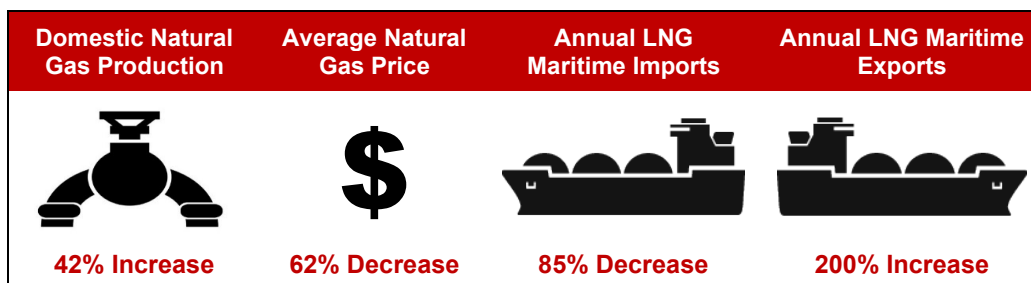


## U.S. Liquefied Natural Gas: Opportunity Becoming Reality

### LNG Exports Become a Reality in the United States

When a liquefied natural gas (LNG) cargo ship docked at the Guanabara Bay LNG terminal near Rio de Janeiro, Brazil, on March 15, 2016<sup>1</sup>, 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 several years prior. During that time, the U.S. experienced a domestic energy revolution, particularly in natural gas production from prolific underground shale reservoirs. This revolution was largely driven by technological advances, such as hydraulic fracturing and horizontal drilling, enabling natural gas and oil previously trapped in the formations to be extracted for the first time. As a result, domestic oil and natural gas production boomed, with natural gas production alone increasing over 42% between 2006 and 2016.<sup>2</sup>

**FIGURE 1: U.S. Natural Gas Statistics Comparison: 2006 to 2016** <sup>3 4 5</sup>



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.<sup>6</sup> Companies began modifying existing LNG *import* facilities to become new *export* facilities. In 2016, Cheniere Energy began commercial exports of LNG to foreign countries from its Sabine Pass LNG terminal. The following year, the U.S. became a net exporter of natural gas for the first time.<sup>7</sup>

The U.S. continues to be 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

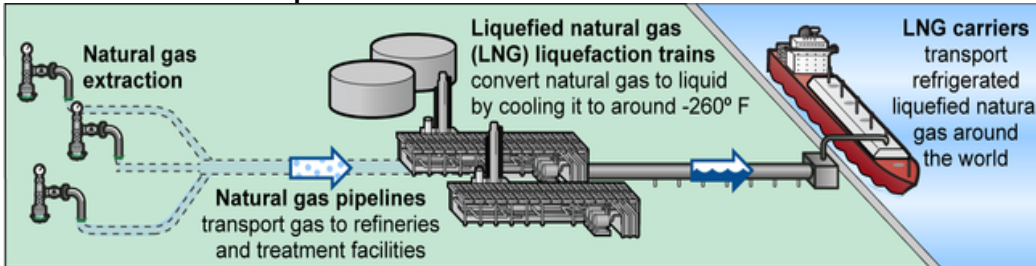
In order to move natural gas overseas in a cost-effective way, it must be liquefied by cooling it to approximately minus 260 degrees Fahrenheit.<sup>8</sup> At commercial liquefaction facilities, this process takes place by moving the natural gas through heat exchangers that circulate the gas through aluminum tube coils that are cooled by compressed refrigerants.<sup>9</sup> These liquefaction processing units are often referred to as LNG trains and most LNG liquefaction facilities have multiple trains.<sup>10</sup> 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 natural gas in a cold, liquid state.<sup>11</sup> Once the LNG tanker reaches its destination, pumps on the ship transfer the liquefied gas off the vessel and into storage tanks, and

*“The U.S. became a net exporter of natural gas in 2017 for the first time.”*

then the liquid is pumped from the tanks to warming systems (vaporizers) where the liquid is heated and returned to a gaseous state.<sup>12</sup>

