NRDC's Memo Regarding DOE's Analysis for Liquefied Natural Gas Exports[1]

Introduction and Summary

On January 26, 2024, the U.S. Department of Energy (DOE) announced that it would update the outdated studies and data it uses to evaluate whether applications to export liquefied natural gas (LNG) are consistent with the public interest—the legal standard required by Section 3 of the Natural Gas Act. DOE last updated its economic and climate studies in 2018 and 2019, respectively. It has not updated its study of local impacts since 2014, and that study focused only on upstream impacts, rather than those along the whole supply chain. DOE has never published a holistic review of the national and energy security implications of LNG expansion.

In this memo, NRDC offers core principles and topic areas that we believe DOE should consider to properly update its LNG export review criteria. We have split our discussion into four areas of analysis: climate, economic, local impacts, and national and energy security. We conclude with some brief comments on DOE's process for updating its analysis and applying it to evaluations of future gas non-free trade agreement (nFTA) export applications. In this section, we highlight the importance of transparency and input into DOE's process, as well as the imperative for DOE to objectively apply its findings to future LNG export applications, such that only projects that are consistent with the public interest are approved.

This memo is focused on areas of NRDC staff expertise; it is not meant to be a comprehensive assessment of all the implications of LNG exports. We hope it will provide a valuable blueprint alongside resources produced by other organizations and perspectives conveyed by communities directly impacted by the LNG export industry.

1. Climate analysis

Scientific knowledge of climate change—and the role that gas extraction and use plays in it—has evolved significantly in the past five years. In its updated studies, DOE must include a comprehensive assessment of how U.S. LNG export expansion affects the feasibility of meeting domestic and international climate targets. In so doing, DOE should evaluate the aggregate climate impacts of current and proposed LNG exports and determine how much space there is, if any, in domestic and international climate budgets to increase LNG exports. Several recent studies have presented at least partial analyses of the life-cycle greenhouse gas (GHG) emissions impacts of the U.S. LNG value chain. DOE's analysis should build on the approaches and findings in these studies to develop a consequential life-cycle assessment (LCA) of the U.S. LNG supply chain, while also providing clear data on the impacts of methane leakage and end-use fuel displacement on U.S. LNG's overall GHG footprint.

a. State of Literature

[1] This memo was written by Gillian Giannetti (Senior Attorney, Sustainable FERC Project), Talia Calnek-Sugin (Senior Policy Advocate, Sustainable FERC Project), Ade Samuel (Energy Analyst, International Program), Amanda Levin (Director, Policy Analysis, Science Office), Morgan Johnson (Senior Staff Attorney, Sustainable FERC Project), Shruti Shukla (International Energy Advocate), Jamie Lee (International Climate Specialist), and Jake Schmidt (Senior Strategic Director, International Climate).

Since the U.S. National Energy and Technology Laboratory (NETL) last conducted its analysis of life-cycle LNG impacts in 2019, several institutions have conducted studies of GHG emissions from LNG supply chains. The scope and key findings of these studies are highlighted in *Appendix I*. These studies offer a wide range of calculated emissions impacts caused by additional U.S. LNG exports, from emissions reductions of 36 Mt of CO_2e per annum to emissions on par with coal consumed in importing markets. While DOE cannot realistically account for the full range of approaches for assessment of LNG life-cycle impacts, this broad spread demonstrates the need for a robust GHG analysis from DOE (and associated national labs) to drive toward consensus on the climate consequences of U.S. LNG export expansion.

b. Key Factor: Accurately Evaluating the GHG Impacts of U.S. LNG Supply Chains

DOE must properly analyze the GHG impacts of U.S. LNG supply chains including exploration and production, pipeline transport, liquefaction, shipping, and combustion overseas. This must include direct emissions from combustion, methane leaks at every stage of the supply chain, and the emissions from energy used to produce and transport LNG (e.g., in liquefaction and shipping).

Estimating methane leakage along the supply chain is essential to this effort, particularly given the increased understanding of methane leakage since DOE's last study of LNG's climate impacts. Gordon et al highlight that the level of upstream methane emissions is likely a determining factor in whether U.S. LNG yields climate reductions as compared to lower-sulfur coal. However, obtaining accurate methane leakage rates can be challenging, and DOE should commission an independent methane leakage assessment rather than relying on companies' self-reporting.

DOE's assessment of life-cycle GHG impacts of additional LNG export facilities is key to a robust public interest determination for future LNG export authorizations. Separately, it also provides an opportunity for DOE to inform efforts to reduce methane emissions across the sector (including for existing LNG export facilities). DOE should model target levels of both methane emissions intensity and gross emissions from U.S. LNG supply chains that are consistent with achieving U.S. and global climate goals. This analysis should also include estimates of "worst case" scenarios for factors such as methane leakage at various points along the supply-chain, rather than only including best case scenarios or an average range. These findings should underpin future public interest consistency determinations and sector-wide methane mitigation efforts.

c. Key Factor: Fuel Displacement Dynamics

DOE's new analyses must include a more sophisticated evaluation of the fuels displaced by additional U.S. LNG export volumes than those in its previous analyses. As findings from recent studies indicate, a simple comparison of attributional life-cycle emissions from LNG supply chains to emissions from coal or alternative gas supply chains does not sufficiently reflect the marginal emissions impacts of adding new U.S. LNG export volumes into the global energy mix. Findings from Smilie et al and Stock et al highlight the importance of accounting for consequential market effects instead of making the simplifying assumption that LNG volumes are a direct substitute for coal or gas in LNG importing markets. Both studies similarly identify the importance of accounting for the effect additional LNG volumes have on the construction and dispatch of renewable generation sources in importing and exporting markets.

