Volume XXVIII 2025
MBNA Publishing House Constanta 2025

Scientific Bulletin of Naval Academy

SBNA PAPER • OPEN ACCESS

Building an LNG cargo and bunkering terminal in the Port of Constanta

To cite this article: Gheorghe Cătălin-Alexandru, Acomi Nicoleta, Scientific Bulletin of Naval Academy, Vol. XXVIII 2025, pg. 151-162.

Submitted: 26.04.2025
Revised: 10.07.2025
Accepted: 25.11.2025

Available online at www.anmb.ro

ISSN: 2392-8956; ISSN-L: 1454-864X

doi: 10.21279/1454-864X-25-I1-014

Building an LNG cargo and bunkering terminal in the Port of Constanta

Cătălin-Alexandru Gheorghe[1] and Nicoleta Acomi[2]

[1]DPO Eng. "Constanta Maritime University", Navigation and Naval Transport Faculty, Research Department, alex.gheorghe24@yahoo.com
[2]PhD. Eng. "Constanta Maritime University", Navigation and Naval Transport Faculty, Navigation Department, nicoleta.acomi@cmu-edu.eu
***Corresponding author: alex.gheorghe24@yahoo.com**

Abstract: As the maritime sector shifts toward sustainable energy, Liquefied Natural Gas (LNG) emerges as a key alternative fuel. The Port of Constanta, strategically located on the Black Sea, holds significant potential to become a regional hub for LNG distribution in Eastern Europe. This study explores the feasibility and strategic relevance of developing an LNG cargo and bunkering terminal in the Port of Constanta, aiming to enhance Romania's energy security and contribute to the decarbonisation of maritime transport. The challenges are high initial capital requirements, complex regulatory frameworks, and market uncertainties. However, Romania's geographic position and the upcoming Neptun Deep offshore gas exploitation offer a favorable context for LNG infrastructure development. A Business Model Canvas is applied in this study to outline the terminal's value proposition, customer segments, key partners, revenue streams, and cost structure. Additionally, a SWOT analysis is conducted to identify internal strengths and weaknesses, as well as external opportunities and threats that may impact the project's success. Initial findings suggest that the terminal could be economically viable, especially if supported by EU funding, private investment, and international partnerships. The facility would improve the regional LNG supply chain, facilitate cleaner maritime operations, support industrial energy needs, and reduce greenhouse gas emissions. Moreover, it may reinforce Constanta's strategic role in the energy transition and positions Romania as a key player in the regional LNG market.
Keywords: LNG terminal; Business Model Canvas; port sustainability; SWOT analysis.

1. Introduction

Liquefied Natural Gas (LNG) has gained strategic importance as a cleaner alternative to conventional marine fuels, with ports worldwide investing in LNG infrastructure to support the maritime industry's transition toward lower emissions. The Port of Constanta, being a crucial gateway between Europe and Asia, presents a significant opportunity for the development of an LNG cargo and bunkering terminal. However, the feasibility and strategic benefits of such an investment require careful analysis of economic, technical, and regulatory factors. This article aims to explore the potential of establishing an LNG cargo and bunkering terminal in the Port of Constanta, assessing its advantages, challenges, and broader impact on regional maritime logistics.

The main objective of this study is to analyze the feasibility and potential benefits of an LNG terminal in Constanta by reviewing existing research on LNG bunkering infrastructure and operational models. The study will address key scientific problems, including the optimization of LNG supply chains, the economic viability of LNG bunkering, and the role of port authorities in facilitating the transition to

LNG as a maritime fuel. To situate this study within its broader regional and historical context, it is important to review previous LNG initiatives in Constanța alongside recent feasibility assessments.

The AGRI (Azerbaijan–Georgia–Romania Interconnector) project, introduced in 2010, aimed to create a mixed gas transport route through pipeline, LNG shipping, and regasification at Constanța. Valued at between €4 and €6 billion, the project was expected to deliver a capacity of approximately 8 billion cubic meters per year. A feasibility study, finalized in 2014, confirmed the technical and economic viability of the project. However, after 2015, it faced significant delays due to a combination of geopolitical factors, investor hesitancy, and shifting priorities within the participating countries. Officially, the project was deemed "frozen" in 2021, with little progress made since then. While some initial optimism suggested a potential restart around 2024–2026, the project is now considered "cancelled," with any future implementation being postponed until at least 2027, in the most optimistic scenario (GEM, 2023).

Meanwhile, in 2024, the Ministry of Energy of Romania announced a positive outcome from the feasibility study conducted for a joint LNG terminal project with SOCAR, planned for Constanța. This new initiative, aimed at diversifying gas sources, has an estimated capacity of 8–9 bcm per year, with the possibility of a floating terminal similar to the one in Alexandroupolis. This marks a shift in Romania's approach to energy infrastructure, focusing on both regional cooperation and flexibility to meet future energy needs (Energynomics, 2024).

Building on this historical context, prior studies on LNG bunkering terminals offer valuable lessons on their successful operation.

