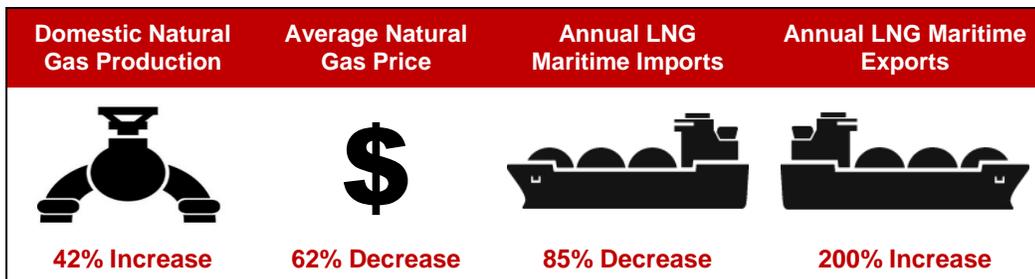


U.S. Liquefied Natural Gas: Opportunity Becoming Reality

When a liquefied natural gas (LNG) cargo ship docked at the Guanabara Bay LNG terminal near Rio de Janeiro, Brazil, on March 15, 2016¹, it represented both the first shipment of American LNG from the lower 48 states to a foreign country and a symbolic turning point for the U.S. energy industry that would have been unimaginable even just a decade ago. In that decade, the U.S. experienced a domestic energy revolution, particularly in natural gas production from prolific underground shale reservoirs. Technological advances, such as hydraulic fracturing and horizontal drilling, enabled natural gas and oil previously trapped in the formations to be extracted. As a result, domestic oil and natural gas production boomed, with natural gas production alone increasing over 42 percent between 2006 and 2016.²

FIGURE 1: U.S. Natural Gas Statistics Comparison: 2006 to 2016^{3 4 5}



As a result of the newly developed domestic supplies of natural gas in the U.S., annual LNG imports declined 85% in just 10 years.⁶ Companies began modifying existing LNG *import* facilities to be capable of liquefying and *exporting* gas, and began constructing completely new export facilities. In 2016, Cheniere Energy began commercial exports of LNG to foreign countries from its Sabine Pass LNG terminal, and in August 2017, the U.S. Energy Information Administration (EIA) projected that the U.S. will become a net exporter of natural gas in 2017.⁷

The U.S. is very well-situated to benefit from the global boom in demand for LNG due to our large domestic natural gas reserves, dependable and established infrastructure, and central location between Europe and Asia. Increased LNG exports present three key benefits, both at home and abroad: 1) as a domestic economic stimulus; 2) as a new geopolitical diplomatic tool; and, 3) as part of an emissions-reduction strategy for countries switching to natural gas for power generation.

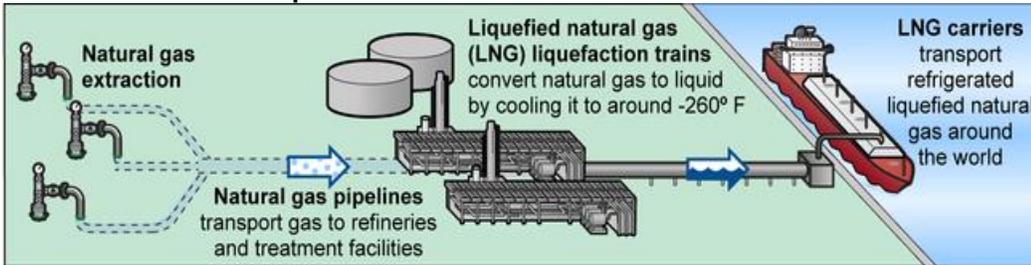
The LNG Liquefaction and Regasification Process

In order to move natural gas overseas in a cost-effective way, it must be liquefied by cooling it to approximately minus 260 degrees Fahrenheit.⁸ At commercial liquefaction facilities, this process takes place by moving the natural gas through heat exchangers that circulate the gas through aluminum tube coils that are cooled by compressed refrigerants.⁹ These liquefaction processing units are often referred to as “LNG trains,” and most LNG liquefaction facilities have multiple trains.¹⁰ Once the gas is liquefied, it is stored in large insulated storage tanks where it is kept refrigerated until it is loaded onto an LNG tanker.

