Master Plan of Energy Networks for the Adriatic-Ionian Region

Study 3 –

LNG INFRASTRUCTURE, LOGISTICS AND DIRECT USE OF LNG FOR MARINE AND ROAD TRANSPORT

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Summary

1 Flagship project – overall goal and expected impact

The third flagship project relates to the **development and operation of logistics for direct LNG use as a clean fuel for the Adriatic-Ionian region.**

Direct use of LNG as a fuel for transport will allow diversification and reduction of greenhouse gas emissions as compared with the oil-derived hydrocarbon fuels. Direct use can be proposed for both maritime and land transport. Small-scale LNG deployment is considered a viable option by the European Commission and several Member States. Development of LNG infrastructure would contribute to LNG use in the maritime transport to comply with the strict emission limits proposed by the European Union and International Maritime Organisation. On the other hand, LNG use for heavy road transport is being promoted along special corridors through the European Union and could be extended to the Balkan Region.

The development of small-scale direct LNG use is contributing to a more secure, competitive and sustainable energy system through the Adriatic-Ionian Region. The deployment of small-scale LNG in the transport and other sectors will cope with two challenges consisting of cleaner environment and climate change with a view at the EU Policy Objectives no. 2 and no. 3. The need for a shared logistic infrastructure and harmonised regulatory standards should be addressed according an integrated approach. Closer cooperation between EUSAIR Member Governments, LNG suppliers and user association at macro-regional level would boost competitiveness and investment.

This study is an integral part of the Master Plan.

2 Description of infrastructural and logistical requirements necessary for LNG for transport

This section describes very schematically, essential plants and technologies in LNG supply chain, used in the transport sector. That is: the LNG terminal, the LNG service station and the LNG technologies used on heavy vehicles.

2.1 LNG Terminal

LNG terminal is a facility for regasifying LNG imported by LNG carrier.

The gas carrier is moored near the terminal and connected to a large gas tank by cryogenic tube[1].

[1] Tube and tank are able to work at very low temperatures: -160°, to maintain gas in liquid form.

