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GREEN LNG AS A HUB FOR THE ENERGY TRANSITION

Natural Gas Working Group
(GAS WG)

Empowering Mediterranean regulators for a common energy future

ABOUT MEDREG

MEDREG is the Association of Mediterranean Energy Regulators, uniting 28 regulators from 23 countries across the European Union (EU), the Balkans, and the MENA region. Established in 2007 and co-funded by the European Union, MEDREG serves as a platform for cooperation, knowledge sharing, and capacity building in energy regulation. It promotes coherent regulatory approaches and practices at the regional level, aiming for progressive market integration within the Euro-Mediterranean basin. To support its members, MEDREG organises training sessions, workshops, and tailored hands-on initiatives that enhance the capacity of energy regulators.

MEDREG's ultimate goal is to establish an integrated Euro-Mediterranean energy market that strengthens energy security and drives a clean energy transition. This includes integrating renewable energy sources, reinforcing cross-border infrastructure, promoting innovation, enhancing energy efficiency, and advancing renewable gases such as hydrogen. Additionally, MEDREG advocates for transparent and non-discriminatory regulation to attract infrastructure investments, modernise electricity and gas markets, and improve consumer protection.

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Executive Summary

This report examined green LNG, which aims to mitigate the environmental impact of liquefied natural gas (LNG) by implementing strategies to reduce greenhouse gas emissions throughout the supply chain. For this, it investigated Mediterranean countries' perspectives on the role of green LNG in their energy transition plans, focusing on its potential as a transitional fuel. Moreover, it assessed their readiness for a successful green LNG transition, evaluating existing infrastructure, regulatory frameworks, and technological capabilities. Furthermore, the report explored the potential for integrating renewable energy sources into the LNG supply chain, such as by utilising renewable energy for liquefaction and gasification processes, thereby enhancing the overall sustainability of LNG production. The data for this report were collected using a survey, which was circulated among the GAS WG members of MEDREG to capture regional trends and advancements, as well as investigate whether green LNG can address energy transition barriers.

The Mediterranean region is actively pursuing the energy transition, with several countries implementing policies that promote clean energy sources, including renewable energy, hydrogen, and biomethane. These policies encompass financial incentives, research and development programmes, and infrastructure development. However, the perspectives on the role of natural gas vary significantly. While some countries view it as a crucial bridge fuel, others prioritise renewable energy and aim to reduce reliance on gas. The transition faces several challenges, such as dependence on fossil fuels, the need for significant infrastructure investments, the problem of securing financing, and the need to ensure energy security. Despite these challenges, the region presents significant opportunities, such as abundant renewable resources, potential for economic diversification, job creation, and the chance to attract international investment in clean energy. The present chapter highlights the case of Portugal, which exemplifies the complexities of balancing natural gas infrastructure with the transition to renewable energy, emphasising the importance of early planning, sector integration, and a coherent policy framework for a successful energy transition.

At present, the development and utilisation of green gases, such as biomethane and renewable gases, are gaining traction within the Mediterranean region. Several countries such as France and Spain have developed national roadmaps and strategies to promote these cleaner energy sources, setting ambitious targets for production and consumption. These initiatives often include financial incentives, research and development programmes, and supportive regulatory frameworks. However, the regulatory landscape for green LNG, which aims to reduce greenhouse gas emissions associated with traditional LNG production, continues to be largely underdeveloped across the region. While some countries are considering revisions to their legal frameworks to accommodate green LNG, most countries surveyed indicated that specific regulations for green LNG are currently lacking. This points to the need for further development of clear and supportive regulatory frameworks to facilitate the development and utilisation of green LNG and other green gases within the Mediterranean region, thereby contributing to a more sustainable energy future.

Carbon neutrality is a crucial area to be addressed within the natural gas sector, where it is necessary to examine various strategies to reduce greenhouse gas emissions. Countries in the European Union (EU) follow the EU Emissions Trading System (EU ETS), whereas others are developing national carbon offsetting mechanisms. As demonstrated by pilot projects outside the Mediterranean region, integrating renewable energy into LNG liquefaction and regasification processes offers significant potential for emissions reduction. However, challenges such as the high costs of carbon capture and storage (CCS), the intermittency of renewable energy sources, and the need for robust monitoring of offset projects require careful consideration. Therefore, this report emphasised the importance of these strategies in achieving carbon neutrality within the natural gas sector while acknowledging the need for further development and implementation of these technologies and mechanisms across the Mediterranean region.

The report examined the critical role LNG infrastructure plays in the Mediterranean, analysing existing terminals, their services, and the evolving landscape of small-scale LNG (SSLNG). The complexities of institutional and financial frameworks governing these projects highlight the interplay of public and private actors. Considering the challenges and opportunities of green LNG, it is evident that there is a need to address these challenges systematically. This stresses the necessity for robust regulatory frameworks, financial incentives, and international cooperation to overcome hurdles such as high investment costs and technological limitations.

Green LNG has significant potential as a transitional fuel in the Mediterranean, bridging the gap between fossil fuels and a renewable energy future. However, realising this potential requires a concerted effort to address key challenges. Therefore, a universally accepted definition of green LNG is crucial, along with developing robust and cost-effective carbon capture, utilisation, and storage (CCUS) technologies, as well as integrating renewable energy sources. Strengthening infrastructure, creating supportive policies, and ensuring the financial viability of green LNG projects are also vital. Collaboration among stakeholders is essential to establish a robust framework that encourages innovation and investment in green LNG technologies, ultimately paving the way for a more sustainable and resilient energy system in the Mediterranean.

1. Introduction

In recent times, the concept of 'green LNG' has emerged as a potential solution to reduce the environmental impact of LNG while maintaining its competitive advantages in the global market. LNG, long considered a cleaner alternative to more carbon-intensive fuels, is widely used in sectors such as maritime transport and heavy-duty vehicles. However, as the world strives for climate neutrality, the LNG supply chain's greenhouse gas emissions—particularly methane—require reassessment, leading to the rise of green LNG initiatives focusing on reducing or offsetting emissions to make LNG more compatible with a low-carbon future. Despite its promise, the green LNG concept faces significant challenges, ranging from the lack of standardised definitions to transparency issues in carbon offsetting practices.

Green LNG represents a critical innovation in the energy sector, aiming to bridge the gap between fossil fuels and renewable energy sources. This report explores the potential of green LNG to serve as a transitional fuel, facilitating a smoother shift to a low-carbon economy.

This report's primary objective was to evaluate the current state and prospects of green LNG. The analysis was based on data collected through a comprehensive questionnaire distributed to the MEDREG GAS WG members from various countries in the Mediterranean region. This methodology ensured a robust understanding of the challenges, opportunities, and regulatory landscapes influencing Green LNG adoption.

1.1. Overview of Green LNG

Green LNG refers to the efforts made by LNG suppliers to either directly reduce greenhouse gas emissions across the supply chain or offset these emissions by investing in external projects such as reforestation or renewable energy initiatives. Offsetting often involves purchasing carbon credits, allowing suppliers to market LNG as carbon-neutral LNG. However, these practices are controversial because of a lack of a universally agreed upon definition of green LNG, as different suppliers use varying methods for measuring and reporting emissions reductions. Most offsetting efforts currently focus on the 'tank-to-wheel' phase of LNG's lifecycle, which deals with the fuel's transport and use. Even so, the upstream 'well-to-tank' emissions—arising from natural gas extraction, liquefaction, and transport—are significant contributors to its overall carbon footprint.

To simplify, from this point forward, LNG will be referred to as green LNG" if efforts are made to decarbonise the LNG supply chain.

A more comprehensive life cycle assessment (LCA) approach is required to fully account for both carbon dioxide (CO2) and methane emissions in LNG's supply chain. Methane, a potent greenhouse gas, often escapes during natural gas extraction and transport, which risks undermining the supposed environmental benefits of LNG. Moreover, while LNG remains a cleaner option than traditional fossil fuels, particularly in transport, its overall impact depends on the effectiveness of these emissions reductions and offsetting strategies. Additionally, alternative approaches, such as liquefied biomethane produced from biogas, could offer a more sustainable version of LNG, even achieving negative emissions under certain conditions.

Green LNG plays a crucial role in the global energy transition by offering a cleaner alternative to oil and coal in hard-to-decarbonise sectors, such as maritime transport. As the world seeks to reduce its reliance on carbon-intensive fuels, LNG can offer a transitional solution, especially when accompanied by rigorous emissions reductions or offsetting mechanisms. However, its long-term viability will depend on how well the key challenges facing it are addressed, such as creating standardised certifications for green LNG, improving transparency in emissions accounting, and adopting more comprehensive LCAs that consider both CO2 and methane emissions.

One of the most promising developments in the green LNG sector is the potential for liquefied biomethane, which is produced from biogas derived from agricultural waste. Biomethane offers the possibility of negative emissions, as it captures methane that would otherwise be released into the atmosphere. While the current costs of liquefied biomethane are higher than those of conventional LNG, its potential to significantly reduce the carbon footprint of natural gas makes it a critical area for further research and development. By integrating green LNG into the broader strategy for energy transition, particularly in sectors where carbon reduction presents a challenge, LNG can contribute meaningfully to global decarbonisation efforts while providing the flexibility needed during this transitional period.

1.2. Objectives and Methodology

This report's primary objective was to provide a thorough understanding of the concept of green LNG and its significance in the context of the Mediterranean region. As LNG is increasingly perceived as a transitional fuel in the global shift towards cleaner energy, stakeholders across the Mediterranean must agree on the role it plays in the energy mix. This report sought to ensure that all parties involved in the region share a common understanding of the opportunities and challenges associated with green LNG, especially concerning its potential for decarbonising sectors such as maritime transport and heavy industry. Establishing a common understanding is vital for fostering regional cooperation, which, in turn, is essential for the success of any energy transition strategy.

A key focus of the report was to assess whether the Mediterranean countries share the same objectives in their energy transition plans, particularly concerning the future role of natural gas. Despite global pressure to reduce fossil fuel dependence, natural gas still plays a significant role in the region due to its relatively lower carbon emissions than other hydrocarbons and its importance for energy security. Many Mediterranean countries are heavily dependent on gas imports from major exporters, and this dependence could influence their approach to the energy transition. The report explored whether these countries perceive gas as a bridge fuel that will continue to play a role in their future energy strategies or if they are committed to reducing reliance on gas in favour of renewables and other low-carbon alternatives.

Another important aspect of the report was the evaluation of the Mediterranean region's readiness to implement changes required for green LNG and broader energy transition efforts. This involved examining existing infrastructure, regulatory frameworks, and technological capabilities, as well as the financial and political support for adopting new technologies and approaches. The report analysed the extent to which countries in the region are equipped to make the necessary investments in green LNG and whether they have the institutional capacity to manage the transition effectively. This includes considerations such as the ability to monitor and reduce emissions throughout the LNG supply chain and the potential for integrating more sustainable practices into gas-related processes.

