Istituto Affari Internazionali

Small-scale LNG in the Euro-Mediterranean: A Contribution to the Decarbonisation of the Maritime Sector

by Pier Paolo Raimondi

ABSTRACT

While governments have reaffirmed their commitment towards energy transition in light of the current energy crisis, the urgency to act implies to use all possible solutions to reduce CO_2 emissions during the transitional period. Natural gas can play a role in the decarbonisation of certain sectors, such as the transport sector. In this sense, the small-scale LNG industry could contribute to the decarbonisation of the Mediterranean region. Regulatory and political incentives as well as socioeconomic and environmental benefits could represent critical drivers for the growing role of the small-scale liquefied natural gas (SSLNG), while it will need to overcome several challenges (e.g. political pressure, economic and infrastructure constraints).

Mediterranean | Energy | Natural gas | LNG | European Union

keywords

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Introduction

Current geopolitical and energy developments have already resulted in major consequences for the energy sector – and are likely to continue to shape future energy and political trends. These developments heighten the urgency of preserving and reinforcing the energy transition pathway. Governments have reiterated their commitment to their net-zero pledges while considering temporary solutions to preserve energy security. Meanwhile, they highlight the need to use all possible solutions to reduce CO_2 emissions during the transitional period in order to not postpone further the transition.

The 2020s are expected to be a transformative decade for climate policy as governments will need to adjust their policy mix in line with net-zero targets. Therefore, they need to put in place the best framework to cut greenhouse gas (GHG) emissions as much as possible. In the long term, further technological developments and better economic conditions will likely allow the advent and wide use of several solutions (e.g., green hydrogen for industry, ammonia for shipping) to decarbonise the entire economy. Nonetheless, governments need to focus also on viable solutions for the medium term. Especially in certain sectors where electrification is not possible or other alternatives are not currently available – the so-called hard-to-abate sectors – government must deploy and favour medium-term solutions, most of which are readily available in the market.

Russia's invasion of Ukraine has resulted in much higher energy prices and a renewed emphasis on investment in green technologies, yet it has also had another major consequence, that is the newfound relevance of the Mediterranean area for European energy security and the (energy, green) transition. In the past months the European Union as well as several member states have reached out to Southern

* Pier Paolo Raimondi is Research Fellow of the Energy, Climate and Resources Programme at the Istituto Affari Internazionali (IAI) and PhD Candidate at the Università Cattolica del Sacro Cuore, Milan.

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Mediterranean countries to discuss additional gas imports in the short to medium term and clean energy in the medium to long term.

Natural gas can contribute to the carbon footprint reduction of several sectors in the Euro-Mediterranean region, in particular through its role as a transitional fuel in the heavy load sector (i.e., maritime, road and rail) given that it is less emissive than today's fuels (diesel, heavy fuel oil, coal). Moreover, alternative fuels for transport (e.g., hydrogen, ammonia, electricity) will not be economically and technologically ready in the short/medium term. In this sense, a higher contribution of gas in these sectors may be spurred by the development and use of a small-scale liquefied natural gas (SSLNG) supply chain, meaning a set of logistics activities used to handle small/medium quantities of liquefied natural gas (LNG), since it could immediately take advantage of the existing infrastructure networks as well as technological and industrial capabilities.

Over the past decade, the use of SSLNG has been in continuous expansion, accounting today for around 15 per cent of LNG global trade (372 million tonnes, Mt, in 2021). Such expansion was fuelled by an increase in LNG trade with small new country importers. In these countries, smaller projects seemed more reasonable in terms of economics and infrastructural feasibility. SSLNG can provide flexible solutions for both decarbonising some of the transport sector and providing gas supply to the most remote areas for several uses (power generation, industry, households). Given the rise of LNG trade, it is expected that SSLNG volume trade would double up to 90–100 Mtpa (million tonnes per annum) from 48–51 Mtpa in 2021, accounting for around 16 per cent of global LNG trade by 2030.[1]

SSLNG has gained relevance in several regions of the world such as Northern Europe, China and South-eastern Asia, while its role in the Euro-Mediterranean region is still quite modest with a few exceptions (e.g., Spain). The Mediterranean countries could spur further decarbonisation by creating an attractive investment environment through supportive regulatory frameworks and infrastructure development. Nonetheless, countries will need to build infrastructure networks in line with their climate ambitions. Indeed, today's LNG technology is already prepared to receive and manage decarbonised solutions, such as bioLNG and synthetic fuels, while for new solutions such as clean ammonia, once the technology is ready, new infrastructure must be developed.

Before diving into the opportunities and challenges for SSLNG in the Euro-Mediterranean decarbonisation process, it is important to define SSLNG, as no common definition seems to have been agreed upon. One way to overcome this challenge is to classify it by looking at the size of the technology and the SSLNG value chain. Therefore, a definition of SSLNG relates to the equipment specifications

[1] Observatoire Méditerranéen de l'Energie (OME), "Small Scale LNG Business Options in the Mediterranean Region", in *OME Discussion Papers*, July 2019.

and not the size of the destination market.[2] Furthermore, SSLNG can be sourced from an existing conventional-scale LNG facility or from a small-scale liquefaction facility itself. It typically serves a wider range of end users than the conventional LNG value chain (power plant or domestic).