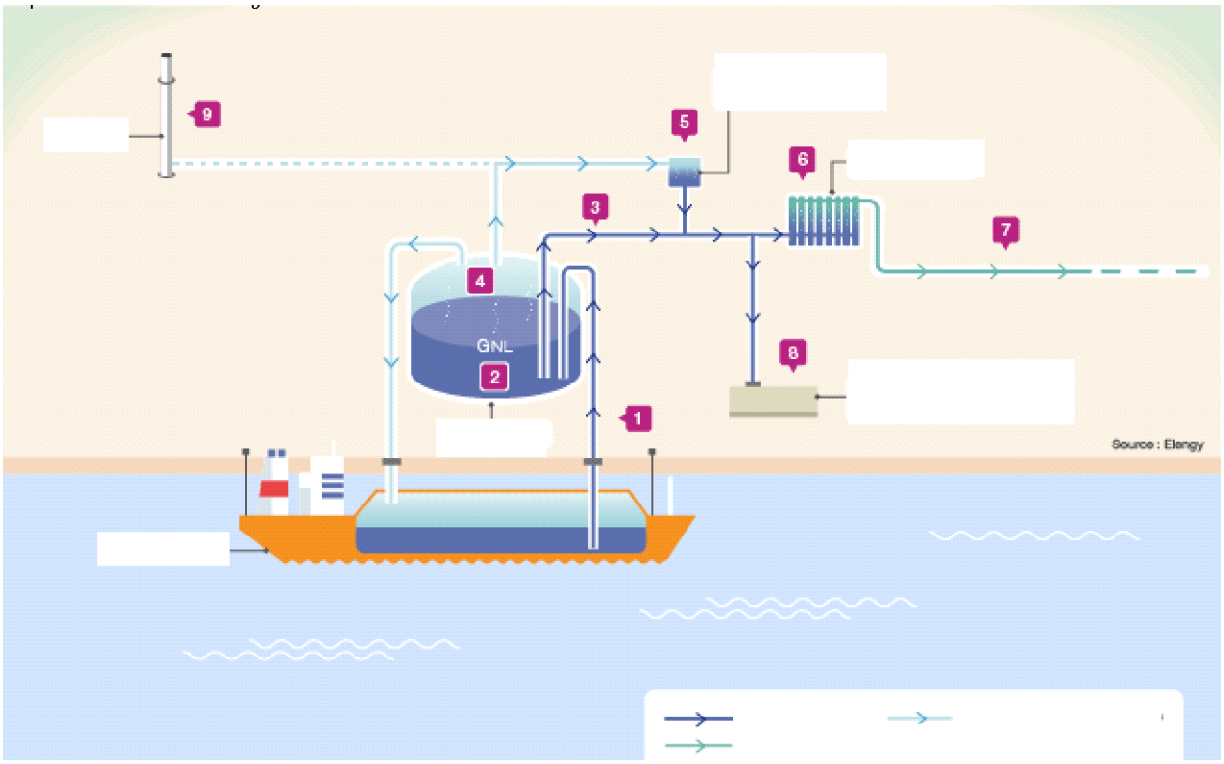


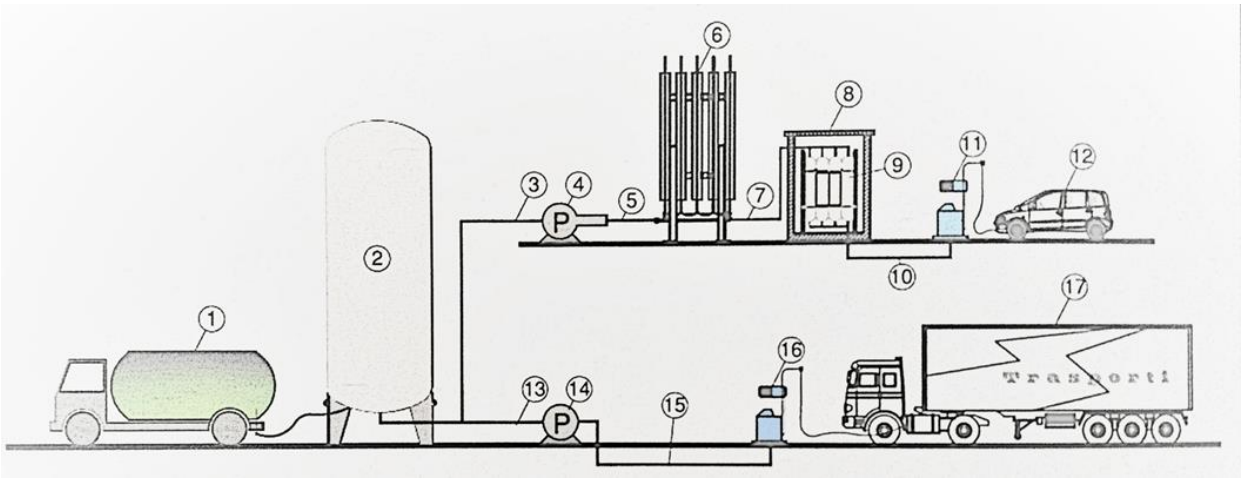
Figure 1 – LNG terminal example

Source: Elengy – What Is LNG

Liquid natural gas contained in tank can be: 1. loaded into another LNG carrier; 2. conducted to a regasifier for injection into gas network, at gaseous state; 3 driven to a service station to load LNG tank trucks that bring LNG to gas service stations or other industrial or civil destinations.

2.2 Service station and dispensing system

Among infrastructural requirements necessary to allow supply of LNG in the transport sector, in particular for heavy vehicles such as trucks and buses, the service station, obviously, plays a central role.



1 LNG tanker; 2 LNG storage tank; 3 LNG power supply line of the pump; 4 High pressure cryogenic pump; 5 LNG supply line of the vaporizer; 6 LNG vaporizer; 7 CNG line; 8 1st grade safety protection; 9 Cylinder pack; 10 CNG line; CNG dispenser; 11 CNG powered vehicle; 13 LNG supply line; 14 Cryogenic pump; 15 LNG supply line; 16 LNG dispenser; 17 Vehicle powered by LNG.

Figure 2 – LNG service station

Source: Certifico - GNL Autotrazione Quadro Normativo

A typical scheme of a service station with LNG tank and dispenser, is the one in the figure, where elements and essential dynamics of station are reported.

The service station is powered by tankers, generally of 40,000 liters, which serve the LNG storage tank, whose standard capacity is 60 m^3, although it is also possible to install 100 m^3 tanks, which reduce the risk of unsold items. Where possible it is preferable to mount the tank vertically, as the supply of the lines downstream of the tank can thus exploit the weight of the gas above (the so-called head) at the outlet nozzle. Weight which, in case of horizontal assembly (due to landscape or other needs) cannot be of advantage to the system.

From the LNG tank, the cryogenic line feeds the cryogenic pump, which in turn can be connected directly to the LNG methane distributor, or to an LNG vaporizer to be transformed into CNG; in the latter case, a CNG pipe feeds a group of CNG cylinders which, in turn, is connected to the final CNG methane distributor.

The standard service station considered here operates, like most of the existing ones equipped with LNG tank, in parallel with both LNG-CNG lines, in order to exploit the market of short-haul economic vehicles (equipped with of CNG system) and cars.

2.3 LNG Plants for Heavy Vehicles

In medium and heavy transport sector, natural gas is gradually establishing itself as the only practical alternative to diesel fuel. This is due to a lower environmental impact with same service provided and a significant economic convenience of operation.

In fact, use of methane in heavy vehicles, instead of gasoil[2]:

- improves air quality, almost completely eliminating atmospheric pollutants (-70% NOx, -99% PM, -90% NMHC compared to the Euro 6 thresholds)
- mitigates global warming, significantly reducing CO2 emissions (about -15% compared to a diesel equivalent, up to -95% with biomethane)
- can drastically reduce noise pollution during transit in urban centers and night deliveries.

Hence political and institutional support that methane alternative has received from beginning and which will continue in the future. Tax support is needed to convince users to buy methane trucks or convert existing ones to methane.

Industry has made vehicles equipped with a methane Otto cycle engine much more similar to corresponding Diesel cycle vehicles. Currently the market for heavy LNG vehicles has 13-liter tractors up to 460 HP and 2 k Nm of torque, which are still a long way from top of Diesel range (16 liters of 750 HP and 3.5 k Nm of torque), have similar performance with their references to diesel fuel of the same displacement.

Currently, economically comparable models are not yet available with 3.5 thousand Nm torque diesels, which have the same performance. For now, the latter are difficult to reach, at competitive prices, with Otto cycle engine.