Several studies have investigated the optimization of LNG bunkering terminals, providing key insights into the factors that influence their successful implementation. Seo & Cho (2014) examined the economic feasibility of floating offshore LNG bunkering systems, highlighting how market share, investment planning, and regulatory frameworks significantly impact project viability (Seo & Cho, 2014). Their findings suggest that early adoption of LNG infrastructure in strategic locations can provide long-term economic benefits.

Optimizing terminal parameters is a crucial aspect of planning an LNG facility. Gucma (2019) investigated how different LNG tanker sizes impact terminal design, emphasizing that terminals should be flexible enough to accommodate various vessel categories (Gucma & Gucma, 2019). This insight is particularly relevant for the Port of Constanta, given its role in handling diverse maritime traffic, including large-scale cargo operations.

The operational performance of LNG bunkering stations has been analyzed through simulation-based approaches. Bruzzone & Sciomachen (2023) explored alternative LNG bunkering technologies and their efficiency in reducing operational costs and environmental impact (Bruzzone & Sciomachen, 2023). Their work suggests that ports investing in LNG infrastructure should prioritize bunkering technologies that enhance operational efficiency and minimize fuel transfer times.

Port authorities play a vital role in LNG terminal development by implementing policies that encourage sustainable energy transitions. Wang & Notteboom (2015) analyzed the strategies used by North European ports to support LNG adoption, highlighting the importance of regulatory incentives, investment partnerships, and infrastructure planning (Wang & Notteboom, 2015). Their findings are relevant for the Port of Constanta, as similar policy interventions could accelerate LNG adoption and infrastructure development.

Given the increasing global emphasis on LNG as a marine fuel, the establishment of an LNG cargo and bunkering terminal in the Port of Constanta represents a strategic opportunity. The findings from previous research indicate that successful LNG terminal development depends on factors such as economic feasibility, terminal optimization, technological efficiency, and supportive regulatory frameworks. By leveraging these insights, this study will provide a comprehensive assessment of the Port of Constanta's potential to become a regional LNG hub.

The paper is structured as follows: Firstly, the Introduction presents the background section providing an overview of the current context and relevance of LNG infrastructure in the Black Sea region; Secondly, the Purpose and Problem Statement defines the strategic rationale for developing an

LNG terminal in the Port of Constanta, outlining the key challenges addressed. The Research Methodology section explains the tools and analytical frameworks employed, including the Business Model Canvas and SWOT analysis. The Results and Discussions section present the key findings regarding the terminal's feasibility, value proposition, and strategic advantages. Finally, the Conclusion summarises the main insights and offers recommendations for potential investment directions.

2. Purpose and Problem Statement

The purpose of this research is to explore the feasibility and strategic planning for building an LNG cargo and bunkering terminal in the Port of Constanta. LNG infrastructure is becoming increasingly crucial in the global energy supply chain, particularly in maritime transport, where LNG is gaining traction as a cleaner alternative to traditional bunker fuels. The development of LNG terminals involves complex planning and logistics, and the effective integration of such terminals into port operations can offer significant economic and environmental benefits. However, these developments also present various challenges, from site selection and infrastructure requirements to regulatory compliance and security measures.

LNG terminals, as critical nodes in global energy and transportation networks, require a well-considered development strategy. Several case studies of LNG terminal projects worldwide provide valuable insights into the planning processes, challenges faced, and strategies employed by different ports. For instance, the Dabhol LNG terminal in India serves as a significant case study in terms of planning and site investigation, with lessons learned emphasizing the importance of careful front-end engineering design (Izzo, 2004). Similar to this, for the Dalian LNG receiving terminal in China there was conducted a thorough analysis of potential locations, taking into account factors such as construction conditions and government plans (Yao et al, 2021). These case studies confirm the need for an comprehensive assessments during the initial phases of LNG terminal development.

Optimization of the infrastructure is one of the key challenges faced by ports undertaking LNG terminal construction, in order to accommodate large-scale LNG operations and also to maintain the safety and security of the port. The Ningbo-Zhoushan port area in China highlighted the challenges of LNG shipments that impact the vessel scheduling and port throughput, emphasizing the operational bottlenecks that can arise when integrating LNG terminals into busy port systems (Zhuo et al, 2014). Therefore, to reduce possible risks related to cargo handling, storage and transport, a well-designed LNG terminal must balance operational efficiency with the safety protocols.

The integration of LNG terminals with port strategies requires a correlation with broader energy policy goals. For instance, U.S. policy has stressed the need for stricter safety regulations governing LNG storage and transportation, giving to the U.S. Coast Guard the role of key regulator for terminal safety (Schneider & Halvorsen, 1976). Moreover, offshore LNG terminals, like those being proposed in the Gulf of Mexico, have led to political debates over safety, environmental concerns, and jurisdictional issues, which demonstrate the complex regulatory environment that LNG terminal projects face (Whitmore et al, 2009).

In the case of offshore LNG terminals, the focus shifts toward choosing best location based on factors such as navigational security and environmental impact. A recent critique of offshore LNG terminal policies points out that safety and environmental protection must be prioritized, as these terminals pose unique risks to maritime environments (Whitmore et al, 2009). Similarly, the compatibility between LNG terminals and large ports has been extensively studied, with research emphasizing the importance of navigational safety for LNG carriers as a key priority in port planning.

