Examining The Sustainability Implications of Global LNG Trade Through A PESTLE Analysis of Political, Economic, Social, Technological, Legal, and Environmental Drivers

Maudlyn Ireju Victor-Ikoh[1], Victor Ikoh[2]

[1]Department of Computer Science and Informatics, Federal University Otuoke, Nigeria.

[2]MLA College, Sustainable Maritime Operations, Plymouth University.

DOI: https://doi.org/10.47772/IJRISS.2026.10200620

Received: 01 March 2026; Accepted: 06 March 2026; Published: 23 March 2026

ABSTRACT

Sustainable maritime transport is a growing concern for the International Marine Organization (IMO) as it seeks to align with the Sustainable Development Agenda of 2030. LNG energy is still within the fossil fuel family; however, it is a better energy source than fossil fuel resources like coal or oil. Consequently, since the use of LNG for energy sources is projected to continue substituting other fossil fuels and play a role in the reduction of carbon emissions, sustainable shipping and LNG trade are critical to address. This paper is a qualitative study that adopts a PESTLE analysis of global LNG Trade and the implications on sustainability. To examine how to achieve a sustainable balance, on how LNG shipping and trade activities operate to meet the present demand for LNG without compromising the sustainable state of future generations. The study reveals that global LNG trade operates within a multifaceted web of forces, each carrying significant implications for sustainable shipping and trade across generations. Geopolitical tensions continue to disrupt trade routes, while market volatility, social equity concerns, and mounting environmental pressures collectively challenge the industry's sustainability trajectory. Nevertheless, accelerating technological innovation signals a growing industry commitment to decarbonization.

Keywords: Global LNG Trade, SDG, LNG supply chain, Sustainable Development Agenda of 2030

INTRODUCTION

Sustainable maritime transport is a growing concern for the International Marine Organization (IMO) as it seeks to align with the Sustainable Development Agenda of 2030. Sustainability as defined by the United Nations' Brundtland Commission in 1987, means meeting the needs of the present without endangering the opportunity of future generations in meeting their own needs. What this implies is that for maritime transport to operate sustainably, shipping activity should be cost effective; its activity on the environment should not impact negatively on the environment more than what the environment can bear for the present and future; and the social community in contact with these activities, either directly or indirectly, should not also be negatively affected (Cabezas-Basurko, Mesbahi and Moloney, 2008). With 80% of world trade dominated by maritime Transport (UNCTAD, 2024), shipping is a vital link in the supply chain and hence a vital link in sustainable development (Pike, 2024). Therefore, shipping must develop sustainably, operating and maintaining a sustainable framework in marine operations for continuity into the unforeseeable future generations.

In fulfilling the 2030 sustainability development agenda, especially in terms of clean energy and zero-carbon emission, the shipping sector has witnessed high demand for Liquified Natural Gas (LNG) because LNG, by the majority, is valued as environmentally friendly energy and an alternative to fossil fuel resources. LNG energy is still within the fossil fuel family; however, it is a better energy source than fossil fuel resources like coal or oil. Thus, LNG energy is a compromise between achieving sustainable energy and decommissioning heavy carbon-emitting energy sources. Consequently, since the use of LNG for energy sources is projected to continue substituting other fossil fuels and play a role in the reduction of carbon emissions, sustainable shipping and LNG trade are critical to address. The Secretary-General of UN Trade and Development adds that "balancing

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue II February 2026

environmental sustainability, regulatory compliance and economic demands is vital for a prosperous, equitable and resilient future for maritime transport" (UNCTAD, 2023). To attain a sustainable balance, how might LNG shipping and trade activities operate to meet the present demand for LNG without compromising the sustainable state of future generations? The PESTLE strategic model will be used for making this analysis.

This is a qualitative study that adopts the PESTLE analytical framework, which involves Political, Economic, Social, Technological, Legal, and Environmental dimensions as the primary analytical lens for interrogating how each factor influences the sustainability of global LNG Trade.

LITERATURE REVIEW

The PESTLE analysis model is a technique used to identify and analyse interrelated external factors that influence a venture. LNG shipping and trade are ventures influenced by various PESTEL factors as highlighted in Figure 1. These factors will be elaborated in subsequent paragraphs in light of how they hinder or promote sustainability.