**FIGURE 2- The LNG Liquefaction Process**<sup>13</sup>



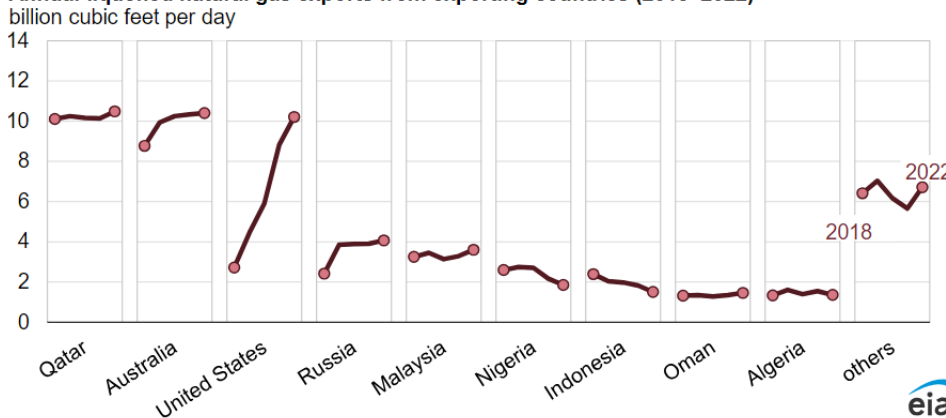
The process of converting gas to liquid drastically reduces the amount of space needed to store the same amount of energy. When natural gas is cooled into a liquid, its original volume is reduced by more than 600 times. This is roughly equivalent to the amount of natural gas filling a beach ball being condensed into the amount of liquid in a ping pong ball.<sup>14</sup> 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.<sup>15</sup>

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. The DOE noted that the safety record of the global LNG industry has been excellent, due to attention to detail in engineering, construction and operations.”<sup>16</sup> 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.<sup>17</sup>

**Current Status of LNG Globally**

LNG continues to be a highly valued commodity in the global market. The global LNG trade set a record high in 2022, averaging 51.7 billion cubic feet per day (Bcfd), which was a 5% increase from the prior year. Liquefaction capacity additions, especially in the United States, supported this growth in the global LNG trade. In fact, The United States became the world’s top LNG exporter in 2022 before the Freeport LNG export terminal shut down due to operational issues.

**Annual liquefied natural gas exports from exporting countries (2018–2022)**

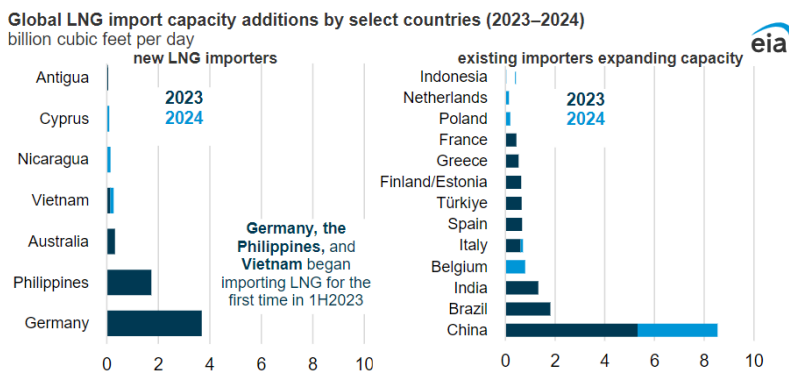


*“A standard shipload of LNG can provide approximately 3 billion cubic feet of natural gas— enough to heat more than 43,000 typical homes for an entire year.”*

Among the LNG-importing regions, Europe had the largest increase of approximately 65% (6.5 Bcfd) largely due to the war in Ukraine and offsetting Russian deliveries.<sup>18</sup>

Beyond Europe, LNG continues to be a 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. The largest LNG-importing country in the world is Japan, an island nation with small amounts of domestic natural gas reserves working to balance rising demand from the power generation and industrial sectors.<sup>19</sup>