There are sectoral and geographic nuances that belie the assumption that additional U.S. LNG volumes will directly displace higher emissions intensity energy sources overseas, as highlighted in analyses and commentary from various institutions since the January 26 announcement. Yang et al's 2022 study points out the macro-scale limitations of defending expanded U.S. LNG exports on the basis of coal displacement overseas, particularly in the long term. The study finds that planned global LNG expansion is inconsistent with 2°C, let alone a 1.5 °C warming trajectory, as emissions benefits from coal-to-gas switching start eroding in 2030 and continue to diminish. As DOE updates its climate analysis, it is important that DOE consider not only fuel displacement patterns in the past and present, but also the projected displacement during the full lifetime of additional LNG export facilities.

While we acknowledge that feasibility constraints may limit the extent to which some of the aforementioned nuances can be captured in models, DOE's climate assessment can more effectively account for emissions impacts of additional U.S. LNG export volumes by employing a consequential emissions accounting methodology and including relevant market effects for a subset of key importing regions or geographies (e.g. Europe, East Asia, and Southeast Asia). This analysis should include the GHG implications of LNG buildout in a scenario in which the world moves rapidly towards renewable energy expansion, in addition to any other scenarios it chooses to employ.

d. Key factor: Economic Impacts of Climate Change

Climate change has a direct effect on global and domestic economies, and there are tools DOE can use to factor the costs of additional LNG exports into its evaluation of additional LNG export terminals. Kotz et al recently calculated global annual damages from climate change at $38 trillion USD, with a likely range of $19-59 trillion USD in 2050. This damage is largely attributable to rising temperatures, increased temperature variability, and changes in rainfall. In the U.S. alone, a 2021 Atlantic Council report estimated that the economic costs of extreme heat alone will reach $100 billion USD every year and claim nearly 60,000 lives per year by 2050. DOE must rigorously evaluate and incorporate the economic impact of climate change when permitting exports of fossil fuels. DOE can factor in the costs of life-cycle greenhouse gas emissions into its public interest determination for new nFTA LNG permits using the U.S. government's standards for the Social Costs of Carbon and Methane, as outlined in EPA's updated Report on the Social Cost of Greenhouse Gases.

e. Conclusion

DOE can add substantial clarity around the climate consequences of LNG by first, rigorously evaluating LNG supply chains (including the role of methane leakage), and second, performing a consequential assessment of emissions impacts from marginal U.S. LNG export increases. DOE can then incorporate this information into an overall public interest determination using the Social Cost of Greenhouse Gases.

Additionally, any climate analysis must bear in mind implications for the U.S.' ability to meet its obligations under the Paris Agreement. With the next round of nationally determined contributions (NDCs) due no later than February 2025, the timing of this reassessment gives DOE an excellent opportunity to bring the U.S.' posture on LNG exports in line with its domestic and international goals and commitments.

2. Economic analysis

The U.S. has, since the fracking boom, been a largely isolated gas market. The new supply of low-cost shale gas in the U.S. resulted in prices well below natural gas prices globally. However, LNG exports have increasingly linked U.S. gas prices to international markets. This has resulted in higher prices and increased price volatility for U.S. consumers, with impacts expected to increase as more LNG export capacity comes online.

For example, natural gas prices remained below 2010 levels (in nominal terms, annually) until 2022 when Russia invaded Ukraine. The annual Henry Hub price increased by 65% year-over-year and more than three-fold from 2020 levels as U.S. gas flowed to Europe. Relatedly, 2022 was also the most volatile year for natural gas prices in the U.S. since before the shale era, with the Henry Hub daily price moving by more than seven percent day-to-day 65 times across the year. Several recent studies catalog these impacts, as elaborated below and in the appendix. DOE must appropriately account for the domestic economic impacts of authorizing additional LNG exports by studying increased gas prices and volatility and their distributional impacts.

a. State of Literature

Studies by federal agencies, academics, and NGOs have looked at the impact of U.S. LNG exports on domestic gas markets. These studies have found that U.S. LNG exports raise gas prices domestically and increase price volatility in domestic gas markets by "recoupling" the historically isolated U.S. gas market to higher-priced global gas markets that are more impacted by geopolitical events. *Appendix II* details key findings from the recent literature on the connection between U.S. LNG exports and domestic gas prices and spending. The appendix includes studies considering both the impacts of current exports and of projected future export capacity additions.

b. Key Factor: Higher Gas Prices and Volatility

As evidenced by the studies overviewed above and detailed in the appendix, rapid growth in U.S. LNG export capacity over the last few years has opened U.S. markets to the broader forces of global supply and demand, increasing U.S. domestic gas prices the U.S. market's exposure to price risks and volatility related to geopolitical forces.

