CORE LNGas hive

LNG hive 2

Ports as an energy bridge to decarbonize Europe

Co-financed by the European Union
Connecting Europe Facility

Coordinator: enagas

Leadership: Gobierno de España · Ministerio de Transportes, Movilidad y Agenda Urbana · Puertos del Estado


CORE LNGas
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PART I

01. Executive Summary

The CORE LNGas project is an initiative co-funded by the European Commission through the 2014 Connecting Europe Facility (CEF) Transport Call for **Innovation**. Its aim: to develop a safe, efficient and integrated logistics chain for the supply of LNG as fuel for the maritime and port sector in the Iberian Peninsula.

This project, **a benchmark in the Iberian Peninsula and in Europe** for being an exemplary public-private partnership; for promoting the energy transition by using LNG as fuel in maritime transport, which reduces CO2 emissions by around 20-30% compared with traditional fuels; in addition to **improving air quality** in port environments by eliminating emissions of sulfur oxides (SOx) and particulate matter (PM) and drastically reducing nitrogen oxides (NOx), as well as promoting ports as energy hubs. It also guarantees both its monitoring through the LNGhive2 strategy and the neutral and decarbonised maritime future.

All this in coordination with Puertos del Estado, has served as an example for the subsequent deployment of a national strategy for the decarbonisation of maritime transport, and from the following points of view:

- **Successful case of public-private partnership with European funds:**

  This public-private consortium project, spearheaded by Puertos del Estado and coordinated by Enagás, has a total of 42 partners from Spain and Portugal, 21 of them public partners (eight state institutions and 13 port authorities) and 21 private partners (industrial companies, shipowners, LNG operators and service providers in the value chain).

- **Decarbonisation:**

  This project has laid the foundations for the beginning of the decarbonisation of port infrastructures, through the use of LNG as fuel, allowing the different agents in the port surroundings to reduce their emissions of CO2 as well as SOx, NOx and PM. Specifically, the project has developed innovation pilots for the supply of LNG as a marine fuel, Onshore Power Supply solutions for ships while at berth, transformation of straddle carrier cranes to LNG and the retrofit of existing locomotives to LNG.

- **Contribution to the adaptation to the regulatory and normative framework:**

CORE LNGas hive is a project which is mainly focused on LNG technology and innovation development for maritime transport at the main points of the Trans-European Transport Network with the aim of supporting the implementation of the Clean Energy Package for Transport Directive 2014/94, in addition to monitoring Directive 2012/33 concerning the sulphur content of marine fuel. Specifically, through the project we collaborated in the transposition of DE 2014/94 which was embodied through the National Action Framework in the maritime part of the port infrastructure to ensure the supply of LNG in the main ports of the TEN-T network.

- **Developments in the field of security of supply operations:**

As part of the project, in terms of safety, a guide has been developed on safety aspects regarding the supply of LNG as fuel, coordinated by Puertos del Estado and the Directorate General for the Merchant Marine. This document is a compendium of the implemented regulations and published guidelines of the procedures and equipment for the supply of LNG from the different types of truck to ship (TTS), ship to ship (STS) or pipe to ship (PTS). This guide contemplates the point of view at the recommendation level for the different aspects to be taken into account by the Port Authority (local storage, handling, transport and bunkering activities) in terms of authorization and permits for LNG bunkering operations.

In addition, an efficient and safe logistics chain has been developed that allows the supply of LNG in all ports, relying on more than 50 years' experience in the operation of LNG infrastructures.

- **Boosting the supply and demand market:**

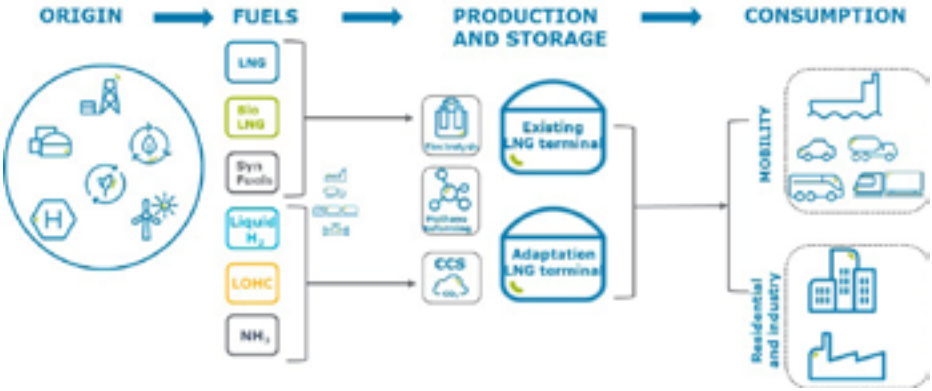
This project has allowed the elimination of barriers found in the development of this type of initiatives (normative, regulatory, training, logistics, innovation, market analysis, etc.) for supply vessels, multi truck to ship (MTTS) equipment, strategic storage and also for demand projects such as the transformation of existing ships to LNG, new constructions, port equipment to LNG, innovative solutions such as a mobile LNG-powered Onshore Power Supply, transformation of straddle carrier cranes or the transformation of locomotives to LNG in the port surroundings.

- **The role of gas infrastructures**

Today's LNG plants have developed as **energy hubs**, playing a key role in the development of LNG as an alternative fuel for all types of transportation. This has been possible thanks to their capacity to adapt, allowing for maximum optimization of logistics chains to be able to supply LNG and future renewable gases for mobility (rail, road and sea). This adaptation has allowed the gas infrastructure to play a strategic role as a leader in the energy transition to renewable gases, through the use of biomethane or hydrogen.

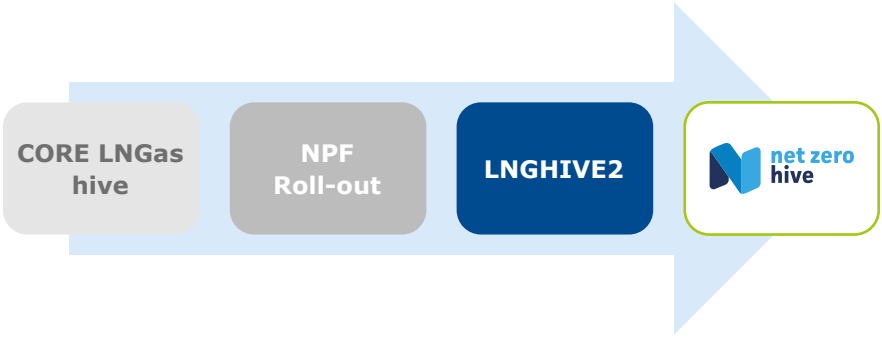
- **Ports and their contribution to the development of renewable gases, present and future**

Thanks to the national effort to comply with the 2014/94 directive,



the Paris agreement and the other commitments at European level -especially the Green Deal, Fit for 55 and Repower EU initiatives, and at national level, the LNGhive2 strategy proposes to boost the transition to renewable gases -both biomethane and hydrogen- in maritime transport by supporting the deployment of infrastructures, consumer vessels and LNG service industry -capable of consuming such renewable gases. In addition, the alternative of renewable gases in Spain is favoured by the characteristics of the national gas system, which facilitates the supply of renewable gases under very competitive conditions compared to other countries without the need for new investments, thus expanding the supply of logistic services of the Spanish gas system.

As a continuation of the LNGhive2 strategy, a fully decarbonised initiative is born as part of the development of the roll-out of the first CORE LNGas hive project. This initiative aims to **decarbonise the**



port environment by promoting ports as energy hubs and the main lever to bring together multimodal transport and begin the de-carbonisation of all types of transport (road, rail and sea). At present, 40% of "heavy" goods move around ports, which are responsible for around 10% of Spain's emissions, so initiating the decarbonisation of transport by centralizing efforts around these logistics nodes is the best way to optimize the efforts of the different agents involved. Specifically, the **objectives** of this initiative are:

◇ **To speed up the deployment of low-carbon fuels** in the Spanish maritime-port sector

◇ **Promotion of ports as energy hubs and multimodal logistics nodes**

◇ **To decontaminate and decarbonise maritime transport and the port sector** in the short term and favour the integration of renewable gases in the energy mix in the medium and long term, both in the shipping and port sectors.

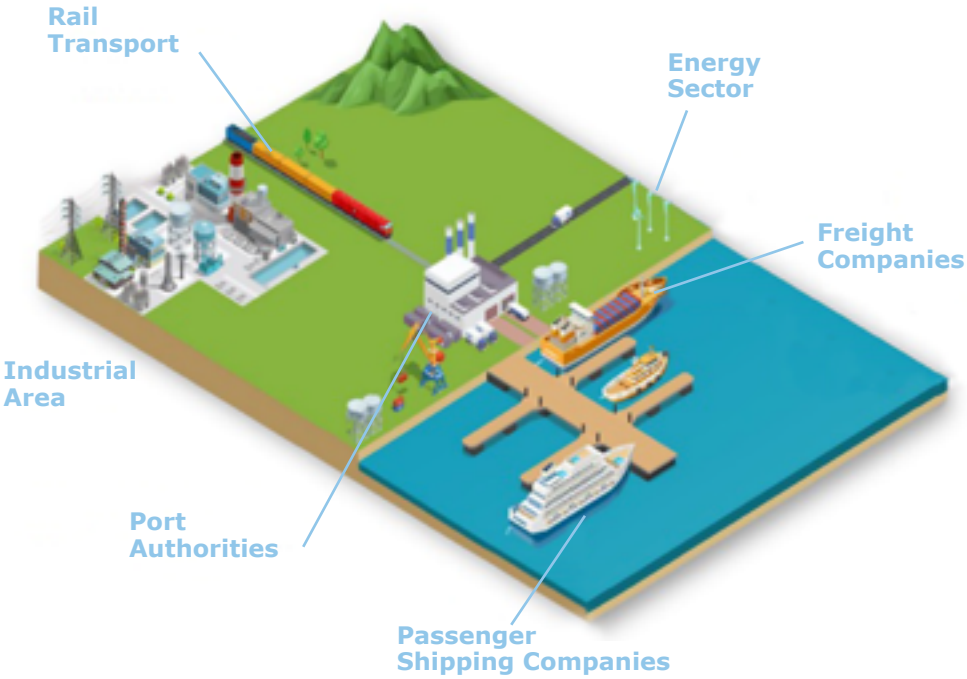
◇ **To increase the competitiveness of the maritime and port sector** by reducing operating costs and reducing the risk of obsolescence of investments as a result of future regulations on atmospheric emissions.

