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Maritime Activities and Energy Security: Contemporary Challenges and Multifaceted Interactions

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ABSTRACT

This article explores how maritime, and port activities underpin energy security at national, regional, and global levels. It identifies key factors – legal (regulatory), environmental, geo-economic, and technological – that shape these contributions. The article also notes that shifting climate, military, political, and economic challenges are influencing energy security strategies. The maritime dimension of energy security goes beyond just safeguarding maritime transport of energy resources; it also includes protecting all infrastructure involved in maritime energy supply chains. Additionally, offshore green energy is becoming increasingly significant. The focus is on evidence from Baltic, Black Sea, and Middle East regions.

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maritime and port activities, maritime supply chains, energy resources, climate change, modern wars, alternative and traditional energy

Introduction

Modern humanity depends on a stable and uninterrupted energy supply like never before. Everyday life relies heavily on digital services, which require sustainable electricity access. New energy-intensive technologies – like electric vehicles, shore-based energy solutions for ships, and industrial cooling units – exacerbate this dependence. Energy is a key driver of global economic growth and development (World Bank, 2025, p. 2). The gradual phase-out of fossil fuels, limited reserves, environmental compliance, and the commitment to the 17 Sustainable Development Goals have reshaped the environmental agenda. This has accelerated the innovation and implementation of alternative fuels and renewable energy sources at various levels. The green energy transition now plays a critical role in managing abnormal peak loads on traditional energy sources. A case in point is the 2025 Iberian Peninsula blackout (Ruiz et al., 2025), where solar panels were crucial; record EU solar generation helped stabilize power supply during demand surges and nuclear plant outages (Czyzak, 2025). Renewables supplied most of the Spain's electricity during the outage, as they often do, with wind providing 25 % and solar 21 % on average (Wind Europe, 2025). In summary, the green transition is expected to enhance energy security by curbing fossil fuel dependence, as increased renewable energy integration within climate policy reduces energy import reliance and fortifies energy security (Kim et al., 2025).

Interest in "green" technologies and alternative energy sources is not a new phenomenon. The first efforts to harness natural forces for energy began in the maritime sector. The Third UN Conference on the Law of the Sea (1973–1982) included this issue in Part V "Exclusive Economic Zone" of UNCLOS 82. Article 56 of this convention grants the sovereign rights

of coastal states to generate energy from water, currents, and winds within this zone. Maritime activities, such as transporting hydrocarbons, developing offshore energy, modernizing port infrastructure for LNG reception and storage, and engaging in "cold ironing," have become strategic elements of energy security for most countries worldwide, regardless of whether they rely on fossil fuels or renewables. Growing international instability caused by military, political, economic, and natural factors prompt a renewed focus on the role of maritime activities in ensuring energy security, as well as the need to identify strategies for strengthening it adaptable to various conditions. The Energy Security Summit 2025 (London, April 24–25, 2025) concluded with a clear message: energy security is a matter of national security, and climate change threatens both. Participants agreed that an effective response requires increased cooperation in reducing reliance on fossil fuel imports and expanding renewable energy sources (Tachev, 2025).

Methodology

The article summarizes views on maritime logistical and infrastructure challenges affecting energy security that are triggered by contemporary issues like the Russo-Ukrainian War, pipeline incidents, the 2025 Israel-Iran War, and climate impacts on shipping routes such as the Suez and Panama Canals. The first part of the article reviews methods for understanding energy security, analyzing threats and practices, and highlights maritime activities as essential at national, regional, and global levels across legal, environmental, geopolitical, and technological dimensions. The second part discusses challenges to maritime energy supply chains and alternative energy sources.

1. Energy Security and Maritime Activities: Facets of the Relationship

While renewable energy and storage technologies are actively promoted, traditional resources – such as oil, gas, and nuclear fuel – still form the backbone of energy security. Therefore, maritime transportation remains a key factor in modern energy security because of its relatively low transportation costs. For example, the International Energy Agency (IEA) (2022b) emphasized that energy security involves not only consistent access to energy but also ensuring that supplies are affordable. The report "A Quest for Energy Security in the 21st Century" (Asia Pacific Energy Research Centre, 2007) outlined the four "A" of energy security: Availability, Accessibility, Acceptability, and Affordability. Furthermore, maritime transport uniquely provides high flexibility and adaptability in choosing ports for loading and unloading, along with shipping routes. This is also an essential factor because diversification of sources and reducing political risks from suppliers are key drivers of energy security (Kim et al, 2025). At the Summit on the Future of Energy Security at Lancaster House in London on April 24–25, 2025, the IEA Executive Director highlighted three enduring principles for addressing energy security: diversification, predictability, and cooperation (International Energy Agency & UK Government, 2025, p. 2).