In its updated economic assessment, DOE should analyze the impact of LNG exports on domestic natural gas prices as well as total gas spending by U.S. households, businesses, and industry. DOE should also consider other potential energy market impacts, including escalating impacts to electricity prices given the interconnectedness of the gas and electric power systems. It should consider the increased costs to industries reliant on gas and its biproducts (e.g., ammonia) caused by higher natural gas prices. Examples include manufacturing industries reliant on gas power and agriculture reliant on ammonia-based fertilizers.

In addition to evaluating the average increases to domestic gas prices from LNG exports, DOE should take a close look at the potential for increased domestic price volatility. High prices for a short period of time may have different – and more acute – impacts on households and businesses, who might be able to implement energy efficiency measures or substitute away from gas on a longer timeline but could be more impacted by short spikes in prices.

c. Key Factor: Distributional Analysis

DOE could greatly improve its LNG evaluation toolkit by incorporating distributional analysis in its economic studies. DOE's current studies include no distributional analysis, despite the disproportionate energy burden borne by low-income Americans and multiple Executive Orders directing agencies to conduct them and providing guidance on how to do so.

Looking forward, DOE must rectify these deficiencies for future analyses. DOE should include an assessment of household distribution impacts. This could look like distribution impact analyses in recent Regulatory Impact Analysis (RIA) by the U.S. Environmental Protection Agency, which includes analysis that tabulates the annualized cost per household across income quintiles and regions.

In addition, DOE should assess the distributional implications of labor impacts, impacts on gross domestic product, and impacts on output for domestic industries arising from any projected price and cost changes related to LNG. Other federal agencies have used computable general equilibrium (CGE) models like the SAGE model to do similar analysis to assess these broader economic impacts from energy policies.

d. Conclusion

DOE must focus its assessments on improving and fine tuning its economic assessment tools. This requires a thorough review of gas pricing impacts as well as a localized, focused analysis that accounts for variations across the value chain and across socioeconomics. The studies outlined in the appendix can help guide DOE.

3. Analysis of Local Impacts

The LNG export supply chain impacts people, ecosystems, and communities at every stage: exploration and production, pipeline transport, liquefaction, shipping, and combustion. As noted in the introduction, DOE has only assessed the upstream (primarily fracking) impacts of LNG exports in previous studies, and it has not done so since 2014, when less was known about the impacts of fracking and methane leakage.

In its updated studies, DOE should take a close look at LNG impacts throughout the value chain, from upstream to liquefaction to end use overseas. In all these venues, DOE should include a wide range of impacts, including those to public health, local environments, and local economies. In addition to everyday risks, DOE should include the potential for risks of acute events, such as explosions at liquefaction facilities, pipeline ruptures, or ship crashes. In line with the Administration's environmental justice guidance, DOE should assess the disproportionate impact of these factors on low-income communities and communities of color, as well as the cumulative impacts of LNG export infrastructure, other industrial infrastructure, and other environmental conditions.

a. State of Literature

As elaborated in *Appendix III*, several studies and analyses have outlined the localized impacts of gas extraction, liquefaction, export, and end use. Existing literature zeroes in on negative impacts on communities' local commerce, health, and environments. Some studies are regionally focused while others are more topical. A comprehensive assessment of impacts would add sector-wide context to the individual impacts explored by available resources.

Appendix III also includes some suggested resources to guide environmental justice and cumulative impact analysis.

b. Key Factor: Evaluating Impacts Along the Supply Chain

The upstream phase, encompassing exploration, production, and transport, warrants meticulous scrutiny of local health, commerce, environmental, and biodiversity impacts. It is not enough for DOE to disclose the source basin for exported gas. DOE should commission studies to robustly examine the impacts of exploration and production in various basins – as well as pipeline transport from these basins to liquefaction facilities – to better inform its decision-making. Gas production and transportation activities, particularly in the Permian and Marcellus basins, are notoriously leaky, and leaked methane represents a significant harm to public health. A robust analysis of the impacts of LNG-driven extraction would shed light on additional water contamination, land degradation, toxic air pollution, and seismic activity risk associated with LNG-driven hydraulic fracturing processes. A similar analysis should be done on the effects of LNG exports on U.S. pipeline systems and other transportation infrastructure to better assess and mitigate the economic and environmental impacts of leaks, spills, and other hazards presented by gas in route to export terminals.

The liquefaction of gas for export imposes significant burdens on local communities, including environmental degradation, health-related impacts, and socio-economic disruptions. Environmental impacts, such as air and water pollution, can arise from the release of greenhouse gases, volatile organic compounds, and other pollutants during the liquefaction process. This pollution often poses health risks to nearby residents and disrupts local ecosystems and biodiversity. Pollution risks are also often compounded by other associated environmental impacts, such as those caused by LNG tankers or construction activities. Also, LNG export construction and operation has a variety of socio-economic costs and benefits, including changes to employment opportunities, impacts to property values, and impacts to community services and community cohesion. A comprehensive, cumulative accounting of the sector-wide effects of the construction and operation of liquefaction facilities is necessary to determine the full environmental, public health, and local economic impacts of gas exports.