Finally, the report explored the potential for renewable energy sources to play an active role in the LNG supply chain, specifically in liquefaction and gasification processes. By assessing the feasibility of using renewables to power these energy-intensive processes, the report aimed to identify opportunities for further reducing the carbon footprint of LNG in the Mediterranean. The possibility of combining LNG with renewable technologies could enhance the region's energy resilience and sustainability, helping to strike a balance between energy security and decarbonisation goals. Thus, this analysis provided valuable insights into how renewable energy can complement natural gas in the energy transition and whether it can serve as a viable long-term solution for the region's energy needs.

To do so, a questionnaire was circulated among the GAS WG members, representing the different national regulatory authorities in the Mediterranean region. The questionnaire was divided into four sections, as shown below:

1. Current State of the Energy Sector
2. Awareness and Perception of Green LNG
3. Reduction of Greenhouse Gas Emissions in the Gas Sector
4. Infrastructure and Regulations

Through the questionnaire, the MEDREG Secretariat collected the data and information from its members and collaboratively drafted the report with the GAS WG chairs. In that regard, responses from Algeria, Egypt, Cyprus, France, Greece, Italy, Lebanon, North Macedonia, Portugal, Spain, and Türkiye were considered in this study. However, it is noteworthy that some countries, such as Cyprus, Lebanon, and North Macedonia, did not have current LNG infrastructures, and, hence, their contributions to the report might be may be smaller compared to those of other countries.

Figure 1 - Countries Assessed in the Report (Map created using Mapchart.net)

To simplify the research and ensure that harmonised results are attained from the questionnaires circulated among the MEDREG members, a generic definition of green LNG that has been agreed upon by the WG members is as follows: *Green LNG refers to liquefied natural gas (LNG) produced from fossil fuel natural gas and utilising mechanisms such as offsetting and carbon capture to reduce greenhouse gas emissions and minimise environmental impact throughout the entire production process.*

When discussing green LNG, we did not consider renewable gases such as biomethane. Conversely, liquefied biomethane is already regarded as zero-carbon LNG and does not undergo any offsetting mechanism. The degree of decarbonisation or offsetting required to identify green LNG should be agreed upon internationally and recognised, should the technology become relevant in the years to come.

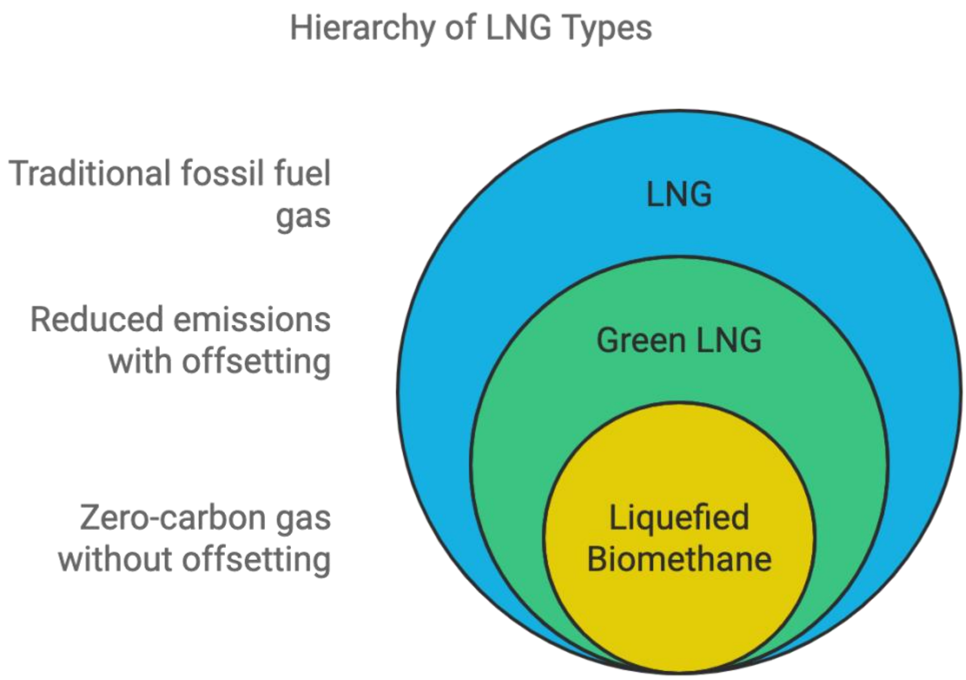

Figure 2 - LNG Types

1.3. Limitations

While every effort has been made to ensure the accuracy and comprehensiveness of the information presented in this report, it is important to acknowledge that the issue is dynamic. Nevertheless, the report offers a snapshot of green LNG's status, contributing to the ongoing dialogue on the energy transition while keeping in mind the priorities to ensure a secure, smooth, and sustainable transition. Additionally, the report also aimed to inform and foster the development of effective strategies to address the challenges.

2. Current State of the Energy Sector

2.1. Promoting Clean Energy Sources and the Energy Transition

2.1.1. Current Policies and Regulations to Promote Clean Energy Sources

It is well-known that the transition to a clean energy economy faces significant obstacles, with natural gas having a pivotal role to play in this transformation given its relative cleanliness compared to other fossil fuels, as well as its ability to provide a flexible energy system. MEDREG member countries are actively exploring and implementing diverse policy approaches to promote clean energy sources within the gas sector, contributing to the overall energy transition.

To facilitate this transition, countries in the Mediterranean region have implemented a range of policies and regulations to promote clean energy within the gas market. For example, Algeria has established national strategies to prioritise energy diversification and renewable energy alongside natural gas. Egypt has implemented regulatory frameworks to support the development of the gas market, whereas France has established favourable regulations and support mechanisms to encourage the development of biomethane. Greece has outlined policies and regulations to promote clean energy sources within the gas market, focusing on green hydrogen. Italy, as an EU member, is bound by EU regulations and targets. The Italian government has implemented policies to promote clean energy sources, including the National Energy and Climate Plans (NECPs) and the Recovery and Resilience Facility (RRF). Lebanon, while primarily focused on renewable energy power generation, has demonstrated support for initiatives to promote clean energy, including green hydrogen. North Macedonia has developed strategies to diversify supply routes and increase market competitiveness. Portugal has stated that it has a NECP 2030, which includes actions to promote renewable gases such as biogas and green hydrogen. Spain has outlined targets for hydrogen and biogas production and consumption. Türkiye is developing policies and regulations for including hydrogen in the natural gas transmission and distribution systems.

Furthermore, these countries have also implemented various financial incentives to encourage investment in clean energy technologies. For example, Algeria offers tax breaks, reduced tariffs, and simplified licensing processes for companies adopting cleaner practices; Portugal has proposed mechanisms to support both the production and consumption of green hydrogen; and Italy has utilised the RRF to promote the production of biomethane and cleaner production processes.

In addition to financial incentives, investments in research and development are crucial for advancing clean energy technologies and reducing costs. Spain has launched economic instruments to promote research and development in the renewable hydrogen production-supply value chain, innovative hydrogen projects, and biogas initiatives, whereas Portugal has plans to encourage research and development in renewable energies, storage, hydrogen, advanced biofuels, and other 100% renewable fuels.

Building the necessary infrastructure, such as renewable energy plants and hydrogen refuelling stations, is another essential component of the energy transition. Greece has plans to expand infrastructure for green hydrogen production, while North Macedonia has strategies to develop natural gas infrastructure to diversify supply routes. Besides, Portugal has plans to implement a collaborative laboratory (COLAB) for hydrogen projects, and Spain has regulatory measures to promote the injection of renewable gases into the natural gas networks.

Green hydrogen and biomethane are two emerging clean energy sources gaining traction in the Mediterranean region. Greece has emphasised green hydrogen development in its draft NECP; Spain has set ambitious targets for hydrogen and biogas production and consumption; and Portugal has plans to produce and consume green hydrogen and biomethane.

Thus, looking at the global picture, several common themes emerge from the responses of the members to the questionnaire. These are presented as follows:

National Strategies: Several countries have established national strategies that prioritise clean energy and set ambitious targets for renewable energy integration, demonstrating a widespread recognition of the importance of transitioning away from fossil fuels.

Regulatory and Legislative Frameworks: Countries are implementing clear and supportive regulatory frameworks to facilitate investment and development of clean energy projects, creating a conducive environment for businesses to invest in clean energy technologies.

Financial Incentives: Governments are offering various financial incentives, such as tax breaks, subsidies, and grants, to encourage investment in clean energy, which helps to bridge the cost gap between traditional fossil fuels and cleaner alternatives.

Research and Development: Investments in research and development are crucial for advancing clean energy technologies and reducing costs. Various countries are supporting research projects and fostering innovation in this area.

Infrastructure Development: Building the necessary infrastructure, such as renewable energy plants and hydrogen refuelling stations, is essential for the widespread adoption of clean energy. Several countries have plans to expand their infrastructure for clean energy projects.

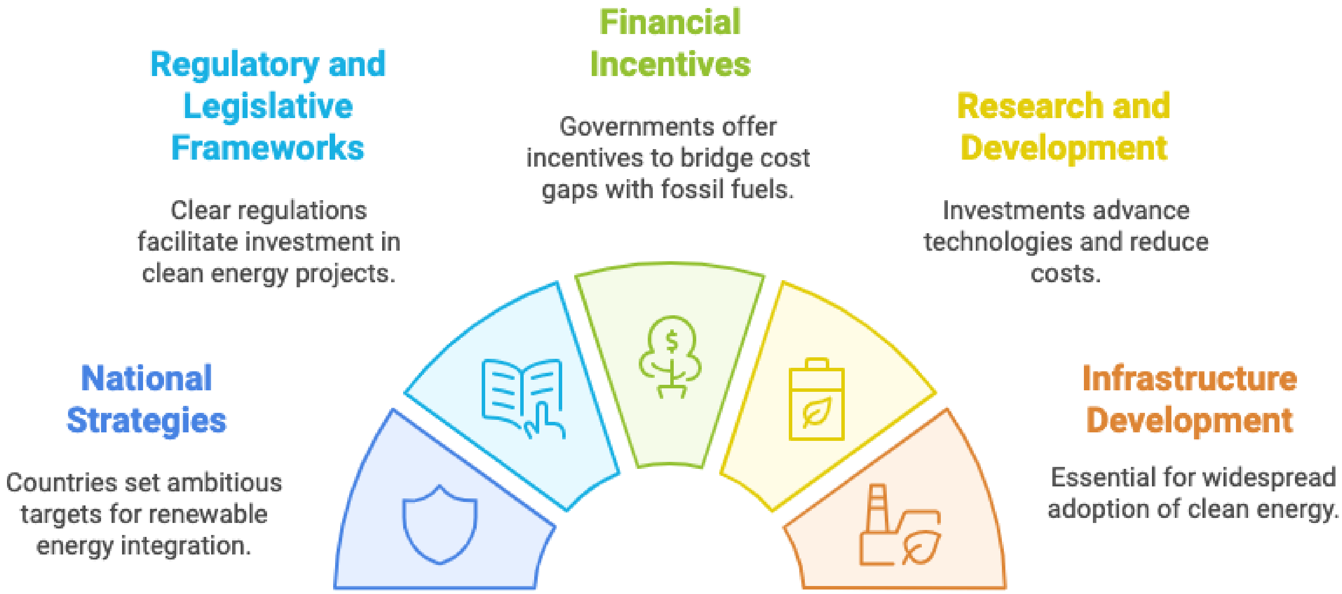

Figure 3 - Summary of Clean Energy Sources Adoption

However, while these countries share similarities, it is important to note that each has its own context and challenges. These factors can often impact the priorities when it comes to clean energy.