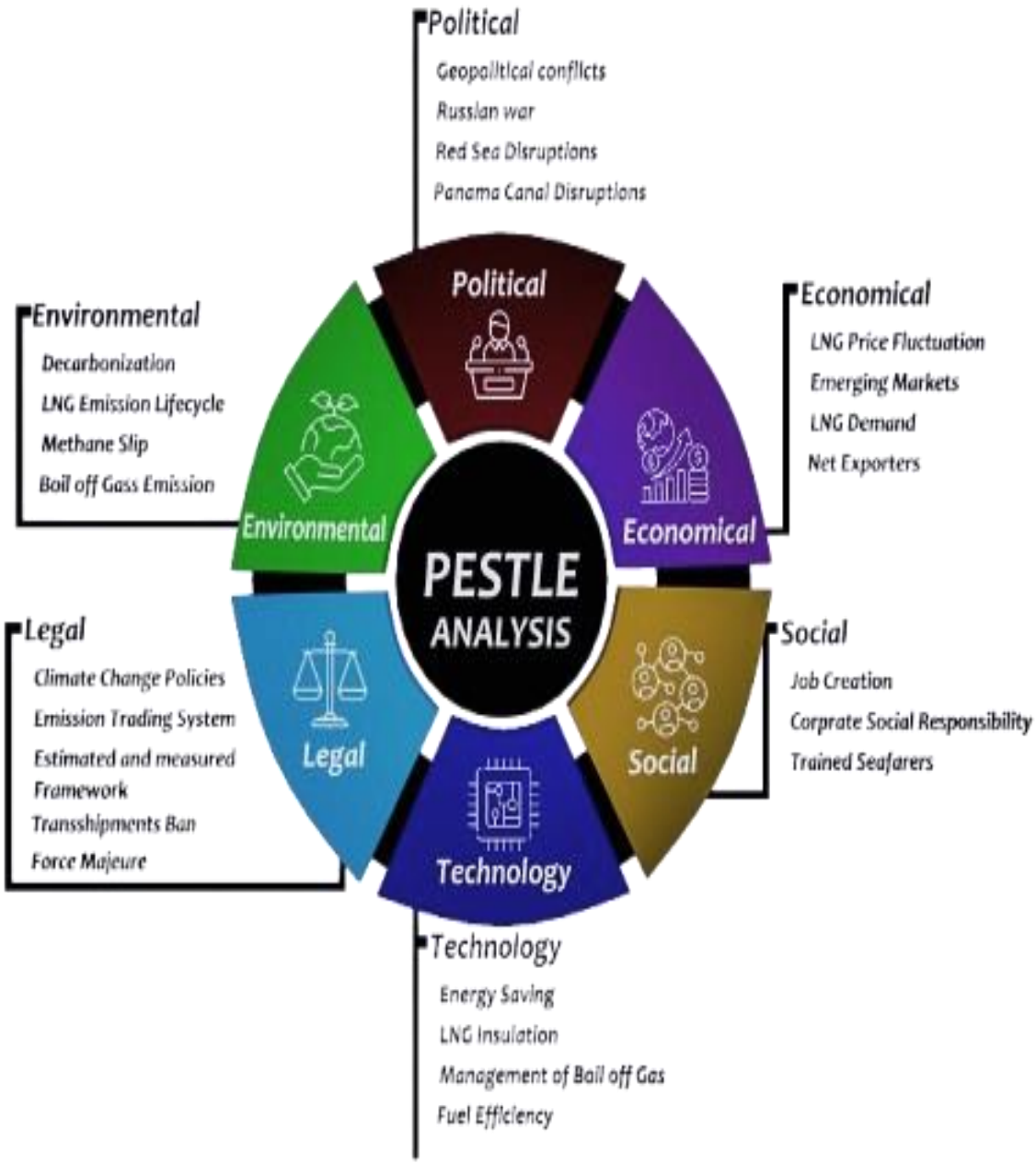

Fig 1. PESTLE Factors Impacting LNG Shipping and Trade

Political Factors

Trading LNG within the same country often experiences little or no political friction. If there is, it is usually over control of resources. However, when shipping and trading LNG within nations, geopolitical conflicts ensue with consequences. In 2022, geopolitical conflicts significantly increased the rate of spot charter for LNG carriers (Michail and Melas, 2022), and also affected LNG freight rates. In 2023 and the first half of 2024, geopolitical issues affected maritime trade volumes across cargo types and routes (UNCTAD, 2024). The Russian war, in particular, led to a cut down of LNG trading through gas pipelines to European countries. The Red Sea and Panama Canal Disruptions have increased shipping distance routes. The Red Sea leads to the Suez Canal, shortening travel distance. However, with war and recent attacks on ships on that route, it is now considered high-risk. A likely escalation of war in the Middle East could probably threaten the flow of marine trade through the Strait of Hormuz and 23% of global LNG flows (Cutright and Palti-Guzman, 2023). The consequences ensuing from geopolitical rifts often weigh negatively on shipping and LNG trade.