Cost of LNG vehicles currently on list is approximately € 30 k - € 40 k higher than diesel vehicles and duration is about half. Gap must be covered by general taxation, through incentive policies. Policies that have proved to be essential to diffusion of these means, for example in Italy. Then for diffusion of methane vehicles, a significant tax advantage on fuel is required, compared to diesel, in every country of the European Union.

Heavy vehicles can be powered by methane through two solutions:

- MONO-FUEL: vehicle, equipped with an Otto Cycle engine, is powered exclusively by natural gas, stored on vehicle in form of Liquid Natural Gas (LNG) in a cryogenic tank, or Compressed Natural Gas (CNG) in a conventional tank or both tanks.
- BI-FUEL: vehicle, originally diesel only and equipped with Diesel Cycle engine, is equipped, generally in after-market, by Natural Gas Fueling System, with cryogenic tank (LNG), or conventional tank (CNG) or both. Engine is powered by a mixture of natural gas and diesel fuel, in a variable proportion of diesel from 10% (flat, extra-urban routes) to 100% (need for maximum power) depending on what is decided by electronic control system, based on operating conditions of engine. On average, replacement rate of diesel with methane is 45%-55% in energy terms. Power available up to 750 hp (depends on diesel model purchased).

[2] Iveco, https://www.iveco.com/switzerland-it/prodotti/pages/nuovo-stralis-np-camion-metano.aspx

MONO-FUEL CNG-LNG Otto Cycle thruster by means of gas (controlled ignition)

In CNG cylinders, at a pressure of 220 bar, methane can be housed on the right, left side, behind the cab and above the frame edge, for a capacity of 450 liters-1,320 liters in steel cylinders. The range is 300 km-600 km. The vehicle can remain stationary for long periods of time, without fuel loss.

Figure 3 – CNG cylinders

Source: Iveco

LNG cryogenic tank, at a temperature of -162 ° ÷ -142 ° C and 8 bar pressure, methane is stored in liquid form (LNG), maybe in 560 liters, for an autonomy of 750 km. Volumetric advantage: 1 lt_{GNL} is equivalent to 3 lt_{GNC}, with same mileage. Vehicle cannot remain stationary for long: increase in temperature of sealed tank causes gas evaporation from safety valves.

Otto Cycle engine can be powered by both tanks; delivery is regulated and optimized electronically. Upstream of the fuel metering, the fuel injection device is different from one and the other storage system.

Figure 4 – LNG cryogenic tanks

Source: Iveco

BI-FUEL Gasoil-Methane (CNG-NGL Diesel Cycle thruster by gasoil/methane blended

In Bi-Fuel systems vehicle, equipped with a diesel engine, is equipped with an additional fuel system (LNG or CNG). The gas is injected into cylinders together with diesel, in a proportion decided by an advanced control unit (which also governs all the equipment necessary for transformation), according to the operating conditions of vehicle. When the engine is not under stress, methane will cover the main part of the overall fuel consumption, up to 80% -90% of the total, while under stress it will be diesel fuel that also covers 100% of overall consumption. A minimum amount of diesel is always required due to the diesel engine technology.

Figure 5 - BI-FUEL LNG / DIESEL, Diesel cycle engine by means of gas and diesel (compression ignition)

Source: Ecomotive Solutions

Diesel fuel boasts highest average mileage per liter of fuel consumed with 3.1 km. LNG follows with 1.4 km/lt and CNG with 0.6 km/lt. However, the advantage of diesel fuel is much lower in terms of mass, given lower density of other fuels. In fact, you travel 3.7 km with one kg of diesel fuel, against approximately 3.3 km for LNG and CNG.

3 Proposed actions and projects

There are several projects regarding infrastructure development for LNG in the EUSAIR countries:

3.1 Harbour LNG infrastructure

The adoption of the "Initial International Maritime Organization (IMO) Strategy on Reduction of Greenhouse Gas (GHG) Emissions from Ships" by IMO Resolution MEPC.304(72) in April 2018 demonstrates IMO's commitment to support the Paris Agreement. The IMO strategy includes initial targets to reduce (as compared to 2008 levels) the average carbon dioxide (CO2) emissions per "transport work" by at least 40% by 2030, aiming to pursue 70% reduction by 2050; and an ambition to reduce the total annual GHG emissions from shipping by at least 50% by 2050. Technical approaches, operational approaches and alternative fuels may be used to achieve these goals.

LNG is seen as an alternative to fuel oil consumption in shipping with less environmental impact - not only does LNG emit less carbon compared to coal and oil, but it also emits next to zero sulfur oxide (SOx).

The IMO regulations of January 1st 2020 (IMO 2020) target ship emissions on a global scale, specifically limiting sulfur (sulfur oxide, SOx) content in marine fuels to a 0.5% cap, from a previous 3.5 %. Reducing sulfur content in ship fuels enables improved emission control and is an important step towards reduced pollution and a green global fleet. Naturally, the IMO 2020 impacts not only the shipping industry, but also the global economy and complementary industries like fuel suppliers and shipyards.

LNG-powered ships, LNG bunkering hubs and facilities are emerging on a global basis. Innovative infrastructure and LNG-compliant solutions are being sought to help boost this industry.

3.1.a Bunkering

The infrastructure necessary for refuelling LNG-powered vessels is currently limited, but expanding as new LNG bunkering projects are underway across Europe. One of these projects is Poseidon Med and Poseidon Med II.