Furthermore, the increasing reliance on LNG as a maritime fuel necessitates strategic investments in infrastructure that can accommodate the increasing demand for bunkering services. As researchers propose (Hadi et al, 2023), the optimization of small-scale LNG supply chains is crucial for reducing logistics costs and improving fuel distribution efficiency. The lessons drawn from such studies stress the importance of integrated planning and advanced logistical systems to manage LNG deliveries effectively.

The purpose of this research is to address these strategic and operational challenges by examining existing LNG terminal projects and providing a roadmap for building a similar facility in the Port of Constanta. By learning from global examples, this study aims to inform about the best practices, key risks, and opportunities inherent in LNG terminal development, thereby enhancing the overall competitiveness and sustainability of the port in the global energy supply chain.

3. Research methodology

This study adopts a qualitative, exploratory research design to evaluate the strategic feasibility and potential impact of establishing an LNG cargo and bunkering terminal in the Port of Constanta. The research follows a case study approach. This methodology was selected due to the exploratory nature of the study and the need to integrate multiple data sources to assess both internal capabilities and external market conditions (Yin, 2018).

Data for this study were collected from a combination of secondary sources, including academic literature, industry reports, policy documents, and strategic plans related to LNG infrastructure, maritime energy transition, and Eastern European energy markets. Key sources included EU energy policy frameworks, Romanian maritime strategies, and investment reports related to offshore gas fields such as Neptun Deep. This desk-based research was supplemented by analysis of stakeholder reports from port authorities, energy companies, and regulatory agencies to ensure contextual accuracy.

To structure the commercial feasibility of the terminal, the Business Model Canvas (BMC) framework was applied (Osterwalder & Pigneur, 2010). The BMC enables a visual and structured examination of research results, being widely used in infrastructure planning. It can be used to identify critical elements improving both the operation of the organization and the level of passenger satisfaction in The Port of Volos (Manginas et al, 2017).

To complement the business model and assess strategic positioning, a SWOT analysis was conducted. This tool is particularly effective in early-stage infrastructure projects where environmental and organizational uncertainties are high (Agbo et al, 2017). The SWOT framework was used to synthesize findings from the business model, industry analysis, and policy review, identifying strengths and weaknesses within the Romanian LNG ecosystem, along with opportunities and threats in the broader geopolitical and energy context of the Black Sea region.

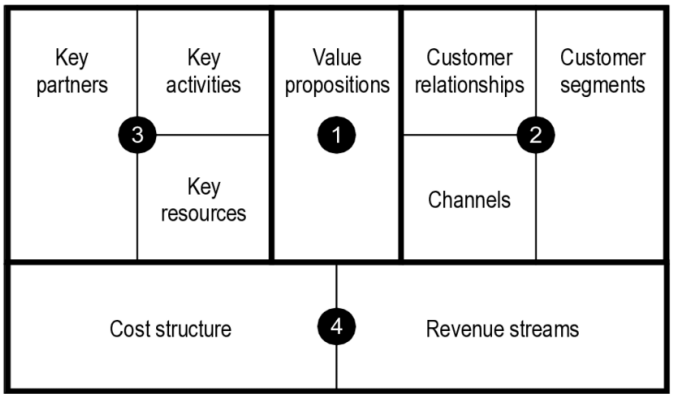
The BMC and SWOT analyses support robust, evidence-informed conclusions and provide strategic guidance for stakeholders considering investment or policy engagement.

4. Results and discussions

The research is based on a comprehensive analysis that integrates a Business Model Canvas and a SWOT analysis. These strategic tools have guided the evaluation of key components necessary for the development and operational success of the terminal.

4.1. Business Model Canvas

The Business Model Canvas provides a structured approach to identifying the core value propositions, customer relationships, key partners, and revenue streams associated with the LNG terminal (Figure 1). By leveraging Romania's strategic position in the Black Sea, the terminal offers economic, environmental, and logistical advantages that enhance the country's energy security and port competitiveness. The ability to load and unload LNG efficiently, attract LNG-powered vessels, and ensure regulatory compliance has been a focal point in defining the business model.



Note: 1 = Product; 2 = Customer interface; 3 = Infrastructure management; and 4 = Financial aspects.

Figure1. Business Model Canvas layout

Value propositions. An LNG cargo and bunkering terminal in the Port of Constanta offers strategic, economic, and environmental benefits. It strengthens Romania's energy market position, boosts economic growth, and enhances port competitiveness by attracting LNG-powered vessels. The terminal's flexibility optimizes operations and lowers costs, while LNG's cleaner profile supports sustainability. Additionally, it ensures a stable LNG supply, reducing reliance on traditional fuels and enhancing energy security.

- The ability to load or unload liquefied natural gas at a terminal connected to the rest of Europe.
- The import of natural gas or the export of gas extracted from Neptun Deep, generating revenue for the state.
- Enhances the competitiveness of ports by attracting LNG-powered vessels, whose number is increasing due to regulatory and environmental requirements.