Notwithstanding the geopolitical risks and consequences, opportunities to maintain sustainable trading of LNG for the present generation would involve targeting markets that have emerged and strategically considering signing a long-term agreement to strengthen the trade pact, which may mitigate geopolitical tensions. Alternatively, net importers can reconsider their reliance on foreign suppliers for LNG and seek regional trade relations with persistent geopolitical tensions and shipping route uncertainties (Wang et al., 2025).

Economic Factors

The economies of nations trading LNG have been impacted globally, and the LNG market is witnessing significant disruptions following events such as the Russian-Ukrainian war (Botão, De Medeiros Costa and Santos, 2023), increased shipping distance due to disturbances in global shipping routes (UNCTAD, 2024), and slow economic growth. This has resulted in unprecedentedly high prices and the emergence of new market opportunities. As an example, the US has seen economic growth profiting from new market opportunities from Europe, which became its largest market, with 65% of its total LNG heading to European ports following the shutdown of the Russia gas pipeline. The US LNG exports have surged by nearly 135% since 2019, making the US the world's largest LNG exporter in 2023 (Cutright and Palti-Guzman, 2023), and is still the top exporter of LNG in 2024 with a slight decline from 2023 (GECF, 2024).

LNG prices will likely be competitive with the emergence of new markets, which will drive higher trade volumes (UNCTAD, 2024). However, as major LNG buyers begin implementing decarbonization policies to drive the sustainability agenda for cleaner energy, the demand for LNG may decline; consequently, prices of LNG may become less competitive, possibly affecting the economic profitability of LNG projects and investments (Botão, De Medeiros Costa, and Santos, 2023). High LNG prices are an incentive for the adoption of sustainable energies, but may bite negatively to exporting nations; however, economic profit from LNG should not come at the expense of addressing clean energy. Therefore, nations must consider the decarbonization push that accelerates the shift away from fossil fuels, regardless of how high the LNG price may be set. LNG stakeholders are to adopt more sophisticated risk management and hedging strategies, which in turn will require better systems and risk models (Morris, 2025).

Environmental Factors

Global LNG trade depends heavily on the maritime sector as its backbone for transportation of LNG but this is not without significant environmental threats due to the carbon emissions in the LNG supply chain lifecycle. Figure 2 shows the LNG supply chain lifecycle and the emissions at each hub. Transporting LNG alone contributes to 4% of the total carbon emissions in the supply chain. This implies serious concerns about the total lifecycle emissions of LNG. For sustainable maritime transport of LNG, an innovative outlook for the reduction of emissions in the supply chain is vital. "A Sustainable Maritime Transportation System must minimize the environmental impact of shipping and activities of maritime industries. Environmental stewardship should be reflected in the development and implementation of global standards for pollution prevention and protection of the marine environment" (IMO, 2013). Therefore, LNG-producing nations should manage the impact of gas flaring, which in the longer term contributes to carbon dioxide and methane emissions. Search for innovations

that could be implemented at each hub of the LNG supply chain lifecycle to reduce the percentile emissions substantially.