◇ **To promote industrial and social growth** in Spain by developing specialized services with high value-added aimed at the specific sector:

a. Refineries and other energy sector facilities and plants in Spanish ports adapted for the production of low-carbon fuels such as bio-LNG, synthetic methane and hydrogen

b. Low-carbon fuel supply for shipping and port applications

c. Introduction of low carbon fuels in ports, dry ports and logistics corridors


Rail Transport
Energy Sector
Freight Companies
Industrial Area
Port Authorities
Passenger Shipping Companies

02. Project impact and roll-out analysis

a) Environmental impact

From an environmental point of view, the impact of the development of these projects has been highly significant, since it must be taken into account that the use of LNG as a fuel has two major environmental advantages over conventional fuels. The first and most important, an almost complete reduction of polluting substances -NOx, SOx and PM- and the second, a reduction of the CO2 emitted. Within the project, activities have been developed where consuming equipment is used, meaning this reduction is direct, compared to the environmental performance of the replaced solution. And there are also activities to develop means of supply, including infrastructure, where this assessment is more complex. This is because it is understood that the environmental value of these solutions lies in allowing the consumption of LNG in means of transport, therefore being an indirect impact.

In addition to the direct and indirect emission reduction of the activities, the future emission reduction due to the forecast demand for LNG bunkering in the Spanish and nearby ports such as Tangier-MED and Gibraltar has been studied.

Once the results of all activities have been analysed, the breakdown is as follows:

Type of impact	GHG Reduction	SOx Reduction	PM Reduction	NOx Reduction
Direct	**33.798**	**1.866**	**406**	**7.494**
Maritime	33.770	1.865	406	7.494
Land	28	0	0	0
Indirect	**420.235**	**45.176**	**31.900**	**53.081**
Maritime	420.000	45.176	31.900	53.079
Land	235	0	0	2
TOTAL	**454.033**	**47.042**	**32.306**	**60.575**

Illustration 1 Annual indirect environmental impact (t pollutant) of infrastructure development projects and means of supply

b) Social/economic impact

The project, with an **approximate duration of 7 years** including the extension through the LNGhive2 roll-out, has been divided into two main phases, an initial one comprising studies and pilots (HIVE 1) that was mainly carried out during the first years of the project, although it has been extended until completion of the project, and a second one that encompasses projects with real roll-out, which started in 2017, with more weight in the final phase. The **total budget** of the project over its **5-year duration amounted to EUR 242 million, of which EUR 54 million came from European funds**. The distribution of the funds in geographical terms is shown on the map below, although the location of the maritime supply means and consumer vessels could vary according to the needs of the operating companies:

PROJECT	CORE LNGas hive						LNGhive2				Total
CORRIDOR	Consumer Equipment	Studies and Engineering	Project Management	Infraestructure	Supply equipments	Total	Consumer Equipment	Infraestructure	Supply equipments	Total	
Mediterranean Corridor	1 mill €	2 mill €		4 mill €		**7 mill €**	72 mill €		47 mill €	**119 mill €**	**126 mill €**
Strait of Gibraltar						**0 mill €**	1 mill €	1 mill €	58 mill €	**60 mill €**	**60 mill €**
Atlantic Corridor	6 mill €			2 mill €		**8 mill €**		32 mill €		**32 mill €**	**40 mill €**
National		5 mill €	1 mill €		8 mill €	**14 mill €**				**0 mill €**	**14 mill €**
Total	**7 mill €**	**7 mill €**	**1 mill €**	**6 mill €**	**8 mill €**	**30 mill €**	**73 mill €**	**33 mill €**	**105 mill €**	**211 mill €**	**242 mill €**

Figure 2 Distribution of the HIVE project budget by geographic area

One of the most widespread techniques for studying the economic impact of an activity on the economy as a whole is the **input-output tables (IOT)** methodology proposed by Leontief. One of the main utilities of this conceptual model is that it allows a simple assessment of the change in demand (in terms of investment, employment or others) that an increase or decrease in economic activity generates in the rest, both directly and indirectly, as a result of an increase in its activity.

In general, the effects that an increase in activity in a sector generates can be classified into three types:

- **Direct impact**
- **Indirect impact**
- **Induced impact**

The CORE LNGas hive project and its roll-out, with a total budget of **EUR 242 million**, only 24% -EUR 54 million- corresponds to the public budget, so it should be noted that the total effects produced by public

spending amount to more than 800%, if both direct and indirect effects are considered:

- **Public financing:** EUR 54 million
- **Private sector spending:** EUR 188 million
- **In the Spanish economy:** EUR 104 million / 757 direct jobs
- **Indirect effect:** EUR 140 million / 963 indirect jobs
- **Induced effect:** EUR 81 million / 661 indirect jobs
- **Total:** EUR 457.5 million / 2,381 jobs
- **Multiplier effect of the project on public financing:** 840%

Breakdown of the economic impact and job creation of the HIVE project

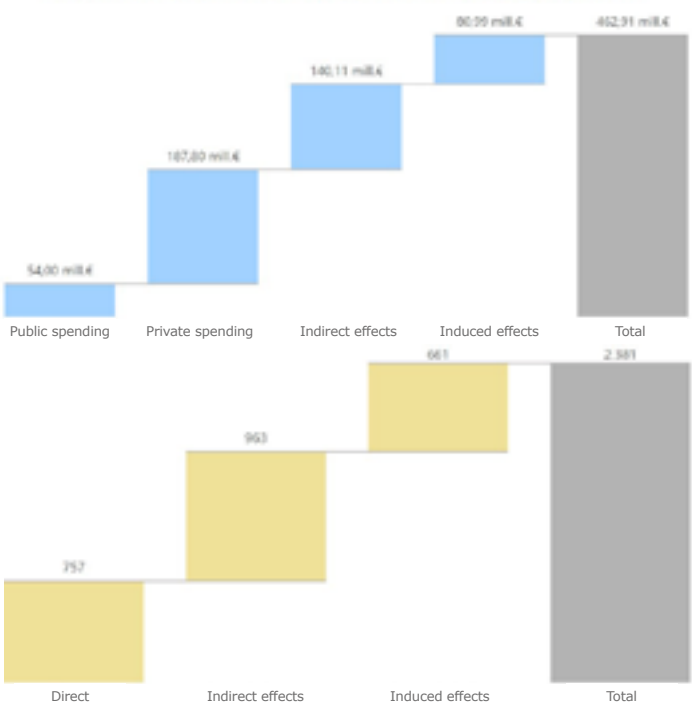
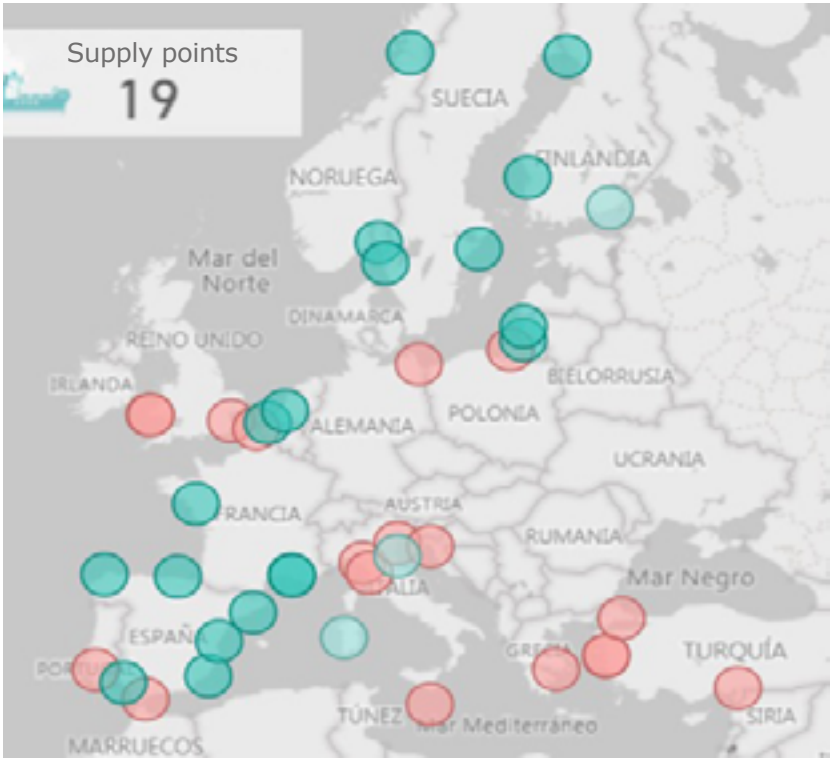


Illustration 3 Summary of the economic impact and job creation of the HIVE project

c) Impact on national competitiveness

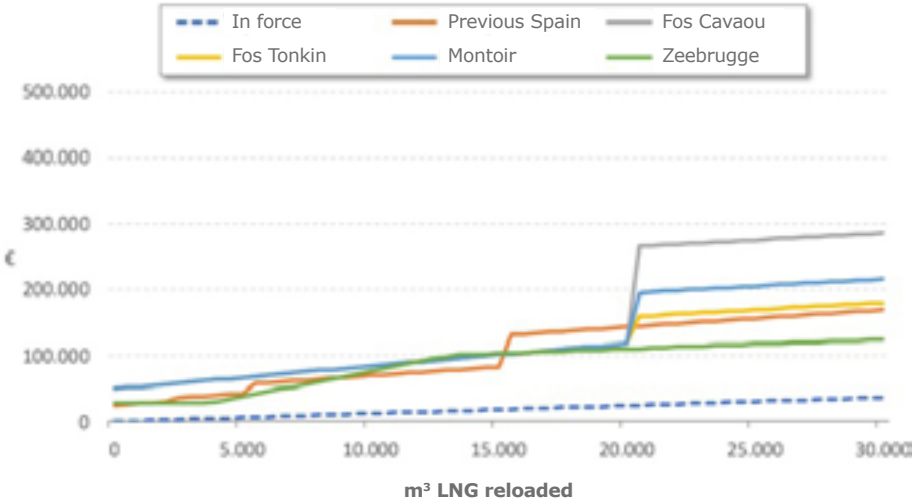
One of the great benefits of first developing a plan of necessary actions and investments to organize the development and deployment of a technology is the ability to support only those actions with the greatest impact in economic, environmental and social terms. Specifically in the field of LNG bunkering, in addition to investments in means of supply already operational, the actions of the CORE LNGas hive project have allowed the Spanish port system to be positioned as:

- **The European system, with the largest number of ports with refuelling points for tankers and supply vessels, especially in the Mediterranean Sea.**



Availability of infrastructure for reloading bunkering vessels in Europe

- **The system with the most competitive logistics costs for the supply of LNG as the most competitive marine fuel in the Mediterranean:** one of the main examples of this dynamic has been the promotion of ship refuelling infrastructures at LNG terminals together with the modification of the regulated costs of their service, positioning Spain not only with the port system with the largest number of supply points, but also the most economical**.**



Comparison of LNG carrier refuelling costs at European terminals with public access. Source: CNMC

◇**LNG port fees:** having proven the ability of LNG-powered ships to reduce polluting emissions, particularly harmful when the ship visits urban areas, the HIVE project has promoted a reduction in port charges at a national level for LNG-powered ships, which is expected to favour the use of these ships in lines or services using Spanish ports.