While resource-rich countries are building LNG *export* facilities, even more resource-poor nations are building LNG *import* facilities. Global LNG import capacity is expected to expand by 16% (23 Bcfd) by the end of 2024 compared to 2022. Before the fourth quarter of 2023, Germany, the Philippines and Vietnam began importing LNG for the first time. By the end of 2024, Antigua, Australia, Cyprus and Nicaragua are expected to start importing LNG, with several more countries in advanced stages of developing LNG export capacity.<sup>20</sup>



### Current Status of U.S. LNG

The LNG export boom continues to grow in America. It is expected that North America’s LNG export capacity will expand to 24.3 Bcfd by the end of 2027, significantly up from 11.4 Bcfd at the end of 2023. While some of this growth will result from facilities commencing operations in Mexico and Canada, the majority (9.7 Bcfd) will be provided by the United States. This expansion of export capacity will be the result of 10 new LNG projects coming online across the three countries.<sup>21</sup>



Data source: U.S. Energy Information Administration, *Liquefaction Capacity File*, and trade press  
Note: Bcfd=billion cubic feet per day. Map current as of October 2023.

In the United States, five LNG export projects (Golden Pass, Plaquemines, Corpus Christi Stage III, Rio Grande and Port Arthur) are currently under construction with a combined 9.7 Bcfd of LNG export capacity. It is currently expected that LNG exports from Golden Pass LNG and Plaquemines LNG could start as early as 2024.<sup>22</sup>

However, in January 2024, the Biden administration announced a temporary pause on approvals of pending applications for LNG exports to countries with which the U.S. does not have free trade agreements until the DOE can update the underlying economic and environmental analyses for authorizations.<sup>23</sup>

According to the Interstate Natural Gas Association of America (INGAA), concerns about the economic impacts of LNG exports are misinformed. INGAA also stated that U.S. LNG plays an important role in the global energy transition by displacing dirtier fuels abroad, including coal and Russian gas, that other countries will continue to rely on without an American-provided alternative.<sup>24</sup>

### Kinder Morgan's Role in the LNG Boom

Kinder Morgan is an active player in the U.S. LNG export business. The company's Elba Island Liquefaction facility (Elba) is one of the seven liquefaction facilities currently producing LNG in the U.S. To make this possible, Elba had to be reconfigured from being exclusively an LNG import facility to a bi-directional facility capable of also liquefying and exporting natural gas. To do so, Kinder Morgan executed a project to install small-scale liquefaction units known as Movable Modular Liquefaction System (MMLS) trains that use Shell technology. These trains provide the flexibility to install additional capacity and can be constructed in a shorter timeframe. The facility has been in full commercial service since 2020.

**FIGURE 5: The Elba Island LNG Terminal**



Beyond exporting LNG from Elba, Kinder Morgan is also benefiting from increased demand for pipeline capacity to supply natural gas to 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% of all natural gas consumed daily in the country.<sup>25</sup> 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.

*“U.S. LNG export capacity is projected to grow by 9.7 Bcfd by the end of 2027.”*

## 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.

### 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.<sup>26</sup> 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.<sup>27</sup>

### International Diplomatic Benefits

Many foreign countries have expressed an interest in importing U.S. LNG, particularly European countries that have decreased their dependence on Russia as a result of the war in Ukraine. In 2022 alone, imports from 27 of the European countries plus the United Kingdom increased substantially by 73% (6.3 Bcfd) compared to 2021 to replace imports via Russian pipelines.<sup>28</sup> Five countries, including France, the UK, Spain, the Netherlands and Belgium, increased LNG imports by a combined 5.4 Bcfd, making up 85% of the total increase.<sup>29</sup>