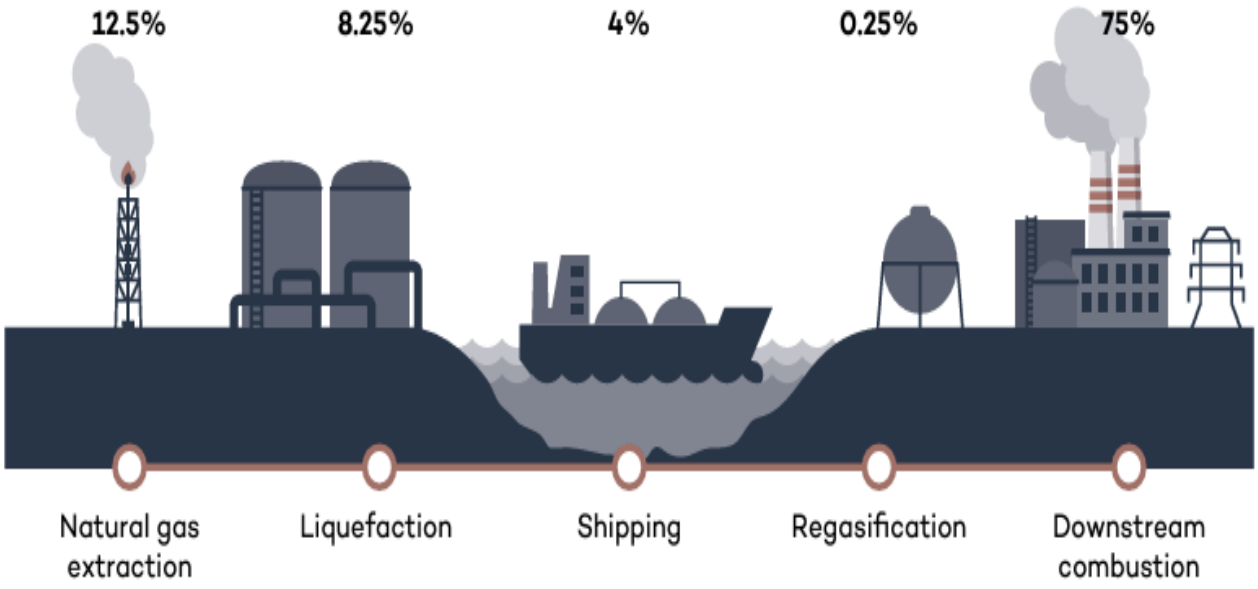

Fig. 2 Carbon emissions in the LNG supply chain. Source: (Vazi and Bridle, 2024, fig. 3)

Technological factors

Technological advancements are reshaping carrier vessels, enforcing decarbonization, and ensuring maritime sustainability. In June 2022, a 33-day transoceanic autonomous navigation test of "Prism Courage" covering 5500nm was conducted. The test results show that autonomous navigation technology can offer a 7% improvement in fuel efficiency and a 5% reduction in greenhouse gas emissions (Xiao et al., 2024). Electric and hybrid electric propulsion is another proven technology, an alternative to mechanical propulsion. Current LNG carriers are designed for a speed of 19.5 km, however, several sources indicate the current average sailing speed to be around 15 km. This means they are not operating optimally and they give off higher emissions (Wärtsilä, 2024). According to Wärtsilä hybrid electric design will reduce greenhouse gas emissions by 15% and methane slip by over 20 %. Hybrid electric design is a sustainable move towards the UN Sustainable Development Goal (SDG) 13 to take urgent action to combat climate change and its impacts.

Another technology for a sustainable maritime operation is improved insulation and re-liquefication of boil-off gas. Boil-off gas if vented into the atmosphere, contributes to greenhouse gas emissions. Failing to capture boil-off gas sabotages the maritime transport sustainability goal. GTT NEXT1 technology is a cryogenic containment used to contain LNG at low temperatures and at atmospheric pressure to reduce the daily boil-off rate to 0.07%V/d (GTT, 2024). These innovations are indications that the shipping industry is leveraging technology to maximize its sustainability performance and aligning with SDG 9 to foster innovation and build resilient infrastructure for sustainable industrialization.

Social Factors

Understanding the social factors that impact communities located throughout the LNG supply chain cannot be underestimated if LNG shipping and trade must operate sustainably. Communities are significantly affected by the boom-bust cycles (Buse et al., 2019) associated with LNG development, production, and trade. During boom periods, communities enjoy job creation and tax revenue increases, but may experience increased pressure on limited infrastructure. In bust season, communities face unemployment, local business closures, property devaluation, and net out-migration, not forgetting the corporate social responsibility problem associated with it

(Wood and Leather, 2024). In return, Seafarers, ships, and shipping lanes must be protected by the communities (IMO, 2013) for all-around community sustainability.