At national level, if the impact of the project is assessed exclusively in terms of compliance with Directive 2014/94, we can conclude that it has been a huge success, as **Spanish ports have evolved from a situation of almost total absence of means and supplies to the current situation in which supplies have been recorded or supply is permitted**, either by ship or tanker, **in practically the entire Spanish port system** -including 10 of the 13 that make up the TEN-T Basic network in Spain-, the remaining absences being due to the lack of demand and not to the lack of means and regulation.

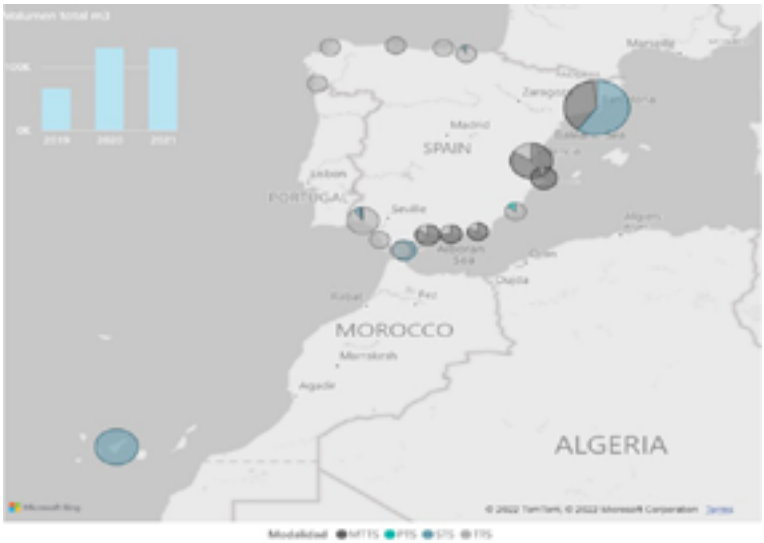


Figure 3.4 Supplies made in Spain (2019-2022) as evidence of compliance with Directive 2014/94

In addition to the contribution made to comply with Directive 2014/94, the actions of the HIVE project are aligned with the guidelines of the subsequently published National Integrated Energy and Climate Plan (PNEIC) and the Biogas and Hydrogen Roadmaps. This is done by favouring the decarbonisation of transport and offering a flexible renewable gas con-sumption platform with high unit consumption (one ship can be equiv-alent to the consumption of more than 10,000 passenger cars), thus facilitating coordination between production, supply and consumption.

These actions, which ensure **the availability of LNG and renewable gas supplies at competitive costs, assisted by studies and measures that directly benefit the demand for alternative fuels** such as

the reduction of port charges for LNG consuming vessels or the promotion of first movers on certain types of vessels **, are expected to significantly enhance the European fleet's ability to meet the challenges of the energy transition**.

d) Regulatory impact at European and international level

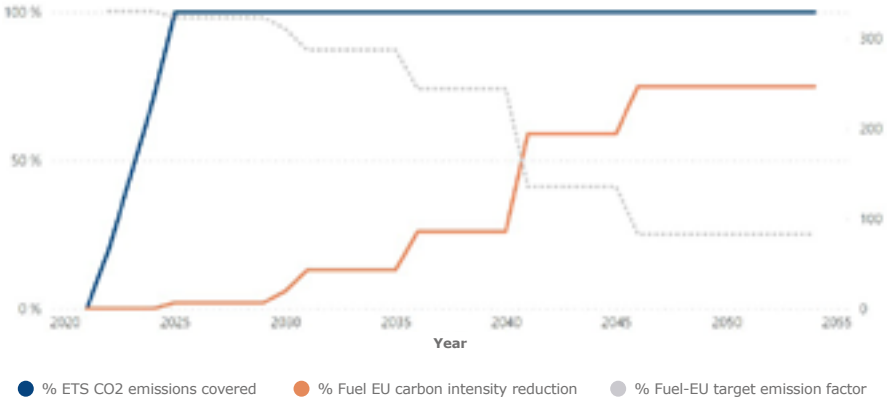
Value-added, defined by the European Union as those actions undertaken by a member state that generate value-added for all states and whose relevance is applicable not only at regional level but also at European level, in this sense the CORE LNGas hive project and its roll-out LNGhive2 have stood out for their ability to:

- **Implement European legislation**

In this regard, the projects have been developing at the same time as European and international regulations, thus allowing each activity to evolve towards the future Pathway of renewable gases, thus allowing the decarbonisation of maritime transport and complying with the objectives of the European Union and the International Maritime Organization.

Specifically, the future regulations for maritime transport have been jointly analysed, thus obtaining the Pathway of mandatory compliance for ships sailing and operating in European ports, in accordance with the Fuel EU Maritime initiative and the incorporation of maritime transport in the ETS (Emission Trading System).

Evolution of FU-EU and EU-ETS requirements



European environmental regulation recognizes a lower carbon footprint of LNG and bio-LNG compared to conventional fuel and bio-fuels, which means an upfront saving in EU ETS credits and in the purchase of biofuels for Fuel-EU compliance.

Specifically, the impact of the use of LNG as a fuel and the use of renewable gases such as biomethane, as opposed to the option of traditional and biofuels, has been analysed.

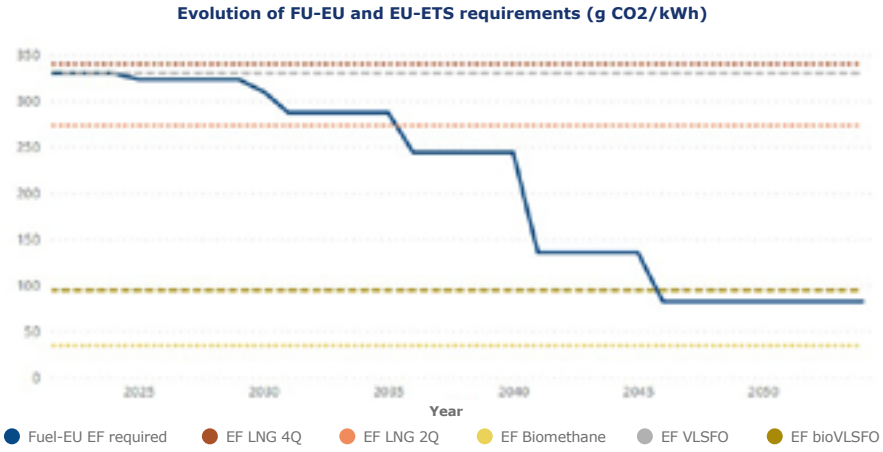


Illustration 4 Expected evolution of Fuel-EU and EU-ETS regulations

The following conclusions can be drawn from the analysis:

- The use of LNG as marine fuel and renewable gases to comply with the Fuel-EU regulation induces large emission savings globally in the shipping sectors where 2-stroke engine propulsion systems predominate.
- Despite the fact that Ro-Pax and cruise ships using LNG-fuelled DF 4-stroke engines are not recognized as having a lower carbon footprint, by operating mainly on the European continent and using bioLNG with a lower price and lower carbon footprint than bioVLSFO they will be greatly favoured by the requirements of the Fuel-EU regulation.
- Ships with 2-stroke DF engines, according to European regulation, will not require the addition of bio-LNG until 2036.
- Ships powered by hydrogen-derived fuels would not pose a competitive threat either to ships built in the first period analysed - 2020 to 2045 - or in the second - 2030 to 2055 -.

03. Abatement cost of emission reduction

There are currently many potential avenues for reducing emissions in transportation by replacing the **traditional fuels** that dominate today with renewable, low-carbon fuels. When comparing technological options and their contribution to climate protection, a holistic approach is needed that takes into account emissions and costs along the value chain. This will ensure that emissions targets are achieved in a value-for-money way when policy makers decide which technology options to support.

Comparison of options is complex due to the different emissions and cost profiles of the vehicles. One method of comparison is to calculate the cost of carbon reduction. The abatement cost is the cost of reducing emissions with respect to conventional technology. Therefore, if calculated for different alternative technologies, it indicates which is the most cost-effective option to reduce emissions.

A recent analysis by Frontier Economics[1] analysed the CO2 emission reduction costs of the main transport vehicles to illustrate the potential mobility contribution of different alternatives. This study has analysed the four modes of transport (light vehicle, heavy vehicle, rail and maritime).

The results indicate that **natural gas mobility** is a readily available option and is an attractive addition to the 2030 technology mix needed to effectively and efficiently migrate to a low-carbon mobility sector.

In fact, by 2030 LNG is expected to have similar or lower costs than all other options, including conventional technologies, in all four sectors analysed. This means that the increased use of natural gas in mobility is expected to reduce both emissions and costs.

As for biomethane (LBM), it is the next most cost-effective way to reduce emissions in all four sectors and the technology with the lowest emissions. Although the limited supply could affect its ability to contribute to the decarbonisation of the sectors analysed, the results indicate that the LBM Pathway is the most optimal solution in terms of emission reduction and cost and therefore its production and use should be supported.

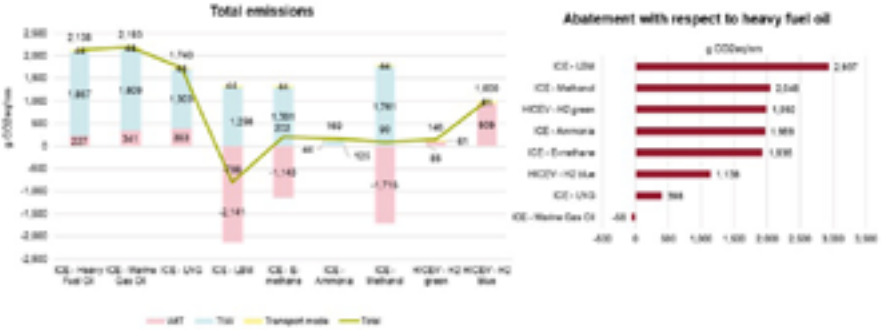


Illustration 5 Maritime case Deepsea container ship

In addition, the use of natural gas reduces the risk of an insufficient or costly supply of minerals such as copper, lithium and cobalt, which are key to building electric vehicle batteries.

Accordingly, although natural gas is not a zero-emission technology and in the long term its direct use in transport will have to be very limited to achieve net zero, during the transition it will provide efficient emission reductions and can help Europe achieve a certain climate protection target at lower costs.

[1]*CO2 EMISSION ABATEMENT COSTS IN THE TRANSPORT SECTOR. A study for Enagás 25 MARCH 2022*

04. Conclusions of impacts

For all these reasons, the impacts resulting from the development of the CORE LNGas hive project and its subsequent roll-out are undoubtedly a **lever towards the decarbonisation of maritime transport**, enabling this sector to meet the targets set by Europe and the International Mar-itime Organization.

This project has been a success story recognized by both the Spanish and European administrations, not only for the collaboration between the public administration and private companies, but also for its results, given that it is a benchmark for the development of future projects at the national and European level within the framework of meeting the decarbonisation goals through renewable gases.

An example of the continuity of this project at national level is the initia-tive that is now being launched for total decarbonisation to contribute to the decarbonisation of ports and thus meet the targets set by Europe in terms of emissions reduction.

