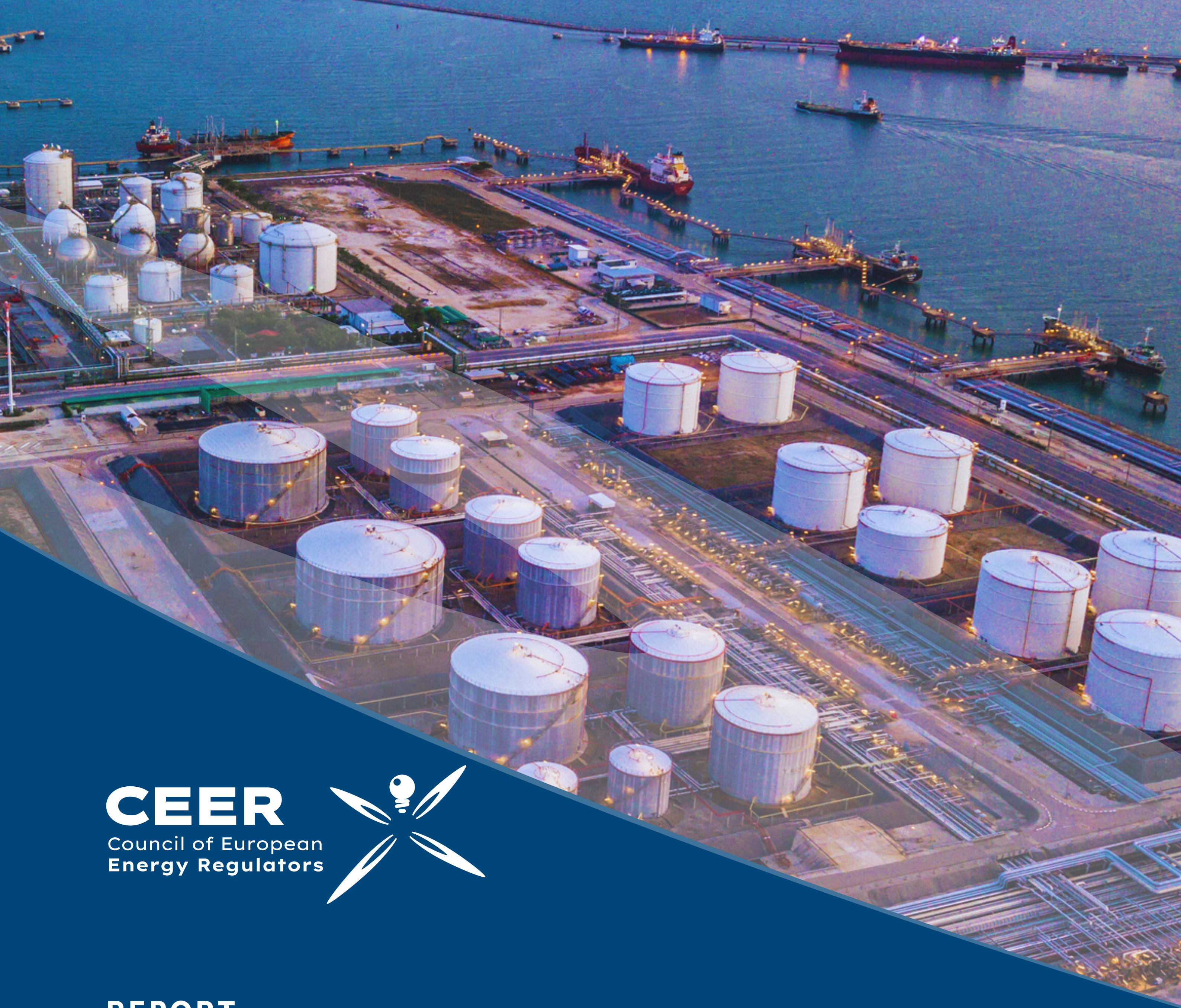

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REPORT

LNG Terminals: A New Role in the Framework of Decarbonisation

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Information page

Abstract

The report seeks to address the challenge of how LNG terminals can adapt and play a new, strategic role in the European Union's ambitious decarbonisation process in the current regulatory framework.

Target audience

European Commission, energy suppliers, traders, gas/electricity customers, gas/electricity industry, consumer representative groups, network operators, Member States, academics and other interested parties.

Keywords

Liquefied natural gas; LNG; LNG terminal; hydrogen terminal; hydrogen carriers; security of gas supply to the EU; energy transition; internal gas market; competition.

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Related documents

CEER Documents

- How to Implement the Gas Package in Relation to LNG Issues, CEER, February 2025.
- Position Paper on the Key Regulatory Requirements to Achieve Gas Decarbonisation, ACER-CEER, December 2021
- How to Foster LNG Markets in Europe, CEER, July 2019.
- Removing LNG barriers on gas markets, CEER, December 2017.
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- Monitoring Report on Implementation of the Transparency Template in the European LNG Terminals, CEER, December 2013.
- Status Review and evaluation of access regimes at LNG terminals in the EU, CEER, March 2013.

External Documents

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- PCI and PMI selection process, EC, September 2025.
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- Introduction to Low Carbon Gas Technologies, IGU, October 2024.
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Executive Summary

Background

The report seeks to address the challenge of how LNG terminals can adapt and play a new, strategic role in the European Union's ambitious decarbonisation process in the current regulatory framework.

This challenge arises in a context marked by the EU's urgent need to reduce dependency on Russian fossil fuels, especially after the 2022 invasion of Ukraine, high energy prices and extreme market volatility since the post-pandemic phase, the necessity to ensure security of supply and market competition in the European energy market and the requirement to align LNG infrastructure with new EU climate and energy policies, including the integration of renewable gases (like biomethane and hydrogen) and the compliance with the latest regulatory frameworks.

Objectives and contents of the document

This report contains a study on how LNG terminals could play a role in the decarbonisation process through different alternatives, including bioLNG, e-LNG, pure hydrogen, ammonia, Liquid Organic Hydrogen Carriers (LOHC) or CCUS.

It has been elaborated by gathering and analyzing information about projects in Europe of LNG terminal adaptations, but also terminal projects related to new energy carriers, based on information obtained from regulators, LSOs and project developers, identifying possible barriers to decarbonisation and suggesting how to overcome them.

Brief summary of the conclusions

LNG has become essential for Europe's energy strategy amid geopolitical tensions and environmental pressures, with strategic adaptation of terminals crucial to balance security of supply and sustainability goals. Decarbonizing these terminals not only greens the gas sector but also supports electricity sector decarbonisation via sector coupling, leveraging gas's storability for large-scale, long-term energy storage amid variable renewables.

LNG terminals decarbonisation projects vary widely: many involve ammonia terminals for hydrogen production, bioLNG imports via existing regasification with RED certification, or repurposing LNG infrastructure like docks, cryogenic systems, and pipelines for CO_2 treatment or multi-molecule operations. Pure liquid hydrogen or LOHC import projects remain rare at present.

Barriers include regulatory gaps, varying permitting across Member States, technological limits, financing hurdles, social concerns, and immature supply chains, requiring case-by-case assessment. Hydrogen and ammonia terminals fall under nTPA rules (with possible exemptions) but face early-stage challenges; LOHC, non-hydrogen ammonia uses, and CO_2 terminals fall outside this scope.

Revenues from repurposed LNG infrastructure for non-regulated activities should reduce costs for traditional users.

1 Introduction

In the current EU energy complex situation, fully committed and embarked in an ambitious decarbonisation process, affected by the very high prices and extreme volatility experienced in the 2021 post-pandemic phase, suffering from the impact of these in our economy and, since February 2022, heavily impacted by the Russian invasion of Ukraine, LNG is called to play a relevant role, being considered as a main source of security of supply and market competition for the European energy market.