The emphasis from international organizations, maritime authorities and businesses on environmental sustainability of shipping (Robalo-Cabrera et al., 2025; Zincir, 2025) corresponds with the broader trends in energy security policy development. Due to the World Bank Group (2005) energy security means enabling countries to produce and use energy sustainably at reasonable costs, which supports economic growth and poverty alleviation; it also enhances people's lives by expanding access to modern energy services. The World Bank Group's Approach Paper, "Power More with Less: Scaling up Energy Efficiency for Growth and Energy Security" (May 2025), underscores the importance of energy efficiency in meeting energy security objectives. It describes energy efficiency as a cost-effective resource

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capable of supporting economic growth, improving energy security, and managing rising energy demand, especially benefiting low- and middle-income countries with numerous socioeconomic advantages (p. 2).

Maritime activities are integral to energy security. Key sectors include shipping, vital for transporting oil, LNG, and coal, along with their safety from piracy, terrorism, and military risks. Subsea pipeline systems serve as crucial transportation routes that do not rely on ships. Modern port infrastructure is essential for hydrocarbon supply chains, storage, and ship maintenance. Additionally, offshore and tidal energy, along with innovative marine fuel alternatives – part of global decarbonization efforts – play a significant role, in line with the 2023 IMO Strategy on Reducing GHG Emissions from Ships.

The maritime aspect of energy security encompasses several key dimensions (components): legal, environmental, geo-economic, and technological.

The legal (regulatory) component includes both international and national maritime and energy law related to resource exploitation and wind farm construction in EEZs, cross-border energy supply regimes, as well as soft law norms, voluntary projects, initiatives, and best practices aimed at enhancing the energy efficiency of seaports, shipowners, and their associations (Issa-Zadeh & Garay-Rondero, 2025; Hahn et al., 2025; Barbieri et al., 2024). This aligns with efforts like the Clydebank Declaration 2021, which advocates for establishing "green" shipping corridors (Song et al., 2025).

The environmental component connects energy sustainability goals with climate neutrality and decarbonization targets, aligning with IMO strategies, European, regional, and international environmental policies, as well as national regulations (Koilo, 2024; Robalo-Cabrera et al., 2025; Sardar et al., 2025). For example, "GreenVoyage2050" is a global initiative aimed at reducing greenhouse gas (GHG) emissions from shipping, supporting the goals outlined in the IMO GHG Strategy.

The geoeconomic component shows how states, associations, sea routes, ports, vessels, and underwater communications support energy supply and route diversification. It highlights access to maritime supply chains for coastal and landlocked states amid global and regional energy competition. It also defines roles in managing energy resources, such as developing shipping along the Northern Sea Route as a new Russian leverage (Bayirhan et al., 2025; Ma et al., 2025), transport projects in the Three Seas Initiative (Bilenets et al., 2022), and LNG terminal construction (Analytical Solutions and Products, n.d.).

The technological component is related to the development of offshore energy, alternative marine fuels, and smart solutions for seaports. For example, in the North Seas region, a coalition of nine countries expressed the ambition to quadruple their offshore wind capacity from 30 GW to 120 GW by 2030, and then more than double that capacity between 2030 and 2050 to reach 300 GW (Meeus, 2025; North Sea Wind Power Hub program, n.d.); Port optimizers employed in different ports (for example in the Port of Rotterdam or in the Port of Los Angeles, make it possible to plan a port call in a much smarter and more efficient way and also to finalize it faster (Suvadarshini & Dandapat, 2022).

This multifaceted interaction enables us to view maritime and port activities as essential components of the energy security framework, demanding integrated management, ongoing modernization, and international cooperation.

2. Contemporary Factors of Instability, Sustainable Development in Maritime Sector, And Energy Security

As noted earlier, while the maritime aspect of energy security once mainly focused on safe navigation for oil tankers, it has now grown more complex. It involves safeguarding energy

production, storage, and transportation facilities from political, military, climatic, and economic risks. A separate concern is sanctions policies and the issue of "shadow fleets," which are used to bypass sanctions and price caps on energy from Russia and Iran. Additionally, energy prices are influenced by many factors. Energy security is especially critical for Small Island Developing States (SIDS), Least Developed Countries (LDCs), and nations facing military threats. For SIDS and LDCs, renewable energy sources such as tides, wind, waves, and geothermal energy are becoming essential in the maritime aspect energy security. For military threatened states, the focus shifts to physically protecting energy infrastructure and diversifying supply routes.