The following are key aspects developed by this project:

- **Promotion of best practices**

  The CORE LNGas hive project has not only addressed the development of the necessary infrastructure and means of supply to comply with Directive 2014/94, specifically, through the project we collaborated in the transposition of European Directive 2014/94 which was embodied through the **National Action Framework** in the maritime part of the port infrastructure to ensure the supply of LNG in the CORE ports of the TEN-T network, in addition, a series of barriers and inefficien-cies that hindered such development were identified and removed, many of them as a consequence of the lack of previous experiences in other port surroundings. As a consequence, during the preparation of projects related to regulatory or training developments, such as safety guides or skills training, the project has considered the main international reference standards and best practices available with the aim of facilitating their application in other EU port environments or the establishment in Spain of companies that operate regularly in other ports with similar references.

- **Benchmarking for decision making**

All pilot and implementation projects carried out by the CORE LNGas hive project and its roll-out LNGhive2 have been preceded or accompanied by multiple studies and tools to assess the suitability of their implementation in the framework of compliance with the 2014/94 directive and to know whether they will be competitive in economic and environmental terms. Of particular note here is the work to develop a methodology for the continuous assessment of the potential maritime demand for LNG and a tool (simlog©) for the design of logistics chains for LNG bunkering, which has made it possible to have updated data throughout the project and to evaluate the suitability of the implementation projects presented. The project has also developed tools for the continuous monitoring of developments related to alternative fuels, through the creation of an observatory led by Puertos del Estado.

- **Networking**

The CORE LNGas hive project and its LNGhive2 roll-out have made it possible to carry out more than 75 events to disseminate and explain its work, with a special focus on disseminating the advantages that LNG and other alternative fuels can offer the national and European port and maritime sector, but also on coordination and understanding between all sectors of activity that converge in these environments.

Illustration 6 Summary of direct and indirect impacts of the HIVE project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PART II

05. Use of this guide

This guide is a compilation of all the experience accumulated through the development of the CORE LNGas hive project in order to serve for the development of LNG bunkering projects, small scale and decarbonisation of the port environment.

You will find different LNG supply and demand projects for the decarbonisation of the port environment and maritime transport.

The guide allows the user to learn about the know-how and experience developed in the different initiatives of the CORE LNGas hive project and subsequent developments through its roll-out LNGhive2.

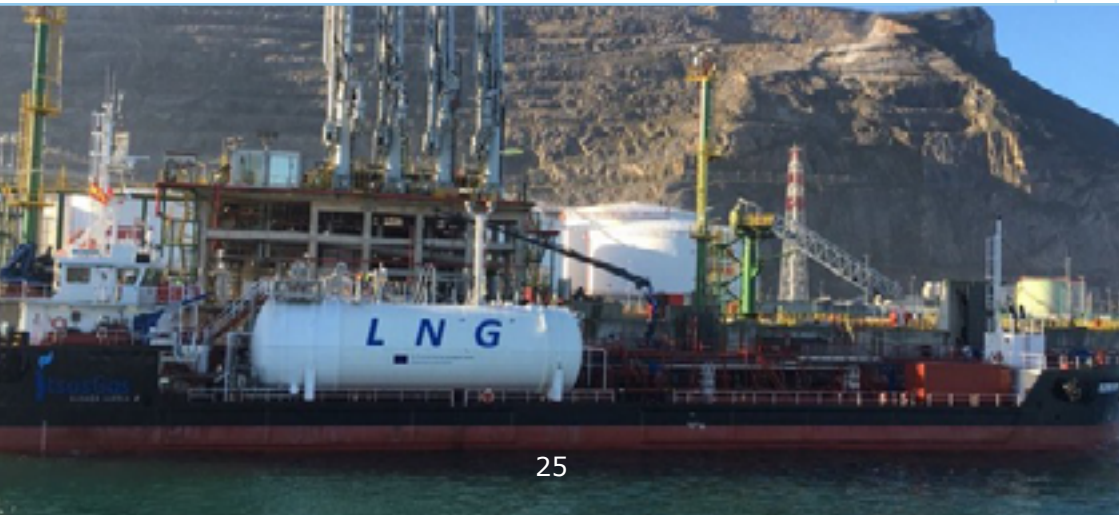
For these projects, a series of cross-sectional studies have been carried out that apply the different pilot projects as a basis(regulatory framework, technical, training, dissemination, demand studies and logistics chains, etc.). These studies are explained at the end of this guide together with the future investment plans and the Puertos del Estado observatory.

06. Projects

A) CORE LNGas hive

1. Adaptation of the Bilbao LNG Terminal to provide small scale and bunkering services

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Adaptation of the Bilbao LNG Terminal, for its validation as an innovative solution for bunkering from pipe to ship. To this end, the following work has been carried out: • Pipeline interconnection works for the supply of LNG, among other aspects, involved modifications to the existing pipelines, as well as a subsequent definition of a suitable manifold for the supply of LNG to ships. • Dock adaptation works, the BBG terminal jetty had to be adapted for the berthing of smaller vessels than the usual LNG tankers, in particular the berthing of the 100m-long vessel Oizmendi was used as a reference.
Budget:	€700,000
Conclusions:	With the start-up of this plant adaptation, small scale services can be offered at the Bilbao LNG terminal. To date, two LNG reloading operations have been carried out for bunkering vessels, specifically for the vessel Oizmendi.



2. Adaptation of existing vessel to provide LNG bunkering services -Oizmendi

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	Transform an existing barge (Monte Arucas/finally named Oizmendi) for conventional fuel and LNG bunkering, with a total LNG bunkering capacity of 600 m3. For this purpose, this activity was divided into the following tasks: • Task 1. Feasibility study of the LNG bunkering service in the port of Bilbao. • Task 2. Selection of the candidate vessel to be converted into an LNG bunkering barge. • Task 3. Basic and detailed engineering for the barge adaptation. • Task 4. Barge acquisition process and transformation in a shipyard. Work carried out at Murueta shipyards • Task 5. Start-up and testing.
Budget:	€5,573,000
Conclusions:	The adaptation of this existing vessel has made it possible to introduce a multi-fuel bunkering vessel into the market, thus guaranteeing all types of supply to the customer and allowing for flexibility in demand. This vessel has a maximum supply capacity of 600 m3. It carried out its first ship-to-ship bunkering operation in the port of Bilbao on the vessel Ireland.

3. Construction of an LNG tugboat at the port of Bilbao

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	The vessel construction is an innovative solution consisting of the first liquefied natural gas (LNG) powered tugboat in the EU and its implementation to test its feasibility and suitability, as well as its value-added before deploying it on a larger scale. The technical characteristics are shown below: • Two Wartsila 9L20 Dual Fuel engines (1,665kW/unit) • LNG tank: 25 m3 • Overall length: 28 m • GT: 395GT • Towing capacity: 55 t
Budget:	€3,346,000
Conclusions:	The tugboat joined the Bilbao port service in July 2020 with full normal service and it performs its LNG supply by tanker truck in the port of Bilbao on a monthly basis.

4. Adaptation of the Ferrol LNG Terminal to provide small scale and bunkering services

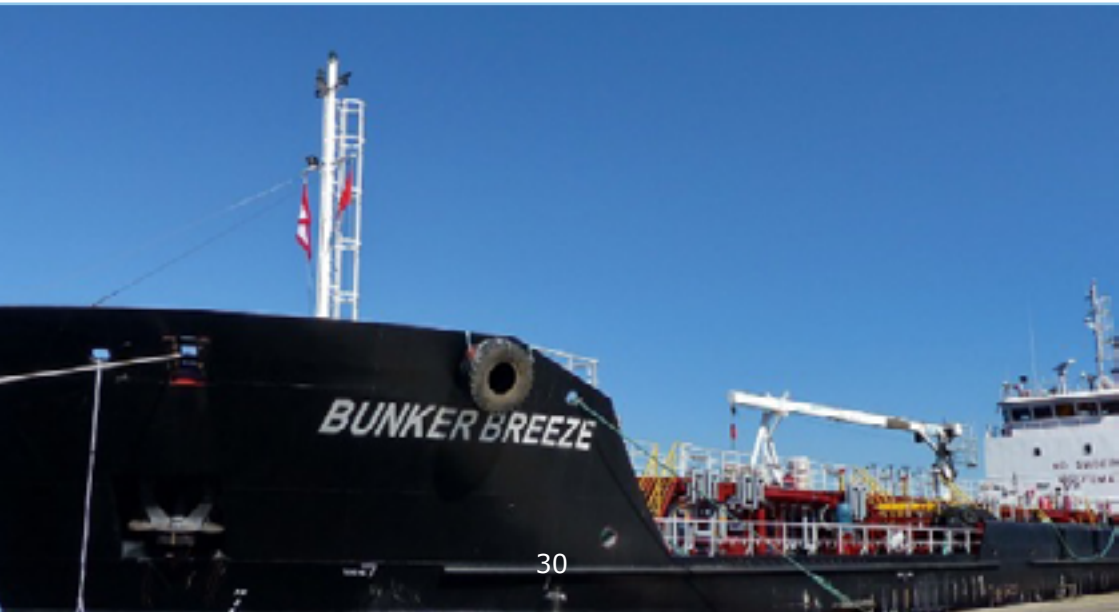
Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Adaptation of the Ferrol LNG terminal for validation as an innovative solution for bunkering from pipe to ship. To this end, the existing berth must have a functionality comparable to that of the current one, able to serve LNG carriers of up to 266,000 m3 capacity, and dedicated to bunkering or small scale distribution, with a minimum capacity of 650 m3. The unloading elements necessary for the operation of the small scale vessels to be adapted to the existing ones are as follows: • Vessel access gangways • Fire extinguishing systems • Control booth
Budget:	€1,268,000
Conclusions:	With the execution of this adaptation, scheduled for completion in early 2022, the terminal will be able to offer small scale and bunkering services.

5. Adaptation of the Barcelona LNG Terminal to provide small scale and bunkering services

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Adapt the Barcelona LNG Terminal for its validation as an innovative solution for bunkering from pipe to ship. This facility at the second berth of the Barcelona LNG Terminal has a capacity for vessels from 80,000 m3 to 600 m3. The filling flow rates of the bunkering installation range between 140-400m3/h
Budget:	€1,525,000
Conclusions:	With the adaptation of the second berth at the Barcelona terminal, a simultaneous service for LNG loading and un-loading is offered. This work allows small scale cargoes to be loaded on vessels with a capacity from 600m3.

6. LNG supply vessel construction (LNG ready)

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	Construction of a supply vessel for the bunkering of conventional fuel and LNG, with a total LNG bunkering capacity of 1,200 m3. For this purpose, this activity was divided into the following tasks: • Conducting compatibility studies of a vessel for LNG supply to ferries, ro-pax, cruise ships, etc, • SIMOPS studies, • Safety areas and procedures. • Construction of a multi-fuel vessel with LNG-ready design.
Budget:	€2,754,000
Conclusions:	The Bunker Breeze vessel was eventually built as an LNG-ready vessel, meaning that at any time it could enter the shipyard to install the LNG part in order to supply. It is currently operating in the Port of Algeciras, which belongs to the Huelva cluster. Its optimal logistics chain is based on the refuelling of LNG tanks from the LNG Terminal in Huelva, although it could also be refuelled through a small scale vessel in an STS operation in the waters of the Port of Algeciras, the average logistics cost would be around €2.2/MWh.