The EC REPower Plan has stated that one of the two pillars to eliminate our dependence on Russian fossil fuels is the diversification of supplies, in particular, by means of higher LNG imports and investment in new infrastructure, including the promotion of biomethane and hydrogen (to be used directly or for e-fuels manufacturing). On May 2025, the Commission presented the updated REPowerEU Roadmap, setting out a coordinated, secure and gradual phase out of Russian gas, oil and nuclear energy imports. Five months later, the Council adopted the 19th sanctions package, which included new measures to gradually phase out the import of Russian gas, including LNG supplies, consisting of a prohibition on purchasing or importing Russian-origin LNG from April 2026, followed by a ban on long-term contracts from January 2027 (with limited exemptions).

Furthermore, it is assumed that, once the ongoing PCI and PMI are implemented, all MS will have access to at least three gas sources or to the global LNG market and, in consequence, the EC recognizes that there will be need for additional investments, to expand the existing LNG terminals or to build new ones, apart from the reinforcement of the networks, where it could be needed.

In short, the efforts to replace Russian gas supplies, to reduce the European dependency and to increase the resilience of our gas system are driving the EU to increase its LNG import capacities and decarbonise the natural gas sector.

In this context, the Gas Decarbonisation Package, published in the 15 July 2024 EU Official Journal, revises the laws governing the EU natural gas market and establishes a new regulatory framework specifically for hydrogen (market rules and infrastructure framework). The package introduces a comprehensive framework to decarbonise the gas sector and, concerning LNG terminals, it takes into consideration their integration with future hydrogen networks, including ammonia-based terminals.

Complementarily, the Renewables Energy Directive (RED III) (Directive (EU) 2023/2413) establishes binding targets for the share of renewable energy in the EU's energy mix, including renewable gases like biomethane and renewable hydrogen.

Europe had never set such an ambitious objective about decarbonisation in such a short period of time. The special circumstances and the imperious need for it, have impelled the EU to mobilise the necessary resources to minimise the impact of the sudden change of, up to then, the historical natural gas sources of supply. If the EU did not accelerate its decarbonisation efforts, it would run a risk of becoming more dependent.

The Fit-for-55 package aims to reduce EU gas demand by 30% by 2030, compared to 2019 levels (a cut of over 120 bcm) and the REPowerEU plan targets a reduction of around 210 bcm by 2030. If only Fit-for-55 goals were achieved, the EU might need 30 bcm more LNG by 2030 than in 2024, likely sourced from the spot market, increasing exposure to price fluctuations.

To achieve these objectives, LNG terminals are more than just import points: they are key assets for energy resilience and the energy transition, providing seasonal flexibility, helping to refill storage, supporting supply diversification, enhancing market integration and ensuring security of supply.

In any case, as the EU moves toward decarbonisation, these terminals must evolve to handle low-carbon fuels, such as synthetic methane, bio-LNG, hydrogen, ammonia, methanol, etc. In this context, CEER has considered very appropriate to undertake the task to analyse the LNG terminals decarbonisation possibilities (alternatives, technical solutions, barriers, adaptation needs, etc.) in order to have an overall vision of the evolution of conventional (possibly multi-molecule) and new terminals, identifying barriers and the regulatory needs to come into play the low-carbon gases.

This deliverable has taken into consideration the importance of LNG decarbonisation in the framework of the current energy crisis. This analysis has also taken into account the newly available information on technical solutions and put them in context with recent and future developments in European LNG terminals.

1.1 Overview of LNG infrastructure in EU

LNG has become a central pillar of Europe’s energy strategy, particularly in response to the geopolitical and environmental challenges of recent years. Following the Russian invasion of Ukraine in 2022, the EU accelerated its efforts to diversify gas supply and reduce dependency on Russian fossil fuels. As a result, LNG’s share in the EU’s total gas supply nearly doubled, from 23% in 2020 to around 40% in 2024.

Europe’s LNG infrastructure is extensive and strategically distributed. As of early 2025, the EU boasts a regasification capacity of 243 bcm, with 13 Member States operating LNG terminals. These include both onshore facilities and FSRU, which have played a key role in rapidly expanding capacity. Only between 2022 and 2024, the EU added 68 bcm of new regasification capacity, with Germany, Greece, and Belgium leading the deployment of FSRU and terminal expansions.

Despite this growth, utilisation rates of LNG terminals declined in 2024, due to high storage levels and reduced summer demand. Many terminals operated below 50% capacity, raising questions about long-term investment viability. However, the strategic value of these terminals extends beyond utilisation metrics. They provide seasonal flexibility, support underground storages refilling, enable market integration and ensure security of supply, not only for terminals hosting countries but for the whole EU.

1.2 The Current LNG market in EU

Given that the ACER report on the European LNG market developments[1] already provides a comprehensive, detailed, and up-to-date analysis of the current state of the European LNG market, the present document will be limited to extracting some of the most relevant data from said market in order to contextualize this report

[1] Analysis of the European LNG market developments. 2025 Monitoring report.

Europe remains the world's largest LNG importer, with 112 bcm imported in 2024, despite a 17% year-on-year decline. This drop reflects lower overall gas demand, improved energy efficiency, and increased renewable energy sources. EU gas consumption reached an 11-year low of 450 bcm, driven by decarbonisation policies and structural shifts in the energy mix.

The United States is the dominant LNG supplier to Europe, accounting for nearly 50% of our imports, followed by Russia (16%), Algeria (11%), and Qatar (10%). Notably, Russian LNG imports increased by 3,9 bcm in 2024, despite sanctions and political pressure.

Europe's LNG procurement is increasingly reliant on the spot market, with 30 bcm purchased in 2024 - more than any other global importer. This strategy offers flexibility but exposes the region to price volatility. The Dutch Title Transfer Facility (TTF) remains the primary benchmark, underpinning 73% of spot transactions. In 2024, 55% of spot trades were concluded below 35 EUR/MWh, indicating improved affordability but persistent market uncertainty.

The EU's future LNG demand is highly uncertain. According to ACER, the gap between the Fit for 55 and REPowerEU decarbonisation scenarios could reach 90 bcm by 2030. Under Fit for 55, LNG demand may rise to 138 bcm, while REPowerEU projects a decline to 48 bcm. This divergence underscores the need for flexible contractual arrangements and adaptive infrastructure planning.

1.3 Strategic outlook

The future role of LNG terminals will depend on Europe's ability to align infrastructure investment with decarbonisation goals, and they could evolve from simple LNG import points into multi-functional energy hubs.

Terminals are expected to support the import of low-carbon fuels such as bio-LNG, synthetic methane, ammonia, and hydrogen derivatives and, while technical and economic challenges remain, several pilot projects are underway to repurpose existing infrastructure.

Moreover, regulatory developments such as the EU Methane Regulation and FuelEU Maritime are reshaping the LNG value chain. Importers must comply with new monitoring, reporting, and verification (MRV) standards, and shipping emissions are now subject to the EU ETS. These measures aim to reduce the carbon footprint of LNG imports and enhance transparency across the supply chain.

LNG terminals are poised to play a critical role in Europe's energy transition. Their ability to provide flexibility, resilience, and integration makes them indispensable assets in the evolving landscape of European gas markets. As the EU moves toward climate neutrality, the strategic adaptation of LNG infrastructure will be essential to balance energy security with sustainability.

2 Decarbonisation pathways and the role of LNG terminals

2.1 Transition fuels and green alternatives

2.1.1 Global and EU climate targets

The fight against climate change is structured around a robust international framework, with the United Nations Framework Convention on Climate Change (UNFCCC) as its cornerstone. Adopted in 1992 and ratified by 195 countries, the UNFCCC set the ultimate objective of stabilizing GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This objective must be achieved within a timeframe sufficient to allow ecosystems to adapt naturally, ensure food production is not threatened, and enable sustainable economic development.

A major milestone was reached with the adoption of the Paris Agreement at COP21 in 2015. The Paris Agreement set a global goal to limit the increase in average global temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C. Subsequent COPs have reinforced these commitments.