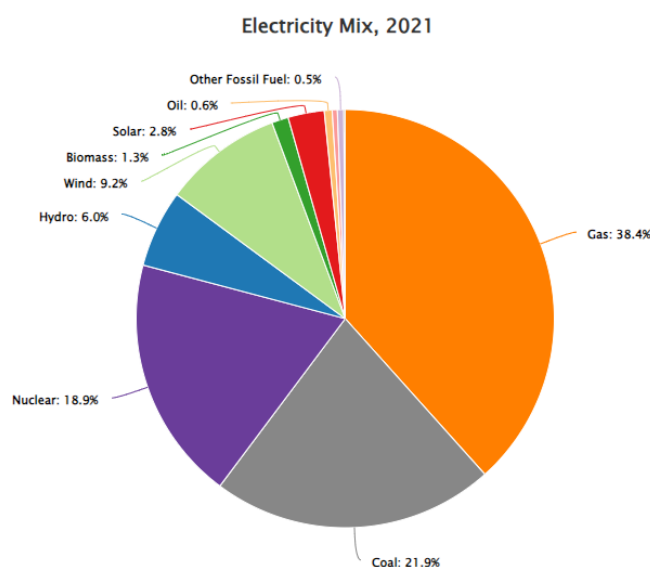
American LNG imports do not just represent a democratic and market-based alternative to other current natural gas supplying countries, they also offer foreign countries the chance to diversify their natural gas sourcing and challenge existing monopolies. When Lithuania opened its first LNG terminal, Russian-owned Gazprom cut prices for Lithuania by 20% in an attempt to dissuade competition from LNG imports.<sup>30</sup>

### American LNG Allows Other Countries to Lower CO<sub>2</sub> Emissions

Over the past 15 years, the U.S. electricity generation mix has shifted away from coal toward natural gas and renewables, resulting in lower CO<sub>2</sub> emissions from electricity generation. In 2019, the U.S. electric power market produced 1,724 million metric tons (MMmt) of CO<sub>2</sub>, which is 32% less than what was produced in 2005.<sup>31</sup> When generating electricity, coal emits significantly more CO<sub>2</sub> than natural gas. For example, in 2019, natural gas fired generation produced 976 pounds of CO<sub>2</sub> per megawatt hour, which was less than half of its coal counterpart during the same period.<sup>32</sup>



As a result of the lower emissions natural gas-fired electricity generation produces when compared to coal, many coal-fired power plants are transitioning to natural gas or are being retired entirely. In 2005, coal made up 50% of the U.S. electricity generation. That market share declined by nearly half in 2019. Conversely, natural gas increased from 19% of total electricity generation to 38% during the same period.<sup>33</sup> In 2021, natural gas remained the most common fuel type for electricity production, accounting for 38.4%.<sup>34</sup>



Reduced emissions from natural gas-fueled power plants have contributed significantly to a recent dramatic drop in CO<sub>2</sub> emissions nationwide. These environmental benefits can accrue to other nations, especially those with rapidly increasing electricity needs. China is currently the world's largest emitter of CO<sub>2</sub>, and India is the third largest. Both countries are replacing some of their coal with LNG for power generation in order to reduce carbon emissions. As of 2022, India and China continue to be two of the largest LNG-importing countries in the world.<sup>35</sup>

While China's LNG imports declined in 2022, largely due to its COVID-19 related economic slowdown, it was the largest importer of LNG the year prior averaging 10.5 Bcfd. This was a 19% increase compared to 2020.<sup>36</sup> China already has 28 operating LNG import terminals and another 8.5 Bcfd of new regasification is under development.<sup>37</sup> 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.<sup>38</sup> Since CO<sub>2</sub> 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 760 million people globally still do not have access to electricity.<sup>39</sup> In fact, the number of people without access to electricity grew largely due to rising prices for fuel and food, which disproportionately impact the developing world.<sup>40</sup> The rise is mostly in sub-Saharan Africa, where the number of people without access to reliable electricity has nearly returned to its 2013 peak.<sup>41</sup> 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 response to this, global natural gas demand is on course to grow by an average of 1.6% per year through 2026.<sup>42</sup> This is partially driven by an increase in the amount of new LNG capacity coming online, which is expected to ease some tightness and unlock price sensitivity – both critical elements to impacting energy poverty around the world. 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 not too long ago. The current LNG boom is a testament to the technological innovation and determination of the country's energy industry. As the U.S. continues to play a large role in the global LNG market, the beneficiaries are numerous—from the foreign countries eager to diversify their energy portfolios to those trying to provide low-cost electricity to their developing populations. The U.S. LNG demand growth has benefits that reach well beyond Kinder Morgan's export facility by supplying feedgas via pipeline to new LNG facilities as they are placed in service. It is certainly an important time to be in the natural gas business to help reduce global emissions while also making an impact on energy poverty in developing nations.