LNG is transported in tanker ships with insulated hull walls up to six feet thick that keep the gas in a cold, liquid state.¹¹ Once the LNG tanker reaches its destination, pumps on the ship transfer the liquefied gas off the vessel and into storage tanks, and then the liquid is pumped from the tanks to warming systems (vaporizers) where the liquid is heated and returned to a gaseous state.¹²

“The EIA projects that the U.S. will become a net exporter of natural gas in 2017.”

FIGURE 2- The LNG Liquefaction Process¹³



The process of converting gas to liquid drastically reduces the amount of space needed to store the same amount of energy. When natural gas is cooled into a liquid, its original volume is reduced by more than 600 times. This is roughly equivalent to the amount of natural gas filling a beach ball being condensed into the amount of liquid in a ping pong ball.¹⁴ Due to the volume reduction, a standard shipload of LNG can provide approximately 3 billion cubic feet of natural gas— enough to heat more than 43,000 typical homes for an entire year.¹⁵

LNG facilities have strong safety records and are highly regulated by multiple government agencies, including the Federal Energy Regulatory Commission, the Department of Transportation’s Office of Pipeline Safety and the Department of Energy (DOE). Maritime and offshore operations of LNG facilities also require oversight by the Coast Guard. As the DOE noted in 2013, “For more than 40 years, the safety record of the global LNG industry has been excellent, due to attention to detail in engineering, construction and operations.”¹⁶ This attention to detail and strict regulatory oversight means that constructing a new LNG facility is a multi-year process. As many as 100 permits and approvals from federal, state and local government agencies may be required.¹⁷

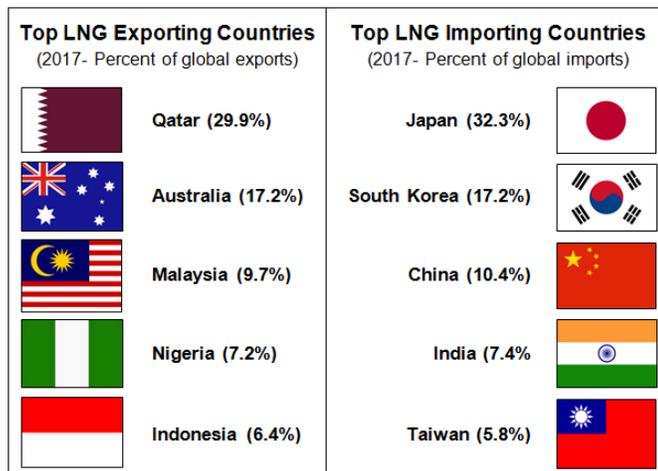
“A standard shipload of LNG can provide approximately 3 billion cubic feet of natural gas— enough to heat more than 43,000 typical homes for an entire year.”

Current Status of LNG Globally

As a new exporter, the U.S. is entering a highly competitive global market. In 2016, global LNG trade volumes led by Qatar, Australia and Malaysia set a new record for the third consecutive year.¹⁹

On the import side, LNG is a growing and vital resource to many other countries that have insufficient energy resources to meet their demands. Many of the countries that import the largest amount of LNG are in Asia, with the Asia-Pacific market accounting for 54 percent of all global LNG imports in 2016.²⁰ The largest LNG-importing country in the world is Japan, an island nation with small amounts of domestic natural gas

FIGURE 3: Top LNG Exporting and Importing Countries¹⁸



reserves and a population of 127 million people who rely on natural gas for cooking and heating as well as for generating 40 percent of the country's electricity.²¹

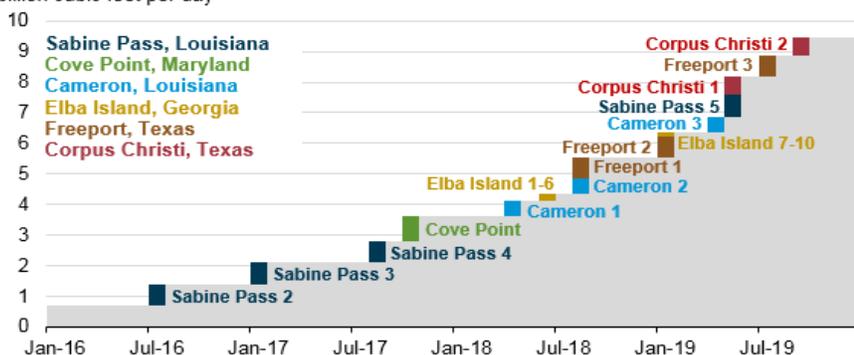
While resource-rich countries are building LNG *export* facilities, even more resource-poor nations are building LNG *import* facilities. In 2016, new import facilities opened in China, Japan, France, India, Turkey and South Korea.²² Additionally, Colombia and Jamaica opened their first LNG terminals in 2016 and began importing LNG for the first time.²³ The global fleet of LNG ships has more than doubled over the past decade—from 194 vessels in 2005 to 439 by the end of 2016.^{24 25}