Poseidon Med is the first LNG bunkering project in the Mediterranean and Adriatic Sea crossing European borders aiming at introducing LNG as the main fuel for the world shipping industry and develop a sufficient infrastructure network of bunkering. The project aims to design a comprehensive value chain for the use of LNG as marine fuel in East Mediterranean and Adriatic Sea, including the development of an LNG transportation, distribution, and supply network, as well as the establishment of a well-functioning and sustainable related market for its demand.

Project Leader is Qatar Energy Europe, with the support of other partners from Cyprus, Greece, Italy, Slovenia and Croatia. The Port Authority of La Spezia, Venice and Trieste, Contship Italia and the Grimaldi Group are the Italian partner for Poseidon Med. Project was completed in 2016.

Poseidon Med II LNG Bunkering Project Formally commenced in February 2016 as a continuation of the previous Poseidon Med and Archipelago LNG projects. This European cross-border project, co-financed by the European Union through the Connecting Europe Facility, aims to take all necessary steps towards adoption of LNG as marine fuel in the east Mediterranean and Adriatic Seas, with the aim of making Greece an international marine bunkering and distribution hub for LNG in South Eastern Europe. It encompasses three EU member states (Greece, Cyprus and Italy) and its task is to prepare a detailed infrastructure development plan promoting the adoption of LNG as marine fuel for shipping operations. The project is coordinated by the Public Gas Corporation of Greece (DEPA) and comprises 26 partners including DEFSA (the Greek gas system operator), Lloyd's Register, Ocean Finance, all major short sea shipping companies operating in Aegean, Ionian and Adriatic seas, as well as several of the main seaports in the region such as the Port of Piraeus, the Port of Venice and the Port of Limassol. The project was completed in 2021. Based on the results of the project, both the projects in Revithoussa for the construction of a new jetty for the loading of LNG on small-capacity vessels and the institutional framework for the use of LNG as a fuel in shipping as well as for the supply of LNG to off-grid ports, consumers and cities are progressing. Regarding the infrastructure in the reference ports in Greece: Patras, Igoumenitsa, Heraklion, the environmental permitting procedures are progressing and the respective Port Authorities are exploring the possibility regarding the required investments.

BlueHUBS: LNG and CNG Supply chains upgrading Core TEN-T Ports in Eastern Mediterranean. The Action is Motorways of the Sea wider benefit project, contributing to environmental gains in maritime transport. It aims at establishing the fundamental supply chains for the distribution of Natural Gas to port users in the forms of LNG for vessels and LNG/CNG for port heavy duty vehicles and buses.

The Action upgrades important parts of the Orient/East-Med Corridor by providing LNG and CNG bunkering and refueling facilities in the Core TEN-T Port of Limassol (in Cyprus) and the Core TEN-T ports of Piraeus and Heraklion (in Greece) and by setting a new intermodal sea-based system, integrated in the logistic chain.

Consistent with the overall EU strategy for a more resource-efficient Europe, the Action utilizes alternative energy sources in a way that the environmental impact is minimized.

It focuses on:

1. The construction of two LNG Bunkering vessels (indicative capacity 3.000 m3 each) serving the purposes of bunkering LNG fueled vessels at the Ports of Piraeus, Heraklion and Limassol and the small-scale mobile LCNG stations to service the ports of Heraklion and Limassol:
    - One registered in Core TEN-T Port of Piraeus
    - One registered in Core Ten-t Port of Limassol
2. The development, procurement and commissioning of:
    - One mobile LCNG Station (indicative capacity 200m3) to service the Core TEN-T Port of Heraklion

- Two Mobile LCNG Stations (indicative capacity 60m3 each) to service the Core TEN-T Port of Limassol (Terminal 1 and Terminal 2) for bunkering LNG fueled vessels and refueling the LNG/CNG for port heavy duty vehicles and buses

3. The procurement of small fleet of eight LNG Tanker Trucks (indicative capacity 50m3 each) with bunkering equipment:
    - Five based in the Core TEN-T Port of Heraklion and
    - Three based in the Core TEN-T Port of Limassol

Project is planned to be completed by end 2024.

SuperGreen Action, co-financed by the EU, aims to bring forward a holistic approach towards the electrification and utilization of alternative fuels of shipping in Greece, by implementing innovative technological systems, based on a market-oriented approach.

The SuperGreen Action involves:

- One catamaran vessel that will connect the Core TEN-T Port of Piraeus to other ports of the Comprehensive TEN-T network
- Purchase and delivery of two LNG semi-trailers for the refueling of the Hybrid Catamaran Vessel (DEPA)
- Member States Involved: Greece, Cyprus
- Implementation schedule: January 2019 to July 2023

3.1.b Large and small scale LNG

The development of Small Scale LNG (ssLNG) is supported by a positive institutional strategic context both globally and nationally. To achieve the long-term goal to reduce emissions set by COP 21 in Paris, G20 countries confirmed the role of natural gas as a source for energy transition.

New projects of small-scale LNG terminals and small-scale liquefaction plants are developing in more and more countries. Related services are now or will soon be available in nearly all large-scale terminals.

The following table shows the large-scale LNG terminals in the Adriatic-Ionian Region.