2.1.2. The Role of the Gas in the Energy Transition

As previously mentioned, the role of natural gas in the energy transition is a complex and highly contested topic, eliciting varying perspectives across the Mediterranean region. While some countries perceive gas as a crucial bridge fuel given its numerous advantages in providing a stable energy system, others are more cautious about its role in decarbonisation efforts, fearing that using natural gas would lead to increased dependence.

Algeria is a prominent example of a country that considers natural gas a key component of its energy transition. The country possesses significant natural gas reserves and relies heavily on gas for both domestic consumption and exports. Algeria's strategy involves leveraging its gas resources to support the development of renewable energy infrastructure while reducing greenhouse gas emissions through initiatives such as gas flaring reduction and hydrogen production. Similarly, Egypt also sees gas as part of its clean energy transition, recognising its role as a bridge fuel to provide stability while renewable energy sources are scaled up. Both countries are net gas exporters, being the only countries in the region with the ability to liquefy and ship out LNG globally.

Conversely, France adopts a more cautious stance, focusing on biomethane as a key part of its decarbonisation strategy. While natural gas is not considered part of the energy transition in France, the country is exploring CCS technologies to reduce emissions from the gas sector.

Greece prefers to reduce dependence on hydrocarbon energy imports and is prioritising renewable energy source development. Although Greece acknowledges the role of gas as a transition fuel in neighbouring countries, it is not promoting gas as a component of its own clean energy transition. Italy recognises the complexity of the energy transition and the need for a balanced approach that includes both renewable energy and conventional sources. Its strategy involves promoting renewable energy while ensuring adequate supplies from conventional sources in the short term. The country is also exploring the potential for reconverting gas infrastructure for hydrogen transmission and distribution in the long term. Lebanon perceives natural gas as a temporary part of its energy transition but not a long-term solution, aiming to gradually reduce its reliance on gas-fired power plants and increase renewable energy source usage. North Macedonia considers natural gas a transition fuel to replace coal by 2050. The country is planning to expand its gas infrastructure through interconnections with neighbouring countries and is also exploring the potential for hydrogen production. Portugal identifies potential challenges related to infrastructure cost recovery, guaranteeing gas needs with renewable gases, and sector integration. However, benefits can be reaped from the Energy Efficiency First principle and sector integration. Moreover, Spain recognises the role of gas as part of its energy transition but prioritises renewable energy and hydrogen as key components of its decarbonisation strategy, whereas Türkiye views natural gas as a cleaner alternative to coal and is actively promoting its use in various sectors. The latter is also working on reducing emissions from the gas sector through initiatives such as gasification and CCS.

Overall, the Mediterranean region showcases a diversity of perspectives on the role of gas in the energy transition. While some countries regard gas as a valuable bridge fuel, others are more focused on renewable energy and other low-carbon alternatives. The choice of approach depends on various factors, including a country's energy resources, infrastructure, and economic priorities. However, with some of MEDREG's goals such as establishing a coherent regulatory framework and taking a more collaborative approach, certain challenges should be addressed collectively.

2.2. Challenges and Opportunities Involving the Energy Transition

The energy transition presents significant barriers that must be addressed. While some countries, such as France, have a head start due to their existing energy infrastructure, others, like Algeria and Egypt, face significant hurdles in transitioning from fossil fuels. Algeria faces challenges related to its dependence on fossil fuels, infrastructure needs, and financing, although the country also possesses abundant renewable resources and has the potential to attract foreign investment in clean energy projects. Egypt, on the other hand, is heavily reliant on natural gas for power generation and requires clear financing support and practical deployment showcases to accelerate its energy transition. Nevertheless, Egypt's ambitious renewable energy targets offer significant opportunities for growth.

Moreover, France has a strong foundation for decarbonisation due to its historical focus on nuclear power and renewable energy development. However, the country still faces challenges in reducing its reliance on fossil fuels and increasing electricity production. Greece faces challenges in meeting energy efficiency targets, ensuring energy security, and developing infrastructure for renewable energy integration. Despite this, Greece has high potential for wind and solar power and can benefit from initiatives to promote electromobility and improve energy efficiency. Italy must balance decarbonisation objectives with security of supply and energy affordability. The country also faces challenges in persuading energy partners outside the EU to adopt cleaner production processes. However, Italy has vast opportunities for growth in renewable energy, job creation, and investment attraction. Lebanon has made progress in adopting renewable energy, particularly solar photovoltaic (PV) systems. While the country has opportunities to expand its renewable energy mix, the exploration and production of natural gas remains challenging. North Macedonia faces challenges related to the timely implementation of planned measures and inter-institutional cooperation. However, the country has opportunities to leverage its renewable energy potential and secure additional funding for clean energy projects. Portugal faces obstacles related to infrastructure cost recovery, guaranteeing gas needs with renewable gases, and sector integration. However, the country can benefit from the Energy Efficiency First principle and sector integration. Spain aims to achieve ambitious greenhouse gas reduction targets but faces challenges in decarbonisation, energy efficiency, security of supply, and competitiveness. However, Spain has opportunities to leverage its renewable energy potential and promote research and innovation. Finally, Türkiye faces challenges related to the additional cost of new clean energy facilities and systems. However, the country has significant potential for producing green gases using its renewable energy resources.

Figure 4 - Challenges and Opportunities of the Energy Transition

In summary, the challenges and the opportunities can be outlined as follows:

Key Challenges

- Dependence on fossil fuels: Several countries rely heavily on fossil fuels for their energy needs, making it difficult to transition to cleaner alternatives.
- Infrastructure needs: Substantial investments are required to develop the necessary infrastructure for renewable energy sources, such as grids and storage systems.
- Financing: Securing financing for renewable energy projects can be challenging, especially when competing with established fossil fuel markets.
- High Costs: In addition to financing difficulties, the costs associated with decarbonising the system are significant.
- Technical expertise: A lack of skilled labour and technical expertise in renewable energy technologies may hinder progress.
- Energy security: Ensuring a stable and reliable energy supply during the transition can be a concern, especially for countries that rely on imports.

Key Opportunities

- Abundant renewable resources: Several countries have significant potential for renewable energy sources, such as solar and wind power.
- Economic diversification: Transitioning to clean energy can create new economic opportunities and reduce dependence on fossil fuels.
- International investment: Renewable energy projects can attract foreign investment, boosting economic growth and development.
- Climate commitments: Investing in clean energy can help countries meet their international climate commitments and improve their global standing.
- Energy security: Diversifying energy sources can enhance energy security and reduce reliance on imports.
- Job Creation: This would lead to the creation of more green job opportunities.

To successfully navigate these challenges and capitalise on the opportunities, these countries must adopt tailored strategies that address their specific needs. This entails investing in renewable energy infrastructure, developing supportive policies, and fostering international cooperation.

Quick Look

Portuguese Case Study: Balancing the Need for Natural Gas Infrastructure with the Transition to Renewable Energy Sources

Portugal, like many European countries, is facing the challenge of decarbonising its energy system while ensuring a stable and reliable energy supply. The country has ambitious renewable energy targets and is investing in renewable energy projects. However, natural gas remains an important part of Portugal's energy mix, particularly for the security of the electric system supply given the high contribution of renewable energy to electricity production, as well as for industrial processes. Nevertheless, there are some key issues that need to be considered:

<u>Infrastructure cost recovery</u>: As the demand for natural gas decreases due to the increasing adoption of renewable energy sources for electricity production and fuel switching from natural gas to other energy sources, there is a risk of infrastructure cost recovery issues. Portugal may face challenges in recouping the investments made in natural gas infrastructure.

<u>Guaranteeing gas needs:</u> Portugal needs to ensure that it has sufficient gas supplies to meet its needs, especially during peak demand periods or in case of supply disruptions.

Sector integration: Integrating the electricity and gas sectors is becoming increasingly important. Therefore, Portugal must consider the effects of this integration on both sectors and ensure that they work together efficiently.

<u>Energy efficiency:</u> Portugal is prioritising energy efficiency measures to reduce overall energy consumption and decrease the demand for both natural gas and electricity.

<u>Renewable gases:</u> The country is exploring the potential of renewable gases, such as biomethane, to replace fossil natural gas.

<u>Policy framework:</u> The country is developing a comprehensive policy framework to guide its energy transition, which comprises measures to support renewable energy, promote energy efficiency, and ensure energy security.

Lessons Learned:

<u>Early planning:</u> Portugal's experience highlights the importance of early planning and strategic thinking in managing the transition to renewable energy while maintaining a stable gas supply.

<u>Sector integration</u>: Integrating the electricity and gas sectors can offer opportunities for optimising energy use and reducing costs, but it requires careful planning and coordination.

<u>Policy coherence</u>: A clear and coherent policy framework is essential for guiding the energy transition and ensuring that all stakeholders are aligned.

Portugal's efforts to balance natural gas infrastructure with renewable energy integration can serve as a valuable case study for other countries facing similar challenges. By learning from Portugal's experiences, other countries can develop effective strategies to manage their energy transition and ensure a sustainable and secure energy future.

3. Cleaner Sources of Gas

3.1. Roadmaps and Strategies for Green Gases

This sub-chapter explores the national roadmaps and strategies implemented by MEDREG member countries to promote the development and utilisation of green gases, focusing especially on biomethane and renewable gases. It provides an overview of the diverse approaches adopted by these countries and highlights the key trends and challenges in the region.