In the downstream and end-use context, DOE's current practice is to solely consider perceived economic and strategic benefits of LNG export in the trade context. But DOE should also assess the local environmental and public health implications of imports of U.S. LNG, particularly in the context of transitioning energy systems abroad. DOE should also account for the ecological and developmental impacts to protected ecosystems and biodiversity hotspots near LNG regasification terminals in importing countries.

c. Key Factor: Assess a Wide Range of Impacts

The health impacts of LNG export must be thoroughly evaluated, as detailed in the previous section and in sources cited in *Appendix III*. This means assessing air and water pollution levels and levels of exposure to hazardous chemicals throughout the extraction, transport, liquefaction, and regasification stages.

Understanding the local economic and commerce-related impacts of LNG exports is also vital to a comprehensive public interest analysis. DOE should fully account for the economic benefits and drawbacks of export-driven jobs. As elaborated, for example, by the Southeast Laborers District Council, there is often a wide discrepancy between companies' promised jobs for local communities and the actual employment benefits to those communities. DOE should look closely at evidence of jobs created by the LNG industry, the number of permanent vs temporary jobs (e.g., operation vs construction jobs), and whether jobs (particularly high-paid opportunities) are going to people in local communities. In addition, DOE should fully examine the LNG export industry's effects on other commercial industries and activities. Along the Gulf Coast, for example, this could include fishing, shrimping, and tourism. DOE should analyze revenue generation and losses, shifts in property values, and overall market dynamics within affected regions.

DOE's analysis of export-related economic impacts should factor in state and local tax advantages granted to projects. DOE should consider knock-on effects of tax abatements, including, for example, lost future earnings due to poorer education systems or productivity losses caused by reduced public transportation. Some examples are included in *Appendix III*.

DOE must study impacts to local environments, including impacts on biodiversity, local aquatic and terrestrial ecosystems, and endangered species. *Appendix III* includes a study of aquatic impacts, and we encourage DOE to seek out additional resources, many of which are project or location specific. DOE should also examine the impacts of LNG export expansion on coastal resilience, protection from extreme weather events, and other climate risks. This analysis, while specific to Plaquemines, Louisiana, provides a useful blueprint.

Finally, DOE should consider the probability and consequences of catastrophic risk in its assessment of the local impacts of LNG exports. As evidenced by the June 2022 explosion at Freeport LNG, LNG facilities carry a high risk of explosion given the volume of highly pressurized gas. A 2020 report from the Congressional Research Service provides a helpful overview of risks including flammable vapor clouds, boiling liquid expanding vapor explosions, and other LNG safety risks.

d. Key factor: Cumulative Impacts and Environmental Justice Considerations

Cumulative impacts must be carefully evaluated to account for the compounding effects of multiple stressors on ecosystems and communities. DOE should assess the cumulative environmental, social, health, and economic effects of LNG exports alongside concurrent conditions, such as climate change, extreme weather, and industrial activities. A comprehensive assessment of cumulative impacts is critical to analyzing the full extent of impacts disproportionately affecting disadvantaged communities.

The U.S. government already has multiple tools to identify environmental justice communities, like EJ Screen or the Climate and Economic Justice Screening Tool. As the EPA explains, environmental justice communities' "combined exposures to pollutants often increases their vulnerability to new or ongoing environmental hazards, which can cause, perpetuate, or exacerbate disproportionate environmental and public health harms and risks." EPA recently issued guidance on approaches for assessing cumulative impacts that can provide a blueprint, and we have included some additional resources in *Appendix III*, including a new report from the Bullard Center for Climate and Environmental Justice.

4. **National and Energy Security**

DOE must incorporate an assessment of the national and energy security implications of continued LNG expansion. The recent geopolitical situation in Europe is illustrative of the nuances required in this analysis. Following Russia's invasion of Ukraine, existing U.S. LNG export capacity was critical to meet Europe's energy security needs. However, Europe is rapidly transitioning away from gas in line with its ambitious climate goals and will have less demand for U.S. LNG by the time that facilities approved today would come online. Similarly, Asian allies dependent on U.S. LNG, of which Japan and South Korea made up the largest share historically, are headed toward a future where gas plays a less prominent role in their energy mixes. We detail the LNG-related dynamics of Europe, South Korea, and Japan in *Appendix IV*.

a. Key Factor: Analyze Allies' Demand for U.S. LNG alongside Climate Goals

In its energy security analysis, DOE should consider global energy demand in the context of global and national climate goals. Global projected gas demand is subject to different scenarios, contingent upon renewable energy expansion, electrification ambitions of given energy systems, achievements in energy efficiency, energy pricing dynamics, and gas consumption reduction measures. DOE can incorporate findings from the International Energy Agency's Net Zero Roadmap and World Energy Outlook, as well as projections from DOE's own Energy Information Administration, as it models gas demand alongside climate goals.