Table 1 | Defining SSLNG and comparison with "standard" LNG

	Upstream	Mid- Stream	Down-Stream	
	Liquefaction	Shipping	Regasification	Storage
Standard LNG	3-7 MTPA	Qmax 244,000 cu.m Qflex 220,000 cu. M Standard 145,000 cu. m	1.5MTPA	170,000 cu. m
Mid/SS-LNG	< 1MTP	7,500- 20,000 cu. M	0.5-1.2 MTPA	<10,000 cu.m Vacuum Insulated Tanks
Mini/Micro LNG			50,000 cu. m	>15,000 cu. m Flat Bottomed Tanks Preferred
	<3000 TPA	Barges/ ISO Containers	760 cu. m (bullets)	Bullets and ISO Containers

Source: OME, "Small Scale LNG Business Options in the Mediterranean Region", cit.

Several factors could enable a larger use of SSLNG in the transport sector. Among these are climate and environmental policies which set targets for decarbonisation of the maritime sectors. This environment has enabled a growth in demand for bunkering over the past years – i.e., the supplying of fuel for use by ships, including the logistics of loading and distributing fuel among available shipboard tanks.

1. Drivers and contribution to decarbonisation

The European Commission has set ambitious climate targets, aiming at making the EU the climate-neutral by 2050, leading many countries to follow its example by setting similar targets.

To achieve this objective, a 90 per cent reduction in transport emissions is needed.[3] Transport represents almost a quarter of Europe's greenhouse gas emissions and interestingly the sector has not followed the same gradual decarbonisation path experienced by other sectors. Indeed, its emissions remain higher than in 1990.

[2] Ibid.

[3] European Commission, *Proposal for a Regulation on the Use of Renewable and Low-Carbon Fuels in Maritime Transport and Amending Directive 2009/16/EC* (COM/2021/562), 14 July 2021, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52021PC0562.

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The contribution to the sector's emissions is unevenly distributed among transport modes. Road transport is by far the biggest emitter accounting for around 70 per cent of all GHG emissions from transport. Nonetheless, all transport modes will have to contribute to such reduction efforts. Electrification, coupled with renewables, seems to be the trajectory of choice for light duty vehicles, but is less promising for heavy duty, long haul transport (e.g., heavy trucks, maritime and rail). The widespread use of electrification in these sectors faces several challenges, such as different energy density and the size of batteries required. Therefore, both countries and companies need to evaluate potential alternatives for the medium and longer term in these crucial sectors.

Maritime transport is the backbone of international trade and the global economy, as over 80 per cent of the volume of international trade in goods is carried by sea.[4] Maritime transport is also an essential component of EU's transport system and plays a critical role for the European economy – contributing around 75 per cent of EU external trade volumes and 31 per cent of EU internal trade volumes.[5] This has environmental consequences, with ships generating 13.5 per cent of all GHG emission from transport in 2018 in the EU.[6] Furthermore, rising maritime traffic causes other environmental consequences such as marine and air pollution and underwater noise. This context is particularly pertinent for the Mediterranean Sea, which is one of the most strategic seas in the world, carrying 20 per cent of seaborne trade, 10 per cent of world container throughput and over 200 million passengers[7] while at the same time being densely populated and presenting a fragile ecosystem. The development of SSLNG in the Euro-Mediterranean region could yield positive economic and environmental benefits.

1.1 Drivers/reasons for SSLNG

LNG could contribute to the decarbonisation of maritime ships in the short to medium term as it represents a mature technology vis-à-vis alternative fuels. LNG-fuelled ships can bring positive environmental benefits by reducing substantially the air pollutants SOx particulate matter (PM) up to 90 per cent and NOx up to 80 per cent compared to traditional fossil fuels,[8] Using LNG would also reduce black carbon emissions, while GHG emissions can be reduced by up to 23 per cent with

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[4] United Nations Conference on Trade and Development (UNCTAD), *Review of Maritime Transport 2021*, November 2021, https://unctad.org/webflyer/review-maritime-transport-2021.

[5] European Commission, *Proposal for a Regulation on the Use of Renewable and Low-Carbon Fuels in Maritime Transport*, cit.

[6] Marketa Pape, "Sustainable Maritime Fuels. 'Fit for 55' Package: The FuelEU Maritime Proposal", in *EPRS Briefings*, April 2022, https://www.europarl.europa.eu/thinktank/it/document/EPRS_BRI(2021)698808.

[7] UN Environment/MAP, *Mediterranean 2017 Quality Status Report*, 2017, https://www.medqsr.org/node/235.