Algeria has embarked on a comprehensive National Renewable Energy Strategy, aiming to diversify its energy mix by incorporating biomass and biogas. Supported by Law 04-09, this strategy establishes a robust regulatory framework to develop and integrate renewable energy technologies, including those associated with green gases. Although Egypt has not yet developed a specific roadmap for green gases, the development of such strategies likely falls under the purview of the Ministry of Petroleum and Ministry of Environment, potentially within the framework of the Energy Strategy 2035. France has taken a proactive approach, implementing a national strategy that promotes biomethane production. The strategy, which is currently under consultation, sets ambitious targets, aiming for 50 TWh of biogas production by 2030 and at least 15% grid injection. A favourable regulatory framework supports this goal, including the 'right to injection', feed-in tariffs, and biomethane production certificates. The strategy envisions further production increases by 2035. Italy, while lacking a dedicated green gas strategy, has incorporated biogas and biomethane into its 2023 NECP, which sets a 2030 production target of 5 Mtoe (6 billion m3) of biogas and biomethane, divided between thermal and transportation uses. Lebanon has not yet developed a roadmap for green gases, but the presence of a biogas plant demonstrates its potential for future development in this area. North Macedonia has included measures for constructing biomass and biogas power plants in its Strategy for Energy Development until 2040. Portugal has adopted a comprehensive approach with the Biomethane Action Plan 2024–2040, which establishes a strategy for developing the biomethane market, aiming for 2.72 TWh by 2030 and 5.57 TWh by 2040. This could lead to a significant reduction in natural gas consumption. Spain has demonstrated a strong commitment to green gases with dedicated roadmaps for hydrogen (2020) and biogas (2022). These roadmaps, along with the NECP (2021-2030), set ambitious targets for hydrogen and biogas production and consumption. Spain has also implemented economic and regulatory instruments to support renewable gas development. Finally, Türkiye has set the target of publishing the regulation for the utilisation of biogas and biomethane in the gas network in its Energy Strategic Plan 2024–2028, demonstrating a growing interest in these green gases.

Quick Look

Spanish Case Study: Focus on Green Gas

Spain has emerged as a frontrunner in adopting and promoting green gases within the MEDREG region. The country's comprehensive approach, encompassing strategic planning, policy implementation, and investment, has positioned it as a model for other member states.

Key Elements of Spain's Green Gas Strategy:

- Strategic planning: Spain has developed dedicated roadmaps for hydrogen and biogas, outlining ambitious targets for production and consumption by 2030 and 2050. These roadmaps align with the broader objectives of the NECP, further strengthening the country's commitment to green gases.
- Policy implementation: Spain has implemented a range of regulatory measures to foster the development and utilisation of green gases. These include guarantees of origin, favourable tariff schemes for renewable gas injection, and support for innovative projects.
- Investment: Spain has launched economic instruments to promote the research, development, and deployment of green gas technologies. These initiatives have attracted investments from both the public and private sectors, contributing to the growth of the green gas industry.

Impact and Achievements:

- Production targets: Spain's ambitious targets for hydrogen and biogas production have positioned the country as a leader in the region.
- Regulatory framework: The country's regulatory framework has created a conducive environment for green gas investments and development.
- Technological advancements: Spain has fostered innovation in green gas technologies, contributing to advancements in production, storage, and utilisation.

Lessons Learned:

- Strategic vision: A clear and comprehensive national strategy is essential for guiding the development of green gases.
- Policy coherence: Aligning green gas policies with broader energy and climate objectives ensures consistency and effectiveness.
- Investment incentives: Financial support can play a vital role in attracting investments and accelerating the deployment of green gas technologies.
- International cooperation: Collaboration with other countries can facilitate knowledge sharing, best practices exchange, and the development of regional synergies.

Spain's experience in promoting green gases offers valuable insights for other MEDREG member states seeking to accelerate their transition to a more sustainable energy future. By adopting a similar approach, these countries can leverage the potential of green gases to achieve their climate goals and enhance energy security.

3.2. Potential Room for Green LNG

The development of green LNG presents a promising opportunity for reducing greenhouse gas emissions and promoting a more sustainable energy future. However, the regulatory landscape for green LNG varies significantly across MEDREG member countries, with some establishing frameworks while others lacking specific provisions.

Algeria's energy policy is evolving towards a more sustainable approach, with a growing focus on renewable and low-carbon energy sources, including green LNG. While traditional hydrocarbons still dominate, the government is actively considering revising existing laws to better accommodate green energy projects. A key factor influencing Algeria's stance on green LNG is its commitment to reducing greenhouse gas emissions. The country has recognised the potential of green LNG as a cleaner alternative to traditional LNG, especially considering its large natural gas reserves. By developing green LNG, Algeria can diversify its energy mix, reduce its carbon footprint, and potentially increase its exports to international markets.

Egypt's existing legal framework appears to support the development of LNG – both green and conventional – from a business and technical perspective. This indicates that the country's regulatory environment is generally conducive to LNG projects. Egypt has been actively promoting the development of its LNG industry, focusing on both domestic consumption and exports. Moreover, the government has implemented various policies and incentives to attract investments and facilitate the construction of LNG infrastructure. While specific provisions related to green LNG may not be explicitly stated, Egypt's overall approach to LNG development seems to align with principles of sustainability and environmental protection.

North Macedonia is in the process of updating its energy laws to address the issue of green LNG development. However, its current regulations do not specifically support such projects. The country has been attempting to transition towards a more sustainable energy mix, focusing on renewable energy sources. While it may not have large natural gas reserves, North Macedonia could benefit from green LNG as a cleaner alternative to traditional fossil fuels. By developing a regulatory framework that supports green LNG projects, North Macedonia could attract investments and contribute to global efforts to reduce greenhouse gas emissions.

Finally, Türkiye has proposed the inclusion of green LNG in its energy transition roadmaps, pointing to a potential future regulatory framework. However, at present, there is no specific legal framework in place to support green LNG development.

Most countries have stated that green LNG has not currently been addressed, and for the time being, it seems like a long-sought dream. It is noteworthy that for EU member countries, this is the case since a specific definition for green LNG is not considered in European regulations.

4. Efforts for Carbon Neutrality

4.1. Carbon Mitigation and Offsetting Mechanisms

The transition to a low-carbon economy necessitates innovative solutions to reduce greenhouse gas emissions across various sectors. The natural gas sector, although often perceived as a bridge fuel, presents opportunities for decarbonisation. Carbon mitigation and offsetting mechanisms, which allow entities to compensate for their emissions by supporting emissions reduction projects, can contribute to mitigating the environmental impact of natural gas operations. This sub-chapter explores the potential of carbon offsetting mechanisms to decarbonise the natural gas sector, focusing on specific initiatives and strategies implemented or under development within MEDREG member countries.

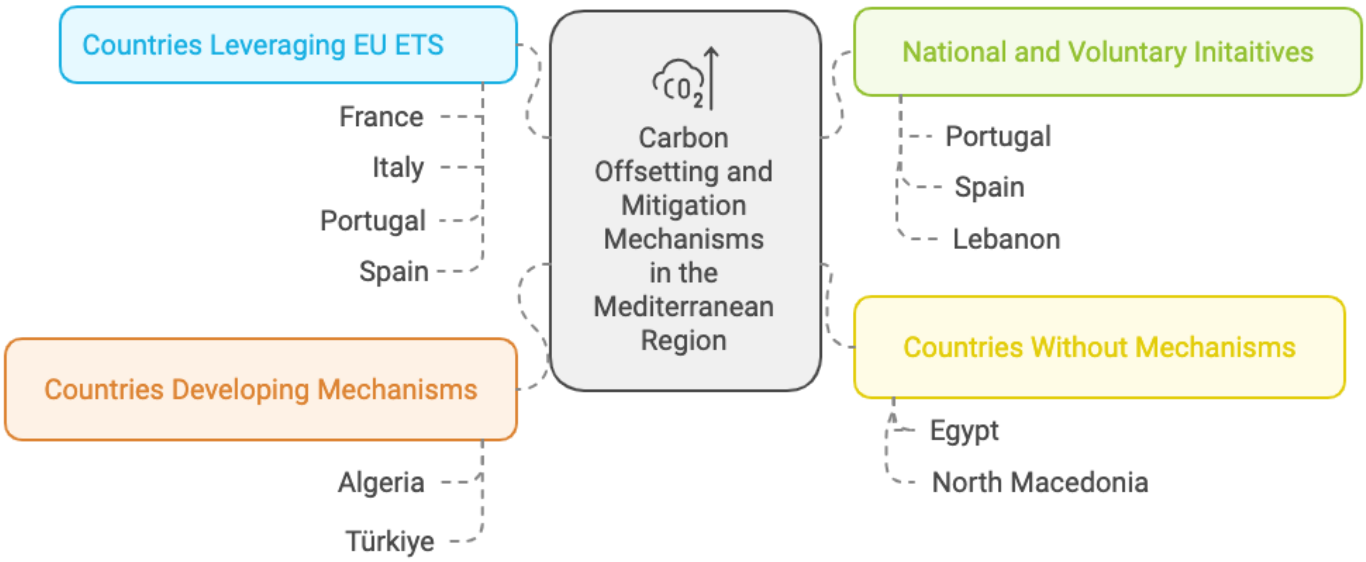

Figure 5 - Carbon Mitigation in the Mediterranean Region

European Union Emissions Trading System (EU ETS):

Several countries within the MEDREG region leverage the EU ETS to manage carbon emissions in the natural gas sector. Some prominent examples are France, Italy, and Spain, which rely on the cap-and-trade scheme to set limits on greenhouse gas emissions and incentivise emission reduction strategies. Notably, the ETS is considered a carbon mitigation mechanism and not an offsetting one.

- France: France's adherence to the EU ETS aligns with its broader climate goals, and the country's commitment to renewable energy and energy efficiency initiatives further supports the reduction of natural gas-related emissions. Moreover, France has implemented additional policies such as the 'low carbon label' to encourage emissions reduction projects and promote sustainable practices within the natural gas sector.

- Italy: Italy's participation in the EU ETS is complemented by its focus on promoting renewable energy sources and improving energy efficiency to reduce the overall carbon footprint of the country's energy mix, including natural gas. Additionally, Italy has also implemented policies to support the development of CCS technologies, which can be used to offset emissions from natural gas-fired power plants.
- Spain: Spain's implementation of the EU ETS is accompanied by a voluntary registry for carbon footprint calculation and offsetting, which provides companies with a framework to voluntarily reduce their emissions and support emissions reduction projects. Besides, Spain has also implemented policies to promote the use of biofuels and renewable gases, which can help reduce the carbon intensity of the natural gas sector.
- Portugal: Portugal is also among the countries that implement the EU ETS.