In this context, the EU has positioned itself as a global leader in climate action, embedding its commitments in binding legislation. The European Green Deal (2019) set the objective of achieving climate neutrality by 2050. To operationalize this vision, the EU adopted the “Fit for 55” package in 2021, which raises the 2030 targets and updates key climate and energy policies:

- At least 55% reduction in net GHG emissions compared to 1990 levels.
- 42.5% share of renewable in final energy consumption.
- 38 – 40.5% improvement in energy efficiency.
- EU ETS strengthening and extension to new sectors (maritime, road, buildings).
- Introduction of the Carbon Border Adjustment Mechanism (CBAM).

Subsequently, REPowerEU was the EU’s response to the energy crisis and the need to reduce dependence on Russian fossil fuels, while accelerating the green transition:

- End EU’s dependence on Russian fossil fuels well before 2030.
- Accelerate the deployment of renewables (targeting 45% of total energy by 2030).
- Double the rate of energy efficiency improvements.
- Diversify energy sources and invest in new infrastructure, including h2 and biomethane.
- Promote electrification and the development of a more interconnected energy system.

The EU’s climate and energy policy is now anchored in the Fit for 55 and REPowerEU frameworks, which together set the most ambitious legally binding targets in the world for 2030 and 2050. These policies are designed to ensure a just, secure, and sustainable energy transition, positioning the EU at the forefront of global decarbonisation efforts.

2.1.2 The role of gas in transition and LNG as a transitional energy source for green alternatives

Natural gas has long been considered a bridge fuel in the transition from high-emission fossil fuels to low-carbon energy systems (a temporary solution that supports the integration of renewable energy while reducing emissions in the short to medium term). Its relatively lower carbon intensity compared to coal and oil, combined with its flexibility in power generation and industrial applications, makes it a valuable asset during the decarbonisation process. Furthermore, gas is essential in hard-to-abate sectors such as industry (high and medium-temperature processes) and transport, where electrification is not yet fully viable.

However, the long-term use of fossil-based gas is incompatible with climate neutrality. Therefore, the transition must involve a gradual shift from conventional natural gas to low-carbon and renewable gases, supported by infrastructure adaptation and innovation.

Among the most promising green alternatives are:

- Biomethane: produced from organic waste, biomethane is chemically similar to natural gas and can be injected into existing gas grids. It offers a renewable substitute with no need or minimal infrastructure adaptation.
- Synthetic methane (e-methane): generated via Power-to-Gas technologies using renewable electricity and captured CO_2, synthetic methane can be liquefied and transported through LNG infrastructure, offering a carbon-neutral alternative.
- Hydrogen and its derivatives: while pure hydrogen requires new infrastructure due to its physical properties, LNG terminals may be adapted to handle hydrogen carriers such as ammonia, methanol, liquid organic hydrogen carriers or liquefied synthetic fuels. These derivatives can be stored and transported more easily and integrated into existing supply chains.
- Carbon-neutral natural gas: This concept involves offsetting emissions through carbon credits or integrating CCS technologies. Though not a permanent solution, it provides a transitional pathway while green alternatives scale up. No need for infrastructure adaptation.

In any case, decarbonizing LNG terminals plays a pivotal role not only in greening the gas sector by enabling the use of low-carbon fuels like green hydrogen and biomethane, but also in advancing the decarbonisation of the electricity sector through enhanced sector coupling. This dual benefit is particularly crucial given gas's unique storability, which positions it as a large-scale, long-term storage technology essential for ensuring energy supply security across both, gas and power systems, amid variable renewables. The interrelation between these sectors is exemplified by "power to gas and gas to power" pathways, where surplus electricity is converted into storable gas during off-peak times and reconverted to power when demand peaks, stabilizing grids and maximizing renewable integration.

2.2 Technological solutions

LNG terminals, traditionally used for the import and regasification of natural gas, are now being reimagined as multi-functional hubs capable of supporting the transition to green alternatives. Their strategic locations, existing infrastructure, and technical expertise make them well-suited to accommodate renewable and low-carbon gases. Their adaptability and strategic importance position them as key players in achieving EU and global climate goals, bridging the gap between current energy needs and future sustainability.

While maintaining flexibility and security of supply, LNG terminals can be repurposed or complemented to handle low-carbon gases and integrate emerging technologies, through different solutions, as we analyse below.

Bio-LNG (CH_4)

Bio-LNG or liquefied biomethane is produced from organic waste through anaerobic digestion or gasification. The resulting biogas, composed mainly of methane (CH_4) and carbon dioxide (CO_2), is purified to remove impurities and then liquefied at -162°C. Bio-LNG is renewable and carbon-neutral, fully compatible with existing LNG infrastructure, and supporting circular economy principles. However, its scalability is limited by feedstock availability and higher production costs. It is already used in heavy transport and maritime sectors, with medium-term potential for regional expansion and long-term integration into international LNG trade.

E-LNG (CH_4)

E-LNG or synthetic LNG is produced by combining green hydrogen - produced, for example, via water electrolysis ($2H_2O \rightarrow 2H_2 + O_2$) - with CO_2 in a Sabatier reaction ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$), followed by liquefaction. This process yields methane that is chemically identical to fossil LNG but carbon-neutral if powered by renewable energy avoiding, for example, renewable energy curtailments. E-LNG is compatible with existing infrastructure and its disadvantages include high energy consumption, technological complexity, and high cost. While pilot projects are underway, large-scale deployment is expected in the long term, contingent on policy support and cost reductions.

Hydrogen (H_2)

It can be produced through several methods, including steam methane reforming ($CH_4 + H_2O \rightarrow CO + 3H_2$), electrolysis ($2H_2O \rightarrow 2H_2 + O_2$), and methane pyrolysis ($CH_4 \rightarrow C + 2H_2$). If it is generated with renewable sources and energy, it can be used as an energy vector with zero emissions at the point of use. Although it has high energy density by weight. it has low volumetric energy density, requiring specialized infrastructure for storage and transport. Green hydrogen remains costly. Apart from conventional uses, it is increasingly or expected to be more and more used in industry, mobility, and power generation. In the short term, blending with natural gas is feasible but limited, while medium and long-term strategies involve adapting LNG terminals for liquid hydrogen handling, entailing costs and technical challenges.

Ammonia (NH_3)

It is synthesized via the Haber-Bosch process ($N_2 + 3H_2 \rightarrow 2NH_3$) under high pressure and temperature using iron-based catalysts. It serves as a LOHC and can be also used directly as a fuel. Ammonia benefits from existing global infrastructure and high hydrogen density but poses safety risks due to toxicity and produces NO_x emissions when combusted. It is mainly used in fertilizers and could be used as maritime fuel, and for power generation. Medium-term developments focus on retrofitting LNG terminals for ammonia import and storage, with long-term prospects for its direct use as a fuel.

Methanol (CH_3OH)

This is a versatile chemical compound increasingly considered in the decarbonisation of fuels and industrial processes. E-methanol is synthesized by combining green hydrogen with captured CO_2 in a catalytic reactor, under moderate temperatures (200–300°C) and high pressures using some catalysts. Bio-methanol, on the other hand, can be produced from gasified biomass or biogas. It is a LOHC at ambient conditions, making it easy to store, transport, and handle using existing infrastructure; it is less toxic than ammonia; and it can be used directly as a fuel or as a feedstock for producing other fuels. Disadvantages include high production costs and the availability of renewable CO_2 and hydrogen remains a bottleneck. In terms of uses, methanol is gaining traction as a marine fuel and a potential component in synthetic fuels for aviation.

LOHC

They are organic compounds that reversibly bind hydrogen through hydrogenation and releases it via dehydrogenation (LOHC_sat → LOHC_unsat + H_2). These carriers allow safe and staºble hydrogen transport using existing liquid fuel infrastructure. Their main drawbacks are the energy intensity of the dehydrogenation process and the early stage of technological development. LOHCs are promising for long-distance hydrogen transport and seasonal energy storage, with pilot projects expected in the medium term and broader integration into LNG terminals in the long term. Terminals can be equipped to handle LOHCs with specialized dehydrogenation units.