Furthermore, the quality of life of seafarers at sea is also important to sustain the maritime transport industry (IMO, 2013). The SDG 8 advocates for decent work. Therefore, seafarers who are the lifeblood of world trade cum LNG Trade require decent work-life and environment. This involves training for seafarers and decent work hours. Studies show that seafarers are happiest when they sail within 1-3 months (Seafarers Happiness Index, 2024). This happiness index has been seeing an upward trend. Improved decent work practices will keep this trend upward, resulting in a more sustainable work environment for seafarers.

Legal Factors

Sustainability policies, sanctions, and legal frameworks are shaping LNG Trade. In this context, policymakers have the delicate task of balancing energy security, affordability, and sustainability. One such initiative toward creating balance is the LNG legal framework for estimated and measured emissions (Stern, 2022). This means laws, policies, and guidelines for calculating or directly quantifying emissions. Methane emissions regulation is another policy for regulating methane emissions. In December 2023, the US Environmental Protection Agency (EPA) made a final ruling on methane emissions, which is expected to reduce its emissions significantly. In May 2024, the EPA announced a final rule for methane emission reporting, a key part of the US Inflation Reduction Act's methane emission reduction program (Ouki, 2024). Another legal structure is the Emission Trading System (ETS), which means a methane fee for some volume of GHG, which will be used to purchase financial instruments representing reductions or removals of GHGs through reforestation or renewable energy projects (Stern, 2022).

A transshipment ban is another policy implemented to enforce sustainability compliance. However, the impact of the transshipment ban on LNG affects LNG supply contract transshipment services and several other aspects that facilitate the contract's execution. A declaration of force majeure by a terminal operator under a transshipment ban appears to be the most likely contractual response to the transshipment ban, which allows parties to be relieved from their contractual obligations when unforeseen events prevent them from fulfilling them. As in the case of sanctions prohibiting the transshipment of Russian LNG through EU ports to non-EU countries (Yafimava et al., 2024). Lastly, seafarers are backed by maritime labour law that ensures they work sustainably, following SDG 8 for decent work. The Maritime Labor Convention (MLC) of 2006 ensures fair treatment at work, commensurate wages, breaks, and better living standards for seafarers to contribute to their well-being and job satisfaction.

DISCUSSION

By 2050, global economies will have committed to achieving net-zero greenhouse gas emissions. This is a critical factor shaping the sustainability of LNG shipping and trade. LNG has become a global energy market; consequently, LNG trade is growing, particularly the seaborne LNG market for countries that lack gas reserves or pipelines. The PESTLE analysis has exposed some of the implications of sustainable shipping and the trade of LNG. This calls for urgent actions on stakeholders to immediately implement measures to reduce carbon emissions, while energy-saving plans must be embraced via investment in an efficient renewable fuel for the marine sector, and enforce the use of innovations that decarbonize the shipping sector. The PESTLE analysis also reveals that sustaining this growth responsibly demands coordinated, system-wide transformation across the entire value chain. Producers must embed flexibility in offtake agreements to buffer against demand shocks, traders must leverage dynamic cargo reallocation to navigate geopolitical disruptions, and buyers must diversify sourcing to manage market volatility. Simultaneously, facility operators must adopt predictive maintenance technologies to improve production efficiency, while shipping teams require real-time vessel visibility to manage increasingly longer trade routes. LNG explorers must become responsible to their host communities through their corporate social responsibility and continuously seek out innovations that could be implemented to substantially reduce emissions at each hub of the LNG supply chain lifecycle. Invest in decent work for seafarers that promotes life-work, family, and social life balance. Legal frameworks are the compliance tools needed to drive the decarbonization agenda. Adopting strict policies and sanctions that promote decarbonization is highly

recommended for sustainable global trade. Without regulatory convergence, technological and economic efforts risk remaining fragmented and insufficient.

CONCLUSION

This PESTLE analysis has shown that global LNG trade operates within a complex web of political, economic, social, technological, legal, and environmental forces, each of which carries significant implications for the long-term sustainability of global LNG shipping and trade activities. The findings demonstrate that while LNG continues to play a critical role in meeting present global energy demand, its trade is increasingly shaped by geopolitical tensions, market disruptions, and environmental pressures that collectively challenge the industry's ability to operate sustainably across generations. Political frictions between trading nations continue to disrupt global shipping routes. On a bright note, technological advancements signal a growing industry commitment to reshaping LNG transportation for a more sustainable future. Therefore, in order to achieve a truly sustainable balance in global LNG trade, it will require a coordinated approach that harmonizes geopolitical cooperation, economic resilience, technological innovation, and robust environmental governance to ensure that the energy needs of the present are met without compromising the sustainability of future generations.

