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Environmental implications of LNG usage: A comparative review of policies in the USA and Africa

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Abstract

This study presents a comparative review of the environmental implications of Liquefied Natural Gas (LNG) usage in the United States (USA) and Africa, examining the policies that govern LNG-related environmental concerns in these regions. Recognizing the global significance of LNG as a pivotal energy source, the analysis explores the distinct policy landscapes shaping its utilization in two diverse contexts. In the USA, where LNG has emerged as a key component of the energy mix, the study scrutinizes federal and state-level environmental policies. This includes regulations governing the extraction, production, and transportation of LNG, with a focus on mitigating emissions, preserving air and water quality, and ensuring ecological sustainability. The review also encompasses the regulatory frameworks promoting the integration of LNG into the broader strategy for reducing carbon footprints in the country. In contrast, the study delves into the nuanced environmental policies across multiple African nations where LNG is increasingly gaining prominence. Africa, with its unique environmental challenges and diverse regulatory approaches, presents a dynamic landscape for LNG utilization. The analysis explores how environmental policies address the specific needs and challenges of African nations, emphasizing sustainable practices, biodiversity conservation, and community welfare. By undertaking this comparative review, the study aims to highlight commonalities and disparities in the environmental policies governing LNG usage in the USA and Africa. Understanding these variations can contribute to the development of informed and context-specific approaches to LNG-related environmental challenges. Additionally, the study seeks to identify areas for potential collaboration and knowledge exchange, fostering a global dialogue on sustainable LNG practices. Ultimately, the findings aim to inform policymakers, industry stakeholders, and environmental advocates, promoting responsible LNG usage that aligns with both regional and global environmental goals.

Keywords: Environmental; Implications; LNG Usage; Review; Policies

1. Introduction

The global energy landscape has witnessed a profound transformation with the emergence of Liquefied Natural Gas (LNG) as a pivotal and versatile energy source (Adekoya *et al*., 2024). As a cleaner alternative to traditional fossil fuels, LNG has garnered significant attention for its potential to address growing energy demands while mitigating environmental impacts (Al-Enazi *et al*., 2021). Acknowledging the importance of sustainability in energy transitions, this study focuses on the environmental implications of LNG usage, undertaking a comprehensive comparative review of policies governing its utilization in two distinct regions: the United States (USA) and Africa.

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LNG, derived from natural gas through a liquefaction process, has become a cornerstone in the diversification of global energy portfolios (Shah *et al*., 2021). Its liquefied form facilitates efficient storage and transportation, making it a key enabler of energy security and accessibility across the world (Zhang *et al*., 2024). LNG's role extends beyond traditional energy sources, positioning it as a catalyst for meeting the demands of a rapidly evolving global energy landscape (Telegina and Chapaikin, 2022). In the pursuit of sustainable energy solutions, the environmental implications of energy sources have come to the forefront. The ecological footprint of LNG, spanning its entire lifecycle, requires careful consideration to ensure that its benefits in terms of lower carbon emissions are maximized (Park *et al*., 2022). Striking a balance between energy security and environmental responsibility is paramount for a successful transition to cleaner energy systems.

This study aims to shed light on the diverse policy landscapes shaping the environmental aspects of LNG usage in the USA and Africa. By conducting a comparative analysis, the study seeks to identify commonalities, disparities, and areas for improvement in the environmental policies of these regions. The overarching goal is to contribute valuable insights that can inform sustainable practices, foster international collaboration, and guide policymakers towards a responsible and environmentally conscious approach to LNG utilization (Serra and Fancello, 2020).

2. Environmental Policies in the USA

As the United States (USA) navigates the complex landscape of energy production and consumption, environmental policies play a pivotal role in shaping the sustainable utilization of Liquefied Natural Gas (LNG) (Litvinenko, 2020). This segment provides an in-depth examination of the federal and state-level environmental regulations governing LNG in the USA, highlighting their focus on emissions mitigation, air and water quality, and integration into broader carbon reduction strategies. The Environmental Protection Agency (EPA) stands at the forefront of federal efforts to regulate LNG operations. Stringent emission standards are in place, addressing methane and other greenhouse gas emissions throughout the entire LNG lifecycle. This includes regulations on exploration, extraction, and production activities, emphasizing the reduction of fugitive emissions to minimize environmental impact.