CCUS

This involves capturing CO_2 from industrial processes or directly from the air, then either reusing it in synthetic fuels or storing it underground. It enables the decarbonisation of fossil-based systems and supports e-fuel production. However, it is capital-intensive, requires extensive infrastructure, and faces regulatory and public acceptance challenges. In the short term, CCUS is being integrated into industrial clusters (capture phase), from which CO_2 can be transported through pipelines to LNG terminals and then liquefied using cryogenic energy from the regasification process. It can then be loaded onto ships and transported to the final destination for long-term storage or utilization.

The table below summarizes these LNG decarbonisation possibilities, showing the technological processes, current or potential uses, advantages, disadvantages and development outlook.

Technology	Definition & Chemical Process	Advantages	Disadvantages	Uses	Development Outlook
Bio-LNG (CH_4)	Produced via anaerobic digestion (Biogas: $CH_4 + CO_2$), updating and liquifying.	Renewable, carbon-neutral, compatible with LNG infrastructure (drop-in fuel).	Scability limited for feedstock and high cost.	Heavy transport, maritime, high-temperature industry, power generation.	Short term: operational; Medium term: regional expansion; Long term: international trade.
E-LNG (CH_4)	Green H_2 via electrolysis ($4H_2$) + captured CO_2 (CO_2) → CH_4 (Sabatier reaction) + $2H_2O$	Carbon-neutral (if powered by renewable energy, avoiding renewable energy curtailments), compatible with LNG infrastructure (drop-in fuel).	Energy-intensive, costly, depend on CCUS system and H_2 sector development.	Heavy transport, maritime, high-temperature industry, power generation.	Short term: no operational; Medium term: pilot projects; Long term: industrial scale-up.
Hydrogen (H_2)	Produced via steam methane reforming ($CH_4 + H_2O \rightarrow CO + 3H_2$), electrolysis ($2H_2O \rightarrow 2H_2 + O_2$), pyrolysis($CH_4 \rightarrow C + 2H_2$).	Zero emissions (if powered by renewable energy, avoiding renewable energy curtailments), versatile (enables e-fuels).	Low volumetric density, infrastructure needs (little quantity can be blended with natural gas), safety and stability problems (see LOHC), costly.	High-temperature industry, mobility, power generation.	Short term: blending; Medium-term: infrastructure; Long term: liquid H_2 terminals.
Ammonia (NH_3)	Produced via Haber-Bosch process: $N_2 + 3H_2 \rightarrow 2NH_3$	Efficient H_2 carrier, existing infrastructure.	Toxic, NO_x emissions, energy-intensive, depend on H_2 sector development	Maritime fuel, fertilizer, power generation.	Medium term: terminal retrofitting; Long term: direct fuel use.
Methanol (CH_3OH)	Produced via steam methane reforming ($CH_4 + H_2O \rightarrow CO + 3H_2$) and the syngas catalytically converted ($CO + 2H_2 \rightarrow CH_3OH$) or via CO_2 hidrogenation ($CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$)	Liquid fuel at ambient conditions (easy to store and transport), versatile, less toxic than NH_3.	High cost, limited renewable feedstock, depend on CCUS system and H_2 sector development	Maritime fuel, chemicals.	Short term: pilots; Medium term: shipping/chemicals; Long-term: e-methanol scale-up.
Liquid Organic Hidrogen Carriers (LOHC)	Organic liquids bind/release H_2. LOHC_unsat + H_2 ↔ LOHC_sat	Safe transport and storage, infrastructure-compatible.	Energy-intensive, early-stage tech.	H_2 transport, energy storage.	Medium term: pilots; Long-term: terminal integration
Carbon Capture, Utilisation and Storage (CCUS)	Captures CO_2 post-combustion (CO_2 + solvent → CO_2_captured) oxicombustion (recirculating CO_2) or pre-combustion (via steam methane reforming) treatment.	Reduce emissions, enables e-fuels.	Energy-intensive, high cost, infrastructure, regulation.	CO_2 feedstock, industrial decarbonisation.	Short-term: single integration; Medium-term: development of regional hubs; Long-term: large-scale deployment

Table 1: LNG terminals decarbonisation alternatives. Source: own elaboration.

2.3 Potential barriers to terminals decarbonisation

The decarbonisation of LNG terminals in the EU is a critical component of the broader energy transition strategy. However, several potential barriers could hinder the effective transformation of these infrastructures. This section outlines the potential barriers and key challenges, of a very different nature, that could obstruct or delay the LNG terminals decarbonisation process.

Regulatory complexity and fragmentation

The EU's new Gas Decarbonisation Package introduces updated rules for LNG and hydrogen terminals. While it aims to enhance transparency and third-party access, the regulatory landscape could remain complex in the very short term and implementation challenges may arise:

- Limited experience and guidance on how existing LNG terminals could smoothly transition to low-carbon operations under the new framework.

- Diverse national regulations and permitting procedures across Member States, which could hinder harmonised decarbonisation efforts and lead to inconsistent access and operational standards.

Infrastructure and technological limitations

In some cases, retrofitting LNG terminals to handle different technical solutions could entail significant technical challenges, because they were designed for handling fossil-based natural gas, not for handling other alternatives, such as liquid hydrogen, ammonia, methanol or other LOCH:

- Temperature and material constraints: liquefied hydrogen requires storage at - 253°C, far colder than LNG (-162°C), making existing tanks and pipelines or other materials and components incompatible.
- Cost of conversion: repurposing LNG terminals for ammonia or liquid hydrogen may cost even more than building specific new terminals. For liquefied hydrogen, costs can be up to 50% higher due to tank replacement.
- Lack of operational experience, adding uncertainty to investment decisions.
- Lack of standardisation in terminal design for future fuels.
- Limited availability of repurposed/multi-molecule floating storage and regasification units (FSRUs), which could offer more flexible and lower-cost solutions than low-carbon onshore terminal alternatives.

Economic and Financial Constraints

Decarbonising LNG terminals requires substantial investment, but several financial hurdles could emerge:

- High capital expenditure for upgrades and new technologies.
- Uncertain medium and long-term demand for hydrogen and lack of long-term offtake agreements deter investors.
- Limited access to financing, due to the risk associated with these new technology and uncertain utilisation rates or weaker business cases.

Market and supply chain challenges

The EU's LNG market is still adapting to the post-Ukraine invasion landscape, with LNG imports replacing Russian pipeline gas and, therefore, the EU LNG market is shaped by geopolitical shifts and supply volatility:

- Volatile global LNG prices and competition for supply could affect investments certainty. Volatility in LNG prices makes it difficult to invest in decarbonisation projects, as high prices promote the new technological solutions but low prices could slow down decarbonisation.
- Uncertain medium and long-term demand could lead to the lack of investment on developing technological solutions supply chain (offer) and vice versa. The potential competition between technologies adds uncertainty to the demand and offer of each product.

Environmental and social concerns

LNG terminals face growing scrutiny over their environmental footprint:

- Methane emissions during liquefaction, transport and regasification remain a major concern.
- Local opposition to new or repurposed terminals due to land use, emissions, and safety risks.

Specific hydrogen integration barriers

The new regulatory framework includes provisions for hydrogen terminals, but practical integration is still in early stages. Hydrogen, hand in hand with CCUS, is central and the backbone to EU decarbonisation plans (especially long-term plans), but integration into LNG terminals is limited:

- No hydrogen-ready infrastructure: The lack of hydrogen networks (under development) connected to LNG terminals delates repurposed LNG terminals.
- Existing LNG infrastructure is designed for methane, not hydrogen or carriers. Retrofitting requires new materials, safety systems, and operational protocols. These carriers require for instance specialised cracking or dehydrogenation facilities, which are largely absent at LNG terminals, without experience on it.
- No clear business models for hydrogen and carriers' terminal operators under current market conditions.
- Regulatory fragmentation and slow permitting. There is some sectorial regulation but not for all the different technical solutions (hydrogen and carriers) and specially their interfaces besides strategic uncertainty and lack of harmonised standards delate the permitting process.
- Despite ambitious targets, the EU hydrogen strategy faces implementation hurdles, for instance hydrogen import terminals are in planning, but few are operational or integrated with LNG terminals. The Directive encourages hydrogen infrastructure but does not mandate readiness for terminals.