[8] European Maritime Safety Agency (EMSA) and European Environment Agency (EEA), *The European Maritime Transport Environmental Report 2021*, September 2021, https://www.emsa.europa.eu/publications/item/4513.html.

modern engine technology.[9] Moreover, LNG could contribute directly to improving air quality in ports and harbours. For example, most of the cruise ships directly enter city harbours, being responsible for about 38 per cent of Hamburg's NOx emission and a major source of fine particle emissions as engines keep running even when at berth to produce power.[10]

Compared to alternative decarbonised fuels, LNG presents some competitive advantages in the short/medium term. Hydrogen has drawn significant attention and interest from both public and private sectors. Indeed, hydrogen potentially can replace natural gas in the hard-to-abate sectors. Despite the potential contribution in the long term, a hydrogen-fuelled maritime sector faces some challenges in the short/medium term. Currently, the major barrier to the contribution of hydrogen is the lack of a mature engine technology, infrastructure and supply coupled with security concerns and high cost. In addition, currently hydrogen is mostly produced through highly emissive processes. In order to produce clean hydrogen from renewables, countries will need to install a significant amount of renewable capacity, a complex task hindered by intricate permitting processes throughout the EU. Lastly, hydrogen is highly flammable, provoking a great deal of concern regarding its storage and on-ship use, something that warrants adequate infrastructure, proper certification and training of staff.

Another promising fuel for decarbonising the maritime industry is ammonia.[11] In order to contribute significantly to the decarbonisation pathways, the industry is considering ammonia, especially because it can be produced by renewables. Green ammonia does not emit CO_2 during combustion and has a similar energy density to methanol, which makes it more favourable than other decarbonised fuels, such as hydrogen. However, its current production level is negligible. Almost all ammonia comes today from hydrocarbons, which does not provide any emissions reduction and would imply only additional costs for operators – a similar issue to the hydrogen option. A potential enabler for the development of ammonia as maritime fuel is the declining costs of renewables, which could spur scalability and reduce cost.

Nonetheless, ammonia needs to overcome several challenges in the short/medium term before contributing to the decarbonisation of the maritime industry.[12] First, ammonia is highly toxic, flammable and corrosive, implying higher safety concerns and need for training compared with LNG. Second, ammonia is rich in nitrogen,

[9] DNV website: *LNG as Marine Fuel*, https://www.dnv.com/maritime/insights/topics/lng-as-marine-fuel/index.html.

[10] Gas Infrastructure Europe (GIE), *LNG as the Fuel of Choice for Road and Maritime Transportation: The Case for (Small-Scale) LNG in Europe*, GIE Position Paper, November 2018, https://www.gie.eu/wp-content/uploads/filr/2570/2018%20GIE%20SSLNG%20position%20paper_FINAL.pdf.

[11] Produced by electrolysis powered by renewables or nuclear.

[12] DNV, "Smells Like Sustainability: Harnessing Ammonia as Ship Fuel", in *Industry Insights*, 8 February 2022, https://www.dnv.com/expert-story/maritime-impact/Harnessing-ammonia-as-ship-fuel.html.

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which results in both NOx and nitrous oxide emissions. Although ammonia could bring environmental benefits compared to traditional fuels, nitrous oxide emissions are quite challenging as they are 283 times stronger than CO_2.[13] Third, currently ammonia is largely used in other sectors (80 per cent of the global ammonia supply is used as fertiliser) meaning that the maritime industry will need to compete with other industries regarding the use of ammonia. This means that global (green) ammonia production will need to ramp-up in order to satisfy both maritime and other sectors. Moreover, massive investments in renewables will be needed to meet demand from the maritime sector and simultaneously satisfy decarbonisation of other crucial sectors (i.e., power). Lastly, from a technological perspective, ammonia burns much more slowly, meaning that sustaining combustion once it gets started is also more difficult than with other fuels and, not less important, it will require the creation of a new supply chain, from distribution to storage in ports to development of engines.

Given its competitive advantages (i.e., lower costs and existing infrastructure) vis-à-vis other alternative fuels, SSLNG can play an important role in the Euro-Mediterranean region in the short/medium term. As already mentioned, the growth of SSLNG has followed the expansion of global LNG trade, which has reached an all-time high of 372.3 Mt as the post pandemic recovery and the need for gas sources alternative to Russia resulted in a surge in LNG demand.[14] Along with the availability of LNG supply and infrastructure, there are other drivers and enablers for SSLNG growth – of an economic, environmental and regulatory nature. Economically, LNG used to have an energy cost advantage over alternative energy sources for end-users, including gas in the absence of pipeline infrastructure.[15] Moreover, governmental decisions on environmental and energy security concerns are a driver for the growth of SSLNG.

LNG is a mature and commercially viable marine fuel. It benefits from existing infrastructure around the world and in the Euro-Mediterranean region as well. Therefore, it can provide an immediate contribution to decarbonisation pathways. These positive features, coupled with stricter environmental measures, pave the way for a higher LNG role in the future, as proven by rising bunkering demand. Indeed, LNG represented less than 3 per cent of ship fuel consumption between 2013 and 2015. Yet, because of the aforementioned enablers, operators have shown an increased interest in considering LNG as their maritime fuel of choice.