Air and water quality regulations are closely monitored, ensuring that LNG facilities adhere to strict standards to prevent pollutants from adversely affecting local ecosystems. The Clean Air Act and Clean Water Act provide the regulatory framework to control emissions and discharges, fostering responsible LNG practices (Ballentine *et al*., 2021). The USA's commitment to carbon reduction is reflected in the integration of LNG into broader strategies aimed at transitioning to cleaner energy sources. The federal government actively promotes the use of natural gas, including LNG, as a bridge fuel in the transition to a low-carbon economy. This integration aligns with national climate goals, emphasizing the role of LNG in reducing carbon emissions compared to conventional fossil fuels.

While federal regulations set the overarching standards, individual states in the USA have the autonomy to enact additional policies tailored to their unique environmental considerations (Lee *et al*., 2022). State-level regulations often go beyond federal requirements to address localized challenges and promote sustainable practices.

State environmental agencies work in tandem with federal counterparts to enforce regulations specific to LNG facilities operating within their jurisdictions. This collaborative approach ensures a comprehensive and regionally nuanced approach to environmental protection. Case studies from states with robust environmental policies showcase successful implementation and positive outcomes. States like California, with ambitious climate goals, have implemented stringent regulations on emissions and have actively encouraged the adoption of cleaner energy alternatives, including LNG (Payne, 2020).

Successful outcomes are measured not only in emissions reductions but also in the development of innovative technologies and practices that enhance the environmental performance of LNG operations. Collaboration between federal and state agencies, along with industry stakeholders, has led to the identification and dissemination of best practices that contribute to sustainable LNG usage in the USA.

Environmental policies in the USA encompass a diverse array of regulations and initiatives aimed at mitigating ecological challenges. Legislation such as the Clean Air Act and Clean Water Act establishes stringent standards for pollutants, safeguarding air and water quality. The Endangered Species Act protects biodiversity by identifying and conserving imperiled species and their habitats. Additionally, the National Environmental Policy Act mandates thorough environmental assessments for federal projects. Climate-related policies, like the Clean Power Plan, focus on reducing greenhouse gas emissions to combat global warming. The integration of science-based strategies and continual policy evolution is crucial for sustainable resource management and resilience against environmental threats (Shao *et al*., 2021).

3. Environmental Policies in African Nations

As Africa undergoes rapid economic development and increasing energy demands, the adoption of Liquefied Natural Gas (LNG) emerges as a critical component of the continent's energy portfolio. This section provides an insightful analysis of environmental policies in key African nations embracing LNG, with a focus on biodiversity conservation, community welfare, and the unique challenges and opportunities within the African environmental policy landscape.

The adoption of LNG in Africa is gaining momentum, driven by the continent's pursuit of cleaner and more sustainable energy sources. LNG is recognized for its potential to meet the growing energy demands of African nations while aligning with global efforts to reduce carbon emissions (Al-Kuwari and Schönfisch, 2022). As nations seek to diversify their energy mix, LNG emerges as a flexible and efficient solution, capable of supporting industrial growth and enhancing energy security.

Environmental policies in African nations are designed to balance the economic benefits of LNG with the preservation of biodiversity and the well-being of local communities (Acosta *et al*., 2020). Nations such as Mozambique, Nigeria, and Tanzania are at the forefront of LNG adoption, each tailoring its environmental policies to address the specific challenges and opportunities within its borders. Biodiversity conservation measures focus on protecting ecologically sensitive areas affected by LNG operations. Robust environmental impact assessments (EIAs) are conducted to identify and mitigate potential threats to flora and fauna, ensuring the coexistence of LNG projects with local ecosystems. Community welfare is a central consideration, with policies emphasizing the inclusive and equitable distribution of benefits arising from LNG projects. Social responsibility initiatives, including job creation, education, and healthcare, are integral components of environmental policies, fostering sustainable development alongside LNG activities (Mollaoglu *et al*., 2024).