DOE should assess the demand for additional U.S. LNG supply that meets allies' energy security needs while minimizing the climate and economic impacts of LNG infrastructure overbuild. One option for DOE would be to conduct an in-depth medium- to long-term study of allies' LNG demand to determine whether approved export applications are truly insufficient to meet energy security needs (particularly for nFTA markets), considering domestic and global commitments under the Paris Agreement and cost-competitiveness of renewable energy and energy efficiency solutions. Suggested key markets for study include the European Union, Japan, and South Korea. In all markets, it is important to consider the implications of upcoming revised national climate plans and targets (in addition to the current ones), under the obligations imposed by the Paris Agreement and other commitments made by those countries, to fossil fuel demand.

b. Key Factor: Consider the Security Implications of Climate Change

The world is experiencing a convergence of extreme weather events, food and energy crises, and global competition for critical resources, all of which highlight the profound security implications of climate change. The international nature of these challenges requires increased cooperation among global actors (both public and private) to find effective and lasting solutions to reduce the likelihood of intensifying climate impacts that lead to further large-scale disasters. As a responsible security partner to many nations and allies, the U.S. must ensure that its actions do not multiply security challenges overseas due to rising climate impacts. DOE should consider whether U.S. LNG expansion runs counter to the warnings of the scientific community and world leaders about the risks of investing in fossil fuels. As DOE determines how to include the national security implications of climate change in its analysis, it could look to the White House's National Security Strategy and the report on National Security and the Threat of Climate Change commissioned and signed by the Military Advisory Board, comprised of retired U.S. Admirals and Generals.

Process

As DOE studies the climate, economic, environmental justice, and security implications of LNG exports, the agency should ensure its process is transparent. We welcome DOE's plan for an open comment period following the publication of draft studies, but additionally suggest that DOE make room for broad stakeholder input earlier in the process. To provide a forum for such input, DOE could open a docket or Request for Information. DOE could also host a technical conference—including individuals directly impacted by LNG exports—to receive feedback and enhance discussion. Regardless of the mechanism, it is imperative that frontline communities directly impacted by LNG exports weigh in on DOE's studies of local impacts. This is the only way those studies will be robust and relevant.

We recognize that many of DOE's studies will include factors with a range of uncertainty, such as methane leakage, impacts on domestic gas prices, or extent of wetlands destruction. DOE's analysis should include an examination of worst-case scenarios, given the major potential ramifications for the climate, economy, human health, and the overall public interest. In particular, we recommend that DOE publish worst case scenarios for: (a) each individual factor (e.g., methane leakage rate, energy source displacement, etc.); (b) each of its analyses (i.e. climate, economic, local impacts, and national security); and (c) the combined impact of the former on the public interest. This worst-case scenario analysis would complement other elements of DOE's studies.

DOE's updated analysis is only as valuable as its application in DOE's decision-making process for future LNG export authorizations. To that end, DOE should remove barriers to comprehensive export reviews, such as the categorical exclusion from NEPA review. When possible, DOE should also leverage analyses to examine sector-wide impacts of LNG exports (including existing and approved facilities) on the climate, economy, local communities, and energy security.

DOE's studies will inform its assessment of whether proposed additional LNG exports to nFTA countries are consistent with the public interest, in conformity with the Natural Gas Act. Ensuring these updated studies are comprehensive, accurate, and reflect a whole-of-sector assessment is essential to meeting DOE's statutory obligations and to addressing the realities of the climate, economic, and community-level impacts of gas export. Once these studies are complete, DOE must objectively apply them to future LNG export authorizations and only approve projects if the benefits exceed the costs and if they are truly in the public's interest.

Appendix

Appendix I – Climate Impacts: Relevant Literature.

Title / Author	Scope	Findings
Evaluating net life-cycle greenhouse gas emissions intensities from gas and coal at varying methane leakage rates / Gordon et al	• Attributional analysis of methane and SO_2 life-cycle co-emission rates for gas and coal production operations across the globe • Scenarios explored comparing life-cycle emissions of coal and gas at varying leakage rates	• U.S. oil and gas basins have methane leakage rates ranging from .65% to 11% for numerous onshore oil and gas basins and as high as 66% for offshore oil and gas basins. • Gas operations with methane leakage rates above .2% have greater life-cycle GHG emissions than 1.5% sulfur coal operations with a 90% scrubber efficiency over 20 years.
Greenhouse Gas Estimates of LNG Exports Must Include Global Market Effects / Smilie et al	• Consequential LCA of GHG emissions from North American LNG exports • Includes analysis of shifts in coal consumption and resultant emissions in importing and exporting markets	• Modeled 2.1 Bcf/d export facility results in global emissions reduction of 8 Mt of CO_2e per annum. • This result is a smaller GHG reduction than the 36 Mt of CO_2e per annum calculated by previous methods that assume perfect substitution of LNG for coal.
The Market and Climate Implications of U.S. LNG Exports / Stock et al	• Empirical economic analysis of recoupling of U.S. fossil fuel prices to global market • Applies NREL ReDS energy system model to determine U.S. power sector emissions impact from this recoupling	• Recoupling of U.S. gas prices to global markets due to LNG exports has resulted in a domestic gas price increase of $1.60 per MMBtu for U.S. consumers, and the linking of domestic gas and coal prices has resulted in an effective carbon tax of roughly $20-30 per MT of CO2e on coal and gas consumed in the U.S. • This increase in gas and coal prices causes U.S. power sector emissions to decrease by a projected 145 million MT of CO2 through 2030 due to displacement of fossil fuel generators by lower emissions power generation sources in modeled scenario.