In 2019, there were 756 LNG-fuelled ships, up from 355 ships in 2012.[16] This growth over the past decade can be seen for various types of ships and shows no sign of

[13] Ibid.

[14] International Gas Union (IGU), *World LNG Report 2022*, July 2022, https://www.igu.org/?p=20755.

[15] This comparative advantage has been undermined by the gas price spikes in 2021/22, which could result in a loss of competitiveness, as is addressed in section 4.

[16] Nikita Pavlenko et al., "The Climate Implications of Using LNG as a Marine Fuel", in *ICCT Working Papers*, No. 2020-02 (January 2020), https://theicct.org/?p=343.

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slowing. Indeed, LNG is increasingly being adopted to address emissions from the shipping industry, with 30 per cent of new large ship orders being for LNG vessels in 2021, according to the 2022 Shell LNG Outlook.[17] In the Euro-Mediterranean, in 2021 Turkey's oil and gas company, BOTAS, joined with Arkas Bunkering and Sumitomo Corporation to establish LNG bunkering infrastructure in the country aiming at establishing an LNG bunkering hub in Turkey for the Eastern Mediterranean.[18]

Alongside its potential contribution in the short term, LNG could also pave the way for further emissions reduction through wider adoption of bioLNG and renewable synthetic LNG. These solutions would allow optimisation of existing infrastructure and investments by decreasing GHG emissions down a virtuous environmental stairway. Indeed, no adjustments to vessels are required for the safe use of bioLNG and renewable synthetic LNG. Some Northern countries have already considered projects in their ports that envisage the use of bioLNG.

1.2 SSLNG development to date

Until now, SSLNG has developed gradually. Norway, China and Southeast Asia (i.e., the Philippines and Singapore) have emerged as leading SSLNG markets. The growth of SSLNG has been remarkable in China, which has become one of the largest SSLNG markets globally, mainly thanks to the availability of domestic gas resources, low state-controlled gas prices and the political commitment both at the local and central government level to fight air pollution in cities.[19]

Another positive case study is the Norwegian (and more broadly Scandinavian) one. Norway has a long history of SSLNG, starting in the late 1980s, mainly driven by governmental decisions and environmental measures. Back then the Norwegian sovereign wealth fund, supported and encouraged by the government, solicited operators in the Norwegian North Sea to reduce SOx and NOx emissions from offshore gas fields.[20] In a second moment, local legislation incentivised cruise liners and fishing trawlers to switch from heavy fuels to gas. In the early 1990s, the government introduced a tax on CO_2 emissions for offshore field operators. All this legislation paved the way for innovative use of clean fuels in the Norwegian North Sea. Furthermore, the government built a platform involving private industry, academia and major oil and gas players aimed at creating pan-industry innovation programmes (e.g., Network LNG Norway). This cooperative approach among industry and academia would yield several positive consequences also for

[17] Shell, *Shell LNG Outlook 2022*, February 2022, https://www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2022.html.

[18] Sanja Pekic, "Turkey All Set for LNG Bunkering Hub with 3-Party Deal", in *Offshore Energy*, 9 September 2021, https://www.offshore-energy.biz/?p=482429.

[19] IGU, *Small Scale LNG*, June 2015, http://members.igu.org/old/IGU%20Events/wgc/wgc-2015/committee-reports-with-tnematic-sessions/pgcd-3-paper.pdf.

[20] OME, "Small Scale LNG Business Options in the Mediterranean Region", cit.

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the Euro-Mediterranean area.

Another useful case study relates to Singapore. The development of SSLNG in the Southeast Asian country was mainly driven by the aspiration to become a SSLNG hub for Asia. That was instrumental to enhance Singapore's position as the pre-eminent gas trading hub for Asia. The main driver behind such ambition was to capture greater value from the growing Asia Pacific gas trade.

Conversely, SSLNG has been developed in the Euro-Mediterranean region more modestly compared to those other regions. Among Euro-Mediterranean countries, Spain was the first mover since the commissioning of the Barcelona LNG terminal in 1969. The Iberian country has evolved into a multi-modal delivery model for LNG for the Peninsula, developing and linking large-scale LNG terminals with SSLNG terminals.

The development of SSLNG in the EuroMed area has different prospects depending on each country. For example, Italy and Turkey are among the most promising given their large gas markets and their demonstrated interest in the technology. SSLNG investments in Italy had grown from 300 million euro in 2017 to 1.8 billion euro by mid-2019.[21] Eastern Mediterranean countries like Israel and Lebanon, along with Tunisia, could see a more moderate growth given delays in project development.

Historically, another major driver for fostering SSLNG has been inter-fuel economic competition. Favourable approaches and environment in favour of SSLNG are traceable in those countries that have higher priced gasoline. The highest interest in SSLNG is visible in countries with high gasoline prices (e.g., Spain, France, Italy, Greece and Turkey).