2.1. Climate Change and the Maritime Aspect of Energy Security

Despite technological progress, climate remains a key factor in maritime operations and port activities. Forecasting is challenging, with significant deviations often occurring. Offshore renewable energy also depends heavily on weather conditions; lack of wind, waves, or sunlight significantly reduces power generation (Abdelaziz et al., 2025). The rise in extreme weather events like hurricanes and typhoons also impacts offshore construction projects (Heather, 2025). Additionally, climate change is transforming supply chains, prompting new logistical strategies that typically increase shipping costs. This results in higher prices for transported goods due to longer delivery times, increased fuel use, crew wages, and other costs (Britannia Group, 2025a, 2025b; Kivalov, 2024). While underwater communications are less affected by weather, they are still vulnerable to interference and other risks, which will be discussed below.

The International Energy Agency's 2022 report, "Climate Resilience for Energy Security," highlights the crucial role of weather and climate change in influencing energy security. It emphasizes that climate change threatens global energy stability by impacting fuel and mineral extraction, processing, and transportation, as well as altering the capacity, efficiency, and dependability of power generation. Additionally, climate change increases variability in precipitation patterns, raising the risk of heavy rains, flooding, and droughts (p. 9). Rising sea levels could also significantly disrupt crude oil shipments and undermine energy security in countries dependent on imports like China, South Korea, and Japan, where many key terminals face flood risks (Stanway, 2024).

Climate change frequently causes shifts in typical weather patterns, leading to strong winds and dust storms, such as the grounding of the container ship Ever Given in the Suez Canal in March 2021 (Port Economics, Management and Policy, n.d.) and a 6 % rise in oil prices (Obayashi et al., 2021). It also results in the drying up of key shipping routes like the Panama and Suez Canals (SuperDry, 2024; Anderson, 2025), along with various other natural changes impacting the maritime and port sectors, including rising sea levels, increased water temperatures, and more frequent extreme weather events.

Developing effective strategies for maritime and port climate security requires cross-sector collaboration, integrating climate modeling data into planning, establishing resilience standards for extreme weather, and attracting investments to modernize key infrastructure. International efforts aimed at mitigating climate risks and transforming supply chains – such as creating "green" shipping corridors and climate-resilient ports – are crucial. Though these initiatives may not yield immediate results, they can significantly reduce environmental impacts over time. The necessity of a comprehensive approach was also emphasized during the Summit on the Future of Energy Security (Lancaster House, London, 24–25 April 2025): it was highlighted that a holistic strategy must address energy supply security, competitiveness, and decarbonization simultaneously, as focusing on only one aspect may lead to suboptimal outcomes (p. 2).

Regarding offshore green energy, most countries remain dedicated to greening and decarbonization efforts. Challenges in servicing offshore wind systems, such as those mentioned by Rodríguez (2023), do not prevent countries from expanding their adoption, especially amidst ongoing military conflicts and sanctions (Rifelj, 2025). Offshore wind energy is increasingly seen as vital to Europe's energy independence. In 2020, eight Baltic Sea nations – Poland, Germany, Denmark, Sweden, Finland, Lithuania, Estonia, and Latvia – signed a declaration with the European Commission to boost offshore wind development in the Baltic Sea (Buljan, 2020). Then, in 2022, the Marienborg Declaration was signed, setting a regional offshore wind capacity goal of 19.6 GW by 2030 and pledging to strengthen energy cooperation further (Wind Europe, 2022).

In April 2024, Energy Ministers from eight Baltic Sea nations approved the Vilnius Declaration, committing to enhanced cooperation to protect critical offshore energy infrastructure in the Baltic Sea. This decision follows the Russian invasion of Ukraine and several acts of sabotage targeting Baltic Sea energy infrastructure, raising new security concerns. The signatories agree to prevent any activity misalignments against offshore and underwater infrastructure within NATO and the EU (Wind Europe, 2024). In May 2025, the Transmission System Operators (TSOs) from these eight countries jointly released an expert report on boosting cross-border collaboration for offshore wind energy and the related electricity transmission grid infrastructure (Baltic Wind, 2025).

This example illustrates a consistent and sustainable approach to incorporating maritime energy security for both individual countries and regions. Achieving this requires leveraging all available opportunities and tools, including joint planning, investment, and regulatory unification. Amid geopolitical instability, sanctions, trade restrictions, and the push for decarbonization, such technologies are increasingly vital for sustainability. Maritime energy is rapidly transforming from an alternative option into a crucial component of energy stability.