State	Italy	Croatia	Greece	Greece (Under construction)	Italy (Planned)
Large LNG Plant	**Porto Levante**	**Krk Island**	**Revithoussa**	**Alexandropolis**	**Ravenna**
Internet Site	www.adriaticlng.com	www.lng.hr	www.desfa.gr	www.gastrade.gr	www.snam.it
Start-up	2009	2021	1999	2023	2024
Type	Offshore GBS (Gravity Based Structure)	FSRU	Onshore Facility	FSRU	FSRU
Maximum Hourly Capacity $m^3(N)/h$ Current	1.180.000	300.000	820.000	944.000	
Maximum Hourly Capacity $m^3(N)/h$ In future (+)	70.000 (2024)	300.000 (2029)	-	-	
Nominal Annual Capacity bln $m^3(N)/y$ Current	8,58	2,60	7,00	5,50	
Nominal Annual Capacity bln $m^3(N)/y$ In future (+)	0,5 (2024)	2,6 (2029)	-	-	5,00
LNG Storage Capacity m^3 Current	250.000	140.000	225.000	153.500	
LNG Storage Capacity m^3 In future (+)	-	300.000 (2029)	-	-	170.000 (2024)
Number of Tanks Current	2	4	3	4	
Number of Tanks In future (+)	-	2 (2029)	-	-	
Max Ship class size receivable m^3	217.000	265.000	260.000	170.000	

Number of Jetties Current	1	1	1	-	
Number of Jetties In future (+)	-	1 (2029)	-	-	1 (2024)
Minimum Sea Depth Alongside m	27,0	16,0	13,5	-	
Maximum sent out pressue Bar	70	100	64	100	
TPA Regime	Hybrid	Regulated	Regulated	Exempted	Regulated

Table 1 - Large scale LNG plant in Adriatic Ionian Area

Source: GIE Gas Infrastructure Europe, 2022

Italy

The Adriatic LNG terminal is Italy's most significant LNG terminal by import capacity. With a regasification capacity of 9 billion cubic meters/year of natural gas (equal to more than half of the national LNG regasification capacity) the Adriatic LNG terminal ensures approximately 12% of national natural gas consumption The two modular LNG storage tanks have a capacity of 125,000 cubic metres each. 80% of the regasification capacity at the Adriatic LNG terminal (6.4 bcm) is reserved for the import of Qatari gas in accordance with a long-term supply contract. The terminal is owned by Adriatic LNG, in which ExxonMobil Italiana Gas has a 71% share, Qatar Terminal Company Limited has a 22% share, and Snam Group has a 7% share. The regasifier is connected to the national gas pipeline network through a pipeline that connects it to the station station in Cavarzere (Venice): from here the gas can be withdrawn by the user - and eventually sold on the market or consumed at its point of consumption - without further infrastructure investment.

Another LNG regasification terminal is under construction in front of **Ravenna, a FSRU** that was decided to be completed immediately after the beginning of the gas crisis triggered by the Russian war in Ukraine of February 2022. The facility will have a capacity of 5 bcm per year and will provide additional capacity and supply for LNG for transport in the North of Italy.

Croatia

Krk FSRU is an operating **floating LNG terminal** in Omisalj on the island of Krk in northern part of Croatia. It started operations on 1 January 2021 with full capacity of 2.9 bcm/y booked for the next three years. The FSRU vessel is equipped with four LNG storage tanks with a total capacity of 140,206 cubic meters.

A Phase 2 expansion of the existing floating LNG terminal on Krk Island from 2.9 to 6.1 bcm of gas per year, project is proposed.

The expansion of the capacity of the LNG terminal in Krk will be accomplished by installing an additional regasification unit with a capacity of 250,000 m3/h on the existing FSRU. As a result, the new maximum regasification capacity will be 700,000 m3/h, which equals 6.1 bcm/y.

The Project implementation will enhance the diversification of the natural gas supply, increase the security of the gas supply, improve the region's competitiveness, and provide for more effective integration of key infrastructure projects into the European gas market.

The necessary precondition for utilization of the expanded capacity of the LNG Terminal in Krk is the further development of the gas pipeline. In order to achieve this goal, Croatian Government directed the Croatian Transmission System Operator, Plinacro Ltd, to commence the construction-related tasks for the Zlobin - Bosiljevo pipeline.

The plan is for the works to be completed till Q3 2025 to be able to offer additional capacity for the gas year 2025.-2026.

The additional capacity that can be offered to the market is limited with the gas pipeline development and for the first phase the expected additional capacity will be about 0.6 bcm/y.

The capacity of the expanded terminal will go beyond the needs of Croatia's industry and households allowing Croatia to play a more regional role and many countries in the neighbourhood such as Slovenia, Hungary or Bosnia and Herzegovina to benefit from diversified supplies.

Greece

The Revithoussa LNG Terminal is located on the island of Revithoussa, in the gulf of Pachi at Megara, 45 km west of Athens and is the only one operational regasification and storage terminal in Greece that receives LNG cargoes, temporarily stores and regasifies LNG and supplies the National Natural Gas Transmission System. It has played an important role in the country's strategy to diversify from Russian gas and secure the security of supplies.

It can store 225,000 cubic metres of gas and regasify 1,400 m3/h. It was completed in 1999 and is operated by DESFA SA. In 2022, DESFA started the upgrading of the terminal by adding a floating storage unit to the existing facilities in order to increase storage capacity to 380,000 cubic meters.

