23.8 percent of global LNG supplies.[3]

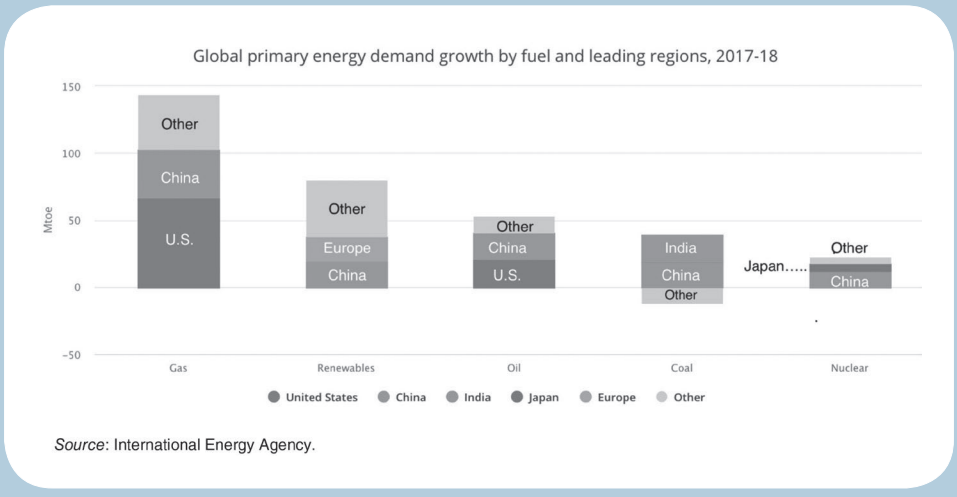
Natural gas demand in China increased by approximately 18 percent—or 42 billion cubic meters (Bcm), or 1,483 billion cubic feet (Bcf)—the fastest growth rate since the introduction of China's 13th Five-Year Plan (2016–2020) and the country's more aggressive promotion of natural gas uses relative to previous plans. Natural gas now accounts for 8 percent of primary electricity demand in China, double its share at the start of the decade.

China became the world's largest natural gas importer in 2018, ahead of Japan, and was the second-largest contributor in volume to global demand growth after the United States, which uses the fuel in its power generation sector. Higher gas imports resulted from Beijing's policy for cleaner energies (known as the "Three-Year Action Plan for Winning the Blue-Sky War"). The plan aggressively restricted the use of coal boilers for industrial and residential use. Across all economic sectors, the switch from coal to gas contributed 17 Bcm, or 600 Bcf, to demand growth.

The current trade tariff dispute between the United States and China are bearish on US exports to China. Despite potential declines in CO_2 emissions that may result from lower LNG imports, China may offset these declines by using more coal to produce electricity and curtail its

[3] International Gas Union. (2018). *IGU world gas LNG report—2018 edition*. Retrieved from https://www.igu.org/sites/default/files/node-document-field_file/IGU_LNG_2018_0.pdf.

Figure 4. Global Energy Demand Growth by Fuel and Leading Regions and Countries



Source: International Energy Agency.

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growth in renewable electricity generation. China already withdrew support for solar in 2018 by phasing out its feed-in tariff, which was an economic drain on the central government.

In the Asia-Pacific region, natural gas demand was also pushed by growing industry and power generation needs in South Asia, as well as by nuclear reactor shutdowns in South Korea.

In the Middle Eastern and North African oil- and gas-producing countries, reducing oil burn for power generation through the development of natural gas–fired combined-cycle power plants contributed to the global gas demand trend. Egypt, which achieved self-sufficiency in its gas supply in late 2018, inaugurated the world's largest combined-cycle gas-fired power plant, with a capacity of 14.4 gigawatts. In Iran, the region's largest natural gas consumer, consumption growth is driven by power generation growth and the phasing out of fuel oil burn.

Europe experienced a decline in natural gas use in 2018 after two years of growth, due in part to the temperature sensitivity of gas demand, with demand for space heating reduced by a mild fourth quarter (in spite of cold snaps in the first quarter). Additionally, 2018 saw lower gas use for power generation, especially in some of the largest natural gas consumers, such as Germany, Italy, Spain, Turkey, and the United Kingdom. Despite lower demand, the combination of declining domestic production and the urge to replenish storage after massive withdrawal over the first months contributed to a record of over 200 Bcm, or 7,063 Bcf, of imports from Russia.

Despite the expected completion of the controversial Nordstream 2 pipeline to Germany by the end of 2019, Germany may be a buyer of LNG.[4] Four new LNG regasification projects are proposed at Brunsbuettel, Wilhelmshaven, Stade, and Rostock.[5] These LNG terminals should provide Germany some optionality to mitigate price increases from the Nordstream 2 pipeline and extreme winter weather conditions. Poland is driven by policies to increase its energy security by relying less on pipeline gas from Gazprom and aligning itself with the United States. In late 2018, the country signed a 20-year deal with Sempra Energy to buy LNG, marking its third contract that year with US LNG companies.[6]

US LNG EXPORT CHALLENGES

Today's LNG industry has come a long way from the traditional long-term contracts with destination restrictions common years ago. The entrance of US LNG exporters has enabled spot trading of LNG cargos and will, over time, allow LNG to be traded as a global commodity like crude oil. Even in the event of rising disputes between China and the United States over trade, US LNG might still find its way to China, because LNG is relatively fungible, and cargos can be relatively easy to store, mix, and trade.[7] However, the LNG market infrastructure is not as mature as the oil market.