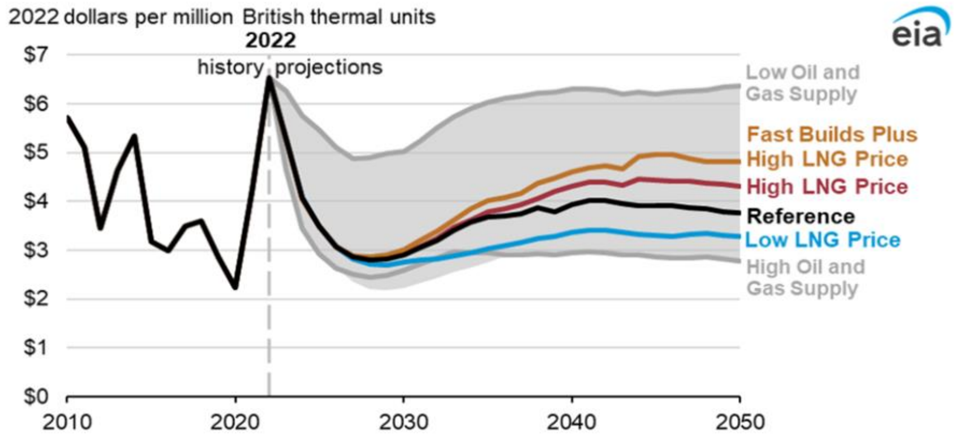
Global liquefied natural gas expansion exceeds demand for coal-to-gas switching in Paris compliant pathways / Yang et al	• Attributional life-cycle assessment of LNG supply chain emissions • Calculation of cumulative emissions impact of planned LNG infrastructure buildout • Scenario analysis of coal-to-gas switching compatibility with 1.5, 2.0, and 3.0°C warming scenarios	• Long-term planned LNG expansion is inconsistent with 1.5- and 2-degree C pathways. • In all analyzed trajectories low upstream methane emissions and high coal-to-gas substitution are crucial to achieving short term emissions reductions.
US oil and gas system emissions from nearly one million aerial site measurements / Sherwin et al	• Integrated analysis of 1 million aerial site measurements from six U.S. regions into regional emissions inventories (including the Permian Basin)	• U.S. oil and gas operations are emitting over 6 million tons per year of methane. • Leaked methane accounts for $10bn in annual economic damages, when factoring in climate damages as well as lost commercial value. • Emissions and cost estimates are 3 times that of the U.S. government.

Appendix II – Economic Impacts

The **U.S. Energy Information Administration (EIA)** projects that natural gas exports will become a larger source of gas demand in the U.S. than any domestic end-use sector by the early 2030s. EIA analyzed the impacts of LNG exports on domestic gas demand, prices, and supply, finding that a faster buildout of LNG terminals and sustained LNG demand could increase domestic gas prices by $1.04/mmbtu (2022$) compared to reference case by 2050.[2] This is a 28% increase in wholesale gas prices in the U.S. In a lower LNG demand case (Low LNG Price), where LNG exports are about 45% below reference case, U.S. wholesale gas prices fall by $0.49/mmbtu (2022$) or a 13% decrease. EIA concludes that "higher LNG exports results in upward pressure on U.S. natural gas prices and that lower U.S. LNG exports results in downward pressure."

[2] The "Fast Builds Plus High LNG Price" case sees a 76% increase in LNG exports by 2050 compared to reference. In 2050, exports are 48.2 bcf/day in the Fast Builds Plus High LNG Price case and 27.3 bcf/day in the Reference case.

Figure 2. Natural gas spot price at the Henry Hub, AEO2023



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

Energy Innovation estimates that approving pending LNG export terminals would increase natural gas spending by U.S. households, businesses, and industry by $11 - $18 billion annually. They found that the 11.6 bcf per day of LNG export capacity for the projects pending approval would increase domestic natural gas prices by 9 to 14 percent.

A working paper for the **National Bureau of Economic Research (NBER)** explored the price impact of "re-coupling" U.S. gas prices to the broader, global market.[3] They estimate that compared to a "shut-in" scenario, like U.S. markets before 2016, "recoupling" results in a 54% increase in domestic gas prices in 2030. This is a $1.60/mmbtu increase in domestic gas prices, which is equivalent to a $30/ton carbon tax. And these price increases will have rippling effects in other markets, like the electricity market where natural gas provides over 40 percent of all generation in the country today.

These studies are consistent with more anecdotal evidence from the **Federal Energy Regulatory Commission**'s (FERC) past winter assessments. For example, in the 2022–2023 Winter Assessment, FERC noted:

> "Even though natural gas production growth will likely outpace domestic natural gas demand growth in winter 2022-2023, forecasts anticipate that continued growth in net exports, including from liquified natural gas (LNG) export facilities, will place additional pressure on natural gas prices this winter. Specifically, the Henry Hub natural gas futures contract price is averaging $6.82 per million British Thermal Units (MMBtu) for winter 2022-2023, up 30% from last winter's settled price, discussed in more detail below... Winter 2022-2023 demand for natural gas is expected to increase 2.4% over winter 2021-2022 levels to 121.2 Bcfd, driven primarily by growth in demand for natural gas exports. The anticipated greater volume of natural gas exports primarily results from the increase in LNG liquefaction capacity over the last year, as well as increased pipeline exports to Mexico." (pg. 1 – 2).