2.2. Military Threats and Other Crisis Factors

Since late 2019, ongoing strategic challenges have tested maritime energy supply resilience. The COVID pandemic caused global disruptions, followed by military conflicts and trade sanctions, straining energy infrastructure. The maritime industry was among the first to recover, reopening ports by mid-2020, maintaining vital supplies and economic ties (Faqiang & Abliakimova, 2020, pp. 25–26; UNCTAD, 2020, p. 66). Countries with limited sea access or dependence on external maritime supplies, like SIDS and LDCs, faced greater vulnerability due to lockdowns and port bans disrupting their supply chains. These conditions necessitated a rethinking of maritime policies, labor, and services to safeguard energy, trade, food, and health security.

The Russo-Ukrainian war, which started in February 2022, has had a significant impact on global energy markets. With over three and a half years passing since Russia's invasion, it is now possible to analyze its effects on energy security and observe shifts in trade patterns. The war, along with Europe's reduction of Russian oil and gas imports, has led Russia to increase exports to Asia, while European nations are becoming more interested in Gulf energy resources. These developments present both opportunities and challenges for expanding energy cooperation between the European Union and Gulf countries. The invasion caused sharp rises in oil and gas prices in Europe, energy shortages, and a pressing need to decrease reliance on Russian energy. In response, the EU has increasingly sourced fossil fuels from the Middle East and North Africa (Aminjonov, 2025).

In September 2022, the North Stream 1 and North Stream 2 underwater pipelines were sabotaged, ending Germany's dependence on Russian gas and prompting the EU to look for

alternative sources of supply (DW, 2022; Wettengel, 2025). Despite this, Russian gas routes to Europe by sea were not entirely cut off. Gas is still transported indirectly through the Turkish Stream pipeline along the bottom of the Black Sea (Daily Sabah with Agencies, 2025). Additionally, Russia's "shadow fleet" and LNG supplies continue to play a role in maritime delivery (Ukrainian Business News, 2025; Ukrainian Energy, 2025), efforts that the EU's 18th sanctions package against Russia aimed to severely restrict (European Commission, 2025).

The European Initiative for Energy Security (EIES), launched after Russia's 2022 invasion of Ukraine, aims to promote policies for diverse supply chains, resilient energy systems, and a strong European industrial base. It brings together policymakers, business, and military leaders to foster cross-sector collaboration and works with the Energy Security Leadership Council-Europe (ESLC-Europe). EIES has been officially registered as Stichting European Initiative for Energy Security in the Netherlands since April 2025.

EIES's July 2025 brief highlights that despite operational benefits, the distributed model's biggest strength – offshore applications – creates vulnerabilities through submarine cables. The Baltic Sea exemplifies this, where undersea cables linking offshore wind farms to mainland grids pose "single points of failure" susceptible to damage or sabotage. The severing of Estonia-Finland's Estlink 2 shows how such failures can impact large parts of wind capacity, as cables often serve multiple installations. Offshore farms also face security threats from rising maritime traffic, especially in the Baltic Sea, with LNG carriers creating collision risks due to large turning radii incompatible with turbine spacing. Effective maritime spatial planning requires early stakeholder involvement, including military coordination, to coordinate navigation and schedules, reduce risks, and promote coexistence (p. 11).

Besides, the European approach to climate change, known for strict policies, is becoming an obstacle to LNG supplies from Qatar. Qatar threatened to cut gas to the EU in response to its due diligence law on forced labor and environmental damage, as shown in a letter to Belgium seen by Reuters. Qatar, the world's third-largest LNG exporter after the US and Australia, supplied 12–14 % of Europe's LNG since Russia's 2022 invasion of Ukraine (Abnett, 2025). The Corporate Sustainability Due Diligence Directive (CS3D), effective July 25, 2024, requires large companies to address human rights and environmental impacts in their supply chains, aiming to prevent harmful corporate behavior and promote sustainability (Sustainability Rulebook: The Corporate Sustainability Due Diligence Directive). Qatari officials stated these rules may not be enforced, and LNG routes could be revised. Furthermore, Qatar, a major fossil fuel exporter, faces the challenge of balancing economic growth with climate commitments. As a Paris Agreement signatory, it aims to cut GHG emissions by 25 % by 2030, as detailed in its National Climate Change Action Plan 2030 and NDCs, reaffirming its commitment to global climate efforts (Al-Noaimi et al., 2025).