2. Regulatory opportunities for the development of SSLNG

The growth of SSLNG is driven and enabled by different factors: emergence of gas/LNG as a fuel of choice in transportation, emergence of new customer segments, technological advances and inter-fuel economics, and environmental and regulatory pressure. One of strongest drivers is, however, the rising international environmental policy framework. As stricter environmental legislation is being implemented at both the local and international levels to reduce maritime emissions, companies are considering the use of cleaner alternative bunker fuels to comply with the new regulations. These stricter regulations have emerged at all levels – multilateral, European and national as well.

[21] Ibid.

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2.1 Multilateral level

At the international level, the main player is the International Maritime Organisation (IMO). In 2018, the IMO's Marine Environment Protection Committee adopted an initial strategy for the reduction of GHG emission from ships, calling for shipping emissions to be reduced by at least 50 per cent by 2050 compared with 2008 while pursuing efforts to phase them out entirely. Furthermore, since January 2020 the IMO has enforced a new global limit of 0.5 per cent on the sulphur content of ships' fuel oil, encouraging the switch to LNG-fuelled vessels through the installation of new systems or conversion where possible, alongside the construction of related bunkering infrastructure.[22]

The creation of regional emission control areas (ECAs) has been a key contributor to the growth of SSLNG. Norway has set SOx and NOx caps leading to the creation of Sulphur ECAs (SECAs), which have been now universally accepted in the form of ECAs, with the Baltic Sea one being the first coming into existence. Until 2022, there was a cleavage within the European context, with Northern Europe putting in place an ECA while Southern Europe witnessed slower progress. Northwest Europe introduced an ECA in 2015, which was instrumental for the development of SSLNG in the area.

A key opportunity for further development of SSLNG in the Euro-Mediterranean area occurred in June 2022, when the IMO's Marine Environment Protection Committee approved a 0.1 per cent sulphur emission control area for ships in the Mediterranean, which could come into force as soon as 2025.[23] This development is particularly relevant for SSLNG growth in the Euro-Mediterranean as it is expected to encourage further investment in the sector. The decision to set an ECA in the Mediterranean is instrumental also to address and avoid the risk of the so-called "tankering" (a process similar to carbon leakage but for bunkering). Furthermore, in 2021 significant developments in the regulatory arena occurred with the IMO adopting carbon intensity requirements, outlined by the carbon intensity indicator (CII), energy efficiency existing ship index (EEXI) and ship energy efficiency management plan. The IMO's EEXI and CII, expected to come into force in January 2023, have put further pressure on shipowners to switch to LNG to comply with regulations and are encouraging the rapid increase in LNG-fuelled vessel orders across different vessel classes.

[22] IGU, *World LNG Report 2022*, cit.

[23] "Mediterranean ECA Approved at MEPC78", in *Ship & Bunker News*, 10 June 2022, https://shipandbunker.com/news/world/611246; UNEP/MAP, *IMO Body Grants Green Light to the Proposal on Curbing Emissions from Ships in the Mediterranean*, 14 June 2022, https://www.unep.org/unepmap/node/23042.

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2.2 European level

In 2021, important developments occurred also at the European level. The Commission proposed in July 2021 its ambitious "Fit for 55" package aiming at securing a decarbonisation pathway in the 2020s through the improvement of new and old climate targets.[24]

One of the key pieces of legislation for decarbonisation of the maritime sector is the FuelEU Maritime initiative. The initiative proposes a common EU regulatory framework to put the sector on track to decarbonisation by 2050 by increasing the share of renewable and low-carbon fuels in the fuel mix of international maritime transport, without creating barriers to the single market. The proposed regulation sets a goal-based GHG intensity target that increases in stringency over time, requiring ship operators to reduce the carbon footprint of the energy used onboard ships.

Alongside the FuelEU Maritime initiative, the Commission proposed the extension of the European Emissions Trading System (ETS) to the maritime sector in order to support increasing demand for renewable and low-carbon fuels.[25] The EC has also proposed a revision of the Alternative Fuels Infrastructure Directive and the Renewable Energy Directive (RED II) in order to deal with both fuel supply (RED III) and infrastructure (AFIR) to boost the uptake of renewable and low-carbon fuels. This holistic approach intends to stimulate both demand and supply, overcoming previous market failures.

It should be noted that the FuelEU Maritime initiative will be only the latest legislative effort in this field. The initial legislative enabler for SSLNG development was put in place with the adoption of the Directive for Alternative Fuels Infrastructures (2014/94/EU, AFID), which resulted from the adoption of the Clean Power for Transport Package. Its upgrade, AFIR, requires European ports to develop the infrastructure needed to enable alternative fuel use. To do this, significant investments are needed. For example, ports will need to expand electrification in order to provide onshore electricity supply (the so-called "cold-ironing"), which allows ships at berth to turn their main and auxiliary engines off. Importantly, AFIR calls on member states to install an appropriate number of LNG recharging stations at ports, and for heavy duty vehicles to align with the Trans-European Transport Network by 2025.