The African environmental policy landscape is characterized by its diversity, reflecting the continent's varied ecosystems, socio-economic conditions, and developmental priorities. Policymakers face the dual challenge of supporting economic growth through LNG development while safeguarding environmental integrity. Unique challenges, such as inadequate infrastructure and limited regulatory capacity in some nations, underscore the importance of tailoring policies to local contexts. Environmental policies are evolving to address these challenges by promoting technology transfer, capacity building, and international collaboration. Opportunities arise from Africa's vast renewable energy potential, and environmental policies increasingly integrate LNG as a transitional fuel toward a more sustainable and diversified energy future (Kabeyi and Olanrewaju, 2022). This approach aligns with the African Union's Agenda 2063, emphasizing the role of LNG in powering economic transformation while minimizing ecological impact.

Environmental policies in African nations are critical for addressing the region's unique ecological challenges. Many countries have adopted policies to combat deforestation, soil degradation, and loss of biodiversity. Efforts focus on sustainable land management, reforestation, and wildlife conservation. Water resource management policies aim to ensure equitable access and safeguard against pollution. Some nations prioritize renewable energy sources to mitigate climate change impacts. Challenges include balancing economic development with environmental conservation. International collaborations, like the African Union's Agenda 2063, seek to harmonize policies for regional sustainability (Masanja, 2022). Scientifically informed strategies are essential to address the complex interplay of environmental, social, and economic factors in Africa.

In conclusion, the adoption of LNG in Africa is intricately woven into the fabric of evolving environmental policies. As nations navigate the complexities of balancing energy needs with environmental conservation, the continent stands poised to leverage LNG's benefits responsibly (Alita *et al*., 2023). This comparative review illuminates the dynamic interplay between environmental policies, LNG adoption, and sustainable development across African nations.

4. Comparative Analysis

Liquefied Natural Gas (LNG) plays a pivotal role in the global energy landscape, and as nations worldwide incorporate LNG into their energy portfolios, environmental policies become crucial in mitigating potential environmental impacts (Kotagodahetti *et al*., 2023). This section provides a comparative analysis of environmental policies related to LNG usage in the United States (USA) and African nations, identifying commonalities, disparities, and evaluating the effectiveness of these policies in addressing environmental concerns. Additionally, we consider the impact of cultural, economic, and geographical factors on the variations observed in these policies. Robust Federal Oversight: The USA exhibits a strong federal regulatory framework overseen by agencies such as the Environmental Protection Agency (EPA) and the

Department of Energy (DOE) (Krahn, 2022). Emission Reduction Targets: Both the federal government and individual states in the USA have emission reduction targets, emphasizing a commitment to environmental sustainability.

State-Level Variations: Environmental policies related to LNG in the USA can vary significantly at the state level. States like California may have more stringent regulations compared to others, reflecting regional priorities. Regulatory Approaches: While federal oversight is a commonality, the specific regulatory approaches and mechanisms may differ, impacting the stringency of environmental requirements. Environmental Impact Assessments (EIAs): Many African nations, including Nigeria, Mozambique, and Tanzania, conduct comprehensive EIAs to assess and mitigate the environmental impact of LNG projects (Adeleke *et al*., 2019). Community Engagement: Both the USA and African nations recognize the importance of engaging local communities in the decision-making process surrounding LNG projects. Developmental Context: African nations, facing diverse developmental challenges, may prioritize economic growth alongside environmental considerations. This can result in variations in policy focus compared to more mature economies. Capacity and Infrastructure: Disparities in regulatory capacity and infrastructure can lead to differences in the enforcement and implementation of environmental policies.

The USA has well-established monitoring systems to track emissions, ensuring compliance with environmental regulations. Continuous refinement of policies based on scientific advancements and changing environmental dynamics contributes to policy effectiveness. African nations are enhancing their regulatory capacity, and the effectiveness of policies is evolving alongside this capacity building (Kasprowicz *et al*., 2020). Flexibility in adapting policies to the unique environmental challenges of each nation demonstrates an adaptive approach to address concerns effectively. Cultural values in the USA often emphasize public participation in decision-making processes, leading to inclusive environmental policies. African policies may reflect cultural values that prioritize community involvement, recognizing the importance of local perspectives in shaping environmental regulations. The economic capacity of the USA enables the adoption of advanced technologies to minimize environmental impacts, influencing policy directions. Economic African nations, in pursuit of economic growth, may adopt policies that balance environmental sustainability with the imperative to uplift communities through energy projects (Vincent *et al*., 2021). The USA's vast and diverse ecosystems necessitate region-specific policies, contributing to variations in environmental regulations. African nations, with rich biodiversity hotspots, craft policies addressing the protection of these ecosystems, showcasing geographical considerations (Ilugbusi *et al*., 2020).