The LNG loading terminals allow the handling of a wide range of LNG tank sizes, optimizing operational flexibility and reducing costs associated with ship operations. This aspect is particularly advantageous for accommodating both small vessels and large tanks, enhancing the strategic positioning of the port in the global LNG trade (Gucma & Gucma, 2019). Moreover, LNG is a cleaner energy source that reduces sulfur oxides (SOx) and nitrogen oxides (NOx) emissions, aligning with international environmental regulations such as those of the IMO. As a result, the LNG terminals are considered key players in the green transition of the maritime industry (Bruzzone & Sciomachen, 2023). In addition, the LNG loading terminals reduce dependence on traditional fuels, and ensure a stable supply chain for LNG-powered vessels while improve the reliability of LNG distribution to regional and global markets (Bittante et al, 2018).

Customer Relationships. In the context of building an LNG cargo and bunkering terminal in the Port of Constanta, customer relationships focus on establishing long-term partnerships with shipping companies and operators of LNG-powered vessels. These operators require reliable bunkering services that ensure smooth and timely refueling in order to avoid operational delays. In addition, it is necessary to maintain high safety standards and operational efficiency to build trust and to meet industry expectations. To strengthen the relationships with key stakeholders and to create the premises for long-term collaboration, as well as to position the port as a preferred hub for LNG-powered maritime transport, the terminal shall offer a well-structured LNG supply chain with optimized refueling processes.

- Long-term partnerships with shipping companies

It shall be noted that the operators of LNG-powered vessels may expect reliable bunkering services, integrated safety measures, and optimal refueling times. For example, the importance of safety and efficiency in bunkering operations has been highlighted in studies modeling LNG distribution systems (Bruzzone & Sciomachen, 2023).

Customer Segments. This segment includes identification of the categories of key stakeholders in the maritime and energy industries. It includes companies operating LNG-powered vessels, which require reliable and efficient refueling infrastructure to comply with environmental regulations and maintain operational efficiency. Additionally, LNG transport companies benefit from specialized terminals capable of accommodating vessels of various sizes, ensuring smooth loading and unloading processes. Energy distributors and importers also represent a crucial segment, as they rely on LNG terminals for storage, regasification, and regional distribution. By addressing the needs of these diverse customer groups, the terminal enhances its strategic importance as a key hub in the LNG supply chain.

- Companies that operate vessels using LNG as fuel
- LNG transport companies
- Energy Distributors and Importers

This identification considered that the operators handling high-capacity LNG tanks require specialized terminals capable of accommodating vessels of various sizes, as demonstrated by the optimization study of the Świnoujście port (Gucma & Gucma, 2019). In addition, the energy companies seeking LNG for domestic or regional distribution use port facilities for storage and regasification. Ports in the Baltic Sea, for example, integrate LNG terminals both for fuel supply and regional energy needs (Rozmarynowska, 2010).

Channels. As connectivity and networking become increasingly important, this section discusses the methods used to engage with customers and efficiently deliver LNG services. Digital platforms enable real-time scheduling and logistics coordination, while direct service supply through Truck-to-Ship, Ship-to-Ship, and Pipeline-to-Ship refueling ensures seamless operations. Flexible infrastructure, including floating LNG terminals, enhances adaptability, while collaboration with port authorities and energy suppliers strengthens compliance and industry partnerships.

- Digital Platforms for Logistics Coordination – Logistics software and digital platforms enhance scheduling and communication between terminal operators and shipping companies, enabling better fleet and cargo management. (Al-Haidous et al, 2016).
- Direct Service Supply – Direct channels, such as on-site refueling (e.g., Truck-to-Ship, Ship-to-Ship, and Pipeline-to-Ship), are essential. They ensure immediate availability and adherence to customer schedules, especially for LNG-powered vessels. (Bruzzone & Sciomachen, 2023)
- Flexible Infrastructure Development – Investments in multifunctional infrastructure, such as floating LNG bunkering terminals, address diverse customer needs and reduce operational costs. (Jung et al., 2020)
- Collaboration Channels with Stakeholders – Partnering with port authorities, local governments, and energy suppliers ensures regulatory compliance, efficient operations, and community engagement. (Lu & Jeong-Ho, 2019)

Key Partners. This section includes engineering firms for infrastructure development, LNG suppliers for a stable fuel supply, and port authorities for regulatory compliance. These partnerships ensure efficient operations, market stability, and adherence to environmental and safety standards.

- Engineering and construction firms: Collaborations are necessary for terminal infrastructure, including storage tanks, docking systems, and safety systems. (Gucma & Gucma, 2019)
- LNG suppliers – Agreements for the constant supply of LNG for fueling and storage, which also help maintain price stability despite market fluctuations. (Bruzzone & Sciomachen, 2023)
- Port authorities and regulators: Collaboration ensures compliance with emission standards, environmental regulations, and safety protocols. For example, IMO regulations have driven port projects focused on reducing sulfur emissions and greenhouse gases. (Park & Park, 2019)

Key Activities. The key activities for the LNG cargo and bunkering terminal in the Port of Constanta focus on efficient and safe operations. This includes loading and discharging LNG vessels, bunkering

ships that use LNG as fuel, and developing necessary infrastructure such as storage tanks, transfer systems, and terminal facilities. Managing boil-off gas through reliquefication systems is also critical to ensure operational efficiency. Additionally, safety and risk management, including addressing LNG leaks and potential accidents, are vital for the terminal's smooth operation.