Current Status of U.S. LNG

The LNG export boom is just beginning in America. As of August 2017, the U.S. has only one commercially operating LNG export terminal^a, which is a new facility in Sabine Pass, Louisiana, that became operational and shipped its first cargoes in 2016.²⁶ The Sabine facility, as currently configured, has an export capacity of 2.1 billion cubic feet per day (Bcf/d) of natural gas, and it exported 187 billion cubic feet (Bcf) of natural gas to 18 different countries in just its first year of operations.^{27 28} This will increase greatly in the upcoming years as there are currently seven FERC-approved LNG export terminals under construction totaling 9.65 Bcf/d of export capacity, with another four approved by FERC but not yet under construction.²⁹

FIGURE 4: U.S. LNG Export Capacity Timeline³⁰

U.S. liquefied natural gas export capacity
billion cubic feet per day



A recent annual report by the International Energy Agency (IEA) estimates that, in 2022, the U.S. will be the second largest LNG exporter in the world, behind Australia but ahead of Qatar and accounting for 40 percent of the world's additional natural gas production between now and 2022.³¹ U.S. LNG export capacity is projected to grow from 1.4 Bcf/d at the end of 2016 to 9.5 Bcf/d by the end of 2019.³²

Despite the large increase in projected LNG exports in the coming years, these facilities will still only export 10-12 percent of total domestic natural gas production.³³ While the U.S. is able to produce more natural gas than it consumes, Australia is exporting natural gas at a faster rate than it is increasing production. In 2016, Australia liquefied and exported approximately 62 percent of the natural gas it produced, causing price spikes for consumers.^{34,35} As a result, the Australian government established a mechanism that gives it the power to restrict exports if there is a risk of domestic shortages.³⁶

“U.S. LNG export capacity is projected to grow from 1.4 Bcf/d at the end of 2016 to 9.5 Bcf/d by the end of 2019.”

^a NOTE: There is also an older LNG export terminal in Kenai, Alaska. However, it did not export any natural gas in 2016.

Kinder Morgan's Role in the LNG Boom

Kinder Morgan will be an active player in the U.S. LNG export business. The company's Elba Island Liquefaction Project is one of the seven liquefaction projects under construction in the U.S. The project will reconfigure the existing Elba LNG Terminal from being exclusively an LNG import facility to a bi-directional facility capable of also liquefying and exporting natural gas. The project received authorizations from FERC in June 2016, and construction began on Nov. 1, 2016.³⁷ The facility will begin LNG production by mid-2018 and be at full production capacity of approximately 350 million cubic feet per day before the end of 2019.³⁸

The Elba Liquefaction Project is utilizing innovative small-scale liquefaction units known as Movable Modular Liquefaction System (MMLS) trains using Shell technology. These trains provide the flexibility to install additional capacity and are able to be constructed in a shorter timeframe.

In addition to the Elba Island LNG export project, Kinder Morgan is also pursuing the Gulf LNG Liquefaction Project, which will add liquefaction and export capabilities to the existing Gulf LNG Terminal located near Pascagoula, Mississippi. In addition to the newly proposed export capabilities, the Gulf LNG terminal would also retain its current capability to receive, store and regasify natural gas as originally constructed.³⁹ The FERC application was filed in June 2015, and FERC is in the process of preparing a draft Environmental Impact Statement for the project.⁴⁰

In addition to the Elba Island LNG Terminal and the Gulf LNG facility, Kinder Morgan will also benefit from increased demand for pipeline capacity to supply newly constructed LNG export facilities across the country. Kinder Morgan owns an interest in or operates approximately 70,000 miles of natural gas pipelines—the largest natural gas pipeline network in the U.S., delivering about 40 percent of all natural gas consumed daily in the country.⁴¹ These pipelines are connected to every major natural gas shale play in the country, including the Eagle Ford, Marcellus, Bakken, Utica, Uinta Permian, Haynesville, Fayetteville and Barnett. Kinder Morgan's large footprint of assets is very well-situated to transport additional natural gas from those regions to proposed export facilities, particularly along the Gulf Coast where many proposed facilities will be located.