A comparative analysis of the environmental implications of liquefied natural gas (LNG) usage involves assessing its impact on ecosystems, air quality, and climate change, juxtaposed against alternative energy sources. LNG combustion produces fewer greenhouse gas emissions compared to conventional fossil fuels like coal and oil, making it a transitional cleaner energy option. However, methane leakage during the extraction, production, and transportation phases can offset these benefits, as methane is a potent greenhouse gas.

Comparing LNG to renewable energy sources like solar or wind power reveals differences in long-term sustainability. While LNG can provide a reliable energy source, its finite nature raises concerns about future resource availability. Additionally, LNG extraction may involve habitat disruption and water pollution.

In contrast, renewable energy sources have minimal emissions and can contribute to a more sustainable energy landscape. However, challenges such as intermittency and storage capacity must be addressed to ensure consistent energy supply.

Lifecycle assessments considering the entire LNG supply chain and alternatives are crucial for informed decision-making. Comparative analysis aids policymakers in crafting effective environmental policies, balancing energy demands with ecological preservation in a rapidly evolving energy landscape (Abrahams *et al*., 2023).

In conclusion, the comparative analysis underscores the dynamic interplay between environmental policies, LNG usage, and the broader socio-economic and cultural contexts of the USA and Africa. Recognizing the shared commitment to environmental stewardship and understanding the contextual nuances in policy formulation is essential for promoting sustainable LNG practices globally (Hossain *et al*., 2021).

5. Areas for Improvement and Collaboration

As nations navigate the challenges associated with Liquefied Natural Gas (LNG) usage, it is imperative to identify areas for improvement in environmental policies and explore collaborative initiatives (Serra and Fancello, 2020). This section outlines recommendations for enhancing environmental policies in both the United States (USA) and Africa, identifies potential collaboration opportunities between regions, and explores knowledge exchange initiatives to promote

sustainable LNG practices. Develop a more cohesive and harmonized regulatory framework at the federal and state levels to minimize disparities in environmental policies (Montez and Farina, 2021). This can enhance clarity for industry stakeholders and streamline compliance efforts. Introduce incentives for the development and implementation of innovative technologies aimed at further reducing the environmental impact of LNG projects. Encouraging technological advancements aligns with the USA's commitment to sustainability.

Strengthen mechanisms for involving local communities in decision-making processes related to LNG projects. Establishing platforms for constructive dialogue can foster mutual understanding and trust (Hung-Baesecke and Chen, 2020). Invest in building regulatory capacity in African nations to ensure effective implementation and enforcement of environmental policies. This includes training personnel, improving monitoring capabilities, and enhancing institutional frameworks. Develop policies that consider the unique environmental, social, and economic contexts of each African nation. Tailoring regulations to the specific challenges and opportunities within each country can lead to more effective outcomes. Foster multi-stakeholder engagement, involving governments, industry, local communities, and environmental organizations (Eikelenboom and Long, 2023). Collaborative decision-making processes can result in more comprehensive and inclusive environmental policies (Jager *et al*., 2020).

Collaborate on joint research and development initiatives between the USA and African nations. Shared projects can focus on advancing cleaner technologies, reducing emissions, and enhancing environmental monitoring. Establish policy exchange programs to facilitate knowledge transfer and mutual learning. Representatives from regulatory bodies, environmental agencies, and industry stakeholders can participate in collaborative workshops and seminars. Create platforms for the sharing of best practices in environmental policy implementation. Regular forums, webinars, and conferences can serve as avenues for exchanging successful strategies and addressing common challenges (Sottilare, 2023).