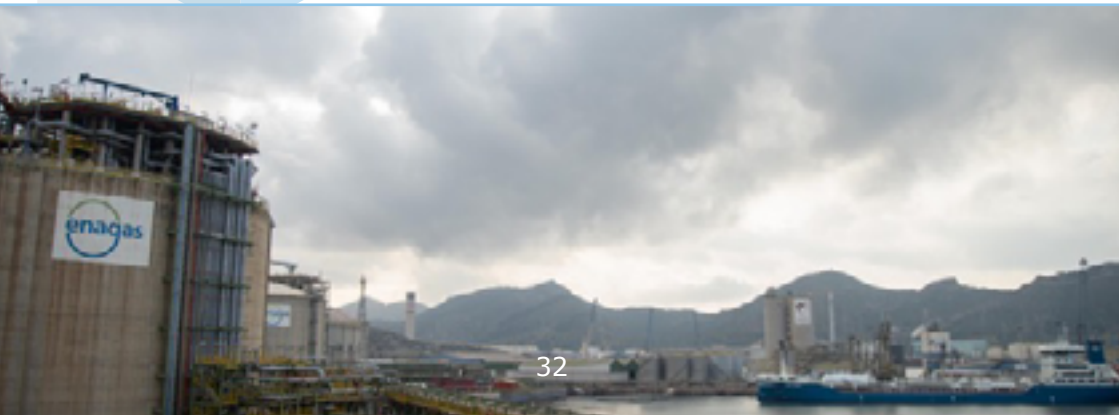


7. Adaptation of straddle carrier to LNG at the port of Barcelona

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	To develop an innovative solution consisting of the adaptation of port cranes to LNG, with the consequent environmental benefit for the port surroundings and the city of Barcelona. This activity has removed barriers to commissioning the LNG-powered container terminal equipment, as its feasibility and suitability, as well as its value-added for deployment on a larger scale, have been analysed.
Budget:	€1,334,990
Conclusions:	The adaptation of the straddle carrier, which was completed in mid-2021, was a success, as the emissions of the LNG engine could be analysed and were much lower compared to the diesel equivalent. As for the LNG supply system of the straddle carrier, it is designed to feed the designed twin-engine system, which implies that the initial fuel system was not modified. The LNG supply system will be located at the bottom of the straddle carrier, opposite the engine, thus facilitating the LNG supply operation.

8. Adaptation of the Cartagena LNG Terminal to provide small scale and bunkering services

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Adapt the Cartagena LNG Terminal for its validation as an innovative solution for bunkering from pipe to ship. This facility at the berth of the Cartagena LNG Terminal has a capacity for vessels from 80,000 m3 to 600 m3. The filling flow rates of the bunkering installation range between 140-400m3/h.
Budget:	€2,730,000
Conclusions:	The adaptation of the berth at the Cartagena terminal allows a small scale and LNG bunkering service to be offered. This work allows small scale cargoes to be loaded for vessels from 600m3 capacity.



9. LNG generator to provide cold-ironing services to ships (Onshore Power Supply)

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Construction and operation of a mobile LNG-fuelled electricity generator to power the auxiliary engines of the vessels during their time in port. Demonstrate the capacity and feasibility for deployment on a larger scale, during tests carried out in the ports of Barcelona, Tenerife and Vigo. This has made it possible to develop a feasible, versatile and economical solution for ports and shipowners to give continuity and development to this emission reduction measure in ports located in the vicinity of cities.
Budget:	€2,262,840
Conclusions:	This system has been tested in three different ports (Barcelona, Vigo and Tenerife), and all tests have shown that it is able to provide services. Undoubtedly, this innovative solution can be extrapolated to any port, thus being able to provide cold-ironing services through the use of LNG or BioLNG, without the need for a fixed infrastructure in port, since this solution is totally mobile.

10. Multimodal transport of an LNG iso container by road, rail and sea transport

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	To analyse the technical and economic feasibility of multimodal LNG transport (road, rail and sea), addressing issues of safety, logistics, costs and permits. In November 2018, a test was carried out from Huelva to Melilla, using the three types of transport (road, rail and sea). The test was a resounding success and demonstrated the logistical capacity of LNG for transport using the most efficient mode depending on the territory. To achieve multimodal transport complying with all safety requirements and using a single multimodal CSC consignment note.
Budget:	€500,000
Conclusions:	In November 2018, a multimodal test was conducted for the transport of LNG by rail, ship and truck. This test was successfully completed and the iso container was transported from Huelva to Melilla using the three types of transport and a single multimodal consignment note.

B) LNGHIVE2: Roll-out of projects

Objective: The LNGhive2 Strategy aims to continue the process of adapting the infrastructure to supply LNG to transport services and to the construction and modernization of means of transport in Spain, boosting the demand for LNG as a marine fuel.

Contributions:

These supply and demand projects have obtained EU funding, through CEF calls, approved for the development of LNG as a marine fuel in Southern Europe in 2017, 2019 and 2020.

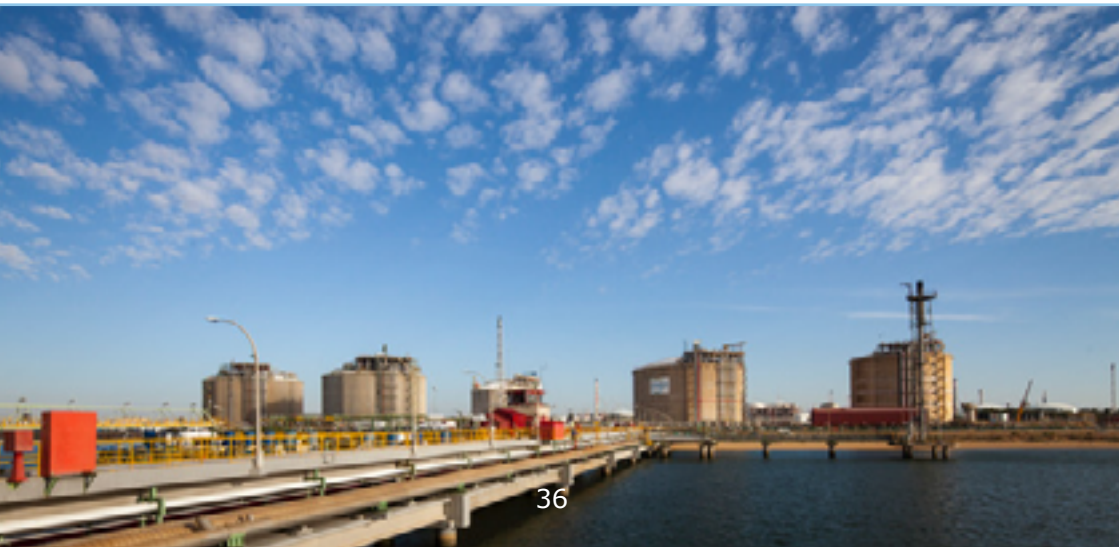
- **LNGHIVE2 infrastructure and logistics solutions**

This Enagás-coordinated project aims to enable the Iberian Peninsula to offer holistic solutions to the new requirements of the shipping and railway sector by promoting LNG as a railroad fuel.

Due to completion of the feasibility studies in the CORE LNGas hive project, development has continued in this project, specifically with the following actions:

11. Adaptation of the Huelva LNG Terminal for small scale and bunkering services

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	Adaptation of the Huelva LNG Terminal for its validation as an innovative solution for bunkering from pipe to ship. This facility at the berth of the Huelva LNG Terminal has a capacity for vessels from 80,000 m3 to 600 m3. The filling flow rates of the bunkering installation range between 140-400m3/h. This facility is designed to load LNG in type C tanks (IMO classification) (cylindrical tanks pressurized up to 9-10 bar), although it can also be used to load quasi-atmospheric type B tanks with variable geometries. In any case, load flow rates must be limited to the design pressure of the tanks and the limitations they impose on the handling of BOG
Budget:	€1,640,000
Conclusions:	The role of the Huelva LNG Terminal is very important in the development of the optimal logistics chain of the whole cluster, since it is based on the reloading of small scale vessels at the Huelva LNG terminal to subsequently carry out their bunkering operations in the Strait of Gibraltar surroundings, the average logistics cost would be around €2.2/MWh.



12. Construction of a multi truck to ship system (MTTS) in the surroundings of the Port of Huelva

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	The MTTS system is an engineering element whose goal is to be a common manifold so that LNG can be supplied with a higher flow rate to the vessel. This system can use its own pumps that can increase the flow rate beyond the usual in the current tanks (approx. 40-50m3/h). This system will also have pumps from the tanker or common equipment that will also facilitate the inerting prior and subsequent to the bunkering operation. As such, the MTTS system with its own pumps that facilitate the operation of filling LNG fuel tanks in ships of up to 500 m3 from tanker trucks, is able to increase the discharge flow rate of the same through the use of this intermediate system. Within this system, the vessel's fuel tank can be filled by up to three tankers at the same time. In addition, the system could depressurize a fourth truck at the same time.
Budget:	€375,750
Conclusions:	With this system it will be possible to offer an MTTS service in the Port of Huelva and its surroundings to optimize the times of LNG bunkering operations while ships are in port.

13. Transformation of a freight locomotive to LNG

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	The project replaces the current diesel rail traction means, which are used in the existing rail freight traffic between the two intermodal rail platforms (dry port of Majarabique in Seville and the seaport of Huelva), separated by 110 km of track. At present, this rail traffic consists of 2 weekly round-trip services, with the intention of incorporating a third one soon after the retrofitted LNG locomotive comes into operation. This activity is part of a feasibility study developed in the CORE LNGas hive project for a traction locomotive for port manoeuvring. As a result of the work described above, the Port Authority of Huelva and RENFE will be able to offer more sustainable rail services, reducing the carbon footprint of freight in this corridor. Tasks to be performed: •Retrofitting of the LNG locomotive, including conversion of the locomotive engine to LNG, 3,000, CV installation of the LNG tanks, rail integration, and all associated with the risk analysis. • On-track tests for authorization for commercial operation by the Spanish Railway Safety Agency (AESF).
Budget:	€1,780,000
Conclusions:	With the completion of this activity, this freight locomotive will enter into commercial service, running the Huelva-Majarabique route and developing the green corridor, as well as promoting multimodality between the two ports.