National and Voluntary Initiatives:

Several countries have established or are developing their own carbon offsetting mechanisms. Lebanon, Portugal, and Spain have taken notable steps in this direction.

- Lebanon: The International Renewable Energy Certificates (IREC) scheme has been approved in Lebanon, with the Lebanese Center for Energy Conservation (LCEC) acting as the issuer of the IREC certificates. This will encourage more citizens to register their systems for the certification scheme and open doors to more benefits from installing solar PV systems. IRECs are used to offset Scope 2 emissions, which refer to indirect greenhouse gas emissions from the consumption of purchased electricity.
- Portugal: Portugal's voluntary carbon market, launched in 2024, offers companies the opportunity to offset emissions by purchasing carbon credits from verified projects. This mechanism provides a flexible approach for businesses to address their carbon footprint, including those operating in the natural gas sector. Further, Portugal has also implemented policies to support the development of renewable energy sources and energy efficiency improvements, which can help reduce the overall carbon footprint of the natural gas sector.
- **Spain**: Spain has established a voluntary registry for carbon footprint calculation and offsetting. This registry allows companies to calculate their emissions, set reduction targets, and offset remaining emissions through approved projects.

Countries Developing Mechanisms:

Certain countries within the MEDREG region are actively working on developing their own carbon offsetting mechanisms. For instance, Türkiye is establishing a directorate of climate change with the mandate of developing an emissions trading system alongside a carbon offsetting mechanism.

- Algeria: Algeria has committed to reducing its greenhouse gas emissions and taken steps to increase its renewable energy capacity. While it currently lacks a formal carbon offsetting mechanism, Algeria's efforts to transition to a low-carbon economy could create opportunities for developing such mechanisms in the future.

- Türkiye: The establishment of a carbon offsetting mechanism in Türkiye is a significant step towards addressing climate change and reducing emissions from the natural gas sector. This initiative's success hinges on the enactment of the Climate Law and the effective implementation of the developed framework. Additionally, Türkiye has also implemented policies to support the development of renewable energy sources and energy efficiency improvements, which can help reduce the carbon footprint of the natural gas sector.

Countries Without Formal Mechanisms:

At present, Algeria, Egypt, and North Macedonia lack formal carbon offsetting mechanisms. However, Algeria acknowledges the importance of such systems and is taking steps to lay the groundwork through climate commitments and renewable energy initiatives. North Macedonia plans to introduce a CO_2 tax within its NECP, which could potentially pave the way for future offsetting mechanisms.

- Egypt: Although no mechanism is in place or is being developed at present, the financial regulatory authority has adopted an ambitious plan to establish the first African voluntary carbon market (VCM), which is a part of the financial regulatory authority's continuous efforts to support the government's effective policies and procedures to achieve carbon neutrality. As a first step toward establishing the VCM in Egypt, the Prime Minister issued Decree No. 4664/2022, amending some provisions of the Executive Regulations of the Capital Market Law issued by Law No. 95/1992 to consider carbon credits as a financial instrument.
- North Macedonia: North Macedonia's planned introduction of a CO_2 tax could be a significant step towards addressing climate change and reducing emissions from the natural gas sector. Implementing a CO_2 tax could also create a financial incentive for companies to invest in emissions-reduction technologies and practices.

The use of carbon offsetting mechanisms within the natural gas sector varies significantly across MEDREG member countries. Therefore, the development of green LNG, derived from renewable sources such as solar or wind power, could offer a promising avenue for reducing the carbon footprint of the natural gas sector. Carbon offsetting mechanisms can also play a crucial role in supporting the growth of green LNG by providing a means to offset the residual emissions associated with its production and transportation.

However, one must be wary of the actual effectiveness of such mechanisms, as they depend on the quality and credibility of the offset projects involved. Therefore, one must ensure that offset projects are verified and deliver genuine emissions reductions. Furthermore, carbon offsetting can add to the cost of green LNG production. While the financial burden may be offset by increased market demand

and potential regulatory benefits, it is essential to carefully consider the cost-related implications of offsetting.

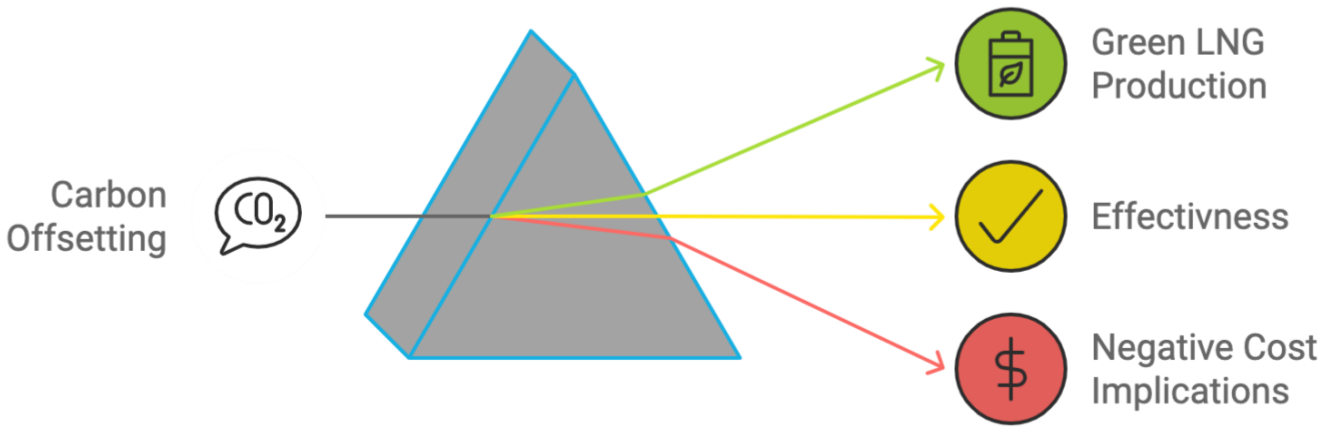

Figure 6 - Effects of Carbon Offsetting

4.2. Carbon Capture Technologies

CCS technologies are critical for reducing emissions from natural gas production and use, as they capture CO2 at its source and either store it underground or use it in other industrial processes. Thus, the deployment of CCS is essential for minimising the environmental impact of green LNG.

MEDREG members are at varying stages of development and implementation of carbon capture technologies (CCTs). While some countries have made significant strides in this area, others are still in the nascent stages of exploration. This sub-chapter provides an overview of the current state of CCTs and mechanisms in the region, highlighting key developments and challenges.

Algeria has emerged as a pioneer in CCS, with the In Salah Gas Project serving as a notable example. This project demonstrated the technical feasibility of CCS in Algeria and has laid the foundation for further research and development in this field. The Algerian government's commitment to mitigating greenhouse gas emissions and addressing climate change has driven the exploration of CCS technologies as a potential solution.

France has ambitious plans for CCS, with the government aiming to rapidly deploy the CCUS projects in the coming years. The country has identified potential CO_2 targets and is investing in infrastructure and regulatory frameworks to support these initiatives. France's commitment to meeting its Paris Agreement obligations has spurred the development of CCS as an integral part of its climate mitigation strategy. In addition, France and Spain have submitted a cross-border project that is still under study to transport and store CO_2 from emitters in Spain and France, with the storage portion to be carried out in France. Spain's participation in this international project demonstrates its commitment to contributing to regional and global efforts to reduce greenhouse gas emissions.

Italy is also actively involved in CCS development, with a regional plan in place to support the development of CCS infrastructures in the Mediterranean Sea basin. This collaborative effort with France and Greece hopes to promote further projects in the region and strengthen regional cooperation on CCS. Italy's recognition of the importance of CCS in achieving its climate goals has led to its participation in this regional initiative.

Lebanon, although still in the early stages of developing CCTs, recognises their potential role in meeting its climate change commitments. The country faces challenges in terms of infrastructure and costs but also has opportunities regarding geological storage sites. Lebanon's commitment to reducing greenhouse gas emissions has prompted the exploration of CCTs as a potential mitigation strategy.

North Macedonia and Türkiye currently do not have any established mechanisms regarding CCTs; however, these countries may be considering the potential benefits of CCS in the future as they seek to address climate change challenges.

Portugal has incorporated CCS in its national long-term strategy despite considering it economically and technically viable only in the cement sector. The country is also focusing on increasing the natural carbon sink capacity of its land use, land use change, and forestry sector. Portugal's approach to CCS reflects its broader strategy of balancing carbon capture with natural carbon sequestration.

Thus, MEDREG members are demonstrating a growing interest in CCTs to address climate change. While some countries have made significant progress in this area, there is still considerable potential for further development and collaboration. The region's diverse energy landscape and varying levels of economic development present unique opportunities and challenges for deploying CCTs. As the MEDREG region continues to transition towards a low-carbon future, the role of CCTs is likely to become increasingly important.

Quick Look

Algerian Case Study: In Salah CCS Project

Algeria has made significant advancements in addressing climate change by implementing CCS technology. The In Salah CCS project, located in the south of Algeria, serves as a pioneering example of the successful deployment of this technology on a large scale since 2004, representing one of the earliest experiences with CCS in the world.

Key Elements of Algeria's In Salah CCS Project:

The In Salah CCS project, located in the south of Algeria, aims to capture and store CO_2 emissions produced during natural gas extraction. The project utilises a deep saline aquifer formation in the Krechba field as the storage site, where CO2 sourced from the In Salah gas processing plant is collected. Once captured, the compressed CO_2 is transported via pipeline to the storage site, where it is injected into a geological formation 1,900 meters deep for long-term sequestration.

Impact and Achievements:

- Cumulative CO_2 storage: The In Salah project has successfully stored over 4 million tonnes of CO_2, significantly contributing to Algeria's climate mitigation efforts.
- Reduced greenhouse gas emissions: The initiative decreases CO_2 emissions associated with natural gas extraction, aligning with Algeria's broader environmental goals.
- International collaboration: The project has fostered partnerships and knowledge sharing with international organisations, enhancing the global understanding of CCS technologies.

Challenges and Lessons Learned:

- High costs: The capital-intensive nature of CCS technology requires significant investment in infrastructure and operations, posing a challenge for wider implementation.
- Technological complexity: Successful deployment of CCS requires advanced technologies and innovative solutions to effectively capture, transport, and store CO_2, emphasising the complexity of the processes involved.
- Long-term monitoring: Continuous monitoring of the storage site is essential to ensure the safety and integrity of the stored CO_2, necessitating robust monitoring systems.

4.3. Renewable Energy Integration to Support LNG Infrastructure

Incorporating renewable energy sources into natural gases' liquefaction and regasification processes further reduces emissions. Using renewable electricity for these processes not only lowers the carbon footprint of LNG but also supports the broader integration of renewable energy into the energy system.