3 Mapping terminal adaptation projects in EU

After reviewing the different technical possibilities for decarbonising LNG terminals, we consider essential to analyse the market in order to gain a more accurate insight into the current and real types of projects being considered by stakeholders in Europe.

This section provides a compilation of projects related to the decarbonisation of European LNG terminals, based on information gathered from GLE's Terminals Observatory platform, the process for the elaboration of the list of Projects of Common Interest and Projects of Mutual Interest, as well as information provided by NRAs.

While our aim is not to produce an exhaustive inventory of all projects envisaged by stakeholders - GLE's platform would serve that purpose better - we intend to get an overview of the technological solutions, key features, and interactions of these initiatives with existing or planned LNG terminals.

3.1 Summary of the projects

Firstly, according to the processed information, summarized in the table below, it is observed that a significant portion of the announced projects related to some of the technologies previously mentioned in this report, consist of the construction of new import and/or export terminals for molecules with high hydrogen content, primarily green or low-carbon ammonia, which in most cases are associated with the possibility of building cracking units for the subsequent production of hydrogen and its injection into the hydrogen transport network.

Additionally, one of the analyzed projects refers to the importation of bioLNG through an existing regasification terminal, as well as the certification of the plant according to the Renewable Energy Directive (RED) by an EU-recognized certification body for the currently provided services by the terminal, including the certification of biomethane liquefaction originating from the pipeline.

Alternatively, many the announced projects involve the conversion, integration, or utilization of part or some of the infrastructures of existing LNG terminals, such as unloading docks and arms, terminal surface/civil infrastructure, cryogenic energy, transport pipelines, etc. Generally, this type of project is more related to CO2 treatment infrastructures for liquefaction, temporary storage, and subsequent export to the final destination, within carbon capture and storage (CCS/CCSU) processes. For these projects, it makes sense from a technical point of view, as there are multiple synergies with LNG plants. This is not only because of transport and ship loading infrastructures but also due to the possibility of utilizing the cryogenic energy derived from the heat exchangers generated in the LNG regasification processes, which is highly useful for the liquefaction of gaseous CO2 captured from nearby industries and transported to the plant.

However, this is not the only case, as there are also projects integrating multiple technologies within a single LNG terminal, creating multi-molecule terminals that would encompass LNG, ammonia, CO2 and the potential production of hydrogen derived from ammonia cracking, with subsequent injection into the hydrogen transport network.

Finally, it should be noted that, concerning the import or export of pure hydrogen in its liquid form or via LOHC, this is only mentioned in a few of the projects analysed. Therefore, at the current moment, these technologies appear to be less present than those related to ammonia, CO_2, or bioLNG.

Country	Ref.	Project	Technology	Promoters	Year of Start-up	New/existing terminal
Belgium	1.	Antwerp Import Terminal	Ammonia / H2 injection	Fluxys and Advario	2029	New
	2.	Vopak Energy Park Antwerp	Ammonia / H2 injection	Royal Vopak	2029	New
	3.	Zeebrugge Multi-molecule hub	Multi-molecule (ammonia, H2, CO2)	Fluxys	2032	Existing (Zeebrugge terminal)
France	4.	Medhyterra	Ammonia	Elengy, Trammo	2029	Existing (Fos Tonkin terminal)
	5.	Bordeaux Port H2Hub - Ammonia	Ammonia	Grand Port Maritime de Bordeaux	2029	New
	6.	Dunkerque New Molecules development	Ammonia / H2 injection	Fluxys and Dunkerque LNG	2034	Existing (Dunkerque terminal)
	7.	Dunkerque CO2 terminal	CO2 terminal	Dunkerque LNG and Air Liquide	2027	Existing (Dunkerque terminal)
Germany	8.	Green Wilhelmshaven H2 Terminal	Ammonia / H2 injection	Uniper	2029	Existing (Wilhelmshaven terminal)
	9.	Ammonia Terminal Brunsbüttel	Ammonia / H2 injection	RWE and Yara	2027	New
Greece	10.	Ionian Energy Terminal	Ammonia / Liquid H2	IGI Poseidon	2034	New
	11.	ApolloCO2	CO2 terminal	DEFSA	2029	Existing (Revithoussa terminal)
Lithuania	12.	CCS Baltic Consortium	CO2 terminal	KN Energies	2030	Existing (Klaipeda terminal)
The Netherlands	13.	Amplifhy Rotterdam	Ammonia / H2 injection	VTTI	2033	New
Poland	14.	Świnoujście BioLNG	BioLNG	Gaz-System	2026	Existing (Świnoujście terminal)
Portugal	15.	H2elektra Ammonia	Ammonia	Iberdrola	2028	New
Spain	16.	Palos de la Frontera	Ammonia	Iberdrola	2028	New
	17.	Valley of Andalucía	Ammonia/H2	Moeve	2027	New
	18.	CO2necta	CO2 terminal	Enagás and Holcim		Existing (Sagunto LNG terminal)

Table 2 – Projects related to the potential decarbonisation of European LNG terminals. Source: Based on GLE's Terminals Observatory platform information, the process for the list of Projects of Common Interest and Projects of Mutual Interest, and information provided by NRAs.

3.2 Projects description

This section includes a brief technical description of the projects classified by technology.

3.2.1 Ammonia

1. Antwerp Import Terminal

The project involves creating an open-access ammonia import terminal at the Antwerp-Bruges port. It is planned to include infrastructure for berthing, unloading, loading, and transshipment for seagoing vessels, barges, and trains, along with buffer storage, ammonia bunkering, and facilities for cracking ammonia into hydrogen and subsequent hydrogen purification. There is potential for converting the ammonia into hydrogen for transmission through the hydrogen network. This initiative is part of the CH2-4EU project, which aims to facilitate the transport of renewable and low-carbon hydrogen along the HI West hydrogen corridor. The plan envisions an interconnected cross-border hydrogen transport network centred on integrated infrastructure. The terminal's hydrogen import capacity is projected at 16.2 GWh per day. After completing the feasibility study, the project is now advancing to the Front-End Engineering Design (FEED) phase, with commissioning expected in 2029.

2. Vopak Energy Park Antwerp

The development of a new green energy hub with the Port of Antwerp Bruges is being discussed by Vopak Energy Antwerp. The site where it would be developed and where there was a previous refinery, has deep-sea, river, road, and rail access, as well as pipeline connections to Northwest Europe for propylene, ethylene, CO2, and hydrogen transport. The project would include a jetty, on-site piping and storage tanks, is currently designed to import 1 million metric tons per annum of ammonia. The imported ammonia will be cracked into hydrogen through a partnership with a third-party entity. Finally, the hydrogen would be injected into the open access backbone of Fluxys. The H2 import capacity is expected to be 15 GWh/d. The project is planned to be in operation in 2029.

4. Medhyterra project

It is foreseen to redevelop part of the Fos Tonkin site into a low-carbon ammonia import terminal. The Fos Tonkin terminal could receive around 200,000 tonnes of low-carbon ammonia per year, what would mean between 10 and 15 ship unloading operations per year. A 30,000 m³ storage tank would be built to replace an LNG tank that has been out of operation for some years. In this tank the ammonia would be stored and kept in liquid form, at -33°C at atmospheric pressure, pending distribution. The project would include: transfer facilities for loading and unloading ships carrying ammonia on the existing jetty; a cryogenic ammonia storage tank ; a pipeline supplying nearby industrial sites; railcar loading bays; tanker loading bays; a connection to the French national railway network; safety devices including an emergency purification column and a vent and utility networks (cooling/heating water, nitrogen, instrument air, electricity, fire-fighting network, fuel gas). The ammonia would be distributed from the terminal: by pipeline to neighboring industrial sites; by train or by tanker truck. The project is expected to be operational in 2029.