14. Construction of LNG station in the Port of Majarabique

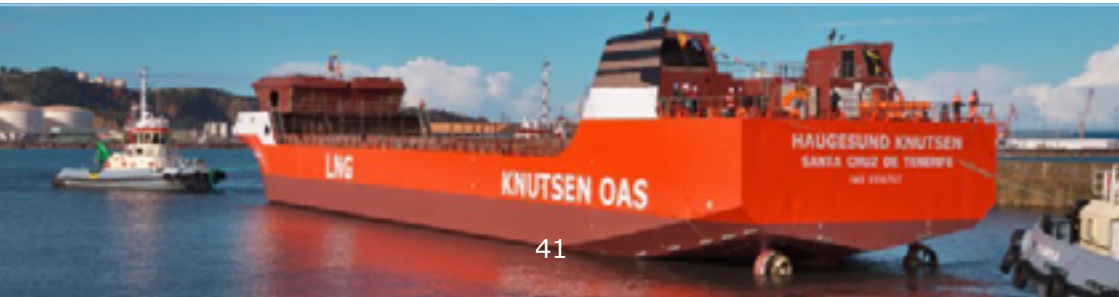
Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	Construction of an LNG station at the Seville dry port to provide LNG supply service to the new LNG-fuelled line locomotive operating on a green freight corridor between Seville and Huelva and to LNG-fuelled trucks. In addition, this automatic LNG facility will have an LNG tank, approximately 20m3. This facility will also have a compressor that will compress the natural gas to 200 bar, which, through a specific CNG dispenser, can supply light vehicles. On the other hand, LNG will be supplied by another dispenser that will be supplied on one side to heavy road vehicles and via another system of hoses it will supply the LNG locomotive.
Budget:	€1,197,000
Conclusions:	This gas plant will be responsible for feeding the LNG locomotive that will run the Majarabique-Huelva route of the green corridor. In addition to the locomotive service, it will also provide service to heavy vehicles. As it is located in a logistics area, this gas station will take advantage of the synergies of multimodality.

15. Adaptation of the Sagunto LNG Terminal to provide small scale and bunkering services

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	The works required for adaptation of the SAGGAS regasification plant for LNG bunkering/small-scale services were determined as a result of the previous studies carried out in the CORE LN-Gas hive project, which included financial and technical feasibility studies of the adaptation of the SAGGAS facilities and the LNG systems engineering project. The terminal has developed the following studies aimed at assessing the feasibility of developing this new business based on LNG bunkering and the small-scale LNG market: • Moored vessel • Geometric compatibility study for small-scale LNG carriers • Conceptual design of new LNG loading facilities • Geometric compatibility study for LNG bunkering operations
Budget:	€996,000
Conclusions:	With the execution of this adaptation, scheduled for completion in early 2022, the terminal will be able to offer small scale and bunkering services. In addition, the Sagunto cluster is quite similar to that of Barcelona for the following reasons: • An approximate 85% concentration of demand in the port of Valencia • Around 85% of its total demand comes from the port of Valencia. • The LNG terminal is located less than 15 nm from the port with the highest demand. Considering the price vs demand curve, this cluster shows a high variability of costs during the first 10 years of operation, due to the low demand expected during these first years. The minimum threshold of expected demand needed for LNG supply to be competitive, compared to TTS and other fuel types, is estimated to be about 150,000 m3. Volumes above this threshold significantly reduce costs, which range from €5/MWh to €2.5/MWh.

16. Construction of a 5,000 m3 LNG bunkering vessel to operate in the Port of Barcelona

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	This project aims to develop the final part of the LNG supply chain, through the construction of a supply vessel to operate in the surroundings of the port of Barcelona. This project will develop the operational procedures of the vessel (STS and PTS), training of port personnel involved in the operations and measurement of emissions in the supply operations. The new LNG bunker barge will target the growing market segment of large LNG-fuelled vessels calling at the port of Barcelona. The expansion of the fleet of large LNG-fuelled ships will speed up the demand for LNG as a fuel. The Port of Barcelona aims to become a premier destination for the next generation of LNG-powered cruise ships, container ships and ferries. Potential shipping companies operating in the port of Barcelona have orders for LNG-powered vessels. Carnival Cruise Lines' latest addition was the AIDAnova cruise ship, the first cruise ship in the world to be fuelled by LNG in the port of Barcelona. MSC Cruises, Disney Cruise Line, Royal Caribbean and TUI have ordered several LNG-fuelled ships for their own fleets, to be delivered around 2025.
Budget:	€45,788,500
Conclusions:	With the entry of this vessel in the Barcelona cluster, the supply alternative requires little discussion. This is because, in addition to having all the demand and storage capacity in the same port, the LNG terminal has a berth specially dedicated to the operation of these vessels, so the only criterion for the selection of the means is the criterion of lowest unit cost, in this case fulfilled throughout the period by the simulations included in "M1". As regards the level of service and the use of the gas system infrastructure, neither the use of a vessel with greater capacity would considerably increase the level of service in the port of Barcelona, nor does the selected alternative seem likely to saturate the terminal dedicated to small scale vessels at the Barcelona terminal. Given that a maximum of 125 reloads will be registered, this solution will allow a 5,000 m3 vessel operating regularly in the Port of Barcelona to carry out the necessary STS operations. The expected average cost for 2030 is €5/MWh



17. Construction of a 12,500 m3 LNG bunkering vessel

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	The aim of this project is to build a supply vessel to operate around the port of Algeciras. This vessel will reload at the Huelva plant and then return to the Strait of Gibraltar area for two specific operations: • The supply operation directly to consumer vessels, bunkering STS • The reloading operation to other supply vessels. This will enable the vessel to carry out both operations, allowing the development of a more efficient logistics chain in the port of Algeciras. This project will develop the vessel's operating procedures (STS and PTS), training of port personnel involved in the operations and emission measurements in the supply operations. Specifically, this project aims to build a 12,500 m3 capacity LNG supply vessel with high flexibility, manoeuvrability and fuel efficiency to fuel large LNG-fuelled vessels at sea and in port in the Strait of Gibraltar. This vessel will mirror the efficient bunkering supply chain and is the result of extensive interactions with customers who identified the need for more flexible and economical LNG bunkering solutions than the bunkering vessels currently in use. In addition to conducting larger bunkering operations, the new vessel will also serve as a mother ship for filling small bunkering barges, allowing for greater utilization of all assets.
Budget:	€56,464,000
Conclusions:	This solution enables the virtualization of the Port of Huelva LNG Terminal, allowing the Huelva cluster solutions to be extended. With this capacity, the vessel will be able to supply other LNG bunkering vessels and also supply LNG to vessels with high demand, such as container ships with tanks of up to 15,000 m3. In 2030, the alternative that proposes the introduction of a mother ship (12,500m3) is the lowest cost (€5.3/MWh), and if demand develops as per the estimates, this alternative could serve as a transition to a model with storage in Algeciras and begin to reduce the level of occupancy at the loading and unloading terminals of the Huelva LNG terminal. Moreover, it could be the most competitive solution as early as 2025 if additional activity could be found and the mother ship could be considered non-dedicated.

LNGHIVE2 VESSELS DEMAND

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	This project coordinated by Balearia will boost the Spanish liquefied natural gas (LNG) fleet by adapting 5 ROPAX vessels of the Balearia shipping company (Abel Matutes, Nápoles, Sicilia, Bahama Mama and Martín i Soler). It aims to create the market basis for the deployment of LNG bunkering services and to enable the use of LNG on land and on board for shipping and port operations.
Budget:	€58,987,122
Conclusions:	*https://lnghive.com/*

LNGHIVE2 Santander

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	This project, approved in the 2019 CEF call, is carried out in the Port of Santander located in the Integral TEN-T Network. Its goal is to build an LNG bunkering terminal and the necessary infrastructure to enable the berthing of LNG carriers. There will be studies to obtain permits for the construction of the terminal. A new dock will be built, including a Ro-Ro ramp. Engineering studies, civil works, equipment installation and commissioning are planned for the LNG terminal. Training of port personnel is also planned. The main benefits will be in terms of sustainability of maritime transport and security of supply in the area surrounding the city and port of Santander.
Budget:	€31,577,035
Conclusions:	*https://lnghive.com*

LNGHIVE2 vessels demand: Completing green links (Balearia)

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	Continuation of the transformation process of Balearia's fleet (1 Ro-pax vessel, the Hedy Lamarr) to LNG to contrib-ute to the decarbonisation of maritime transport and the improvement of air quality in port cities.
Budget:	€12,672,750
Conclusions:	*https://lnghive.com*

C) Basic Studies

a) Safety guide for Port Authorities

Impact:	**Decarbonisation** **Contribution to adapting to the regulatory and normative framework** **Developments in the field of supply operations safety**
Description:	The aim of this activity, coordinated by Puertos del Estado and the Directorate General for the Merchant Marine, has been the development of a guide on safety aspects of LNG bunkering. This document is a compendium of the implemented regulations and published guidelines of the procedures and equipment for the supply of LNG from the different types of truck to ship, ship to ship or pipe to ship. This guide contemplates the point of view at the recommendation level for the different aspects to be taken into account by the Port Authority (local storage, handling, transport and bunkering activities) in terms of authorization and permits for LNG bunkering operations.
Budget:	€300,000
Conclusions:	As a result of this work in public-private partnership, two summary documents have been developed for consultation, aligned with the EMSA guide and with the published standards, for the sector's agents. The document includes the contents for the knowledge of supply operations in the field of safety, port equipment specifications and operating procedures. Documentation available: • EMSA Guide: *http://www.emsa.europa.eu* • Book I Common Guidelines • Book II Common Guidelines

b) Vetting Small Scale Operations from Regasification Plant

Impact:	**Decarbonisation** **Contribution to adapting to the regulatory and normative framework** **Developments in the field of supply operations safety**
Description:	According to the current regulation of the Spanish gas system, all methane tankers carrying out unloading/loading operations at regasification facilities must have successfully passed the vetting procedures required by a company of recognized international prestige. The objective of the project is the development of criteria applicable to small scale operations and to all types of vessels that may undertake bunkering at regasification terminals.
Budget:	Not applicable
Conclusions:	Depending on the type of ships, three groups have been established as the risks they carry are not deemed comparable. These types are ships carrying LNG (LNG Barges), ships carrying chemical products (Tankers) but endorsed by OCIMF and the rest of the ships, which carry other goods or passengers. After a detailed analysis, the following criteria have been established to be applied in the small scale vetting procedure: • Class status and accreditation of the classification society, which must be an IAC member. • Vessel inspections (SIRE, flag and port inspections) • Maritime Safety Regulations (compliance with STWC and IGF Codes). • Crew matrix (1 month's seniority) and experience in navigation (3 years) and in the company (2 years). • P&I club of recognized prestige. • Maximum age of vessel (20 years) and qualifications due to expiry (CAP).