At present, Algeria relies solely on natural gas for powering its liquefaction plants, as there has been no concrete implementation of renewable energy integration into this process. However, the idea aligns with the country's broader energy transition goals. As Algeria seeks to expand its renewable energy capacity and reduce its carbon footprint, there is potential for future integration of renewable energy into the liquefaction process. This could involve using renewable energy to generate electricity to power the upstream processing plants and liquefaction plants.

Egypt's energy strategy for 2035 prioritises renewable energy as a significant component of its energy mix. This suggests that renewable energy could be integrated into various applications, including LNG production, in the future. While no specific mention of using renewable energy for liquefying gas has been made in response, the overall energy strategy indicates potential for future exploration and implementation of such initiatives. This could involve using renewable energy to generate electricity for powering liquefaction plants or produce hydrogen as a feedstock.

Other countries, should they use renewables with LNG technology, would be using it in regasification efforts. However, none of the countries with regasification plants have incorporated renewables into regasification.

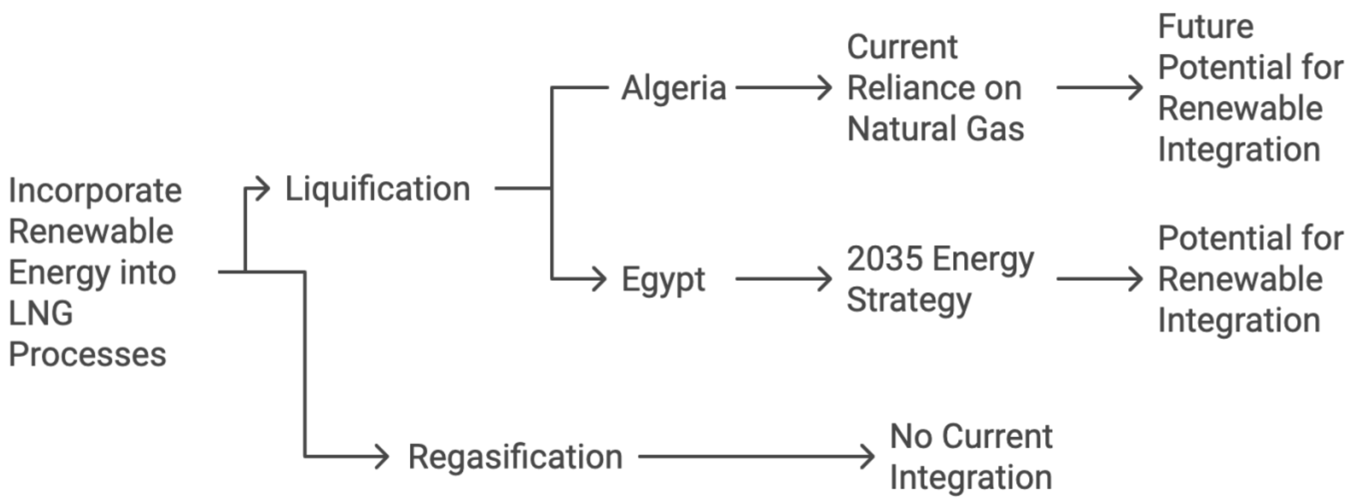

Figure 7 - *Renewable Integration in Liquefaction and Regasification*

Quick Look

Japanese Case Study: Asian Effort to Use Renewables in LNG Regasification

Japan, one of the world's largest LNG importers, has been actively exploring renewable energy use in its regasification facilities. Accordingly, the following initiatives have been undertaken in the country:

- Pilot projects: Japanese companies have partnered with renewable energy developers to conduct pilot projects at existing LNG regasification terminals. These projects aim to assess the technical feasibility and economic viability of integrating solar or wind power into the regasification process.
- Government support: The Japanese government has provided incentives and policy support to encourage the adoption of renewable energy in the LNG sector, which includes subsidies, tax breaks, and regulatory frameworks that facilitate the integration of renewable energy into the grid.
- Technological innovation: Japanese companies have been at the forefront of technological advancements in renewable energy and energy storage, enabling them to develop innovative solutions for integrating renewable energy into LNG regasification facilities.

Challenges and Opportunities

Despite the progress made, several challenges persist in integrating renewable energy into LNG regasification in the Asian market:

- Cost: The initial investment required to install renewable energy infrastructure at LNG regasification facilities can be significant.

- Intermittency: Renewable energy sources such as solar and wind power are intermittent, which can pose challenges for grid integration and reliable power supply to LNG facilities.
- Infrastructure: Developing necessary infrastructure, such as transmission lines and energy storage systems, is essential for integrating renewable energy into the LNG supply chain.

However, the region also presents significant opportunities, as listed below:

- Abundant renewable resources: Several Asian countries have abundant renewable energy resources, such as solar and wind power.
- Growing demand for clean energy: There is a growing demand for cleaner energy sources in the region, which creates a favourable environment for renewable energy adoption.
- Technological advancements: Advances in renewable energy technologies and energy storage solutions are making it more feasible to integrate renewable energy into LNG regasification.

As the region continues to expand its LNG infrastructure, we will likely see more initiatives to incorporate renewable energy into the regasification process. Thus, by addressing the challenges and capitalising on the opportunities, Asia can play a leading role in developing a more sustainable and environmentally friendly LNG supply chain.

5. Infrastructure and Regulations

5.1. Current LNG Infrastructure

The state of LNG infrastructure varies significantly across different regions, with the key components including import terminals, storage facilities, and floating storage and regasification units (FSRUs). The capacity and efficiency of these infrastructures play a crucial role in the feasibility of green LNG projects.

Table 1 - *Current LNG Infrastructure in Algeria, Egypt, France, and Greece*

	Algeria[1]		Egypt[2]		France		Greece	
	2022	2023	2022	2023	2022	2023	2022	2023
Terminals	4	4	2	2	4	4	1	1
Capacity (bcm/y)	N/A	N/A	17	17	35	41	7	7
Storage Capacity (m3)	1,200,000	1,200,000	270,000	270,000	1,370,000	1,512,750	225,000	225,000
No. of Tanks	N/A	N/A	3	3	9	9	3	3
FSRUs	0	0	0	0	0	1	0	0
Small-scale Terminals	0	0	0	0	0	0	0	0

[1] Algeria is an exporting country.

[2] Egypt is an exporting country.

Table 1 - *Current LNG Infrastructure in Italy, Portugal, Spain, and Türkiye*

	Italy		Portugal		Spain		Türkiye	
	2022	2023	2022	2023	2022	2023	2022	2023
Terminals	2	2	1	1	6	7	4	5
Capacity (bcm/y)	16.3	19.3	7.6	7.6	35	41	56.556.5	56,5
Storage Capacity (m3)	487,100	657,100	390,000	390,000	3,316,500	3,446,500	871,631	1,134,631
No. of Tanks	8	12	3	3	25	27	5	5
FSRUs	1	2	0	0	0	0	2	3
Small-scale Terminals	7	7[3]	0	0	0	0	0	0

5.2. Policies Promoting SSLNG

Several policies and initiatives aim to promote the adoption of SSLNG, which can provide more flexible and localised energy solutions. These policies often include subsidies, tax incentives, and streamlined regulatory processes to encourage investment and development.

Developing SSLNG infrastructure has emerged as a significant strategy to enhance energy security, diversify gas supply sources, and reduce greenhouse gas emissions, with several Mediterranean countries having taken steps to promote the development of SSLNG facilities. This sub-chapter provides a comparative analysis of the policies and initiatives implemented by various countries in the region.

At present, France is exploring the potential for SSLNG development through market consultations conducted by Dunkerque LNG, a company that aims to understand market interest, needs, and expectations for SSLNG services. This could lead to the development of new infrastructure for small-scale bunkering and truck loading. While the SSLNG market in France is still nascent, these initiatives demonstrate a growing interest in this sector.

Greece has approved three SSLNG projects as part of its National Transmission System Development Plan (TYNDP). These projects involve constructing SSLNG facilities to supply

[3] The latest data available is from 2021.

specific regions, especially during periods when they are not connected to the main gas pipeline network. The projects emphasise using modular tanks and gasifiers to minimise costs and maximise synergies. Additionally, Greece plans to construct a new jetty at the Revithoussa LNG terminal to facilitate the loading of LNG onto small-scale ships, which can then supply LNG-powered boats and other vessels.

Italy's current legal framework does not specifically regulate SSLNG activities, allowing for a more flexible approach to their development. While LNG terminals are subject to regulation by the National Regulatory Authority (NRA), SSLNG activities are generally not regulated. This regulatory environment provides opportunities for the growth of SSLNG infrastructure in Italy.

Spain has already established SSLNG services through its existing LNG plants. Some plants have dedicated jetties for these services, and the country is currently revising its natural gas access regulation to include measures that promote SSLNG development, such as capacity reserves and increased flexibility for small-scale services.

Finally, Türkiye has introduced exemptions for new storage facilities and additional capacities, including LNG terminals and FSRUs, through a 2024 amendment to its natural gas legislation, providing a potential avenue for supporting the development of new SSLNG facilities.

Other countries in the region have not yet implemented specific policies or initiatives to promote SSLNG development. However, Portugal's recent Council of Ministers Resolution allows for installing the infrastructure necessary for LNG transfers between ships, potentially laying the groundwork for future SSLNG activities.

Several key trends can be observed in the policies promoting SSLNG development across the Mediterranean region. These are as follows:

- Regulatory flexibility: Countries such as Italy have adopted a more flexible regulatory approach, allowing for greater innovation and investment in SSLNG infrastructure.
- Infrastructure development: Greece and Spain have invested in new infrastructure, such as jetties and storage facilities, to support SSLNG activities.
- Market-based approaches: France's market consultations demonstrate a reliance on market-driven approaches to assess demand and guide infrastructure development.
- Policy Support: Türkiye's legislative amendments provide a clear policy framework for promoting SSLNG investment.

Despite the positives of SSLNG, including its promising potential contribution to decarbonisation and reinforcement of security of supply, it faces significant economic challenges. Factors such as gas prices, demand fluctuations, and infrastructure costs can significantly impact the profitability of SSLNG projects.

Compared to large-scale LNG facilities, SSLNG often incurs higher operating costs per volume, making it more difficult for SSLNG projects to compete economically, especially during periods of low gas prices or declining LNG demand. Therefore, careful analysis of these economic factors is essential to ensure the long-term viability of SSLNG. Strategies such as optimising operational efficiency, diversifying revenue streams, and exploring innovative financing models may be necessary to mitigate risks and improve profitability.