Implement training programs and capacity-building initiatives where experts from the USA contribute to building regulatory expertise in African nations. This can include workshops, seminars, and collaborative projects. Foster international partnerships between environmental organizations, research institutions, and industry bodies. Collaborative initiatives can address global environmental challenges, leveraging combined expertise. Facilitate the transfer of environmentally friendly technologies from the USA to African nations (Wang *et al*., 2022). This can be achieved through technology-sharing agreements, joint ventures, and collaborative projects aimed at improving sustainability practices.

Efforts to address environmental implications of liquefied natural gas (LNG) usage can benefit from targeted improvements and collaborative initiatives across several key areas (Jang *et al*., 2021). Firstly, reducing methane leakage throughout the LNG supply chain is crucial. Enhanced monitoring technologies and stricter regulations can mitigate this potent greenhouse gas, improving the overall climate footprint of LNG.

Technological advancements in extraction processes can minimize habitat disruption and water pollution associated with LNG production (Shamoon *et al*., 2022). Collaborative research and development can drive innovation toward more sustainable practices, ensuring a balance between energy needs and ecological preservation.

Furthermore, collaboration is essential in developing and implementing standardized life cycle assessments (LCAs) for LNG and alternative energy sources. LCAs should comprehensively evaluate environmental impacts, providing policymakers and stakeholders with a holistic view to guide decision-making.

International cooperation is vital to establish consistent environmental standards for LNG production and consumption. Shared best practices and knowledge exchange can promote global sustainability, avoiding the shifting of environmental burdens to less regulated regions (Chan *et al*., 2020).

Promoting research on LNG's long-term sustainability and encouraging investments in renewable energy technologies are areas for improvement. This collaboration can accelerate the transition towards cleaner energy alternatives, mitigating the environmental impact of fossil fuel use.

In conclusion, identifying areas for improvement in environmental policies and fostering collaboration between the USA and Africa is essential for promoting sustainable LNG practices globally (Kulkov *et al*., 2023). By implementing recommendations, seizing collaboration opportunities, and engaging in knowledge exchange initiatives, both regions can contribute to the responsible development and usage of LNG while minimizing environmental impacts (Makarova *et al*., 2023).

6. Implications for Global Sustainability

As the United States (USA) and African nations shape their environmental policies concerning Liquefied Natural Gas (LNG) usage, the global implications of these regulatory frameworks extend beyond regional boundaries (Oyewunmi, 2021). This section reflects on the broader implications of regional environmental policies, discusses the role of LNG in the global energy transition, and emphasizes the significance of informed and adaptive environmental regulations for long-term global sustainability. The USA's environmental policies play a crucial role in preserving diverse ecosystems, including those surrounding LNG production sites and transportation routes (Ahmed *et al*., 2023). Robust regulations ensure the protection of biodiversity, water quality, and air purity, contributing to the broader global effort to safeguard natural habitats.

In Africa, environmental policies shape the preservation of unique ecosystems and biodiversity. Regulations must balance the extraction of natural resources with the conservation of vital habitats, aligning with global goals for biodiversity preservation (Bhola *et al*., 2021). Stringent regulations in the USA focus on minimizing emissions during LNG extraction, production, and transportation. This commitment to air quality standards and water protection contributes to global efforts to address climate change and mitigate the impacts of industrial activities. African nations, in developing environmental policies, have an opportunity to set high standards for air and water quality, aligning with international benchmarks (Caglar *et al*., 2023). Sustainable practices can contribute to the global aspiration for clean and healthy environments.

The USA's emphasis on community engagement in decision-making processes ensures that local populations benefit from LNG projects while maintaining social and environmental sustainability (Adefemi *et al*., 2023). This approach aligns with global principles promoting social responsibility in resource extraction. Environmental policies in Africa need to prioritize community welfare, ensuring that the benefits of LNG projects are distributed equitably (Olawuyi, 2022). This reflects a global commitment to inclusive and socially responsible energy development.