Since 2015, the LNG fuelling infrastructure for road transport has increased almost fourfold at the European level. Three Mediterranean countries stand out:

[24] Simone Tagliapietra, "Fit for 55 Marks Europe's Climate Moment of Truth", in *Bruegel Blog*, 14 July 2021, https://www.bruegel.org/node/6497.

[25] European Commission, *Proposal for a Regulation on the Use of Renewable and Low-Carbon Fuels in Maritime Transport*, cit.

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Spain with 49 new stations, Italy with 47 and France with 32.[26] Regarding LNG for water transport, in 2019 there were 85 large-scale operational LNG tanks installed in 35 ports in the EU, mainly in Spain (29 tanks in nine ports) and Italy (eight tanks in three ports).[27] Lastly, the European Commission included certain natural gas activities in its Complementary Climate Delegated Act, in the "transitional" category of activities. Although the Taxonomy Regulation does not directly address the issue of LNG as a marine fuel, it paves the way for its use in land-side industries during the transitional period. Moreover, the EC indicates that natural gas use will be accepted for economic activities where there is no technologically and economically feasible low-carbon alternative.

2.3 National level

Within the Mediterranean area, the EU AFID was adopted in Italy in 2016 while cold ironing is promoted in the Italian recovery and resilience plan (PNRR) with investment amounting to 700 million euro.[28] SSLNG could reduce emissions in the short to medium term by replacing the current use of high-polluting ship-board diesel generators. Moreover, there have been some encouraging developments in the country. Edison is working on several coastal depots in Ravenna, Napoli, Brindisi and Oristano.[29] It has also signed a non-exclusive agreement with Snam to identify and develop opportunities for collaboration along the SSLNG value chain, joining up the specific expertise of each company.[30] Such a collaborative approach among industrial players is needed to develop projects and foster SSLNG development.

3. Different barriers to SSLNG development

Despite its immediate contribution to emission reductions, a larger use of LNG in the Euro-Mediterranean context faces several barriers of an economic, environmental and regulatory nature in both the short/medium term and the long term.

[26] European Commission, *Evaluation of Directive 2014/94/EU of the European Parliament and of the Council on the Deployment of Alternative Fuels Infrastructure* (SWD/2021/637), 14 July 2021, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52021SC0637.

[27] Ibid.

[28] Italia Domani portal: *Electrification of the Platforms (Cold Ironing)*, https://italiadomani.gov.it/en/Interventi/investimenti/elettrificazione-delle-banchine-cold-ironing.html.

[29] Edison website: *Small-Scale LNG*, https://www.edison.it/en/lng-small-scale.

[30] Snam, *Snam and Edison Sign Agreement for the Joint Development of Small-Scale LNG Projects in Italy*, 25 July 2022, https://www.snam.it/en/Media/Press-releases/2022/Snam_Edison_Small_Scale_LNG_Italy.html.

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3.1 Economic barriers

The immediate future development of SSLNG in the Euro-Mediterranean region may be undermined by current high gas prices, which highlights the issues of volatility and tightness of the LNG market. One of the main drivers of SSLNG growth was the availability and abundance of cheap LNG supply. Since 2021, European gas prices have been surging due to a combination of market and geopolitical factors. In 2021, gas markets experienced a growth in demand,[31] which was however not followed by a similar upward trend on the supply-side. Since late 2021 and even more clearly in 2022, European gas markets have been suffering a geopolitical risk premium due to Russia's invasion of Ukraine and the consequent Russian weaponisation of gas exports as well as the European commitment to phase out Russian energy imports by 2027.[32]

High gas prices result in an immediate loss of competitiveness over other fuels. Moreover, the tight gas market means that LNG will be directed towards other crucial sectors, such as power and industry. Nonetheless, the high prices and tight market may be considered temporary as high prices could spur new exploration and production activities. Indeed, previous energy crises were followed by an energy glut. New capacity will come onstream over the coming years. However, rebalancing will also depend on demand dynamics and several other factors (e.g., Russian gas demise, nuclear restart in several countries like Japan and so on). New LNG projects have been developed, for example in Qatar, which will increase LNG capacity by 58 Mt by 2024-25.[33] The crucial aspect will be how fast new LNG supplies could come online due to the risk that a supply-constrained scenario, coupled with rationing measures, could erode future gas demand and the role of gas as a transitional fuel. Until now, most of the new liquefaction projects that received foreign direct investment were part of the previous "LNG wave".

3.2 Environmental barriers

The role of natural gas in the transitional period is increasingly challenged each day. International political concerns on methane emissions could undermine the role of gas as a "bridge fuel" for the transition, thereby limiting the deployment of SSLNG as an alternative maritime fuel.

Growing international scrutiny may undermine the role of gas also in the transport sector. The use of LNG as maritime fuel faces a challenge related to "methane slip",

[31] European Union Agency for the Cooperation of Energy Regulators (ACER), *High Energy Prices*, October 2021, https://acer.europa.eu/en/The_agency/Organisation/Documents/Energy%20Prices_Final.pdf.