5. Bordeaux Port H2Hub – Ammonia

The port of Bordeaux is surrounded by large quantities of biogenic CO2 originating from paper industries, cogeneration plants, methanizers and biofuel factories. About 1.7 Mt has been identified and could be reused. To do so, green hydrogen is planned to be used. An estimation of 0.3 Mt has been made: 50% would be produced locally from electrolyzers, 50% would be imported. The project "Bordeaux Port H2Hub - Ammonia" is aiming at having the capacity to import the equivalent of 150 kt of green hydrogen through ammonia per year (i.e. 850 kt of ammonia). The H2 import capacity is planned to be 15 GWh/d and the facilities would be repurposed. The project is expected to be commissioned in 2029.

6. Dunkerque New Molecules development

The development of an open-access NH3 import terminal in the port of Dunkerque is being analysed. The project would include facilities for berthing, unloading, loading, transhipments for seagoing vessels and barges, and trains as well as buffer storage, NH3 bunkering and NH3 cracking to H2 and H2 purification, based on existing facilities (Dunkerke LNG terminal). The project would involve the supply of hydrogen and any other carbon-neutral energy carrier such as NH3 as well as CO2, accommodating CCUS of the latter. The H2 import capacity would be 48 GWh/d. The project commissioning year is planned to be 2034.

8. Green Wilhelmshaven H2 Terminal

The project would consist of building an import terminal at Wilhelmshaven, to import up to 2.6mt renewable/green/blue ammonia (NH3) and would include NH3 storage, a rail car loading station and a large-scale NH3 cracking plant for the production of H2. With the cracking facilities, the NH3 will be cracked into up to 0.35 mt/a H2 and injected into the regulated German H2 core network which runs directly alongside the terminal site and which contains cross border connection to Denmark and The Netherlands and also to the future European H2 Backbone. In addition, a potential of up to 20% of the imported NH3 can be transported via railway. The H2 import capacity would be 31,2 GWh/d. The project is expected to be commissioned in 2029.

9. Ammonia Terminal Brunsbüttel

By 2027, the Brunsbüttel terminal is expected to handle around 300,000 tons of green ammonia (NH_3) per year. In a second phase, a large-scale cracker will be installed to produce green hydrogen (H_2) for the pipeline network, increasing the terminal's capacity to 2,000,000 tons of NH_3 per year, equivalent to about 258,000 tons of H_2. The site has direct access to the North Sea and is connected to inland waterways and the rail system. It is also planned to link with OGE and RWE's H_2ercules network via pipelines from Gasunie, Gascade, and Schleswig-Holstein Netz, as included in the German Gas Network Development Plan. This will enable cross-border hydrogen supply to the Netherlands, Belgium, France, and the Czech Republic, contributing to an integrated European H_2 infrastructure. The expected hydrogen import capacity is 30 GWh per day, with commissioning planned for 2030.

10. Ionian Energy Terminal

This project entails the construction of an energy terminal on the Greek Ionian coast, with a potential capacity of up to about 0.5 million tons per year. The facility is intended to meet future demand for renewable hydrogen, green ammonia, and other renewable energy carriers. Developed by IGI Poseidon, the terminal will be equipped to receive both green ammonia and liquid hydrogen, the latter to be regasified and injected into the pipeline network. The energy imported through this infrastructure will be primarily directed to the European hydrogen market. The planned hydrogen import capacity is 50 GWh per day, and commissioning is scheduled for 2034.

13. Amplifhy Rotterdam

This project aims to develop a low-carbon ammonia import terminal and an ammonia cracking facility. The terminal will import low-carbon ammonia—either green or blue—from countries such as Canada, the UAE, and Australia. A significant share of this ammonia will be converted into hydrogen and supplied to different final customers. The development will be implemented in stages, comprising four ammonia cracking units and corresponding storage infrastructure. In the first phase, the cracking capacity will be 140 kilotons of hydrogen per year; in the second phase, this will rise to 300 kilotons, and in the third, to between 300 and 600 kilotons annually. Ammonia storage capacity will progress from 40 kilotons in phase one, to 40 kilotons plus one or two 70-kiloton tanks in phase two, and an additional 70-kiloton tank in the third phase. The hydrogen import capacity is planned at approximately 135.4 GWh per day, with project commissioning scheduled for 2033.

15. H2elektra Ammonia

The project is designed to produce up to 300 tonnes of green ammonia per day, equivalent to around 100 kilotons per year, using green hydrogen and nitrogen extracted from the atmosphere. The output is planned to be partly consumed locally, with the remainder exported to the Port of Rotterdam. The exact allocation between local consumption and exports will be determined at a later stage. Commissioning of the project is planned for 2028.

16. Palos de la Frontera I Ammonia

The project is promoted by the same company as the previous one and shares very similar technical characteristics, differing mainly in its location—this one being in Spain, whereas the previous project is in Portugal. Commissioning is also planned for 2028.

17. Valley of Andalucía of green hydrogen

The project foresees the creation of a green H2 valley with a total electrolyser capacity of 2 GW, distributed equally between two energy parks. The promoter, Moeve, plans to develop the first 1 GW in Huelva, in collaboration with partners such as Fertiberia, Enagás, and AlterEnersun. This phase will focus on the production of hydrogen, ammonia, methanol, and eSAF. The second phase will be developed with new partners and will concentrate exclusively on eSAF production. In Cádiz, the Carteia 1 GW project will be implemented with Yara Clean Ammonia and EDP, focusing on the production of hydrogen and ammonia. The Valley aims to support industrial and transport decarbonisation while establishing a European green maritime corridor between southern and northern Europe, including connections with the Port of Rotterdam. The project will be developed in several sections: Section 1 (400 MWhel; commissioning in 2026), Section 2 (400 MWhel; 2026), Section 3 (200 MWhel; 2028), Section 4 (500 MWhel; 2028), and Section 5 (400 MWhel; 2029). The overall project commissioning is planned for 2027.

3.2.2 BioLNG

14. Świnoujście BioLNG

This project entails the certification of the Polish LNG regasification terminal in Świnoujście according to Renewables Energy Directive. Bioservice implementation is expected to start in 2026.

3.2.3 Multimolecule (ammonia, H2, CO2)

3. Zeebrugge Multi-molecule hub

The development of an open-access NH3 import terminal in the port of Antwerp-Bruges (Zeebrugge) is being analysed by Fluxys. The project would consist on converting the Zeebrugge LNG terminal into a multi-molecule hub for large-scale decarbonisation. The project would comprise facilities for berthing, unloading, loading and transhipments for seagoing vessels and barges, as well as buffer storage, NH3 bunkering and NH3 cracking to H2 and H2 purification. Large-scale maritime imports of low-carbon hydrogen or derivatives would be needed as well as the export of CO_2 for safe and permanent sequestration under the seabed. To support this transition, sufficient inflow of natural gas serving the new flow configurations in Europe is a continued need for which decarbonisation potential of carbon-neutral biomethane and synthetic methane can be leveraged. The H2 import capacity would be 48 GWh/d. The project commissioning year would be 2032.

3.2.4 CO2

7. Dunkerque CO2 terminal

The planned project would consist of the development of a multi-modal open access terminal for the transport, liquefaction and export of CO_2. The capacity would be 1.5 million tonnes of CO_2 annually, with possible expansion. The CO_2 is planned to be carried to permanent offshore storage. The terminal is part of the Cap Décarbonation initiative that would involve capturing CO_2 from cement production in Lumbres and lime production in Réty; transporting the captured CO_2 by pipeline to Dunkerque for shipping to offshore storage. Other objective is the decarbonising the Dunkerque industrial cluster: the emissions of the port area 21% of France's industrial emissions (13.7 million tons in 2020). and the region has the objective of reducing CO_2 emissions by 30% by 2030 to reach carbon neutrality by 2050.

11. ApolloCO2

ApolloCO2 is planned as a large-scale midstream carbon capture and storage project in South-Eastern Europe, designed to collect gaseous CO_2 emissions from industrial sources via a dedicated pipeline. The captured CO_2 will be sent to a centralized liquefaction and temporary storage facility, from which it will be transported by ship to a permanent storage site. The liquefaction and export terminal is proposed to be located on Revythoussa island, home to DESFA's LNG terminal. Here, the CO_2 will be liquefied using an onshore liquefaction unit. Due to limited space on the island, liquefied CO_2 will be temporarily stored on a Floating Liquefied Storage Unit, which will also provide back-up liquefaction capacity. The liquefaction system will use indirect heat exchange to prevent CO_2 from freezing. At start-up, the project's capacity will reach 3 million tons per year, with the potential to expand to 5 million tons annually.