- Loading and discharging of LNG vessels
- Bunkering of vessels that use LNG as fuel
- Infrastructure development
- Boil-off gas management
- Safety and risk management

Building LNG storage tanks, transfer systems, and terminal facilities is a fundamental activity. For example, optimal design and the use of high-quality materials are essential for safe and efficient operations (Chang et al., 2015). Moreover, handling boil-off gas through reliquefication systems ensures operational efficiency and safety (Chang et al., 2015). In addition, addressing risks such as LNG leaks, collisions, and groundings is an essential activity for ensuring operational safety (Fan et al, 2021).

Key Resources. The key resources for the LNG cargo and bunkering terminal in the Port of Constanta include both physical and human assets. The infrastructure, such as storage tanks, transfer systems, and terminal facilities, is fundamental to the terminal's operations. Equally important are the human resources: qualified engineers for construction, safety experts for risk management, and operational staff with specialized training in LNG handling. Additionally, securing investment from the state budget or European funds is crucial for the construction and development of the terminal, ensuring its long-term sustainability.

- The gas extracted from Neptun Deep and Ana platform.
- Infrastructure
- Human Resources and well-trained personnel: qualified engineers for construction, safety analysts for risk management, and operational staff trained in LNG handling
- An investment from the state budget or European funds for the construction of the terminal

Cost Structure. This section is driven by high capital and operational expenditures. Major costs include infrastructure development, such as constructing unloading terminals and maritime facilities, which require significant investment. Location-specific adaptations, like optimizing the terminal for different vessel sizes, add complexity and expenses.

- Infrastructure development
- Specialized equipment such as LNG storage tanks, cryogenic pipelines, and reliquefaction units represent major capital expenditures
- Training costs for human resources specializations
- Fixed costs for staff salaries, utilities
- Variable costs referring to fuel and energy consumption, maintenance and repairs, compliance with safety and environmental regulations.

Constructing facilities such as unloading terminals, maritime infrastructure for offloading, and export terminals can cost hundreds of millions of dollars. For example, the infrastructure for LNG facilities on Curtis Island cost approximately $200 million (Erickson et al, 2013). In particular, there is an essential cost for location-specific adaptations. Optimizing terminal parameters for different vessel sizes or geographical constraints increases complexity and costs. The Świnoujście LNG terminal required detailed simulations and optimization of berthing and access channels (Gucma & Gucma, 2019).

Revenue Streams. In the context of this research, the revenue streams for an LNG cargo and bunkering terminal in the Port of Constanta are primarily derived from usage fees, terminal infrastructure fees, and brokerage fees. The usage fees are charged based on the volume of LNG fuel supplied to vessels, which represents the core revenue model for bunkering services. Additionally, terminals generate revenue by

charging for the use of specialized infrastructure and also by charging brokerage fees. These diverse revenue models are designed to ensure the financial sustainability of the terminal while supporting the growing demand for LNG in maritime transport.

- Usage fees for LNG bunkering services
- Fees for the use of specialized infrastructure, such as storage tanks and berthing facilities
- Brokerage fees

Usually, clients pay for LNG bunkering services based on the volume of fuel supplied. This is the most common revenue model, as highlighted in studies focused on refueling operations and associated fees (Bruzzone & Sciomachen, 2023). The brokerage fees are an important revenue stream, particularly when the port acts as an intermediary in LNG transactions, connecting LNG suppliers with shipping companies. Ports acting as intermediaries in LNG transactions can generate brokerage fees. This includes facilitating sales between LNG suppliers and shipping companies (Steine, 2013).

Following the strategic mapping of the LNG terminal project through the Business Model Canvas, a deeper evaluation of internal capabilities and external market dynamics is essential. To complement the business model and provide a comprehensive perspective, a SWOT analysis is presented in the following section.

4.2. SWOT Analysis

The SWOT analysis was conducted to assess the strengths, weaknesses, opportunities, and threats linked to the project. Strengths such as the strategic location of Port of Constanta and the existent infrastructure have been identified, along with market demand driven by global environmental regulations favoring LNG.

Conversely, potential challenges, including high capital investment requirements and regulatory compliance complexities, have been addressed to mitigate risks.

The SWOT analysis was informed by a review of multiple secondary data sources, including strategic reports on operational LNG terminals within the European Union, such as the Krk LNG terminal in Croatia (Nikše, 2025), (Török, 2022) and Świnoujście LNG terminal in Poland (Gałczyński et al, 2017), (GASsystem, 2022). Additionally, energy forecasts and market outlooks from British Petroleum (BP, 2024), Shell (Shell, 2024), and international agencies such as International Energy Agency (IEA, 2023), were consulted to assess trends in LNG demand, environmental policy impacts, and infrastructure investment.