[32] European Commission, *REPowerEU Plan* (COM/2022/230), 18 May 2022, https://eur-lex.europa.eu/legal-content/en/TXT/?uri=celex:52022DC0230.

[33] Pier Paolo Raimondi, "A Scramble for Gas: Qatari LNG and EU Diversification Plans", in *IAI Commentaries*, No. 22|18 (April 2022), https://www.iai.it/en/node/15144.

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which is the unburned fuel that is not fully combusted in the ship's engine. Methane slip results in negative environmental consequences.[34] However, the industry is investing in preventing methane slip, for example by either adding advanced technology (e.g., exhaust gas recirculation) or redesigning their engines to be more environmentally friendly. What is more, companies are investing to monitor and avoid methane emissions on the upstream and midstream segments. Stricter legislations on and public opposition to methane emissions may discourage investments into SSLNG, even though levels of methane slip vary with engine type and operating mode. In high-pressure dual-fuel engines, the combustion is nearly complete with nearly zero methane slip, whereas low-pressure engines where LNG is injected under low pressure result in an increase in GHG emissions of between 15 and 40 per cent compared with using low-sulphur fuels (i.e., marine gas oil, MGO).[35]

Despite an immediate contribution to emissions reduction, the concerns around LNG may discourage investment as a medium-term solution and prioritise political and financial support for technological development in other long-term solutions (clean ammonia and hydrogen). In 2021, the World Bank released a report addressing the role of LNG in the transition toward low- and zero-carbon shipping.[36] The report suggests that LNG may play only a limited role in the decarbonisation of the maritime sector even in the short term, explaining that there are doubts over the feasibility of cost-competitive and sustainable supplies of bioLNG and renewable synthetic LNG, among other concerns. In short, the World Bank's report affirms that LNG is incompatible with the IMO's 2050 climate target. Given the World Bank's role as major source of funding for developing nations, its warning could make it difficult for those countries to secure financing for infrastructure to provide LNG for ships. Nonetheless, a recent study shows the potential of bioLNG, which could meet up to 3 per cent of the total energy demand for shipping fuels in 2030 and up to 13 per cent in 2050.[37] Furthermore, by being blended with fossil LNG,[38] bioLNG could cover up to 16 per cent and 63 per cent of total energy demand in 2030 and 2050, respectively.[39]

3.3 Political and regulatory barriers undermine infrastructure

Another substantial barrier for the development of SSLNG is the political and regulatory dimension. Politically, along with the US and more than a hundred

[34] Transport & Environment, *Methane at Sea: Finding the Invisible Climate Killer*, 13 April 2022, https://www.transportenvironment.org/discover/methane-finding-the-invisible.

[35] EMSA and EEA, *The European Maritime Transport Environmental Report 2021*, cit.

[36] Dominik Englert et al., *The Role of LNG in the Transition toward Low- and Zero-Carbon Shipping*, Washington, World Bank, 2021, http://hdl.handle.net/10986/35437.

[37] SEA-LNG, *The Role of Bio-LNG in the Decarbonisation of Shipping*, October 2022, https://sea-lng.org/wp-content/uploads/2022/10/SEA-LNG_BioLNG-Study-Key-Findings-Document_October-2022_amended.pdf.

[38] Assuming a 20 per cent blending ratio.

[39] SEA-LNG, *The Role of Bio-LNG in the Decarbonisation of Shipping*, cit.

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other countries, the EU has launched the Global Methane Pledge, which seeks to cut global methane emissions by at least 30 per cent by 2030 from 2020 levels, so as to keep the target of limiting global warming to 1.5°C within reach.[40] This could represent a barrier to the further development of SSLNG industry. Given environmental concerns, policymakers – especially in the EU – are under pressure from public opinion about investments in fossil fuel infrastructure. The risks associated with stranded assets and carbon lock-in effects could represent a barrier to SSLNG development. Therefore, sometimes regulators and policymakers clearly favour one solution rather than promoting a technologically neutral approach. The political barriers entail infrastructural barriers. Long permitting procedure and social opposition to infrastructure may delay further investment decisions on infrastructure and their implementation, resulting in a loss of competitiveness and development.

This is particularly clear in Italy, where the SSLNG domestic market is dependent on imports by truck from France and Spain, even though Italy is a large LNG importer and has three LNG terminals. That is partially because its infrastructure is not perfectly fitted for SSLNG development. Two LNG import terminals are located offshore, which results in operational difficulties in reloading small LNG carriers for re-export and for bunkering as well as the impossibility of supplying inland consumers by truck. Significant constraints in the local road system around the onshore terminal (Panigaglia) hamper LNG deliveries by truck.[41] Italy has been working on expanding its infrastructure. In 2021, it commissioned the country's first SSLNG integrated logistics supply chain through its coastal depot in Ravenna as well as a dedicated gas transport vessel. The coastal depot will have a storage capacity of 20,000 cubic meters of LNG and an annual handling capacity of over 1 million cubic meters of liquid gas sufficient to supply 12,000 trucks and up to 48 ferries per year.