Conversely, net gas exporting countries tend to develop large-scale facilities. For instance, Algeria's focus in the LNG sector has been primarily on large-scale production and export, leveraging the country's significant natural gas reserves. It has been a major exporter of LNG since the 1960s, with its large-scale LNG plants being central to its natural gas export strategy.

The development of SSLNG infrastructure in net-importing countries in the Mediterranean region represents a significant opportunity to enhance energy security, diversify gas supply sources, and reduce greenhouse gas emissions. While progress has been made, further efforts are required to overcome challenges and fully realise the potential of SSLNG. By adopting a comprehensive approach that combines regulatory flexibility, infrastructure development, market-based approaches, and policy support, Mediterranean countries can position themselves as leaders in the global SSLNG market.

Figure 8 - SSLNG vs Traditional LNG

5.3. Services and Institutional Structures

The range of services offered by LNG terminals includes storage, regasification, and transportation. The institutional and financial structures supporting LNG development involve a mix of public and private investments, regulatory oversight, and international cooperation. These structures are essential for the sustainable growth of the LNG sector.

5.3.1. Services Provided by LNG Terminals

While the core services offered by LNG terminals are generally consistent across regions, the specific services provided, and the level of development vary significantly depending on individual countries' energy needs, infrastructure, and market dynamics.

On the northern shore of the Mediterranean, several countries have established well-developed LNG infrastructure. For instance, France boasts multiple LNG terminals operated by companies such as Elengy and Fluxys, which offer a wide range of services, including reception, unloading, storage, regasification, reloading, and transhipment. The country's strategic location in Western Europe makes it a key hub for LNG trade in the region. Greece's LNG facility at Revythoussa, operated by DESFA, provides services such as inerting, gassing up, cool down, partial loading, liquid nitrogen supply, and fresh water supply to LNG tankers. The facility is well-equipped to handle LNG tankers of various sizes and offers a high level of service quality. Italy, with its strategic location in the Mediterranean, offers regasification, virtual regasification, flexibility services, bundled products, and, in some cases, SSLNG services. The country's extensive LNG infrastructure has made it a major player in the European LNG market. Portugal's LNG terminal, located in Sines, provides ship unloading, LNG storage, LNG regasification, and small-scale services such as cooling, reloading, and ship-to-ship transfers. Additionally, the terminal is well-connected to the European gas grid, making it an asset for the region's energy security. Spain, with its extensive LNG infrastructure, offers a comprehensive range of services comprising vessel unloading, loading, storage, regasification, truck loading, ship-to-ship transfers, LNG bunkering, cooling down, gassing up, and virtual liquefaction. Spain's strategic location and well-developed infrastructure have made it a major hub for LNG trade in Europe; in fact, the Spanish LNG imports have caused a major change in Europe's dependence on natural gas, where the generic path of natural gas flow was historically from east to west but is now smoothly changing to being from west to east. Türkiye, meanwhile, offers both land-based and floating storage regasification units, providing services such as unloading, storage, and regasification. Furthermore, the country's strategic location and growing energy needs have made it an attractive market for LNG imports. Türkiye's LNG terminals are well-connected to the European gas grid, making it a potential hub for LNG trade between Europe and Asia.

On the southern shore, countries such as Algeria and Egypt, as previously mentioned, have established LNG terminals primarily focused on liquefaction, storage, and export of natural gas.

Algeria, a major LNG exporter, benefits from its abundant natural gas reserves and well-developed LNG infrastructure. The country's LNG terminals are strategically located to facilitate exports to European and Asian markets. Egypt, which is another significant player in the region's LNG market, has been investing heavily in LNG infrastructure to capitalise on its natural gas resources and diversify its energy exports. Although the country's LNG terminals are primarily focused on liquefaction and export, it has also been exploring opportunities to develop regasification capabilities to meet domestic demand and support regional energy integration.

Certain countries in the region do not have LNG export or import terminals. Among these countries, Lebanon, while facing delays in its FSRU development due to various factors, remains committed to importing LNG to meet its domestic energy demand. Notably, the country's geographical location makes it a potential transit point for LNG trade between Europe and the Middle East. Similarly, North Macedonia does not have any LNG terminals to date; however, the government has expressed interest in developing LNG infrastructure to diversify its energy sources and reduce its dependence on imported fossil fuels. The country's geographical location and proximity to other European LNG terminals make it a potential market for LNG imports in the future.

Overall, the services provided by LNG terminals vary widely across regions, reflecting differences in energy needs, infrastructure development, and market dynamics. As the global energy landscape continues evolving, LNG terminals will likely play an even more critical role in meeting the region's energy demands. The key barrier to such developments is the efforts to decarbonise, as investing in an LNG plant may appear counterproductive from the perspective of environmentalists.

5.3.2. Institutional and Financial Structure of LNG Project Development

The institutional and financial structures underlying LNG project development vary significantly across Mediterranean countries, reflecting diverse economic, political, and regulatory contexts. These structures play a crucial role in shaping the landscape of LNG markets, influencing factors such as investment decisions, project viability, and the overall efficiency of LNG supply chains.

In Algeria, Sonatrach, the national oil and gas company, holds a central position in LNG development, operating under the oversight of the Ministry of Energy and Mines and regulatory agencies (i.e., the Algerian Hydrocarbons Regulatory Authority (ARH) and The National Agency for the Valorization of Hydrocarbon Resources (ALNAFT). Notably, the financial framework primarily relies on government funding, Sonatrach's revenue reinvestment, and partnerships with international companies. This structure has enabled Algeria to maintain its position as a key LNG exporter despite challenges related to infrastructure investment, market competition, and economic diversification.

In contrast, Egypt's LNG development is regulated by the Gas Regulatory Authority (GASREG), with a focus on liquefaction and regasification activities. France, on the other hand, has a mix of regulated and exempted LNG terminals operated by Elengy and Gaz-Opale. The regulatory framework for regulated terminals includes tariff mechanisms designed to encourage efficiency and protect operators from certain risks.

Greece has a heavily regulated LNG development framework overseen by the Greek Regulatory Authority for Energy, Waste & Water (RAAEY). The financial aspects of LNG infrastructure development are supported by regulatory decisions that establish tariffs and revenues. Similarly, Italy's LNG terminals are primarily privately owned and regulated, with one partially exempted from third-party access.

Lebanon's LNG development falls under the purview of the Ministry of Energy and Water and the Lebanese Petroleum Administration. The institutional organisation of the petroleum sector is governed by the Offshore Petroleum Resources Law (OPRL), which defines the roles of various stakeholders and establishes the regulatory framework.

North Macedonia has not planned to construct LNG terminals because of high investment costs. However, the country has signed a Memorandum of Understanding for using the terminal in Alexandropoulos, Greece, and plans to utilise terminals in Albania once the necessary gas infrastructure is connected.

Meanwhile, Spain has the Ministry of Ecological Transition and Demographic Challenge as the competent authority for LNG infrastructure development. The LNG System Operators (LSO) develop LNG facilities and recover investment costs through access tariffs.

Türkiye allows for both public and private ownership of LNG terminals. For both options, third-party access is regulated by the Energy Market Regulatory Authority (EMRA). However, the tariffs for LNG terminals, including FSRUs, have not been regulated since 2018.

The institutional and financial structures for LNG development vary significantly across countries, reflecting differing economic, political, and regulatory contexts. While some countries have established national oil and gas companies that play a dominant role in LNG projects, others rely on a mix of public and private sector involvement. Besides, the regulatory frameworks governing LNG development also differ widely, ranging from heavily regulated to more market-based approaches.

5.4. Challenges and Opportunities in Infrastructure

Developing the infrastructure necessary for green LNG utilisation presents several challenges and opportunities for countries across the globe. Among the primary challenges identified by MEDREG members, the most significant are financial investment and technological capability. This is because the initial costs associated with upgrading existing infrastructure or constructing new facilities for green LNG production and distribution can be substantial. Moreover, the development of advanced technologies for CCSU and methane leak detection is essential but requires significant research and investment.

Another challenge is the availability of applicable regulatory and policy frameworks, as countries need clear guidelines and incentives to encourage green LNG practice adoption. Further, the absence of standardised definitions and criteria for green LNG can create confusion and hinder investment. Furthermore, the availability of skills and expertise to support green LNG initiatives is crucial. Training programmes and knowledge-sharing platforms are necessary to develop a skilled workforce.

Despite these challenges, the opportunities presented by green LNG are significant. The growing demand for environmentally friendly business practices and the need to meet emissions reduction targets provide a strong impetus for developing green LNG infrastructure. Additionally, existing LNG infrastructure can often be adapted to accommodate green LNG services, potentially reducing costs compared to greenfield development.

Leveraging renewable energy resources for LNG production and transportation is another key opportunity. Countries with abundant renewable energy can integrate solar or wind power into their LNG facilities, reducing the carbon footprint of the production process. Collaboration and partnerships between governments, industry players, and international organisations can also facilitate the development of green LNG infrastructure by sharing knowledge, resources, and best practices.

Algeria has established a robust LNG infrastructure and developed extensive expertise in this sector. The country is advancing towards green LNG by integrating CCS in upstream operations and launching extensive reforestation initiatives. However, fully decarbonising the LNG value chain will require additional investments and further efforts. Algeria's abundant renewable energy resources, with 3 GW already under construction as part of its renewable energy strategy, will further strengthen its position in this transition.

Egypt encounters challenges in financing and investment, technological readiness, regulatory and policy frameworks, and skills and expertise. However, the growing demand for green business, adaptability of existing LNG infrastructure, renewable energy resources, and international collaboration offer opportunities for green LNG development.

Greece faces challenges in the ambiguity surrounding the definition of green LNG, substantial investment for infrastructure upgrades, data collection and management, and long-term contracts hindering investment. However, advanced emission reduction technologies, high-quality carbon credits, standardised frameworks, and policy and financial incentives present opportunities for green LNG development.

Italy faces the challenge of high costs associated with infrastructure development and decreasing gas demand. However, integrating green LNG with renewable plants offers the potential for reduced emissions and energy costs.

Lebanon faces challenges in the form of financial constraints, regional instability, lack of investment, and inadequate infrastructure and connections. Nevertheless, the availability of natural gas in the sea basin presents an opportunity for green LNG development.

Portugal, despite not being a producer of LNG, has an established infrastructure that can facilitate the reception of green LNG. Conversely, Spain lacks a specific regulatory framework for green LNG, as the recently approved Directive 2024/1788 is still pending transposition. However, green LNG has the potential to contribute to the energy transition through reduced emissions.

Türkiye faces high costs associated with new facilities and systems for green LNG utilisation. However, its extensive LNG capacity, including land transport trucks, offers an opportunity for green LNG development.