c) Demand

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	These cross-cutting studies were aimed at carrying out analyses to enable investments in both supply and demand for LNG as a marine fuel. LNG demand studies have been carried out for the Iberian Peninsula, identifying the different corridors (Atlantic, Mediterranean and the Islands and the Strait of Gibraltar). Demand study conducted by DNVGL consultancy in 2016. a.LNG demand study for the 2020 to 2050 period by port. b.2019 demand review/update (fleet characterization and allocation to current bunkering ports) performed by SBC.
Budget:	€1,800,000, this budget includes work on demand and logistics chains
Conclusions:	Documentation available: 2016 Studies - DNVGL, *http://corelngashive.eu* • Demand study - bottom up • Demand study - consolidation top down bottom up • Demand study - Top down Analysis • 2020 studies - SBC (roll-out) • Demand table updated in 2020

d) Characterization of LNG bunkering solutions

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	This work package (WP1) focuses on the cost components of all potential elements of the LNG supply chain. The results of this activity fed into the subsequent study of optimized logistics chains. This work was divided into the following tasks: • Firstly, a comprehensive review of possible solutions based on existing literature and previous international studies. • Followed by: Those solutions considered market-ready were studied in detail, with the appropriate regulatory support, obtaining the fixed and variable cost components.
Budget:	€1,800,000, this budget includes work on demand and logistics chains
Conclusions:	Documentation available: • WP1 LNG BUNKERING SOLUTIONS CHARACTERIZATION 2017

e) Logistics chains

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	In this phase of the cross-sectional studies, once the studies of the demand for LNG as a fuel in the Iberian Peninsula had been carried out, studies of the logistics chains were conducted to meet the demand for LNG previously studied and the development of a Simlog® logistics chain simulator to calculate the logistics costs based on a given demand.
Budget:	€1,800,000, this budget includes work on demand and logistics chains
Conclusions:	Documentation available: • Document WP2-3 optimal logistics chains 2018

f) LNG advanced training requirements study and professional training programme

Impact:	**Decarbonisation** **Contribution to adapting to the regulatory and normative framework** **Developments in the field of supply operations safety**
Description:	The aim was to conduct an analysis of the different issues related to training requirements, identifying the requirements of the personnel involved in the operations. This work, performed by the Universidad Politécnica de Madrid, has concluded with the following outcomes: • Document of training requirements and training levels for personnel involved in operations. • Analysis of the accreditation and standardization process, the minimum qualifications required for personnel involved in LNG supply operations by tanker truck and from fixed plant were developed with the Ministry of Education - Incual.
Budget:	€300,000
Conclusions:	Documentation available: • Deliverable ET6

g) Investment roll-out proposal 2030-2050

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	The main objective of this activity, based on the studies and pilots of the CORE LNGas hive project, is to establish a roll-out plan and estimate the investments, both on the supply side (supply chain adaptation) and on the demand side (vessels) that will be necessary in a short-, medium- and long-term horizon (2020-2025-2030-2050) to comply in a coordinated and coherent way with the targets of the National Action Framework. The result will be a key contribution to the definition of the global LNG supply market deployment project in Spain (LNGHive2), providing an indicative investment plan for the horizon (2020-2025-2030-2050).
Budget:	€100,000
Conclusions:	Conclusions: The monitoring phase begins once the projects have been developed. The evolution of the Iberian Peninsula in terms of LNG as a fuel has been studied via the roll-out. This study has enabled us to: • Analyse the evolution of demand from 2014 to 2020 • Review logistics chains and their optimization based on market decisions • Develop a future investment plan for the decarbonizstion of maritime transport. This plan studies the economic impact of the development of LNG as a marine fuel, ensuring supply and demand in accordance with the European Alternative Fuels Infrastructure Directive. For the proper development of this plan, it must rely mainly on private initiative, but with the support of the public entities involved. The following is a summary of this investment plan. For further details, see the available documentation. Documentation available: • Investment roll-out summary • Investment roll-out

h) Impact Assessment in the Atlantic and Mediterranean corridors

Impact:	**Boosting the supply and demand market** **Decarbonisation**
Description:	These documents assess the impact on EU value-added of the results of the CORE LNGas hive project development, in particular through contributions to EU policy needs and objectives in terms of clean fuel infrastructure for the transport sector and TEN-T development.
Budget:	€200,000

i) LNG as a marine fuel LNGhive2 support strategy

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	This consensual strategic positioning will make it possible to objectify the future regulatory development of alternative fuels and guide the gas in mobility sector towards a manda-tory decarbonisation path.
Budget:	Developed in the €100,000 roll-out activity that includes the LNGhive2 marine fuel LNG support strategy and the 2030-2050 investment roll-out proposal.
Conclusions:	Two key proposals of the LNGhive2 strategy are highlighted and developed in the document: 1. The strategy aims to promote the adoption of renewable gases -both biomethane and hydrogen- in maritime transport by supporting the deployment of infrastructures, consumer vessels and the LNG service industry in Spain 2. The strategy is based on the strength of the Spanish gas system with an extensive LNG storage infrastructure and advanced regulation incorporating tank and virtual liquefaction, both of which are world class.

j) Observatory

Impact:	**Boosting the supply and demand market** **Decarbonisation** **Contribution to the targets of Directive 2014/94**
Description:	The purpose of this activity is to monitor demand and supply, through the implementation of an observatory of alternative fuels in maritime transport, to monitor their evolution with the participation and involvement of the entire sector.
Budget:	€120,000
Conclusions:	To this end, a website has been created to compile information by and for maritime transport in order to achieve its decarbonisation. Documents: • Link to the Observatory website

07. Generic contributions resolved by the project

The experience of this project has removed the identified barriers to the development of LNG as a marine fuel. Specifically from the following points:

- **Regulatory level. T**hanks to **public-private collaboration**, it has been possible to implement the 2014/94 directive that required having LNG supply as fuel in the Spanish ports of the Core network. Therefore, this project has served as an example of collaboration between the public administration and private companies for the development of these supply points, allowing Spain to be positioned internationally in the LNG bunker market. Specifically, the following activities are highlighted in this area:

  - ◇ **Training matters:** an analysis has been made on the different matters related to training requirements, identifying the needs of personnel involved in the operations, concluding with the analysis of the accreditation and standardization process, developed with the Ministry of Education - Incual. For further information see "Study on advanced training requirements in LNG and the professional training programme".

  - ◇ **Safety guide for port authorities:** the objective of this activity, coordinated by Puertos del Estado and the Directorate General for the Merchant Marine, was to develop a guide on safety aspects of LNG bunkering. This document is a compendium of the implemented regulations and published guidelines of the procedures and equipment for the supply of LNG from the different types of truck to ship, ship to ship or pipe to ship. For further information see "Safety Guide for Port Authorities".

- **At market level,** Through innovation, this project has allowed us to test different solutions for supply and demand projects, with a view to extrapolation of this project for the development of LNG bunkering and also of LNG-propelled ships. The result of this project has been the LNGhive2 strategy with LNG supply and demand projects, whose investment amounts to a value of EUR 242 million in a time period until 2023.

◇ **Related studies:**

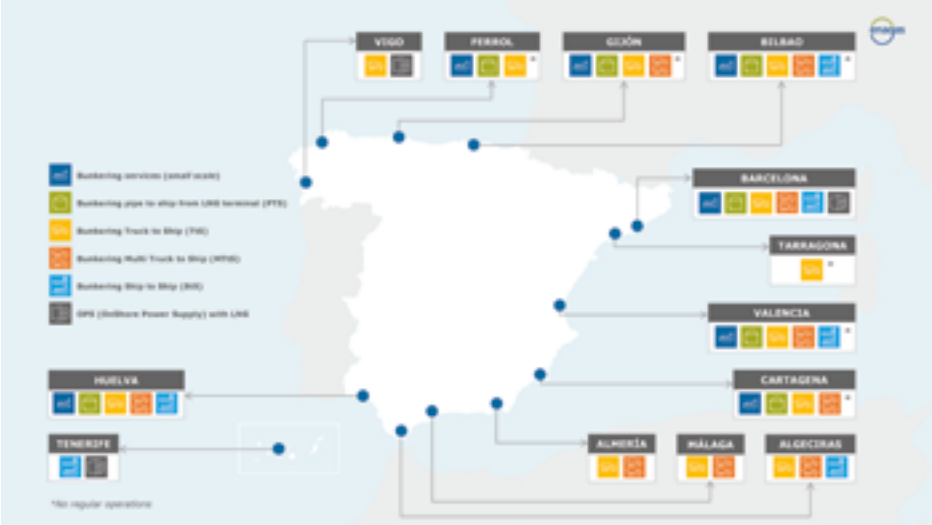
- Demand: demand studies have been carried out on the potential of LNG as a fuel in the Iberian Peninsula.
- Logistics chains: with the demand study carried out, the ports of the Iberian Peninsula were organized on the basis of the existing LNG terminals in order to optimize their logistics chains.

◇ **Projects**

- Mobile Onshore Power Supply: an innovative solution for ships to cold-iron during their stay in port.
- Supply ships
  - » Innovation and initial development phase: the transformation of an existing Oizmendi vessel was carried out, and a newbuild (Bunker Breeze) LNG-ready vessel was also designed.
  - » Roll-out phase: as part of the development of the innovation project and through its roll-out, the construction of two supply vessels for the port of Barcelona and Algeciras is being carried out.
- Adaptation of LNG terminals for the supply of small scale and bunkering services
  - » Innovation phase: the LNG terminals in Bilbao, Barcelona, Cartagena and Ferrol were adapted to provide small scale and bunkering services.
  - » Roll-out phase: as a continuation of the innovation part and in a more developed phase, the Huelva and Sagunto terminals have been adapted.
- Straddle carrier transformation: through the transformation of a gantry crane to LNG, its feasibility and capacity to decarbonise the port environment has been demonstrated.
- Multimodal transport: it has been successfully demonstrated that it is possible to transport an LNG iso container by rail, truck and ship.

- Construction of an LNG tugboat: an innovation project in a vessel segment that has a major impact on air quality in port cities.

- Through the implementation of different activities, it has been possible to promote the benefits of LNG as a fuel in both professional (public administrations, companies, etc.) and educational (universities and other centres) environments. In addition, 75 actions or events have been carried out in different locations in Spain for the local promotion of LNG, including the activities that have been performed in those specific areas.



08. Impacts in the case of Spain

- LNG bunkering impact and development

Throughout these years, Spain has stood out as a world leader in the supply of LNG as fuel for vessels.

LNG bunkering in Spain is becoming increasingly more flexible and efficient through multi truck-to-ship operations, which are now being carried out in the Ports of Huelva and Valencia. These operations are carried out with several tankers at the same time, increasing the transfer flow and thus bringing down refuelling time.

As for the number of LNG-powered vessels, eleven LNG-powered vessels (ferries, cruise ships, tugboats and other types) operate in Spain.