12. CCS Baltic Consortium

This project seeks to reduce CO_2 emissions from Lithuania and Latvia through the creation of a cross-border carbon capture and storage infrastructure. CO_2 will be captured from industrial sources, primarily at the cement plants in both countries. The captured gas will be transported mainly via onshore pipelines, while alternative logistics solutions are foreseen for smaller emitters to ensure open-access participation in the CCS value chain. Captured CO_2 will be sent to the multimodal liquefied CO_2 terminal in Klaipeda, where it will be temporarily stored and prepared for shipping. During the initial project phase, partners are conducting technical and economic studies to evaluate capture technologies, cost efficiency and storage options.

Cooperation is already established with the national TSOs for the planning of the pipeline network. The Consortium, created in 2022, aims to develop a complete CCS value chain connecting industrial emitters with offshore storage facilities in the North Sea. As underground storage is currently prohibited in Lithuania and Latvia, CCS offers a crucial decarbonisation pathway for these countries. The final investment decision is targeted for the end of 2027, with CO_2 capture and export operations expected to begin by 2030.

18. CO2necta

The project involves installing a CO_2 capture facility at Holcim's cement plant in Sagunto. The captured CO_2 will be transported via Enagás' infrastructure to the Saggas terminal, where it will be liquefied. From there, the liquefied CO_2 will be shipped to a site for permanent geological storage. Enagás and Calcinor, a company specializing in industrial mineral production, have signed an agreement to jointly develop projects for decarbonisation and sustainable CO_2 management. Under the agreement, Calcinor will focus on the development of CO_2 capture technologies, while Enagás will oversee transportation, liquefaction, storage, and ship loading at its regasification terminals, for subsequent utilization or permanent storage.

4 Regulatory analysis

In general terms, the aim of the regulation, in particular for the gas sector, is to establish the framework (*the rules of the game*) to ensure a reliable, sustainable, and fair energy supply while protecting consumers and the environment, being also, in the energy liberalization context, a tool to cope with potential drawbacks of the liberalised market in the event of insufficient competition. It must be tailored to yield efficient outcomes in terms of fair and efficient service provision as well as pricing and should establish consistent rules, rights and obligations for all operators with installations serving similar purposes.

Bearing this in mind, in this section we carry out a regulatory analysis of the different terminal decarbonisation possibilities, technology by technology, taking also into account current regulations.

4.1 Bio/e-LNG

Regarding projects related to bio and/or e-LNG imports at existing terminals, it should be noted that, technically, this activity does not differ from conventional LNG importation. Therefore, both fall under the definition of an LNG terminal and no distinction should be made in terms of the application of current regulations. The only difference lies not in the regulation related to the infrastructures but in the certification of the gas (bio/e-LNG) through one of the mechanisms established and recognized by the EU.

In addition to the previously referred bio and e-LNG importation possibilities, decarbonised LNG certification projects originating from the pipeline have already been implemented or are underway at various existing European LNG terminals. In many cases, this is facilitated through the introduction of new terminal services[2], such as virtual liquefaction, relying on reducing regasification nominations instead of physically liquefying decarbonised methane from the gas grid.

4.2 Hydrogen and ammonia

Hydrogen terminals face some barriers, such as regulatory issues, infrastructure and technological limitations, economic and financial constraints, market and supply chain challenges or environmental and social concerns. Regarding the regulatory ones, the decarbonisation package clarifies some of the aspects to bear in mind by business models of hydrogen terminal operators, particularly those indicated below. However the transposition thereof in national legislation is a difficult exercise and should be monitored closely in order to detect potential differences that could affect the market on the European level.

[2] There are two possible liquefaction services possible: (a) recondensed liquefaction where the capacity is based on actual liquefaction (real liquefaction), or (b) virtual liquefaction where the capacity is based on equivalence of decarbonised methane liquefaction. In the latter case, the capacity is related with the terminal send out capacity. The terminal operator needs to be certified as a processing unit and the emission from processing related to decarbonised methane equivalence liquefaction service are reported on the certificate.

4.2.1 Scope of application

Firstly, it is important to bear in mind recital (86) of the Directive (EU) 2024/1788 (the Directive), which includes hydrogen and the possibility of other derivatives in its scope of application:

> *"It is to be expected that hydrogen and hydrogen derivatives, such as ammonia, or liquid organic hydrogen carriers will be imported into and transported within the Union. However, it is as yet uncertain by what means and in what form hydrogen will be transported while various means and forms are likely to coexist and compete with each other. This Directive provides a regulatory framework for infrastructure and markets for gaseous hydrogen. Consequently, only where other forms of hydrogen or derivatives and the facilities that handle them are relevant to ensure the emergence of a competitive market for gaseous hydrogen should their role and the rules applicable to them be defined in this Directive."*

Besides, on this basis and according to the Art. 2 (8) and (9) of the Directive:

> *''hydrogen terminal means an installation used for the offloading and transformation of liquid hydrogen or liquid ammonia into gaseous hydrogen for injection into the hydrogen network or the natural gas system or the liquefaction of gaseous hydrogen and its onloading, including ancillary services and temporary storage necessary for the transformation process and subsequent injection into the hydrogen network, but not any part of the hydrogen terminal used for storage"*
>
> *"hydrogen terminal operator means a natural or legal person that carries out the function of offloading and transformation of liquid hydrogen or liquid ammonia into gaseous hydrogen for injection into the hydrogen network or the natural gas system or the liquefaction and onloading of gaseous hydrogen and is responsible for operating a hydrogen terminal"*

In addition, recital (87) of the Directive mentions that:

> *"Terminals for the offloading and conversion of liquid hydrogen or liquid ammonia transported via ship into gaseous hydrogen constitute a means of hydrogen import, but they compete with other means of hydrogen transport […]".*

We should note that, under the current regulation, hydrogen terminal facilities include both possibilities: not only the offloading and transformation of liquid hydrogen into gaseous hydrogen and the opposite operation (liquefaction), but also those terminals allowing or addressed to the offloading of liquid ammonia and its conversion into gaseous hydrogen for injection into the hydrogen or gas system. Then, in the context of recital 86, ammonia has been considered in this regulation as a hydrogen carrier or derivative, significant enough to ensure the emergence of a competitive market for gaseous hydrogen. Having that in mind it is worth to underline that the operation of a hydrogen terminal will be very different from the operation of an LNG terminal.

According to this, ammonia terminals providing services related to the reception, storage, onloading and/or treatment for transformation in products different from gaseous hydrogen for injection into the hydrogen network or the natural gas system, would not fall under the hydrogen terminal definition and would be outside the scope of this regulation. This is clearly the case for existing conventional ammonia terminals of this kind, but also for the new ammonia terminal projects, in those cases who don't foresee the implementation of a cracker unit aiming at producing hydrogen in the same premises for its injection into hydrogen or natural gas networks.

4.2.2 Third-party access system

The key difference between negotiated and regulated third-party access lies in how contractual terms, including pricing, are established. While nTPA, access terms are negotiated directly between the parties, providing flexibility to terminal operators within a regulatory framework that ensures transparency, objectivity, and non-discrimination, rTPA follows a standardised, non-negotiable approach, where terms and tariffs are strictly regulated to ensure equal access for all market participants.

For hydrogen terminals, with the goal of minimizing administrative burdens for both, operators and regulators[3], the Directive explicitly sets[4] forth a negotiated third-party access (TPA) framework for hydrogen terminals. This access must be provided in a manner that is objective, transparent, and non-discriminatory, and it must be negotiated in good faith.