Currently, the Black Sea region lacks any operational LNG terminals. Both the AGRI project in Romania and the LNG terminal planned for Odessa, Ukraine, were abandoned despite initial plans and investments. This stands in stark contrast to the progress seen in Eastern Europe, where several countries have already established or are advancing their LNG infrastructure (Gusilov, 2019). Lithuania opened the Klaipėda terminal in 2014, becoming a regional leader in LNG importation, while Poland followed suit with the Świnoujście terminal in 2016. Estonia and Latvia are also moving forward with plans to build LNG terminals in key ports like Riga and Tallinn, signaling their commitment to energy diversification. On the other hand, Turkey, while a significant regional player, only operates LNG terminals in the Sea of Marmara.

These sources provided a comprehensive basis for evaluating internal and external factors affecting the feasibility of the LNG terminal at the Port of Constanța.

	Strengths	Weaknesses
Internal	• Proximity to maritime routes in the Black Sea, enhancing accessibility for international LNG trade. • Global increase in demand for LNG as a cleaner alternative to conventional fuels, driven by stricter environmental regulations.	• Substantial investments required for terminal construction, storage tanks, bunkering facilities, and regasification units. • Extended payback periods may deter investors without strong financial incentives.

	• Regional market potential to serve both maritime traffic and local industrial energy needs, boosting energy security and market stability. • Existing port facilities and logistics capabilities reduce the need for extensive new infrastructure investments. • Deepwater port access capable of accommodating large LNG carriers (LNGCs), ensuring compatibility with diverse vessel sizes. • LNG reduces CO_2, SOx, NOx, and particulate emissions, aligning with the European Green Deal and international sustainability goals. • Supports the transition to low-carbon shipping, positioning Romania as a leader in green maritime infrastructure.	• Complex bureaucratic challenges and time-consuming permitting and regulatory approval processes in Romania, could delay project implementation. • Need for compliance with both national and EU environmental and maritime safety regulations, adding administrative burdens. • Limited domestic experience in developing and operating LNG-specific infrastructure. • Dependence on international technology providers and contractors could increase costs and project complexity. • Current limitations in domestic LNG production may affect supply stability; however, this is expected to improve with the development of the Neptun Deep offshore gas field, enhancing national energy security and supply diversification.
External	Opportunities	Threats
	• Access to European Union grants and subsidies for clean energy projects and sustainable infrastructure development. • Alignment with EU regulations on reducing sulfur emissions in maritime transport (IMO 2020). • Increasing adoption of LNG-powered vessels due to stringent emission regulations, driving demand for LNG bunkering services. • Rising demand for LNG in the industrial and energy sectors within the region, opening new business opportunities. • Potential collaborations with international LNG suppliers, shipbuilders, and technology providers to enhance operational efficiency. • Diversifying Romania's energy sources by integrating LNG into national energy mix. • Reducing dependence on conventional fossil fuels and mitigating risks associated with geopolitical tensions in energy supply chains.	• Geopolitical instability in the Black Sea region and proximity to conflict zones may discourage foreign investments. • Trade disruptions or sanctions could impact LNG supply routes and pricing. • Global price fluctuations in the LNG market affecting investment attractiveness and operational costs. • Competition from other LNG terminals in the region, particularly in Turkey and Greece, which may offer alternative supply options. • Environmental concerns and opposition from local communities regarding potential ecological impacts and industrial expansion. • Possible delays or amendments in national and EU legislation that could impact LNG project viability. • Future policy shifts toward alternative energy sources (e.g., hydrogen) could affect long-term LNG demand.

5.Conclusion

The combined application of the Business Model Canvas and SWOT analysis reveals that developing an LNG cargo and bunkering terminal in the Port of Constanța is not only strategically viable but also aligns well with regional sustainability and energy diversification goals. The terminal's value proposition, centered on cleaner fuel alternatives, improved maritime logistics, and energy security, is reinforced by the advantageous geographic location of Romania, connectivity to Central and Eastern

Europe, and the anticipated Neptun Deep gas production. The business model highlights operational flexibility, regulatory alignment, and scalable service offerings, with potential customer segments spanning LNG-powered vessels, energy distributors, and maritime logistics operators. Revenue streams, including usage and infrastructure fees, support the long-term financial viability of the terminal, particularly when combined with EU financing and public-private partnerships.

Several important lessons have emerged from past LNG projects, particularly the AGRI initiative, which can serve as valuable benchmarks for future energy infrastructure in the region.

Lesson 1 focuses on securing financing and fostering active partnerships. AGRI's failure was largely due to the lack of solid investors and firm sale contracts. Securing pre-contracts that guarantee demand is essential for the financial sustainability of large-scale energy projects. Memoranda of Understanding are not enough; binding agreements with committed buyers are necessary to ensure the project's viability.