As for the volume of LNG supplied since the beginning of the project, its evolution is shown below:

Illustration 7 Evolution of LNG bunkering in Spain (m3 of LNG). Source: GASNAM

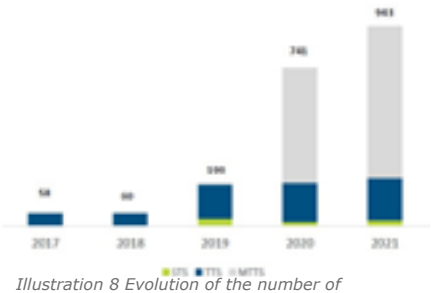


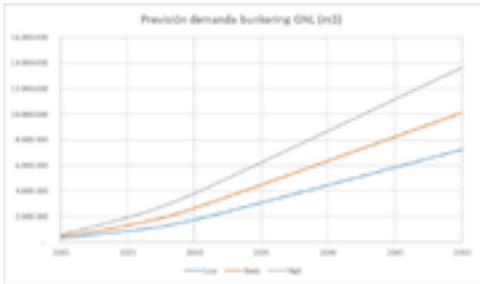
Illustration 8 Evolution of the number of operations by type of bunkering. Source: GASNAM

In 2021 and compared to 2020, the number of bunkering operations has increased by 27% (741 operations in 2020 and 943 operations in 2021), and the volume supplied has increased by 17% (122,058 m3 in 2020 and 142,523 m3 in 2021).

In 2021, orders for LNG-powered vessels have soared, adding 240 new orders, closing the year with 400 LNG carriers on order.

There are currently 368 LNG-powered vessels, of which 247 are already in operation (17 more than in the previous month) and 121 LNG ready. So far this year, 58 LNG-powered vessels have been put into operation, the highest number of LNG-fuelled vessels chartered in one year in the last decade.

In addition, the LNG bunkering demand forecast made within the CORE LNGas hive project, updated in 2020, the following is expected:

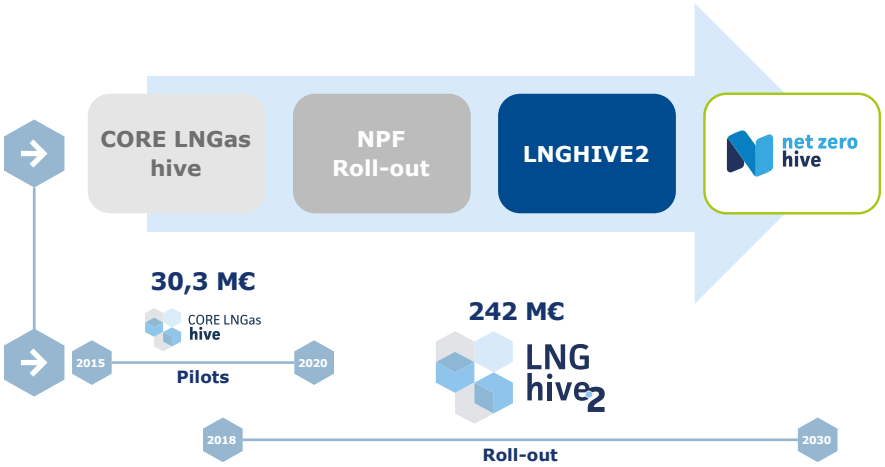



CORE LNGas
hive
LNG
hive2

PART III

09. The future of ports

The development of the CORE LNGas hive project as an innovation project and its roll-out through the LNGhive2 strategy has made it possible to lay the foundation for the decarbonisation of maritime transport and the port environment in the Iberian Peninsula since 2015 and with a time horizon of 2030.

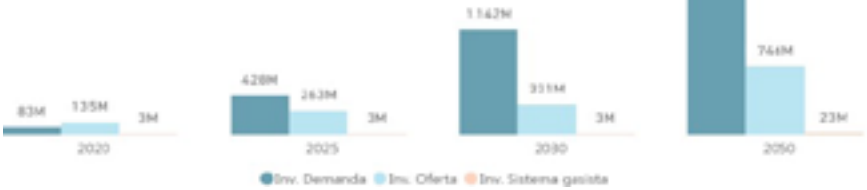


Investment figures reach EUR 242 million between supply and demand projects for LNG as a marine fuel.

As part of the framework of the first innovation project, and specifically within the roll-out activity, the evolution of both supply and demand in the time horizon up to 2050 has been studied. The report has enabled us to obtain the necessary infrastructure (optimized) to be able to guarantee the supply of LNG and also the decarbonisation of maritime transport in the Iberian Peninsula. Below is a summary of the estimated investments to be made in the supply, demand and infrastructure of the gas system.

Requerimiento de inversiones para el desarrollo del GNL como combustible marino

Tipos de buque	2020	2025	2030	2050
Bulk carriers & Tankers	15M €	88M €	368M €	2.175M €
Container ships	0M €	103M €	277M €	1.421M €
General cargo & Other	3M €	20M €	51M €	341M €
Passenger ship	114M €	209M €	227M €	553M €
Ro-Pax	55M €	232M €	263M €	504M €
Ro-Ro	25M €	25M €	25M €	70M €
Total	**212M €**	**678M €**	**1.221M €**	**5.064M €**
Buques	72M €	132M €	144M €	453M €
Feeders	34M €	34M €	90M €	121M €
Terminales	29M €	97M €	97M €	172M €
Total	**135M €**	**263M €**	**331M €**	**746M €**
Terminal de carga SS	0M €	0M €	0M €	20M €
Cargaderos	3M €	3M €	3M €	3M €
Total inversiones	**218M €**	**691M €**	**1.473M €**	**6.188M €**



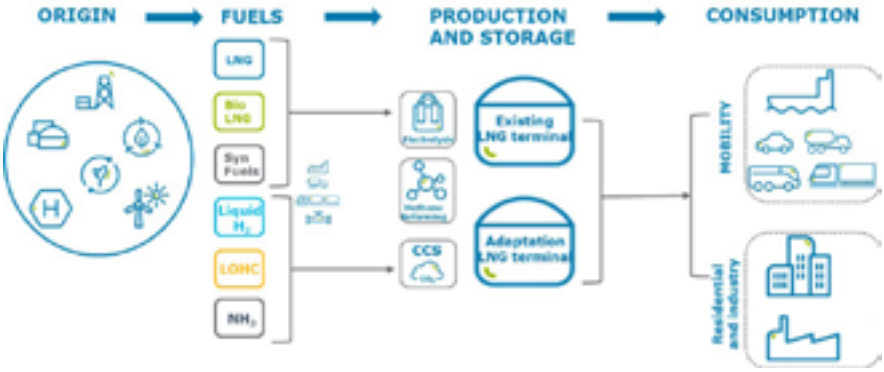
This resulting investment plan can place Spanish ports at the forefront of the global LNG supply market, provided that demand responds to exceed critical activity thresholds that guarantee competitive supply costs. The analysis of external costs avoided, with respect to the base case (conventional fuel) yields interesting data. According to the current plan, by 2030 cumulative investments in supply would reach EUR 364 million, to serve a fleet that would have invested EUR 1.220 billion in LNG adoption, generating annual external cost savings of EUR 555 million, which could reach approximately EUR 800 million if 20% biomethane is added. This implies a high "socio-environmental return" on the investments made and the potential aid granted to promote this roll-out of less than three years.

Taking the foregoing into consideration, the "LNG and renewable gases" alternative is more suitable and convenient as a decarbonisation alter-native in the short and medium term due to the high level of current technology and market development -more than 15% of the total ton-nage under construction refers to LNG-powered vessels and is supplied in more than 100 ports-, the flexibility it provides to modulate the fleet de-carbonization efforts -allowing the addition of different proportions of re-newable fuel and making a gradual effort in line with the future regulation

to be implemented-, and being an effective platform for the development of the demand for alternative or carbon neutral fuels, such as hydrogen (blended), biomethane or synthetic natural gas of renewable origin, by providing consumption points without requiring additional investments in infrastructures or propulsion systems.

Furthermore, the renewable gas alternative in Spain is favoured by the characteristics of the national gas system, which facilitates the supply of renewable gases under very competitive conditions with respect to other countries without the required LNG infrastructure or the extensive offer of logistic services of the Spanish gas system.

Accordingly, as part of the national effort to comply with the 2014/94 directive, the Paris agreement and the other commitments at European -especially the Green Deal and Fit for 55 initiatives- and national level, the LNGhive2 strategy proposes to boost the adoption of renewable gases -both biomethane and hydrogen- in maritime transport by supporting the roll-out of infrastructures, consumer vessels and LNG service industry -capable of consuming such renewable gases.



As a continuation of the LNGhive2 strategy, the total decarbonisation initiative was launched as part of the development of the roll-out of the first CORE LNGas hive project. This initiative aims to **decarbonise the port environment by promoting ports as energy hubs** and the main lever to bring together multimodal transport and begin the decarbonisation of all types of transport (road, rail and sea). At present, 40% of "heavy" goods move around ports, which are responsible for around 10% of Spain's emissions, so initiating the decarbonisation of transport by centralizing efforts around these logistics nodes is the best

way to optimize the efforts of the different agents involved. Specifically, the goals of this initiative are:

- **To speed up the deployment of low-carbon fuels** in the Spanish maritime-port sector
- **Promotion of ports as energy hubs and multimodal logistics nodes**
- **To decontaminate and decarbonise maritime transport and the port sector** in the short term and favour the integration of renewable gases in the energy mix in the medium and long term, both in the shipping and port sectors.

Illustration 9 Development of projects throughout the chain from the source to the end user

- **To increase the competitiveness of the maritime and port sector** by reducing operating costs and reducing the risk of obsolescence of investments as a result of future regulations on atmospheric emissions.

- **To promote industrial and social growth** in Spain by developing specialized services with high value-added aimed at the specific sector:

  a. Refineries and other energy sector facilities and plants in Spanish ports adapted for the production of low-carbon fuels such as bio-LNG, synthetic methane and hydrogen

  b. Low-carbon fuel supply for shipping and port applications

  c. Introduction of low carbon fuels in ports, dry ports and logistics corridors

To this end, a proposal is made to collect projects that bring together both supply and demand for the acceleration of decarbonisation in the maritime-port sector through innovative projects.

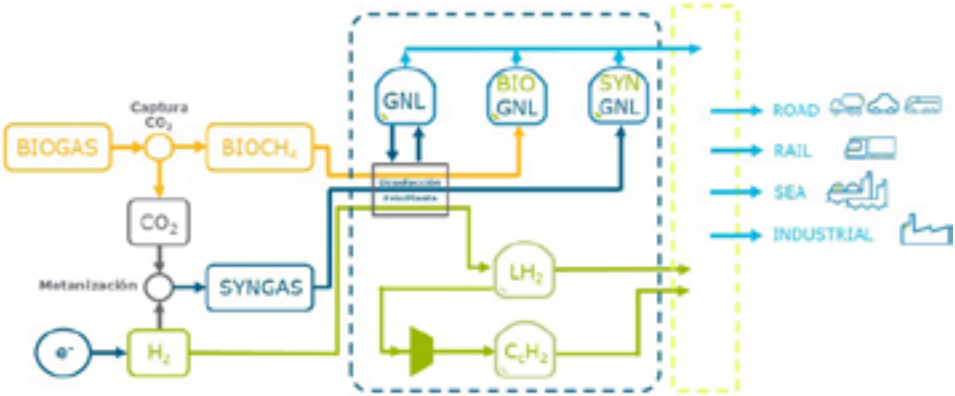


Illustration 10 Adaptation of plants, multimolecule logistic chain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