The USA's focus on cleaner LNG technologies aligns with the global energy transition towards sustainable and low-emission energy sources. LNG, with its lower carbon footprint compared to traditional fossil fuels, serves as a transitional fuel supporting the move towards renewable energy (Mohammad *et al*., 2021). African nations, by adopting LNG and incorporating cleaner technologies, contribute to the global shift towards sustainable energy. LNG can serve as a bridge fuel, helping these nations transition to cleaner energy sources while meeting growing energy demands. Carbon reduction goals embedded in US environmental policies for LNG contribute to international efforts to mitigate climate change (Balcombe *et al*., 2021). By investing in cleaner technologies and reducing methane emissions, the USA plays a part in the global commitment to reducing greenhouse gas emissions. As African nations develop their LNG sectors, aligning policies with global carbon reduction goals becomes essential. Implementing environmentally friendly practices positions these nations as contributors to the broader effort in combating climate change (Cowls *et al*., 2021).

Environmental policies in the USA and Africa must be informed by scientific research, stakeholder consultations, and lessons learned from global best practices (Ningrum *et al*., 2022). Informed decision-making ensures that regulations are effective, sustainable, and adaptable to changing circumstances. Environmental regulations should be adaptive, capable of evolving to address emerging challenges and opportunities. Flexibility in regulatory frameworks allows both the USA and African nations to respond effectively to changing environmental, technological, and socio-economic landscapes (Berka and Dreyfus, 2021). Collaborative efforts between the USA and Africa, as well as international partnerships, are crucial for global sustainability. Sharing knowledge, technologies, and best practices enhances the collective capacity to address environmental challenges associated with LNG usage on a global scale (Durán-Díaz, 2023).

In conclusion, the implications of environmental policies on LNG usage in the USA and Africa extend beyond their respective regions. By reflecting on broader implications, discussing LNG's role in the global energy transition, and emphasizing the significance of informed and adaptive environmental regulations, both regions contribute to the long-term sustainability of the global energy landscape (Brauers, 2022).

7. Conclusion

The comparative review of environmental policies governing Liquefied Natural Gas (LNG) usage in the USA and Africa has illuminated nuanced approaches and regional priorities. As we conclude, we distill the key findings, highlight implications for diverse stakeholders, and issue a call to action for fostering responsible and sustainable LNG usage on a global scale. - The USA's policies showcase a commitment to stringent regulations focusing on emissions reduction,

ecosystem preservation, and community welfare. African nations are navigating a delicate balance between economic development, environmental conservation, and community welfare in their burgeoning LNG industries.

Both regions contribute to global sustainability by aligning their policies with carbon reduction goals, supporting the transition to cleaner energy sources, and emphasizing inclusive community engagement. Identifying commonalities and disparities in environmental policies opens avenues for collaborative initiatives between the USA and African nations, fostering knowledge exchange and collective action. Policymakers in the USA are urged to continue refining and strengthening environmental regulations, ensuring that LNG development aligns with global sustainability goals. African policymakers should leverage lessons from established frameworks, adapting them to suit local contexts while prioritizing environmental conservation and community welfare. Industry stakeholders, both in the USA and Africa, should embrace sustainable practices, investing in cleaner technologies and fostering social responsibility to ensure long-term viability and acceptance of LNG projects. Environmental advocates play a pivotal role in holding both regions accountable. By advocating for transparent and adaptive regulations, they contribute to fostering environmentally conscious decision-making.

The global LNG community must foster international collaboration, sharing knowledge, technologies, and best practices to collectively address environmental challenges associated with LNG usage. Encouraging innovation in LNG technologies is imperative. Governments, industry players, and research institutions should collaborate to develop and implement sustainable solutions that minimize environmental impact. Building public awareness and understanding of LNG's environmental implications is crucial. Education campaigns should highlight the benefits and challenges of LNG usage, empowering communities to actively engage in the discourse. Harmonizing international standards and best practices can create a level playing field for the LNG industry. Policymakers should explore avenues for aligning regulatory frameworks to ensure consistent and effective environmental management.

In conclusion, the comparative review serves as a compass, guiding us toward a future where LNG usage is both economically viable and environmentally responsible. Policymakers, industry stakeholders, and environmental advocates must collaborate, innovate, and educate to ensure that LNG contributes meaningfully to global sustainability goals. The call to action is clear: let responsible and sustainable LNG usage become a shared commitment on the global stage.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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