The LNG market is evolving slowly from a bilateral market to one resembling the oil market.

Today there are many more portfolio buyers and sellers of LNG than years ago when there were only bilateral (two-party contract) sales and purchases. Portfolio players include companies that buy LNG for resale, such as Royal Dutch Shell, Uniper, gasNaturalFenosa, Total Gas & Power, Centrica, and energy traders like Gunvor Group Ltd., Trafigura Group Pte. Ltd., and Vitol SA[8] that could move cargos to China. However, unlike mature crude oil markets, which have decades of experience behind them, LNG markets are not as efficient as oil markets in moving cargos. For example, a typical crude oil transaction may change hands about 25 times

[4] Uniper SE and Mitsui O.S.K. Lines, Ltd. have reached an agreement to continue and intensify their efforts to implement an FSRU (Floating Storage and Regasification Unit) at the Uniper site in Wilhelmshaven, Germany.

[5] Bowden, J. (2019, January 24). Germany closes in on hoisting the LNG flag. *Petroleum Economist*. Retrieved from https://www.petroleum-economist.com/articles/midstream-downstream/lng/2019/germany-closes-in-on-hoisting-the-lng-flag.

[6] DiChristopher, T. (2018, December 19). Poland's goal of ditching Russian natural gas bolsters American LNG and Trump's energy agenda. *CNBC*. Retrieved from https://www.cnbc.com/2018/12/19/polands-goal-of-ditching-russian-gas-yields-opportunity-for-us-lng.html.

[7] Meyer, G., Crooks, E., Sheppard, D., & Ward, A. (2018, January 22). Gas from the Russian Arctic to warm homes in Boston. *Financial Times*. Retrieved from https://www.ft.com/content/56f19604-fd6d-11e7-a492-2c9be7f3120a.

[8] Shiryaevskaya, A., & Hoffman, A. (2019, March 27). Commodity traders turn to LNG as big oil profits prove elusive. *Bloomberg*. Retrieved from https://www.bloomberg.com/news/articles/2019-03-27/lng-grows-for-trading-houses-from-gunvor-to-trafigura-glencore.

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before the shipment eventually ends up at a refinery. Therefore, if a purchaser finds they have more crude oil than needed, they can turn to a very liquid market and find a buyer for their oil. The current LNG market has nowhere near the liquidity of the crude oil market; therefore, it may be much more difficult to find a buyer for the cargo. Furthermore, the cost of maintaining the LNG as floating storage may not be economically feasible. As the LNG market develops and LNG futures contracts become more popular, it will be easier to trade physical LNG cargos irrespective of their source and to hedge the risks.

LNG exports and the industry are also subject to a large number of risks exporters and importers alike cannot overlook. These risks include increased competition from renewable energy and nuclear power, environmental impacts, and geopolitical considerations, as shown in **Table 2**.

FLARING AND METHANE LEAKS—US LNG'S ACHILLES' HEEL

United States LNG is distinguishable from LNG exported by other countries, due to the fact that the United States has a good reputation for environmental regulation and compliance to avoid and mitigate adverse environmental impacts from infrastructure development across the natural gas supply chain. This includes state and Environmental Protection Agency regulations that limit flaring and methane emissions in the United States. In contrast, Russia, Iran, and Iraq flare the most natural gas (**Figure 5**). Therefore, the environmental quality of US LNG should be more attractive to LNG importers who are concerned about climate change and greenhouse gas emissions. Controlling gas flaring has been especially challenging in the Permian in both Texas and New Mexico, as pipelines can't keep pace with the increasing levels of oil production and associated gas. Texas reports flaring 4.4 percent of its associated gas, but some believe the figure is twice that amount. Flaring in the Bakken has been highly problematic. Currently, 20 percent of the associated gas produced from oil wells is flared, constituting an economic loss and increased CO_2 emissions.

CO_2 is typically painted as the culprit of greenhouse gases. According to the Environmental Defense Fund (EDF), methane is a greenhouse gas over 80 times more damaging than CO_2 during the first 20 years it remains in the atmosphere. Scientists say methane accounts for about 25 percent of today's warming and that levels are spiking worldwide.[9] This is not good for US LNG exporters.

The EPA promulgated regulations in 2016 to regulate methane emissions from the oil and gas

[9] Environmental Defense Fund. (2015, October). *Making methane reductions a global priority.* New York, NY: Author. Retrieved from https://www.edf.org/energy/making-methane-reductions-global-priority.