The Benefits of U.S. LNG Exports

The U.S. has enjoyed many domestic economic benefits from our natural gas boom over the past decade. LNG exports will extend these economic benefits overseas, providing a safe, reliable and cost-competitive energy source to foreign countries and a lower-emission alternative for power generation.

FIGURE 5: The Elba Island LNG Terminal



Domestic Economic Benefits

Multiple studies have found that higher levels of LNG exports will yield significant economic gains. The construction of a typical LNG liquefaction terminal will provide an economic stimulus to the surrounding area as materials and services are often purchased locally, many jobs are filled with local employees, and the facilities generate large tax revenues for years to come. One study found an average net job growth of 73,000 to 452,000 nationwide between 2016 and 2035, depending on global natural gas prices and demand.⁴³ Similarly, a 2017 study found that the seven proposed LNG export facilities in Texas alone would generate an estimated 70,000 Texas jobs (within a total 136,000 jobs nationwide), as well as generate more than \$145 billion in economic activity across the country.⁴⁴

International Diplomatic Benefits

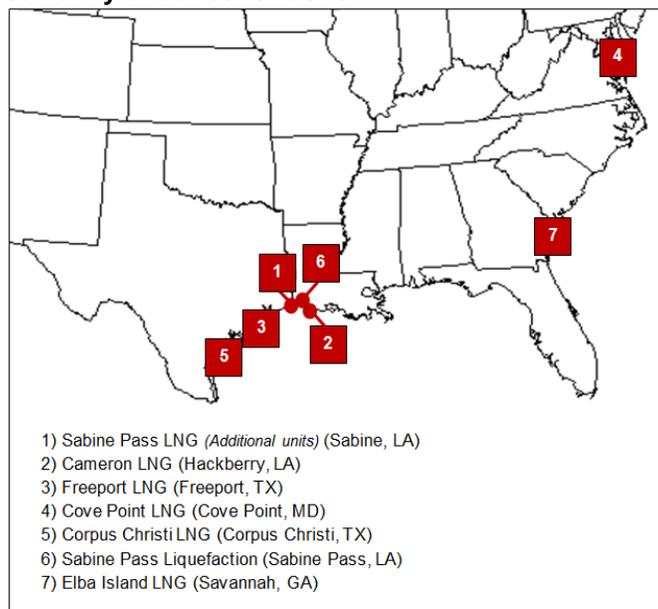
Many foreign countries have expressed an interest in being able to import U.S. LNG, particularly European countries that are overwhelmingly dependent on Russia for their natural gas supplies. The Russian state-owned natural gas company Gazprom is Europe's

leading supplier of natural gas, and 13 European nations rely on Russia for more than 75 percent of their annual natural gas imports; a position that makes these countries vulnerable to Russian market manipulation and political influence.⁴⁵ Russia has taken advantage of its monopoly by reducing natural gas supplies and manipulating prices on multiple occasions, even cutting off natural gas supplies to Ukraine for two weeks in 2009 during a political conflict between the two countries.⁴⁶

Poland, a country which is reliant on Russia for 60 percent of its natural gas, received its first shipment of U.S. LNG in June 2017 at the Port of Swinoujscie. Polish Prime Minister Beata Szydlo praised the delivery stating, "Today, Poland can say that it is a safe and sovereign country... days like this go down in history."⁴⁷ Similarly, the neighboring country of Lithuania announced in June 2017 that it had signed deals to buy LNG from the U.S.⁴⁸ When Lithuania dedicated its first floating LNG regasification terminal in the Port of Klaipeda in 2014, Lithuanian President Dalia Grybauskaitė reiterated the importance of LNG imports stating, "From now on, nobody will dictate us the price for gas - or buy our political will.... once again we have proved to ourselves and to the world that our nation can protect its independence."⁴⁹ That facility now provides roughly half of Lithuania's natural gas supply.