## WORKS CITED

- <sup>1</sup> "Asia Vision docks at Petrobras' LNG terminal to discharge first Sabine Pass export cargo," *LNG World News*, March 15, 2016. <http://www.lngworldnews.com/asia-vision-docks-at-petrobras-lng-terminal-to-discharge-first-sabine-pass-export-cargo/>
- <sup>2</sup> "U.S. Dry Natural Gas Production," *U.S. EIA*, July 31, 2017. <https://www.eia.gov/dnav/ng/hist/n9070us2A.htm>
- <sup>3</sup> "U.S. Dry Natural Gas Production," *U.S. EIA*, July 31, 2017.
- <sup>4</sup> "Natural gas prices in 2016 were the lowest in nearly 20 years," *U.S. EIA*, Jan. 13, 2017.
- <sup>5</sup> "LNG Reports," *U.S. Dept. of Energy*, <https://energy.gov/fe/listings/lng-reports>
- <sup>6</sup> *Ibid.*
- <sup>7</sup> "Natural gas explained," *U.S. EIA*, Jun. 30, 2023. <https://www.eia.gov/energyexplained/natural-gas/imports-and-exports.php>
- <sup>8</sup> "Liquefied Natural Gas: Understanding the Basic Facts," *U.S. Dept. of Energy*, April 2013. [https://energy.gov/sites/prod/files/2013/04/f0/LNG\\_primerupd.pdf](https://energy.gov/sites/prod/files/2013/04/f0/LNG_primerupd.pdf)
- <sup>9</sup> *Ibid.*
- <sup>10</sup> *Ibid.*
- <sup>11</sup> *Ibid.*
- <sup>12</sup> *Ibid.*
- <sup>13</sup> "Obtaining and Processing Liquefied Natural Gas for Transport," *U.S. Government Accountability Office*. Dec. 3, 2015. <https://www.gao.gov/assets/680/673976.pdf>
- <sup>14</sup> "Liquefied Natural Gas: Understanding the Basic Facts," *U.S. Dept. of Energy*, April 2013.
- <sup>15</sup> *Ibid.*
- <sup>16</sup> "Global liquefied natural gas trade volumes set a new record in 2022" *U.S. EIA*, Jul. 5, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=57000>
- <sup>17</sup> "Japan was the world's largest LNG importer in 2022, followed by China" *LNG Prime*, Jan. 19, 2023. <https://lngprime.com/asia/japan-was-the-worlds-largest-lng-importer-in-2022-followed-by-china/71299/>
- <sup>18</sup> "Global liquefied natural gas trade volumes set a new record in 2022" *U.S. EIA*, Jul. 5, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=57000>
- <sup>19</sup> "Japan was the world's largest LNG importer in 2022, followed by China" *LNG Prime*, Jan. 19, 2023. <https://lngprime.com/asia/japan-was-the-worlds-largest-lng-importer-in-2022-followed-by-china/71299/>
- <sup>20</sup> "Three more countries began importing liquefied natural gas this year, and more to follow," *U.S. EIA*, Aug 30, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=60262>
- <sup>21</sup> "LNG export capacity from North America is likely to more than double through 2027," *U.S. EIA*, Nov. 13, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=60944#:~:text=29%20Bcf%2Fd.-,United%20States.LNG%20to%20start%20in%202024.>
- <sup>22</sup> *Ibid.*
- <sup>23</sup> "FACT SHEET: Biden-Harris Administration Announces Temporary Pause on Pending Approvals of Liquefied Natural Gas Exports," *The White House*, January 26, 2024. <https://www.whitehouse.gov/briefing-room/statements-releases/2024/01/26/fact-sheet-biden-harris-administration-announces-temporary-pause-on-pending-approvals-of-liquefied-natural-gas-exports/>
- <sup>24</sup> "INGAA statement on Biden administration move to halt reviews of LNG export terminals," *INGAA*, January 26, 2024. <https://ingaa.org/statement-on-lng-terminal-review-pause/>

*"U.S. LNG has benefits that reach well beyond Kinder Morgan's own export facility in Georgia. This includes supplying feedgas via pipeline to new LNG facilities as they are placed in service."*

<sup>25</sup> "Natural Gas Pipelines," *Kinder Morgan*.