In Greece, the long-planned 153,500 cubic meters **Alexandroupolis FSRU** is expected to start up by end-2023 in the northeast, approximately 17.6 km south-west of Alexandroupolis in the Aegean Sea. The project is being developed by Gastrade. Alexandroupolis will include a floating storage and regasification unit (FSRU) with the ability to transport, store and convert LNG into natural gas. It will also be equipped with a subsea and onshore gas transmission system. The floating terminal will have an incoming LNG transfer rate of 10,000 m3/h, a storage capacity of 170,000 cubic meters and a maximum regasification capacity of 700,000 nm3/h. Regasified LNG will be transported onshore via a gas transmission system consisting of a subsea pipeline and an onshore pipeline. The onshore pipeline will be laid on the coastline of the Apalos area, connecting to the Kipi-Komotini branch of the Greek National Natural Gas System (NNGS) near the Amphitriti village. A new entry station will be built by natural gas operator DESFA near the existing NNGS Alexandroupolis exit station, which is currently being operated by the company.

The new infrastructure is tied to other interconnection projects, such as the Gas Interconnector Greece-Bulgaria (IGB), but also the important gas links between Bulgaria, North Macedonia and Serbia. Through these recent and new projects, these countries will be able to reduce their dependence on Russian natural gas by diversifying their routes and sources of supply.

Infrastructures for **small scale LNG** are continuing to develop for road transport, for ships bunkering and for supplying industrial sites not connected to the gas grid.

Country	Location	Storage m^3 LNG	Truck Loading	Ship Reloading	Ship Fuelling
Italy	Augusta (Sicily)		✓	✓	✓

Italy	Brindisi	19550	✓	✓	✓
Italy	Gela (Sicily)		✓	✓	✓
Italy	Porto Marghera (Venice)	32000	✓	✓	✓
Italy	Ravenna	20000	✓	✓	✓

Table 2 - Small scale LNG terminals in Adriatic Ionian Area

Source: GIE Gas Infrastructure Europe, 2020

In November 2018, Edison launched the first small-scale LNG integrated logistic chain in Italy (small-scale liquefied natural gas plants) with a sustainable mobility development plan in the transportation sector, both for heavy-duty and maritime transport, contributing to the achievement of the European targets for the CO2 reduction and to lower other emissions and particulates. Edison has announced the establishment, together with PIR (Petrolifera Italo Rumena), of Depositi Italiani GNL, the new company (51% PIR, 49% Edison) that will construct the **deposit at the port of Ravenna** for an investment of 100 million euros.

The deposit, which started operations in 2021, has a storage capacity of 20,000 cubic metres of LNG and handles more than 1 billion cubic metres of liquefied gas a year, making LNG available in Italy to fuel at least 12,000 trucks and up to 48 ferries a year.

A project to build a small-scale 32,000 cubic metre LNG storage, supply and distribution terminal in the industrial area of **Porto Marghera in Italy** received government approval in January 2021.

The planned facility will be located at Decal's current oil storage facility in Porto Marghera, which is a part of the Port of Venice. Moreover, the new facility would provide LNG for road transport and shipping as a cleaner alternative to fuel oil and marine diesel. The Venice LNG storage terminal would receive the fuel from small-scale vessels but also medium-sized carriers for onward distribution via trucks, ISO tanks and barges. Works are planned to be completed by the end of 2024

3.1.c Other projects and initiatives

A European project dedicated to increase the level of safety, environmental quality and sustainability of LNG maritime transportation in the Adriatic-Ionian Region is called **Super-LNG (SUstainable PERformance of LNG-Based maritime mobility).** It aims at providing a uniform framework to support the implementation of technical systems for the distribution and supply of LNG in port areas, meeting the requirements of the Seveso Directive (Directive 2012/18/EU). The project is being run by the System Reliability and Industrial Safety Laboratory (SRISL) of Institute of Nuclear & Radiological Sciences and Technology, Energy & Safety (INRASTES) at NCSR "Demokritos". The consortium consists of seven regular partners and six associated partners covering all countries of the eligible area of the INTERREG ADRION programme.

SUPER-LNG project is developing targeted guidelines for the safety assessment of LNG supply systems, supported by a network of external LNG experts operating within the project, and has created a permanent educational system for port operators, maritime educational instructors, public authorities, and other stakeholders.

3.2 Road transport and LNG use in industry

Small scale LNG in road transportation refers to the industry in which the LNG is used directly in liquid form, which is further converted to gas that is used in the vehicles. It is used in various types of vehicles such as heavy and light commercial vehicles and is available in two types: liquefaction and regasification terminal.

The rising demands for electricity due to rising infrastructure and by various end user industries, the rising activities for cooking and heating have also boosted the demands of LNG production over the recent years globally. The expansion of end use industries along with the increase in urbanization and population will further boost the growth rate of LNG market.

Projects:

LNG NET MED The project will connect public and private operators matching demand needs and innovative products and projects, expoliting the new opportunities offered by the deployment of LNG as sustainable alternative fuel for intermodal transport.

AWATRAIN Inland waterways-maritime transport plan for the Northern Adriatic sea, concerning state-of-the-art infrastructures including LNG stations for refueling. The project consists of: mapping all ports, access points, multi-modal infrastructures; cost/benefit analysis; investment plan

DNA Link Development of the Adriatic connectivity and sustainable upgrading of a new multimodal corridor in Mediterranean, from Spain to the East crossing Italy and Balkan Peninsula. Specifically, the project will test a SSS connection between Abruzzo and Ploce, by establishing of a new maritime green link, thanks the development of a prototype of small-scale facility for a green fuel, (bioLNG).