Figure 5. Global Gas Flaring Intensity and Amounts Flared in the US 2013 to 2017

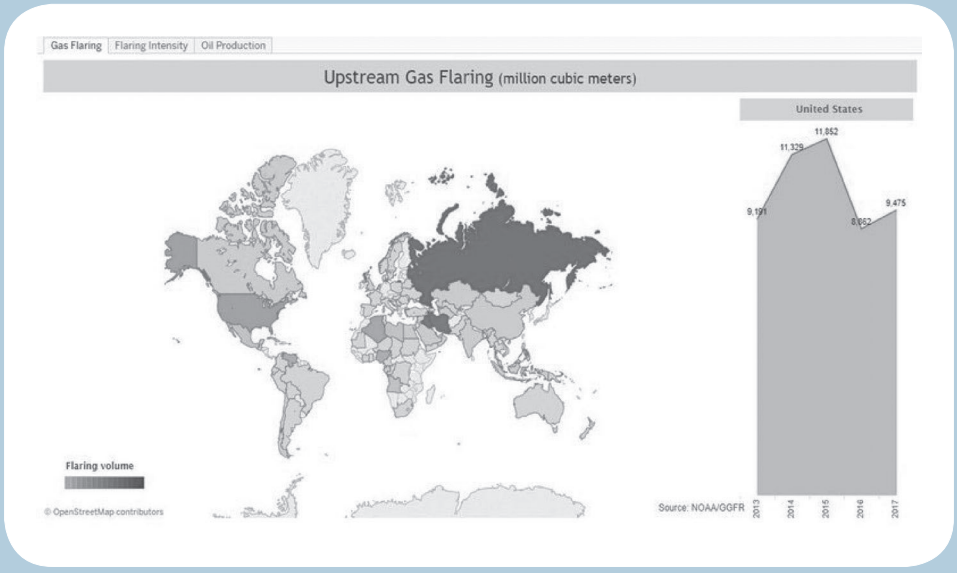

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Table 2. Optimistic and Pessimistic Views on US LNG Exports

Optimistic View	Pessimistic View
• Growing demand outpaces new supply online in the 2020s and world is short LNG	• The United States embarks on a damaging trade war with China
• China, India, and Europe turn away from coal-fired power	• Fracking is banned nationwide
• Global economy continues to grow; emerging economies need more electricity	• China, Mexico, India, and Pakistan reject US LNG and/or decide to develop their shale gas resources
• Japan and South Korea see nuclear power in the past, not the future	• Nuclear power claws back market share and renewable energy gains in favor
• China doesn't purchase a lot of pipeline gas from Russia	• Long application utility-scale battery storage gains traction and is competitive with gas-fired power plants
• Highly liquid LNG futures markets develop to hedge risk	• Another Aliso Canyon storage facility methane leak occurs
• No major LNG plant or tanker accident anywhere in the world	• Industry fails to reduce gas flaring/methane leaks of the supply chain, eroding lower CO_2 benefits that coal-to-gas switching provides

industry. ExxonMobil and BP have made pledges to curb methane emissions and have supported regulations to raise standards across the industry. On the other hand, the American Petroleum Institute and the Independent Petroleum Association of America stated the Obama administration's rules were unnecessarily restrictive. The Trump administration is working to revise the regulations, but some industry participants don't agree.

In the short run, lowering methane standards may help industry, but in the long term it plays into the hands of climate-change activists who argue that any benefits from burning natural gas are canceled by methane leaks. Such methane leaks, like the incident at the Aliso Canyon Gas Storage Facility in southern California that impacted public heath, have undermined confidence in the industry's ability or commitment to safeguarding the public. State regulators in New Mexico are already using California-based Kairos Aerospace patented cameras, known as "LeakSurveyors," which they attach to the wings of rented Cessnas. This practice allows the company to map hundreds of miles of Permian-based methane emissions every day.[10] New Mexico regulators plan on using the information to formulate new regulations and increase oversight.

In a world that seems determined to decarbonize energy, LNG exporters who will have growing purchasing power in the next two decades should be supporting methane emission regulations and insisting that oil and gas producers fix existing leaks and reduce flaring well beyond the revised minimum requirements set by the EPA or the states. LNG exporters should be working with EDF and 12 oil and gas companies that are part of the Oil and Gas Climate Initiative[11] to reduce flaring and methane emissions.

Today's technology enables oil and gas companies and regulators to determine both the source of flaring and methane leaks precisely. If the LNG industry and producers do not take action, they are effectively giving their critics the information they need to persuade lawmakers, governors, and state regulators that the net benefits of LNG exports and coal-to-gas switching are an illusion and not worth the cost.

GLOBAL RISKS

US LNG export companies are exposed to a variety of risks, including weather, changing government mandates, and geopolitics. Table 2 lists the factors beyond those dealing with climate change that make one both optimistic and pessimistic about the growing US LNG export market.

[10] Robinson-Avila, K. (2019, May 6). Measuring methane: Getting accurate data for new regulations. *Albuquerque Journal*. Retrieved from https://www.abqjournal.com/1311318/measuring-methane.html.

[s] The Oil and Gas Climate Initiative companies are BP, CNPC, Eni, Pemex, Petrobras, Repsol, Saudi Aramco, Chevron, Equinor, Shell, Occidental Petroleum, and Total.

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