[3] See Appendix I. James Stock and Matthew Zaragoza-Watkins, "The Market and Climate Implications of U.S. LNG Exports."

Appendix III – Local Impacts

Title / Author	Relevance to which part of local impacts analysis	Relevant scope / findings
Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking and Associated Gas and Oil Infrastructure / Physicians for Social Responsibility	Health impacts - upstream	Includes 2,000 abstracts and links to medical, scientific, and investigative reports about the health impacts fracking and associated processes.
Health Hazards Associated with Oil and Gas Extraction / Occupational Safety and Health Administration (OSHA)	Health impacts for workers- upstream	Potential extraction-related health hazards identified by OSHA include: Particulate Matter, Fatigue, Hazardous Chemicals, Hydrocarbon Gases and Vapors (HGVs) and Low Oxygen Environments, Hydrogen Sulfide, Naturally Occurring Radioactive Material (NORM), Noise, Silica, and Temperature Extremes.
Air pollution and health impacts of oil & gas production in the United States / Buonocore et al in Environmental Research: Health	Health impacts	In 2016, U.S. oil and gas production caused 410 000 asthma exacerbations, 2200 new cases of childhood asthma, and 7500 excess deaths, equivalent to $77 billion in health impacts.
Troubled Waters for LNG / Environmental Integrity	Health impacts - liquefaction	LNG terminals release harmful air pollutants—such as volatile organic compounds, nitrogen oxides, sulfur dioxide, carbon monoxide, and particulate matter—that can contribute to increased incidences of respiratory disease, heart disease, and cancer.
Costly and Unusual: An Analysis of Louisiana's Industrial Tax Exemption Program / Together Louisiana	Local economic impacts	Finds that Louisiana provides a more-than $500,000 public subsidy to industry *per job created* and breaks down the impact per parish.

Louisiana Quality Jobs Program – Tax Incentive Evaluation, Louisiana Legislative Auditor	Local economic impacts	• Outlier projects in these sectors *caused the sector as a whole to have a large overall net loss.* • Only 33.5 percent of Quality Jobs investment spending went to Louisiana-based businesses
Aquatic Species Impacts, Mid-Atlantic Fisheries Management Council	Biodiversity Impacts	• LNG activities (construction, operation, maintenance) pose significant potential impacts to nearshore habitats, estuarine ecosystems, and offshore habitats.
Fossil fuel racism in the United States: How phasing out coal, oil, and gas can protect communities, Timothy Q. Donaghy et al, Energy Research and Social Science	Cumulative impacts and environmental justice	Reviews recent studies on the disproportionate impacts of fossil fuel production on minority and low-income communities.
Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts / U.S. EPA	Cumulative impacts and environmental justice	Analyzes the following 6 impacts of climate on socially vulnerable populations: air quality and health, extreme temperature and health, extreme temperature and labor, coastal flooding and traffic, coastal flooding and property, and inland flooding and property.
EPA Legal Tools to Advance Environmental Justice: Cumulative Impacts Addendum	Cumulative impacts and environmental justice	Discussion of EPA's legal tools to address cumulative impacts, but with broader relevance to other government agencies.
Liquefying the Gulf Coast / Bullard Center	Cumulative impacts and environmental justice	• Analyzes cumulative impacts of LNG infrastructure, particularly on overburdened communities. • Critiques FERC's LNG EJ analyses • Includes recommendations for federal agencies, including DOE

Appendix IV – Energy Mix Dynamics of Large Importers of U.S. LNG

Europe (non-FTA countries)