As a result, hydrogen terminal operators are already expected to provide a nTPA to market players, while regulators have also an important role to play. These are required to monitor conditions and their impact on the market for hydrogen and, where necessary, to take measures to improve access to safeguard competition. To reinforce this, the Regulation (EU) 2024/1789 (the Regulation) specifically establishes the obligation to offer services on a non-discriminatory basis to all network users, to offer services that are compatible with the use of the interconnected natural gas and hydrogen transport systems, facilitate access to them and make relevant information public, in particular data on the use and availability of services.

The Regulation stablishes also the possibility to exempt hydrogen terminals from nTPA upon request, according to its Art 78.1. Nevertheless, even in this case, hydrogen terminal operators shall make public information about the amount of hydrogen, inflows and outflows and available capacities.

[3] See recital 87 of the Directive.

[4] Art. 36.1 of the Directive.

4.3 LOHC

As stated in chapter 4.2.1, LOHC and other hydrogen derivatives (different from ammonia) are not included in the definition of *"hydrogen terminal".* When the Directive was developed and subsequently approved, these hydrogen carriers/derivatives and the facilities managing them were not considered relevant to ensure the emergence of a competitive market for gaseous hydrogen. Therefore, the rules set out in this Directive do not apply to them[5].

4.4 CCUS

As in the previous case, CO_2 hasn't been considered in the definition of hydrogen terminal, so that rules set out in the Directive do not be applied to them.

Nevertheless, according to the information about the projects gathered for the elaboration of this report, in some cases CO_2 could be transported through pipelines to LNG multi-molecule terminals, then liquefied using cryogenic energy from the regasification process and then loaded to ships for export using civil infrastructures of the existing terminal. In these cases, it would be crucial to pay attention to the separation of activities regulation, as well as to avoid cross-subsidies between activities.

The revenues generated from services provided by regulated LNG terminals to new activities outside the scope of the Directive and Regulation, through the use of their infrastructure, should be taken into account when determining the remuneration of the terminal operators. This, in turn, should lead to a reduction in the costs for users of LNG and natural gas-related services.

[5] Nevertheless, it could be mentioned that some of these hydrogen derivatives are considered within the scope of the activity of supply. According to Art.2 (28): "supply means the sale, including resale, of natural gas, including LNG, or hydrogen, including in the form of liquid organic hydrogen carriers or liquid hydrogen and hydrogen derivatives including ammonia or methanol to customers".

5 Conclusions

LNG has become a cornerstone of Europe's energy approach in the face of recent geopolitical and environmental challenges. Adapting LNG terminals strategically is vital to achieving a balance between energy security and sustainability objectives. CEER has recognized the importance of assessing various decarbonisation pathways for LNG terminals by examining technical solutions, obstacles, current regulations and any regulatory gaps.

Decarbonizing LNG terminals is fundamental not only for reducing emissions from the gas sector through the integration of low-carbon and renewable gases such as green hydrogen and biomethane, but also for advancing the decarbonisation of the power sector through stronger sector coupling. In this sense, the role of gas as a storable energy, capable of providing large-scale, long-term storage, is especially valuable to secure supply in both gas and electricity networks amid increasing shares of variable renewable energy.

The future functionality of LNG terminals will largely depend on how infrastructure investments align with Europe's decarbonisation ambitions. Operators are exploring various alternatives, with the potential to transform LNG terminals from mere import points into versatile energy hubs capable of handling bio-LNG, e-LNG, hydrogen, ammonia, methanol, LOHCs, and CCUS technologies, all while maintaining supply flexibility and security. This ongoing evolution is essential for integrating decarbonized fuels into the European energy system.

While maintaining flexibility and security of supply, LNG terminals can be repurposed or complemented to handle low-carbon gases and integrate emerging technologies, through different solutions, such as bio-LNG, e-LNG, hydrogen, ammonia, methanol, LOHC's or CCUS solutions.

Nevertheless, several diverse barriers could hinder the transformation of LNG infrastructures, including regulatory hurdles from limited project experience and varying permitting across Member States, alongside infrastructure and technological constraints, economic-financial limitations, social concerns, and market-supply chain issues. These risks and obstacles demand case-by-case evaluation and mitigation, particularly in early development phases where project immaturity and diversity amplify challenges.

Concerning the nature of the projects, we have observed that a significant portion consist of the construction of ammonia terminals, in most cases associated with the subsequent production of gaseous hydrogen. Some projects refer to the importation of bio-LNG through existing regasification terminals, linked to the certification of the plant according to the RED. In other cases, projects involve the conversion, integration, or utilization of part of the infrastructures of existing conventional LNG terminals, such as unloading docks and arms, terminal surface/civil infrastructure, cryogenic energy, transport pipelines, etc. in relation with CO2 treatment or, even more, some projects aim to create multi-molecule terminals that would encompass LNG, ammonia, CO2 and the potential production of hydrogen.

Concerning the import or export of pure hydrogen in its liquid form or via LOHC, this is only mentioned in a few of the analyzed projects. Therefore, at the current moment, these technologies appear to be less present than those related to ammonia, CO2, or bio-LNG.

Projects involving **bio and e-LNG** imports at existing terminals are technically similar to conventional LNG imports, fitting within the existing LNG terminal definition and regulatory framework. The main distinction lies in the certification of the gas as bio or e-LNG, according to EU-recognized mechanisms, without altering infrastructure regulations.

Hydrogen terminals encompass facilities for unloading and converting liquid hydrogen to gas and vice versa, including terminals handling liquid ammonia and converting it into gaseous hydrogen for injection into hydrogen or natural gas systems. These terminals are subject to negotiated third-party access, with possible exemptions requiring technical market transparency. However, due to their early development stage, these operations face regulatory (among which the transposition into national legislation), technological, financial, and supply chain challenges.

Other hydrogen derivatives like **LOHCs, methanol and ammonia terminals** performing only storage and transfer functions without hydrogen conversion fall outside the hydrogen terminal regulation scope, as it is also the case for **CO2 terminals**. Nevertheless, some LNG terminal infrastructure may be repurposed for these activities, which should be considered in terminal operator remuneration, potentially lowering costs for LNG and gas service users.

Annex 1 – List of abbreviations

Term	Definition
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Utilisation and Storage
CEER	Council of European Energy Regulators
ETS	Emission Trading System
FSRU	Floating Storage and Regasification Unit
FID	Final investment decision
GGP	Guidelines of Good Practice
GHG	Greenhouse Gases
GLE	Gas LNG Europe
LNG	Liquefied natural gas
LOHC	Liquid Organic Hydrogen Carrier
LSO	LNG System Operator
MS	Member States
NRAs	National Regulatory Authorities
nTPA	Negotiated third-party access
rTPA	Regulated third-party access
PCI	Projects of Common Interest
PMI	Projects of mutual interests
RED	Renewable Energy Directive
rTPA	Regulated Third Party Access
SMR	Steam Methane Reformig
SoS	Security of Supply
SSO	Storage System Operator
TSO	Transmission System Operator

About CEER

The Council of European Energy Regulators (CEER) is the voice of Europe's national energy regulators. CEER's members and observers comprise 38 national energy regulatory authorities (NRAs) from across Europe.

CEER is legally established as a not-for-profit association under Belgian law, with a small Secretariat based in Brussels to assist the organisation.

CEER supports its NRA members/observers in their responsibilities, sharing experience and developing regulatory capacity and best practices. It does so by facilitating expert working group meetings, hosting workshops and events, supporting the development and publication of regulatory papers, and through an in-house Training Academy. Through CEER, European NRAs cooperate and develop common position papers, advice and forward-thinking recommendations to improve the electricity and gas markets for the benefit of consumers and businesses.

In terms of policy, CEER actively promotes an investment friendly, harmonised regulatory environment and the consistent application of existing EU legislation. A key objective of CEER is to facilitate the creation of a single, competitive, efficient and sustainable Internal Energy Market in Europe that works in the consumer interest.

Specifically, CEER deals with a range of energy regulatory issues including wholesale and retail markets; consumer issues; distribution networks; smart grids; flexibility; sustainability; and international cooperation.

CEER wishes to thank the LNG WS co-chairs and members who have provided inputs and suggestions to elaborate this report.

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