American LNG imports do not just represent a democratic and market-based alternative to other current natural gas supplying countries, they also offer foreign countries the chance to diversify their natural gas sourcing and challenge existing monopolies. When

FIGURE 6: FERC-Approved LNG Export Terminals currently under construction⁴²



Lithuania opened its first LNG terminal, Gazprom cut prices for Lithuania by 20 percent in an attempt to dissuade competition from LNG imports.⁵⁰

American LNG Allows Other Countries to Lower CO₂ Emissions

Combusting natural gas emits approximately half as much carbon dioxide (CO₂), one-fifth as much carbon monoxide (CO), and virtually no sulfur dioxide (SO₂), particulate matter or mercury compared to coal.⁵¹ An abundant supply of low-cost and cleaner-burning natural gas has encouraged power generators to increasingly use the fuel. In 2016, natural gas provided 34 percent of U.S. electricity, compared to just 20 percent in 2006.^{52 53}

Reduced emissions from natural gas-fueled power plants have contributed significantly to a recent dramatic drop in CO₂ emissions nationwide. For example, CO₂ emissions from electricity generation in 2016 were lower than 1990 levels, and 25 percent below 2007 levels.⁵⁶

Environmental benefits can accrue to other nations, especially those with rapidly increasing electricity needs. China is currently the world's largest emitter of CO₂, and India is the fourth largest.⁵⁷ Both countries are replacing some of their coal with LNG for power generation in order to reduce carbon emissions. As of 2016, India and China are the third and fourth largest LNG-importing countries in the world.⁵⁸

China alone increased its LNG imports last year by 35 percent and was one of the five largest buyers of U.S. LNG in 2016.⁵⁹ China already has 15 LNG import terminals operating and is expected to double that number by the early 2020s.⁶⁰ Additionally, in May 2017, the U.S. Commerce Department reached an agreement with China that provides Chinese companies the ability to negotiate and pursue long-term contracts with U.S. LNG exporters, further encouraging growth in the industry.⁶¹ Since CO₂ emissions have a global impact, supplying LNG to China as an alternative to coal is not just benefiting the Chinese environment, but the world as a whole.

Many other countries are pursuing a similar strategy of utilizing LNG as they expand and modernize their power sectors. The IEA reports that 1.2 billion people globally still do not have access to electricity.⁶² Absent breakthroughs in energy storage technology, expanding power generation to these people will require affordable and reliable baseload coal- or gas-fired power plants.⁶³ Currently, many developing countries have a high percentage of coal-powered plants. Natural gas-fired power plants supplied by LNG will provide a much cleaner-emitting alternative. In its 2017 International Energy Outlook, the EIA projects that global natural gas consumption will increase 43 percent between 2015 and 2040, and that in order to meet some of this demand, global trade in LNG will nearly triple from 12 trillion cubic feet to 31 trillion cubic feet.⁶⁴ This projected boom in demand presents significant opportunities for American LNG abroad.

Conclusion

The idea of the U.S. exporting excess natural gas was nearly unthinkable just a decade ago. The current LNG boom is a testament to the technological innovation and determination of the country's oil and gas industry. As the U.S. begins to take on a

FIGURE 7: U.S. Electric Generation by Energy Source- 2006 and 2016^{54 55}

	2006	2016
Coal	49%	30.4%
Natural Gas	20%	33.8%
Nuclear	19.3%	19.7%
Hydroelectric	7%	6.5%
Renewable (Wind, Solar, Biomass, Geothermal)	2.3%	8.4%
Other (Oil, Other Gases, Etc.)	2.4%	1.2%

“The broader domestic and international benefits should be taken into account when evaluating new LNG exports and related infrastructure.”

larger role in the global LNG market, the beneficiaries are numerous—from the foreign countries eager to diversify their energy portfolios or trying to provide electricity to their developing populations to the over 2.7 million Americans working in the oil and gas industry, and the landowners with revenue-generating natural gas wells on their property.⁶⁵ U.S. LNG has benefits that reach well beyond the company building the export facility or the area where the facility is constructed. The broader domestic and international benefits should be taken into account when evaluating new LNG exports and related infrastructure as the U.S. enjoys the fruits of an age of energy abundance.

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