The development of green LNG infrastructure presents a complex scenario filled with both challenges and opportunities for the countries in the region. While financial constraints, technological limitations, and regulatory uncertainties pose significant hurdles, the potential benefits of reduced emissions, enhanced energy security, and economic growth could make the effort worthwhile.

In this context, Greece, with its perspective on challenges and opportunities, may offer a valuable case study and a starting point for interested parties. By addressing the ambiguity surrounding green LNG definitions, investing in infrastructure upgrades, implementing robust data management systems, and leveraging advanced technologies, Greece can position itself as a leader in the transition to a sustainable energy future in the region.

Ultimately, the success of green LNG initiatives will depend on a concerted effort from governments, industry players, and international organisations to overcome challenges, foster collaboration, and invest in the necessary infrastructure. By embracing the opportunities presented by green LNG, countries can contribute to a cleaner, more resilient, and sustainable energy landscape.

5.5. Regulations and Frameworks for Emission Reduction

Existing regulations aimed at reducing emissions in the LNG sector include emissions caps, reporting requirements, and incentives for low-emission technologies. These frameworks are critical for ensuring that the growth of the LNG sector aligns with environmental sustainability goals.

While Algeria does not have specific rules solely dedicated to reducing emissions in the LNG sector, its broader environmental and energy laws still impact pollution reduction. The country is actively working to decrease gas flaring, which involves burning off excess natural gas during hydrocarbon extraction, transportation, and transformation. By capturing and utilising this gas, Algeria intends to lower greenhouse gas emissions and make better use of its natural resources, an aim that aligns with its broader clean energy transition goals.

While Egypt's LNG industry operates under strict safety and environmental standards, the lack of specific regulations targeting emissions reduction in the LNG sector presents an opportunity for further improvement. Although existing practices contribute to environmental protection, additional measures could be implemented to further minimise emissions.

Türkiye currently lacks specific regulations or frameworks for reducing emissions within the LNG sector, which means that there are no dedicated rules in place to address emissions from LNG operations in the country.

The first-ever EU Regulation on methane emissions reduction in the energy sector was adopted on May 27th, 2024 and came into force in August 2024; consequently, LNG facilities must measure, report, and verify their emissions and meet certain limits. This is a significant step towards reducing greenhouse gas emissions from the energy sector, including LNG. This rule applies to countries such as France, Greece, Italy, Portugal, and Spain, which will have to measure, monitor, report, and verify emissions and take active steps to reduce them from their LNG import operations.

Quick Look

EU Case Study: The New Regulation on Methane Emission Reduction

The EU's adoption of the regulation on methane emissions reduction in the energy sector marks a significant milestone in its efforts to combat climate change. The regulation, a cornerstone of the European Green Deal and REPowerEU initiatives, aims to reduce methane emissions from the energy sector both within the EU and globally. This case study examines the key provisions of the regulation and its potential impact on the energy industry.

The regulation imposes stringent requirements on fossil gas, oil, and coal operators within the EU for the following:

- Improved measurement, reporting, and verification (MRV): The regulation requires energy companies to implement robust MRV systems to accurately measure and report their methane emissions. This includes setting emission baselines, conducting periodic surveys to identify leaks, and submitting annual reports to national competent authorities.
- Leak detection and repair (LDAR): The regulation mandates implementing LDAR programmes to identify and repair methane leaks in energy infrastructure, which involves regular inspections, leak detection surveys, and prompt leak repairs.
- Restrictions on venting and flaring: The regulation prohibits venting and routine flaring of methane, which involves releasing methane directly into the atmosphere. Exceptions are allowed only in limited circumstances, such as for safety reasons.
- Methane transparency for imports: The regulation introduces a requirement for importers of fossil fuels to collect information on the methane emissions reduction efforts of their suppliers. This is intended to encourage international cooperation and promote best practices in methane management.

The EU's regulation has broader implications beyond its borders. By setting a high standard for methane emissions reduction, the EU aims to influence global practices. Moreover, the Commission's plan to establish a monitoring tool for global methane emitters, based on satellite data, will provide valuable information on high-emitting sources worldwide. Additionally, the rapid alert mechanism for 'super-emitting' events will enable early detection and intervention to prevent significant methane releases.

The implications of such a regulation may even affect certain non-EU countries. LNG importers will be required to comply with the regulation's MRV and LDAR requirements, ensuring that the methane emissions associated with their LNG operations are accurately measured and reduced. Furthermore, the regulation's focus on methane transparency for imports will pressure LNG producers to adopt best practices in methane management to maintain access to the EU market.

5.6. Necessary Policy Measures and Incentives

Several policy measures and incentives are needed to encourage the uptake of green LNG. These may include subsidies for green technologies, tax breaks, research and development grants, and international partnerships to share knowledge and resources. To promote green LNG adoption in the future, MEDREG members have identified a range of necessary policy measures and incentives.

A key priority is the establishment of robust regulatory and policy frameworks. Countries such as Egypt emphasise the need for comprehensive regulations and standards that address emissions, methane leakage, and sustainability criteria in LNG projects, providing a clear and predictable environment for investors, fostering confidence, and facilitating green LNG investments.

Moreover, financial incentives are also essential to make green LNG projects more economically viable. Tax credits, rebates, and carbon pricing mechanisms can help reduce the financial burden on investors, making green LNG a more attractive option. Egypt underscores the importance of providing such incentives to encourage green LNG projects and drive investment in this sector.

Supporting research and development in renewable energy integration, methane leak detection, and CCTs is crucial for technological advancement. Greece stresses the need for a comprehensive approach that includes investing in these areas. By fostering innovation, countries can develop more efficient and sustainable green LNG solutions.

International cooperation is vital for harmonising regulations and facilitating global green LNG promotion. Greece emphasises the importance of collaboration to create a consistent and enabling environment for the transition to a sustainable and low-emission industry. By working together, countries can share best practices, address common challenges, and accelerate the deployment of green LNG technologies.

While Italy acknowledges the modest methane emissions associated with EU gas grids, particularly LNG regasification terminals, it stresses the need for careful cost-benefit analyses before investing in emissions reduction measures, ensuring that investments yield a significant impact in terms of emissions reduction, avoiding unnecessary expenditures.

Lebanon highlights the importance of developing a green LNG strategy that considers factors such as continuity of supply and competitive pricing. North Macedonia emphasises the need for a connected gas infrastructure and unified regulations in the region to facilitate the seamless integration of green LNG. Portugal focuses on using green LNG in maritime transport, as outlined in its NECP. Spain proposes a system of guarantees of origin as an effective tool to encourage the uptake of green gases, including LNG. Finally, Türkiye suggests tax exemptions and subsidies for the production, transport, and storage of green LNG.

A common thread among all the countries is the recognition that a combination of policy measures and incentives is necessary to achieve significant progress in adopting green LNG. By implementing these measures, countries can create an enabling environment that fosters investment, innovation, and international collaboration, ultimately driving the transition through green LNG technologies and others.

6. Conclusion and Way Forward

Driven by the imperative to transition towards a low-carbon future and motivate a sustainable energy transition, green LNG is becoming a topic worthy of serious consideration, given the active role that natural gas still plays in our energy systems. The Mediterranean region is acutely aware of climate change pledges and energy security concerns, where natural gas remains the most flexible yet the cleanest form of energy compared to other carbon-based fuels. In this context, green LNG emerges as a compelling proposition.

While renewable energy sources such as solar and wind power are undeniably gaining traction, natural gas offers a bridge between carbon-intensive fossil fuels and a fully renewable energy future, and in some countries, it is still perceived as playing a major role in the years to come. It is indeed in a strong position to act as a valuable transitional fuel.

Carbon-neutral LNG, or green LNG, produced from low-carbon or renewable sources, takes this potential a step further. By leveraging CCUS technologies, integrating renewable energy sources, and utilising low-carbon feedstocks, green LNG can significantly mitigate its environmental impact. However, realising the full potential of green LNG is contingent upon addressing several critical challenges. One of the most pressing challenges is the need for a clear and universally accepted definition of green LNG. A lack of standardised definitions can hinder investment, policy development, and consumer understanding. Therefore, a collaborative effort involving industry stakeholders, policymakers, and international organisations is essential to develop a robust definition that encompasses the various pathways to reduce the carbon footprint of LNG.

Another significant challenge lies in the development of robust and cost-effective CCUS technologies. While significant strides have been made in recent years, further research and development are imperative to improve the efficiency and scalability of CCUS. Additionally, supportive policies and incentives are required to encourage the deployment of CCUS projects, particularly in conjunction with LNG facilities.

Integrating renewable energy into the LNG value chain is another pivotal strategy for reducing emissions. By harnessing renewable energy sources to power LNG production processes and produce green hydrogen as a feedstock, the carbon intensity of LNG can be substantially reduced. Nevertheless, this requires substantial investments in renewable energy infrastructure and the development of innovative technologies to facilitate the seamless integration of renewable energy into the LNG value chain.

To fully capitalise on the potential of green LNG, it is imperative to strengthen infrastructure and regulatory frameworks, which entails investing in the expansion and modernisation of LNG infrastructure, such as terminals, pipelines, and storage facilities, to accommodate the burgeoning demand for green LNG. Moreover, supportive policies and regulations are essential to incentivise the production, transportation, and consumption of green LNG. Clear and transparent standards for the certification and labelling of green LNG are equally crucial to ensure consumer confidence and facilitate trade.

As the energy landscape continues to evolve, a fundamental question arises: Will gas remain a significant player in the energy transition? While renewable energy sources are undoubtedly gaining momentum, the role of gas, particularly in its cleanest form, green LNG, remains a subject of ongoing debate.

MEDREG firmly believes that gas can still play a pivotal role in the energy transition, and if so, reducing its carbon footprint would be even better. By addressing the challenges and seizing the opportunities outlined in this report, we can position green LNG as a vital component of a sustainable and low-carbon energy future.

The potential of green LNG to contribute to a cleaner and more sustainable energy future is undeniable. However, its success hinges on a concerted effort to address the challenges outlined in this report and foster a collaborative approach among industry stakeholders, policymakers, and international organisations. By working together, we can unlock the full potential of green LNG and pave the way for a more sustainable and resilient energy system.

Green LNG presents itself as an attractive proposition and appears promising at first glance. It could serve as a potential bridge between our current fossil fuel-dependent energy systems and a more sustainable, low-carbon future. However, transforming this potential into reality requires a clear and concerted effort to establish a proper path forward. This transition will necessitate collaboration among regulators, stakeholders, and decision-makers to create a robust framework that ensures the effective and efficient development and deployment of green LNG technologies. By aligning policies, standards, and incentives, we can create a favourable environment for innovation and investment in this emerging sector, potentially positioning green LNG as a key player in the Mediterranean and global energy transition.

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