The instability in the Middle East from autumn 2023 highlights how military and political issues affect supplies. Luckily, major energy market shocks were avoided, thanks to lessons learned by the maritime industry from the COVID-19 pandemic (Aljohani et al., 2025; Arsad et al., 2023), the Russo-Ukrainian conflict (Kivalov, 2023; 2024; Kormych et al.; Zinchenko, 2024), earlier industry crises (1973, 1979, 1990, 2003), and improved logistics, including underwater communications and warehouse infrastructure worldwide (Bousso, 2025). In 2024, oil prices have fluctuated due to global influences, though the increases remain relatively modest despite regional conflicts. From January to September, prices rose by over 6 %, with a 3.8 % increase in September, mainly driven by instability in the vital Middle East region. Concerns over potential disruptions in key supply routes like the Strait of Hormuz have added to market uncertainty (Globally Cool, 2024).

The move in oil prices during the 2025 Israel-Iran war shows the energy markets' growing efficiency and fundamental shifts in global crude supply, indicating that Middle East politics are less dominant in oil markets. The price increase after Israel's surprise attack was modest given the conflict's stakes. The doomsday scenario – Iran blocking the Strait of Hormuz, which handles nearly 20 % of the world's oil and gas – did not happen, and there was almost no disruption to oil flows during the conflict (Bousso, 2025). The Strait of Hormuz is vital for global energy, with 20 million barrels of oil and a fifth of liquefied natural gas passing through daily, mainly from Qatar. Its importance lies in lacking alternatives, as rerouting Gulf oil causes delays. It is the only deep-water route for large crude tankers, with 84 % of its oil going to Asia, especially China, India, Japan, and South Korea (Hadchity, 2025).

During the escalation of tensions, ships passing through the Strait of Hormuz and nearby waters have begun broadcasting unusual radio messages to reveal their national affiliations. This tactic aims to reduce the risk of attack amid ongoing tensions between Iran and Israel. From June 12 to June 24, Windward reported that 55 ships transmitted a total of 101 unusual messages while navigating the Gulf and the Red Sea. These messages included phrases such as "China owned," "Russian crude," and "Vsl no link Israel," indicating a strategic effort to associate these vessels with countries perceived as less likely to be targeted, like China and Russia, rather than Western nations such as the U.S., U.K., or Israel (MI News Network, 2025; Melnyk et al., 2025).

During the Israel-Iran war, Iran's GPS jamming in the Strait of Hormuz caused significant navigational disruptions, with over a thousand vessels daily affected, including tankers appearing on land in Iranian ports, Oman, and Dubai. Despite the strait being open to shipping, Iran showed it can cause economic and logistical damage without a naval blockade, exemplifying a new digital threat in maritime risks (Wittels et al., 2025), prompting the adoption of alternative technologies and stricter GPS jammer controls (Combs, 2025).

Conclusions

Recent years have shown that energy security is increasingly complex, involving more than just managing the extraction, transportation, storage, and use of energy and its resources. It has become a key issue for high-level policymakers, with maritime activities and ports serving not only for transport and storage but also as hubs for logistical, legal, climatic, infrastructural, and geopolitical interests. The growing complexity, need for diversified supply routes, climate threats, vulnerability of underwater and port infrastructure, sanctions pressures, efforts to bypass sanctions, and evolving corporate sustainability strategies in the energy sector highlight the need for integrated and coordinated energy flow management. Therefore, maintaining international cooperation, pursuing joint efforts for energy stability, investing in resilient infrastructure, strengthening legal frameworks, and including maritime elements in strategic energy security plans at national and international levels are essential.

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Ківалов С. Морська діяльність та енергетична безпека: сучасні виклики та багатовимірні взаємодії. – Стаття.

У статті досліджується, як морська та портова діяльність забезпечують енергетичну безпеку на національному, регіональному та глобальному рівнях. Визначено ключові фактори – правові (регуляторні), екологічні, геоекономічні та технологічні, – що формують цей внесок. У статті також зазначається, що зміна клімату, воєнні, політичні та економічні виклики впливають на стратегії енергетичної безпеки. Морський аспект енергетичної безпеки виходить за рамки лише захисту морських перевезень енергетичних ресурсів; він охоплює також захист усієї інфраструктури, залученої до морських енергетичних ланцюгів постачання. Крім того, дедалі більшого значення набуває офшорна «зелена» енергетика. Основну увагу зосереджено на даних з регіонів Балтійського, Чорного морів та Близького Сходу. .

Ключові слова: морська та портова діяльність, морські ланцюги постачання, енергетичні ресурси, зміна клімату, сучасні війни, альтернативна і традиційна енергетика.