Lesson 2 emphasizes the importance of understanding geopolitical context and competitive dynamics. AGRI's attractiveness was undermined by regional instability and the strategic redirection of Azerbaijani gas towards alternative routes. It shall be noted that in the energy sector, the geopolitical environment and the evolving strategies of key players can significantly influence the success or failure of infrastructure projects.

Lesson 3 highlights the need for adaptability to internal developments. The discovery of Romania's offshore gas resources, such as the Neptun Deep field, shifted the national priority from importing LNG projects to focusing on domestic energy production and infrastructure. This underscores the importance of being flexible and responsive to changes in national energy strategies, as the emergence of new domestic resources can alter the course of development projects.

Despite the strategic advantages, the analysis highlights several barriers to implementation. High capital requirements, complex regulatory processes, limited domestic expertise, and geopolitical uncertainties in the Black Sea region pose risks to project execution and investor confidence. Addressing these issues requires coordinated policy support, the attraction of foreign technical expertise, and strong international partnerships to share risk and accelerate capability development. Nonetheless, the project offers significant opportunities to position Romania as a regional leader in LNG infrastructure, reduce reliance on traditional fuels, and meet global decarbonization targets. The LNG terminal has the potential to position Constanta as a major LNG hub in Eastern Europe with the right strategic alignment and stakeholder engagement.

This study has various limitations. It relies on qualitative analysis and secondary data, lacking empirical inputs like expert interviews or cost modeling, which limits the precision of operational assessments. In addition, the fluid geopolitical and regulatory context of the Black Sea region may impact on the project's long-term feasibility.

The results of this research have practical implications for policymakers, port authorities, investors, and maritime operators, as they support informed decision-making and encourage strategic investment in clean maritime infrastructure.

Author contributions: Conceptualization: C.A.G.; Methodology: N.A.; Investigation and Writing original draft: C.A.G.; Writing review and Supervision: N.A.

Declaration: During the preparation of this work the authors used Generative AI in order to improve readability and language of the work. After using this tool/service, the authors reviewed and edited the content as needed and they took full responsibility for the content of the publication.

Conflict of interest: The Authors declare no Conflict of interest.

References

1. Agbo, A., Li, W., Atombo, C., Lodewijks, G., & Zheng, L. (2017). Feasibility study for the introduction of synchromodal freight transportation concept. *4*(1). Retrieved from https://doi.org/10.1080/23311916.2017.1305649
2. Al-Haidous, S., Kais Msakni, M., & Haouari, M. (2016). Optimal planning of liquefied natural gas deliveries. *Transportation Research Part C: Emerging Technologies, Volume 69*, 79-90. doi:https://doi.org/10.1016/j.trc.2016.05.017
3. Bittante, A., Pettersson, F., & Saxén, H. (2018). Optimization of a small-scale LNG supply chain. *Energy, 148*, 79-89. doi:https://doi.org/10.1016/j.energy.2018.01.120
4. BP. (2024). *Energy Outlook.* Retrieved from https://www.bp.com/en/global/corporate/energy-economics.html
5. Bruzzone, A., & Sciomachen, A. (2023). Simulating Operating Performance of Alternative Configurations of LNG Bunkering Stations. *Sustainability, 15, 9940*. Retrieved from https://doi.org/10.3390/su15139940
6. Chang, S., Yun, J., Ryu, S., Seo, S., Lee, H., Chung, Y., & Seo, D. (2015). Conceptual design of an offshore LNG bunkering terminal: a case study of Busan Port. *J Mar Sci Technol, 20:226–237*. doi: DOI 10.1007/s00773-014-0266-1
7. Energynomics. (2024). Retrieved from Ministry of Energy announces feasibility study completion for SOCAR–Romgaz LNG terminal in Constanța : https://www.energynomics.ro/en/ministry-of-energy-feasibility-study-for-the-socar-romgaz-lng-terminal-was-completed/
8. Erickson, B., Marsden, P., Kirkup, P., & Vanderloos, C. (2013). Marine Construction Logistics for a LNG Export Facility. *Success through Diversification*, 1315-1324. doi:https://doi.org/10.1061/9780784413067.135
9. Fan, H., Enshaei, H., & Jayasinghe, S. (2021). Safety philosophy and risk analysis methodology for LNG bunkering simultaneous operations (SIMOPs): A literature review. *Safety Science, 136*. doi:https://doi.org/10.1016/J.SSCI.2020.105150
10. Gałczyński, M., Ruszel, M., Turowski, P., Zajdler, R., & Zawisza, A. (2017). *Global LNG Market.* Ignacy Lukasiewicz Energy Policy Institute.
11. GASsystem. (2022). *FSRU in Gdańsk received EU funding.* Retrieved from https://www.gaz-system.pl/en/for-media/press-releases/2022/december/09-12-2022-fsru-in-gdansk-received-eu-funding.html
12. GEM. (2023). Retrieved from Constanța LNG Terminal. Global Energy Monitor: https://www.gem.wiki/Constanta_LNG_Terminal
13. Gucma, S., & Gucma, M. (2019). Optimization of LNG Terminal Parameters for a Wide Range of Gas Tanker Sizes: The Case of the Port of Świnoujście. *Archives of Transport, Volume50*(Issue2). doi:10.5604/01.3001.0013.5696
14. Gusilov, E. (2019). *BLACK SEA LNG: Dreams vs Reality*. Retrieved from https://roec.biz/project/black-sea-lng-dreams-vs-reality/
15. Hadi, F., Supomo, H., & Achmadi, T. (2023). Using genetic algorithm for fleet assignment of small-scale LNG supply chain. *IOP Conference Series: Earth and Environmental Science, 1166*. doi:https://doi.org/10.1088/1755-1315/1166/1/012045
16. IEA. (2023). *Global Gas Security Review 2023.* International Energy Agency. Retrieved from https://www.iea.org/reports/global-gas-security-review-2023
17. Izzo, D. (2004). Lessons Learned in Planning the Dabhol LNG Terminal. *Port Development in the Changing World*, 1-10. doi:https://doi.org/10.1061/40727(2004)39
18. Jung, D., Kim, Y., Oh, S., Cho, S., Nam, B., Jung, D., & Sung, H. (2020). A Study on the LNG Loading or Unloading Operability of Floating LNG Bunkering Terminal with Ship-to-ship Moored. *International Journal of Offshore and Polar Engineering (ISSN 1053-5381), Vol. 30, No. 4,*. doi:https://doi.org/10.17736/ijope.2020.jc788