REFERENCES

1. Buse, C.G. et al. (2019) 'Locating community impacts of unconventional natural gas across the supply chain: A scoping review,' The Extractive Industries and Society, 6(2), pp. 620–629.
2. Botão, R.P., De Medeiros Costa, H.K. and Santos, E.M.D. (2023) 'Global Gas and LNG Markets: demand, supply dynamics, and implications for the future,' Energies, 16(13), p. 5223. https://doi.org/10.3390/en16135223.
3. Cabezas-Basurko, O., Mesbahi, E. and Moloney, S.R. (2008) 'Methodology for sustainability analysis of ships,' Ships and Offshore Structures, 3(1), pp. 1–11. https://doi.org/10.1080/17445300701673841.
4. Cutright, A. and Palti-Guzman, L. (2023) Fragile Equilibrium: LNG Trade Dynamics and Market Risks, International Energy Forum. International Energy Forum and SynMax. https://www.ief.org/focus/ief-reports/fragile-equilibrium-lng-trade-dynamics-and-market-risks.
5. GECF (2024) GECF Monthly Gas Market Report – October 2024, GECF. https://www.gecf.org/insights/monthly-gas-market-report.aspx?p=1&s=.
6. GTT (2024) GTT NEXT1 system. https://gtt.fr/technologies/gtt-next1.
7. IMO (2013) World Maritime Day a Concept of a Sustainable Maritime Transportation system, sustainabledevelopment.un.org.
8. Michail, N.A. and Melas, K.D. (2022) 'Geopolitical risk and the LNG-LPG trade,' Peace Economics Peace Science and Public Policy, 28(3), pp. 243–265. https://doi.org/10.1515/peps-2022-0007.
9. Morris, A. (2025, June). Future of LNG: Global strategy and supply outlook: PwC. PwC. Retrieved March 12, 2026, from https://www.pwc.com/us/en/industries/energy-utilities-resources/library/future-of-lng.html
10. Ouki, M. (2024) 'Market and regulatory headwinds build for MENA gas exporters to Europe,' Oxford Institute for Energy Studies Or [Preprint].
11. Pike, K. (2024) Marine and maritime sustainability [TLP].
12. Seafarers Happiness Index (2024) Seafarers Happiness Index Quarter 3 2024. Seafarers Happiness Index. https://www.seafarershappinessindex.org/ (Accessed: November 12, 2024)
13. Stern, J. (2022) 'Greenhouse Gas Emissions from LNG Trade: from carbon neutral to GHG-verified,' Oxford Institute for Energy Studies [Preprint].
14. UNCTAD (2023) Review of Maritime Transport 2023. Towards a green and just transition https://unctad.org/publication/review-maritime-transport-2023.
15. UNCTAD (2024) Review of Maritime Transport 2024. Navigating Maritime Chokepoints https://unctad.org/publication/review-maritime-transport-2024.
16. Vazi, B. and Bridle, R. (2024) A Balancing Act: Considerations for the expansion of liquefied natural gas projects in Nigeria, www.iisd.org. International Institute for Sustainable Development. https://www.iisd.org (Accessed: November 5, 2024).

17. Wang, K., Zhao, S., & Wang, Z. (2025). Global liquefied natural gas market development and future outlook. Natural Gas Industry B, 12(5), 636–646. https://doi.org/10.1016/j.ngib.2025.10.001
18. Wärtsilä (2024) Hybrid-electric propulsion for large LNG carriers. https://www.wartsila.com/marine/products/ship-electrification-solutions/hybrid-electric-lng-carrier.
19. Wood, D.A. and Leather, D.T.B. (2024) 'Australian LNG sector: struggling to achieve commercial and environmental sustainability or community satisfaction,' in Elsevier eBooks, pp. 125–161. https://doi.org/10.1016/b978-0-443-13420-3.00009-3.
20. Xiao, G. et al. (2024) 'Sustainable Maritime Transport: A review of intelligent shipping technology and green port construction applications,' Journal of Marine Science and Engineering, 12(10), p. 1728. https://doi.org/10.3390/jmse12101728.
21. Yafimava, K. et al. (2024) 'EU sanctions on Russian LNG: choices and consequences,' Oxford Institute for Energy Studies [Preprint].