MIMOSA The project aims to promote new cross-border approaches for passenger mobility, based on sustainable multimodality. The project made significant progresses, including the analysis of the passenger transport demand in the cross-border area, passenger behaviours on mobility choices, carbon footprint of passenger choices; this led to the development of a feasibility study of a cross-border sea link with a LNG powered ship (Abruzzo-Croatia)

3.3 The potential of landlocked countries to use LNG infrastructure

As for the potential for larger-scale usage of LNG in landlocked countries of the Adriatic-Ionian Region (Serbia and North Macedonia), the possibilities in this regard seem limited at the moment for North Macedonia, while with the completion of the Bulgaria-Serbia interconnection in Q4 2023, opportunities for LNG usage in Serbia increase significantly. The main reason for current limits and constraints to LNG usage lies in the preconditions that have to be met, i.e. in gas transportation infrastructure.

Currently, **North Macedonia** is connected to the gas transportation infrastructure through the Kjustendil (Bulgaria) – Židilovo gas interconnector, in the North-East of the country. From there, a pipeline runs via Klečovce and Kumanovo towards Skopje. Branches have also been built from Klečovce, running south towards the valve station BS 5, near Štip, and further south from BS 5 to Negotino, Figure 6.

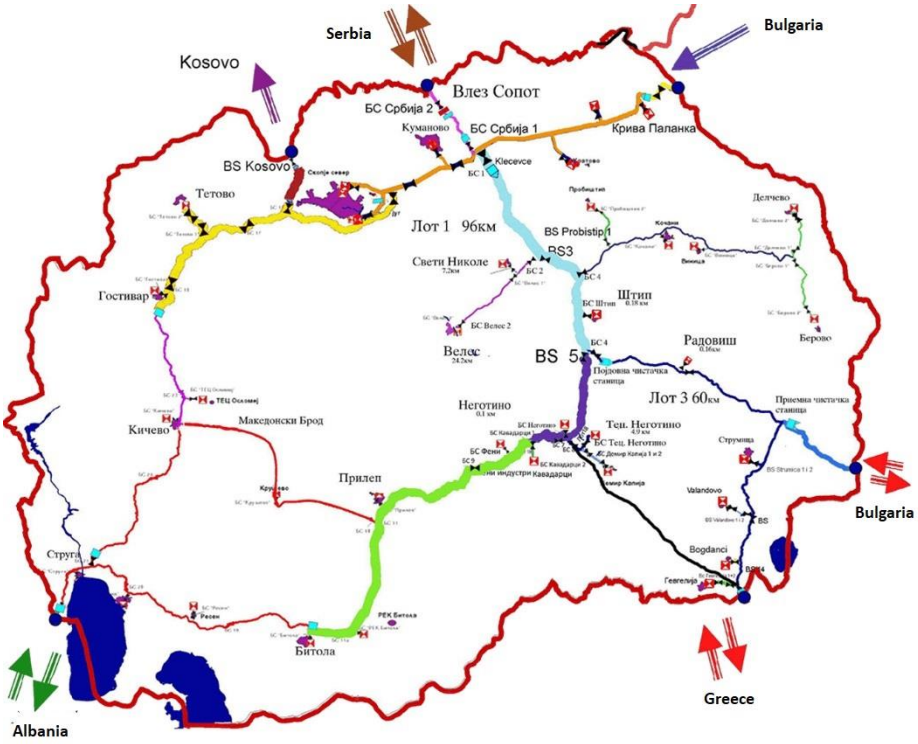


Figure 6. Gas transportation infrastructure in North Macedonia

Currently, gas pipeline sections Skopje-Tetovo-Gostivar (yellow thick line in Figure 6) and Negotino-Bitola (green thick line in Figure 6) are being built. Completion of these sections is foreseen for December 2023. All other sections shown in the above map have yet to be constructed. Out of these, so far plans of the North-Macedonian gas operator "Nomagas" include:

- Interconnection towards Kosovo,
- Section Kičevo – Ohrid,
- Section Sv.Nikole – Veles, and
- Interconnection with Greece.

Through the future interconnection with Greece, gas could be supplied to the North Macedonian gas networks from the LNG terminal which is currently being built in Alexandroupolis (Greece) and is expected to start operating by the end of 2023 (Figure 7). However, construction of the interconnection seems to be behind schedule, with possible further delays. The interconnector between North Macedonia and Greece is planned to be 123 km long (Macedonian and Greek side) and to stretch from Nea Mesimvria to Negotino via Gevgelija and connect the two national natural gas transmission systems.

Figure 7. Gas infrastructure in Greece

North Macedonia has adopted the Law on guarantees referring to obligations related to the contract for financing the interconnector with Greece (North Macedonian section), for which a loan by EIB in the amount of 28.9 million EUR was approved. However, difficulties have reportedly arisen with repayment of the loan by the gas transmission system operator "Nomagas" and new loan conditions are being considered. Further, the costs for the North Macedonian section seem to have been

underestimated, as shown with detailed calculations by the Bill of quantity (design documentation) and changing of the prices of materials and works.

As for the Greek side of the interconnection, available information states that the project is either without final investment decision or implementation is subject to commercial commitment from users. The cost estimate for the Greek section has been revised due to price escalation of steel.

For the reasons explained above, construction of the interconnection has experienced delays. Current estimation for completing the interconnection is Q3 2025, which seems unlikely.

Plans exist also for the gas interconnection between Albania and North Macedonia, which would connect North Macedonia to Fier in Albania, and further to the future LNG terminal in Vlora. Available data collected during preparation of the Master Plan stated that the interconnection could be commissioned in 2026. However, as the Vlora LNG terminal is still at very early development stage, and as immediate plans of "Nomagas" do not include the interconnection, this will probably be delayed.