19. Lu, W., & Jeong-Ho, S. G.-T. (2019). Location Selection of an LNG Bunkering Port in Korea. *Journal of Korea Trade (JKT), Vol.23 No.2*, 59 - 75. doi:DOI: 10.35611/jkt.2019.23.2.59
20. Manginas, V., Manoli, S., & Nathanail, E. (2017). Enhancing sustainable mobility: A business model for the Port of Volos. *Transportation Research Procedia*, 275–279. doi:10.1016/j.trpro.2017.05.118
21. Nikše, D. (2025). *Croatia's LNG terminal one step closer to capacity expansion.* Offshore Energy. Retrieved from https://www.offshore-energy.biz/croatias-lng-terminal-one-step-closer-to-capacity-expansion/
22. Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers.* Wiley.
23. Park, N., & Park, S. (2019). A Study on the Estimation of Facilities in LNG Bunkering Terminal by Simulation—Busan Port Case. *Journal of Marine Science and Engineering, J. Mar. Sci. Eng. 2019 7, 354;*. Retrieved from https://doi.org/10.3390/jmse7100354
24. Rozmarynowska, M. (2010). LNG in the Baltic Sea region opportunities for the ports. *ZESZYTY NAUKOWE AKADEMII MORSKIEJ W GDYNI, 67*, 89-100.
25. Schneider, F., & Halvorsen, A. (1976). LNG in U.S. Ports. *OCEANS*, 590-595. doi:https://doi.org/10.1109/OCEANS.1976.1154287
26. Seo, S., & Cho, S. (2014). A Study on Floating Offshore LNG Bunkering System and its Economic Analysis. *Journal of Korea Port Economic Association, 30*, 69-89. Retrieved from https://koreascience.kr/article/JAKO201406566439106.page
27. Shell. (2024). *Shell LNG Outlook 2024.* Retrieved from https://www.shell.com/media/news-and-media-releases/2024/shell-lng-outlook.html
28. Steine, C. (2013). A New Small-Scale LNG Distribution and Bunkering Facility: - An Approach to Risk Based Design and Verification. Retrieved from https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/238661
29. Török, V. (2022). Experience of the Krk LNG Terminal'sOperation in Croatia Over the Past Year. *Academic and Applied Research in Military and Public Management Science, 21*(2), 55–68. doi:10.32565/aarms.2022.2.4
30. Wang, S., & Notteboom, T. (2015). The role of port authorities in the development of LNG bunkering facilities in North European ports. *WMU Journal of Maritime Affairs, 14*, 61-92. doi:https://doi.org/10.1007/S13437-014-0074-9
31. Whitmore, W., Baxter, V., & Laska, S. (2009). A critique of offshore liquefied natural gas (LNG) terminal policy. *Ocean & Coastal Management, 52*, 10-16. doi:https://doi.org/10.1016/J.OCECOAMAN.2008.10.002
32. Yao, H., Wang, D., Wu, H., Fang, Z., & Ding, W. (2021). Analysis of the elements of the LNG terminal's location in Dalian Port under the background of carbon neutrality in China. *IOP Conference Series Earth and Environmental Science*. doi:10.1088/1755-1315/734/1/012008
33. Yin, R. (2018). *Case study research and applications* (6th ed.). SThousand Oaks: AGE Publications.
34. Yong, X. (2012). Discussion on the compatibility of LNG terminal and Big Port from the view to ensure the special navigation security of LNG carriers.
35. Zhuo, F., Qi, Y., Jun, H., Jun, H., & Dong, M. (2014). Agent-Based Simulation Analysis on the Effect of an LNG Terminal on a Port Transport System. *Safe, Smart, and Sustainable Multimodal Transportation Systems*, 133-144. doi:https://doi.org/10.1061/9780784413623.014