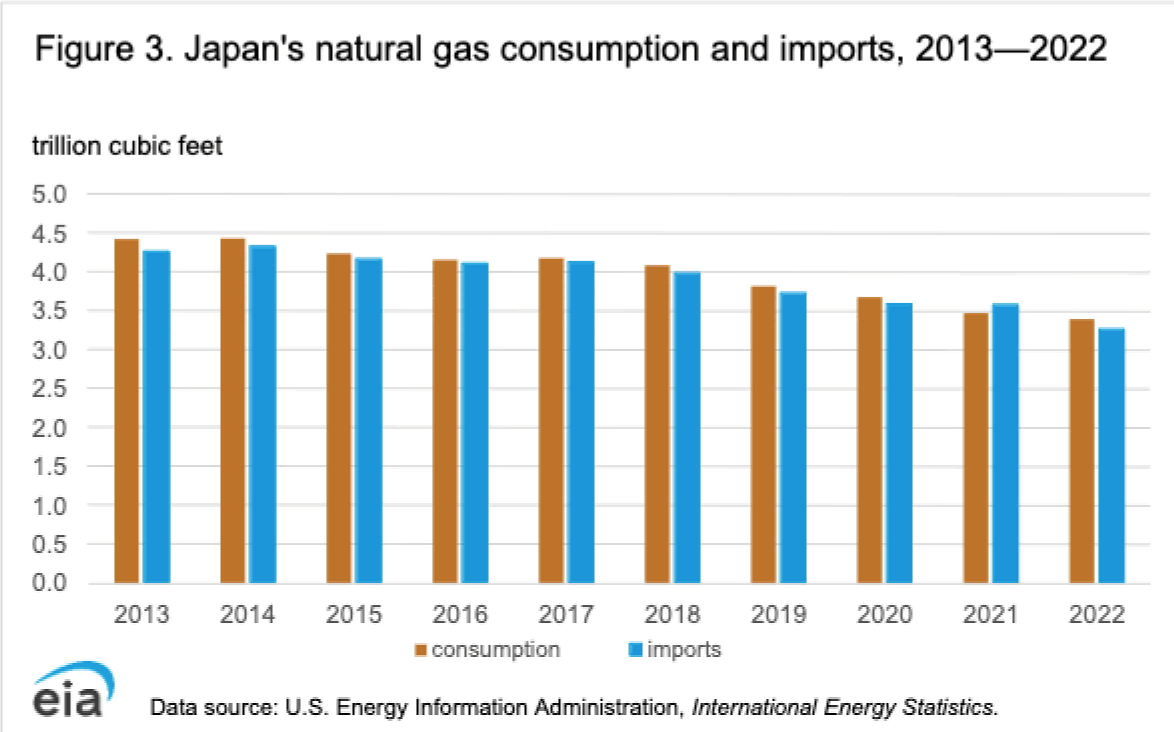
Following Russia's invasion of Ukraine, existing U.S. LNG export capacity was critical to meet Europe's energy security needs. The U.S. met this short-term need in line with President Biden's commitment to provide an additional 15 billion cubic meters (bcm) of U.S. LNG to Europe. In 2022, the U.S. delivered 56 bcm to Europe, an increase of 34 bcm from 2021. Europe entered the 2023 winter with gas storage at 96%, the second highest ever on record and far above the prior seasonal average. European Union (EU) storage was more than 58% full on April 1, 2024—the highest storage level on record for the season. The EU has now gone through two consecutive winters without significant disruptions to its energy system. This suggests that existing U.S. LNG export infrastructure has been more than sufficient to meet European needs.

Meanwhile, the EU has been moving quickly to build renewable energy, increase energy efficiency, and reduce gas demand to increase its energy security and meet ambitious, legally binding climate goals. New installed renewables capacity in 2022 and 2023 replaced the equivalent of 24 bcm of Russian gas with European renewable electricity. The EU reduced demand by 18% between August 2022 and January 2024 compared to the average between April 2017 and March 2022. This corresponds to savings of more than 65 bcm of gas in 2023 alone. On 25 March 2024, the European Council formally adopted a recommendation to Member States to continue reducing their gas consumption by at least 15% until 31 March 2025.

Under the REPowerEU plan, the EU recommitted to reducing overall gas consumption by 30% by 2030. The European Union Agency for the Cooperation of Energy Regulators (ACER) analysis confirms that EU LNG imports are nearing a peak. ACER's analysis of the more ambitious REPowerEU demand reduction scenario reveals two distinct periods of significance. Initially, from 2023 and until 2026, the existing long-term contracts for delivery in Europe are assessed as insufficient to meet the total EU LNG demand. However, from 2027 to 2030, the impact of REPowerEU measures on EU gas demand reductions is expected to result in over-contracted LNG position, with surplus volumes ranging from 30 bcm in 2027 to 66 bcm in 2030. The draft of the forthcoming EU 2040 climate target suggests even steeper cuts to EU gas demand from 2030-2040.

Japan (non-FTA country)

Japan's LNG imports peaked in 2014. Under Japan's Strategic Energy Plan, the share of LNG in the total electricity supply will decrease to 20% in 2030, down from 37% in 2019. Analysis shows that Japan's largest utilities — including JERA, Tokyo Gas, Osaka Gas, and Kansai Electric — are likely to face a over-contracted position of approximately 11 million tonnes per annum (mtpa) for the remainder of the decade.



Government climate and energy plans expect LNG-fired power generation to more than halve by 2030. As a result, estimates show that Japan's LNG demand could fall between 25.7 and 31.6 mtpa — or one-third of 2019 levels — if electricity generation targets are achieved. LNG imports have already fallen 22 mtpa since 2014.

In January 2024, Japan's LNG imports fell to the lowest level for that month in over a decade as nuclear reactor restarts, higher renewables output, and energy-savings efforts curbed fossil fuel consumption.

South Korea *(an FTA country)*

South Korea's 10th Basic Energy Plan (2022-2036) signals a decrease in the share of LNG in the country's power mix. The share will fall to 22.9% in 2030 and further to just 9.3% in 2036, compared with 29.2% in 2021 and 26.8% in 2018. Analysis shows a growing mismatch between LNG import infrastructure and demand targeted in the country's net-zero goal, given the South Korean government's climate targets have projected that the share of LNG-fired power generation will fall to 9.3% by 2036. Through 2036, the government expects natural gas demand to fall to 37.66 mtpa, a 17% decrease from 45.4 mtpa in 2022.

Based on 10^{th} Basic Plan for Long-Term Electricity Supply and Demand, the 2030 renewable energy target of 21.6% is lower than the 30.2% pledged in its Nationally Determined Contribution (NDC) in 2021. Among all power generating technologies, renewable energy installed capacity is planned to grow the most from approximately 30 GW in September 2023 to 73 GW in 2030 and 108 GW in 2036.