Plans also exist for establishing connection points along the route of the Trans-Adriatic Pipeline (TAP – green line in Figure 7), however distribution of this gas to North Macedonia in larger quantities depends on the North Macedonia-Greece interconnection.

Under these circumstances, the feasibility of larger-scale usage of LNG depends solely and strongly on constructing the North Macedonia-Greece interconnection, which will take several years to be completed.

As for **Serbia**, the gas interconnection from Niš (Serbia) to the Bulgarian capital Sofia (Figure 8) is under construction, and the interconnection is expected to be completed in Q4 2023. With its projected capacity, the new gas pipeline will provide additional 80% capacity increase relative to Serbia's current annual gas needs, largely increase the overall security of natural gas supply and contribute to cleaner energy targets. As the interconnection between Greece and Bulgaria (Komotini-Stara Zagora) is already in operation, the Serbia-Bulgaria interconnection will reduce dependency on one dominant supplier, as other sources could include the LNG (liquefied natural gas) from Greece and gas coming from Azerbaijan through the TANAP (Turkey) and TAP (Greece) pipelines.

Figure 8. Serbia-Bulgaria interconnection

An interconnection between Vranje (Serbia) and Klečovce (North Macedonia) is foreseen as well (), and Serbia has started developing planning and technical documentation for this. The project, which

would enable access to various sources of gas for both countries, is at a very early stage of development.

Figure 9. Serbia-North Macedonia interconnection

Finally, the interconnection of Croatia and Serbia is planned on the route Slobodnica - Sotin - Bačko Novo Selo (Figure 10). The main goal of the project is to connect the Serbian and Croatian transmission systems in order to ensure market integration, diversification of gas supply sources and increase security of supply in both countries. It will also provide Serbia with the access to the Croatian LNG terminal on the island of Krk.

The first phase of the project would be the construction of the Negoslavci - Sotin - Bačko Novo Selo gas pipeline (15 km) and Osijek - Vukovar (30 km) gas pipeline. Completion of these sections is envisaged for 2024, and commissioning for 2025. On the other hand, completion of Serbian section of the interconnection is not expected before 2028.

Figure 10. Gas interconnection Croatia - Serbia

To conclude with, prospects of using LNG in Serbia will increase significantly with the completion of the Serbia-Bulgaria interconnection, which is expected in Q4 2023.

4 Level of implementation and Scenarios at 2030

4.1 LNG Terminal Scenario

Based on the analyzes carried out and the scenarios developed in the Master Plan, the import capacity towards the EUSAIR area through offshore regasification terminals is expected to increase in the coming years, going from the current over 25 billion cubic meters to around 65 billion cubes by 2030 at the latest.

Country	Operational	Under construction	Planned	Total
Croatia	2,6		2,6	5,2
Greece	7,0	5,5	13,2	25,7
Italy	16,0		18,0	34,0
Albania			n.a.	n.a.
EUSAIR	**25,6**	**5,5**	**33,8**	**64,9**

Table 3 – Annual regasification capacity of LNG large scale import terminals per country (bcm/year)
Source: Consultant's elaboration on GAS LNG Europe data

This capacity, as seen in the Flagship Study number 2, could alone cover the entire current and prospective gas demand by 2030 for the entire EUSAIR area, expected to be between 58 and 65 billion cubic meters in 2030 depending on the scenario considered (CPS or NPS).

All the more reason, this regasification capacity is overabundant compared to the consumption forecasts of the NZE scenario, where the consumption of natural gas is expected to drop sharply in the long term.

5 Challenges and recommendations

LNG has great potential for replacing heavy fuel oil and diesel in freight transport and shipping, as well as in supply to industrial sites and communities not connected to a pipeline network.

This is thanks to the LNG superior environmental performance. Indeed, LNG has a much smaller carbon footprint and switching to LNG brings an immediate benefit on air quality and therefore health:

- up to 25% less CO2;
- up to 90% less nitrogen oxide (NOx); •
- negligible quantity of sulphur and fine particulates.

Moreover, all LNG infrastructures are “carbon neutral ready”: they can immediately manage, without any limitation, liquid biomethane (which is already happening) or synthetic methane (i.e. methanated green hydrogen), or can adapt to other carbon neutral molecules.

ALTERNATIVE FUELS: STRENGTHS

1. The deployment of alternative fuels and innovation technologies for green & smart ports has a double implication of "less pollution - more efficiency" for ports. Efficiency is strictly linked to a higher competitiveness.
2. The use of alternative fuels could reinforce the possibility to attract private investments. Concretely, this means the development of port traffics and thus new business opportunities.
3. The application of new procedures in the companies brings to significant changes in terms of process innovation.
4. More synergies among the actors involved and more public funding blended with private capitals.

ALTERNATIVE FUELS: WEAKNESSES

1. Financial gap. The use of alternative fuels requires high investments: deep feasibility assessments are required to evaluate the expected return on investment.
2. Permitting. Different levels of laws and guidelines can rule out the private interest for port investments (e.g. several years for final authorization)
3. Technological and digital gap for the production and utilization of alternative fuels.
4. Action plans in this sector are influenced by geopolitical factors and scenarios.

In comparison to other alternative eco-friendly fuels, LNG complies with environmental regulations, it is technologically mature and already available solution, ready for immediate application.