[https://www.kindermorgan.com/pages/business/gas\\_pipelines/](https://www.kindermorgan.com/pages/business/gas_pipelines/)

<sup>26</sup> "U.S. LNG Exports: Impacts on Energy Markets and the Economy," *ICF International*, May 15, 2013. <http://www.api.org/~media/Files/Policy/LNG-Exports/API-LNG-Export-Report-by-ICF.pdf>

<sup>27</sup> "Massive economic benefits from Texas LNG export facilities," *Texans for Natural Gas*, May 1, 2017. [https://www.texansfornaturalgas.com/massive\\_economic\\_benefits\\_from\\_texas\\_lng\\_export\\_facilities](https://www.texansfornaturalgas.com/massive_economic_benefits_from_texas_lng_export_facilities)

<sup>28</sup> "With American natural gas, Russia is losing European energy chokehold," *The Hill*, July 3, 2017.

<sup>29</sup> "First Tanker with U.S. Natural Gas Reaches Poland," *Radio Free Liberty- Radio Europe*, June 8, 2017. <https://www.rferl.org/a/united-states-natural-gas-poland/28536450.html>

<sup>30</sup> "Electric power sector CO2 emissions drop as generation mix shifts from coal to natural gas" *U.S. EIA*, June 9, 2021.

<https://www.eia.gov/todayinenergy/detail.php?id=48296>

<sup>31</sup> *Ibid.*

<sup>32</sup> "What is U.S. electricity generation by energy source?" *U.S. EIA*, April 18, 2017.

<https://www.eia.gov/tools/faqs/faq.php?id=427&t=3>

<sup>33</sup> "Electric power sector basics," *EPA*. <https://www.epa.gov/power-sector/electric-power-sector-basics#:~:text=In%202021%2C%20fossil%20fuels%20remained,for%2021.9%25%20of%20electricity%20production.>

<sup>34</sup> "Table 12.6- "Carbon Dioxide Emissions From Energy Consumption: Electric Power Sector," *U.S. EIA*, <https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>

<sup>35</sup> "Global liquefied natural gas trade volumes set a new record in 2022," *U.S. EIA*. July 5, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=57000>

<sup>36</sup> "As of 2021, China imports more liquefied natural gas than any other country," *U.S. EIA* May 25, 2022. <https://www.eia.gov/todayinenergy/detail.php?id=52258>

<sup>37</sup> "Three more countries began importing liquefied natural gas this year, and more to follow," *U.S. EIA*, Aug. 30, 2023. <https://www.eia.gov/todayinenergy/detail.php?id=60262>

<sup>38</sup> "Trump just gave China a sledgehammer to smash the LNG monopoly," *CNBC*. May 19, 2017.

<sup>39</sup> "Energy Access," *International Energy Agency*.

<https://www.iea.org/topics/energy-access>

<sup>40</sup> "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2017," Table 1-B. *U.S. EIA*, July 25, 2017.

[https://www.eia.gov/electricity/monthly/epm\\_table\\_grapher.php?t=epmt\\_6\\_07\\_b](https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b)

<sup>41</sup> "International Energy Outlook 2017," *U.S. EIA*, Sept. 14, 2017,

[https://www.eia.gov/outlooks/ieo/pdf/0484\(2017\).pdf](https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf)

<sup>42</sup> "After peak in mature markets, global gas demand is set for slower growth in the coming years," *International Energy Agency*, July 2023.

<https://www.iea.org/news/after-peak-in-mature-markets-global-gas-demand-is-set-for-slower-growth-in-coming-years>