4. Policy recommendations

Over the past year, countries have reaffirmed their commitment towards decarbonisation despite the economic, energy and political challenges. Countries need to sustain and support solutions in both the short/medium and longer term, and in each sector. SSLNG can provide several benefits in the short and medium term for the environment and economy of the Euro-Mediterranean. However, countries need to evaluate implementing measures to overcome the challenges addressed in the previous section and promote decarbonisation in the maritime industry.

[40] European Commission, *Launch by United States, the European Union, and Partners of the Global Methane Pledge to Keep 1.5C within Reach*, 2 November 2021, https://ec.europa.eu/commission/presscorner/detail/en/statement_21_5766.

[41] OME, "Small Scale LNG Business Options in the Mediterranean Region", cit.

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Overcoming economic barriers using fiscal policy – In the short term, policymakers should use fiscal policies to boost the development of SSLNG. Inter-fuel economic competition has been one of the main enablers for SSLNG growth. Yet, the general low tax rates on diesel, LNG's main competitor, have limited competition among fuels. Fiscal barriers are more visible in Southern Mediterranean countries as these are characterised by high fossil fuel subsidies which undermine interest in SSLNG in the transport sector. Given high gasoline prices, Northern Mediterranean countries are more eager to develop SSLNG infrastructures. Therefore, governments could implement both direct and indirect incentives to foster the use of gas for the immediate decarbonisation of the transport sector. Indirectly, governments could tax more polluting fuels like diesel and heavy fuel oils in order to encourage the use of less emissive fuels like natural gas. For example, Norway exempted LNG from a carbon tax in order to incentivise operators to switch from diesel to LNG.[42] The Norwegian case shows how incentives can support the initial investment in capital expenditure, thereby improving the economics of the LNG business case.[43] Moreover, governments could establish a series of incentives to switch from more polluting solutions to gas. For example, Italy has announced incentives to support conversion to LNG-powered heavy trucks.[44]

Overcoming environmental barriers through a stable regulatory framework – Policymakers should overcome and address legitimate environmental concerns over the use of gas by setting a stable and solid regulatory framework aimed at reducing and limiting fugitive emissions. While the deployment of LNG can yield immediate emission reductions in the sector, governments should not neglect the environmental downside of SSLNG. Therefore, countries should cooperate on the regulatory side to reduce methane emissions and slip from LNG. The EU should continue in its work on FuelEU Maritime and put in place a common methodology for calculating emissions from different maritime fuels, and proposing a well-to-wake approach. What will be key is to define truly representative default emission values used for calculating the carbon intensity of such fuels – with the possibility to deviate from these when it is possible to prove a better performance of such fuel via certification or direct emissions measurement, also by allowing the updating of such default values based on the most recent technological advancements. Countries on both shores of the Mediterranean should cooperate to develop regulations and measures to correctly account for methane emissions, something that could encourage operators to address the issue through technological developments and infrastructure adjustments. Lastly, Mediterranean countries should learn best practices undertaken in other regions such as Northern European

[42] Irene Øvstebø Tvedten and Susanne Bauer, "Retrofitting Towards a Greener Marine Shipping Future: Reassembling Ship Fuels and Liquefied Natural Gas in Norway", in *Energy Research & Social Science*, Vol. 86 (April 2022), Article 102423, https://doi.org/10.1016/j.erss.2021.102423.

[43] Giorgio Biscardini, Rafael Schmill and Adrian Del Maestro , *Small Going Big… and Greener. LNG: The Green Future for Bunkering*, Strategy& PwC, 2020, https://www.strategyand.pwc.com/it/en/industries/oil-gas/small-going-big-greener.html.

[44] Federmetano, *Incentivi biennio 2021-2026 per l'acquisto di mezzi pesanti a metano CNG e LNG*, 31 January 2022, https://www.federmetano.it/?p=34284.

countries. In doing so, they could promote the use of SSLNG in the Mediterranean Sea and advocate for a harmonisation of rules within the EU. This could prevent loss of competitiveness and lead to decarbonisation.

Overcoming infrastructural barriers through infrastructure compatible with low-carbon fuels – The infrastructural aspect is particularly relevant for energy evolution. Today's energy crisis highlights the need to properly invest in infrastructure. The current crisis is exacerbated by past decisions not to invest in the necessary infrastructure (such as regasification plants) – especially in some countries. Therefore, governments should draw important lessons from current developments, while at the same time avoiding the risk of carbon lock-in effects by reconciling energy security and climate targets. The urgency to decarbonise the maritime sector as fast as possible should not come at the detriment of climate targets. Countries should invest in infrastructural projects which are compatible and ready today to receive and handle low-carbon fuels, such as bioLNG and synthetic fuels – and in the long run, when available, green hydrogen or ammonia – in order to prepare tomorrow's infrastructure and optimise investments. Today's crisis shows also that when urgency is felt by governments, countries can overcome regulatory and permitting obstacles.

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Via dei Montecatini, 17 - I-00186 Rome, Italy
T +39 06 6976831
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