Engineering design of a multimodal LNG bunker berth in Huelva

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More Information

Public CORE LNGas hive reports and additional information related with the project execution and results are available through CORE LNGas hive public website at www.corelngashive.eu

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1. Introduction

The CORE LNGas hive project, coordinated by Enagas, aims at developing a set of studies with pilot tests in order to support the development of an integrated, safe and efficient logistics chain for the supply of LNG as marine fuel in the Iberian Peninsula. In accordance with EU Directive 2014/94 on the deployment of alternative fuels infrastructure (Clean Power for Transport), the project will contribute to the de-carbonization of the Mediterranean and Atlantic corridors.

Due to its strategic location, the Port of Huelva could become a referent in vessels bunkering. This is the reason of performing a study of the possibilities for bunker berth in this port. Once selected the best option, with a multimodal view, the aim is to carry out the detailed engineering of the terminal adaptation and the conceptual design of the extension.

2. Preliminary study "*Feasibility study for new logistics services offered*"

2.1 Introduction

The Port of Huelva has a very important geostrategic location, close to the Gibraltar Strait and facing Atlantic Ocean. Together with existing LNG Regasification Plant, Port of Huelva is very well positioned in supplying of LNG as a bunker fuel.

Therefore, it is necessary to study how Port of Huelva will be able to supply not only bunker barge supplying Gibraltar Strait, but also alternatives to give LNG bunker directly, taking into account the different alternatives that offer to have a Regasification Plant.

On the other hand, this LNG facility has a berth with two sets of loading arms: compatible with ships up to 173,400 m3. So it is necessary to study if it is feasible to use small loading arms, taking into account that share berth with the bigger ones. On the contrary, it could be necessary to take advance of close berths to the Plant that could offer different ways of giving LNG bunker: pipe to ship, truck to ship and transfer of containers.

Firstly, EV7 will study alternatives of a bunker berth in the Port of Huelva, with a multimodal view and, once selected the best option, will start engineering works to produce a basic project of the solution.

For this purpose, the Port of Huelva carried out a first study "Feasibility study of the new logistics services offered" by *Ghenova Ingeniería*. This document is divided into several chapters, the first chapter provides a general description of the current status of LNG taken as an alternative fuel to other fossil fuels, describing the environmental and economic characteristics that position it against these other fuels. The current availability of infrastructure in ports for the supply of LNG as a fuel is noted and, finally, the existing technologies for the containment of LNG, propulsion systems and fleet of vessels with this fuel are commented on.

It also includes the regulations and legislation that circumscribe the object of this study, both from the point of view of emissions regulation and that which could affect the technical definition of the installations on land and on ships to be able to deliver and receive LNG as fuel. In addition, this study includes a description of the physical, environmental and socioeconomic conditions surrounding the port of Huelva, in relation to achieving the final objective, which is the availability of suitable facilities for the supply of LNG as fuel to ships.

The complete document can be found in Annex 1 *"feasibility study for new logistics services offered".*

2.2 Potential of LNG as a marine fuel

At the moment there is a growth in turnover due to the emerging use of liquefied natural gas (LNG) as a fuel due to several environmental and economic factors.

The main environmental factor is the lower values of CO2, SOx, NOx and particle emissions compared to other fossil fuels. This characteristic includes it among the alternative fuels contemplated in the different incentive plans for the creation of infrastructures for the supply of LNG for the maritime sector, as well as one of the possible fuels to be used within the areas of limitation of emissions regulated by the different regulations at a global, European, national and local level.

Another of the conditioning aspects of the development of the use of LNG as a fuel is the economic one, that is, the price of this fuel compared to other conventional fossil fuels.

The environmental and price advantages are allowing the increased use as fuel but the necessary infrastructure for fuel supply on land are not yet sufficiently adequate and are hampering the growth of the fleet of ships, which in turn is slowing down investment in storage infrastructure for supply due to the lack of potential customers. For this reason, the EU and the Member States are providing incentives in both areas for the transition or changeover to LNG, so that the prices of the necessary technology can be reduced, which would serve as a favourable vector for new investment.

One of the important factors conditioning refuelling operations, and therefore the growth of the fleet of ships using LNG as fuel, is the availability of refuelling infrastructure. This refuelling to the receiver can be carried out from an onshore facility by pipeline (Pipeline To Ship, PTS), from tank trucks (Truck To Ship, TTS), from another vessel (Ship To Ship, STS) and using iso-containers, by which intermodality can be used, either with the containers being transported by truck, train or by a combination of other means of transport and arranged on board the receiving vessel with the corresponding lifting gear.

From the above, it follows that depending on the characteristics of each port, and if a demand forecast is available, the most viable options can be analysed from the technical and economic point of view.

2.3 Demand study and analysis of the results

Based on the results obtained in the demand forecast for 2030 in "Annex 1 Feasibility study for new logistics services offered" the following conclusions were reached:

- Even the pessimistic analysis shows that by 2030, given the volumes expected from the tanks of ships that are going to use LNG, it is necessary to have some bunkering system other than the TTS, in order to give supply in times compatible with the operation of the ship.
- It is estimated that the minimum storage capacity for supply, the weekly volume should be 1500 m3 in the case of STS, which would cover the realistic to 2030 and in the short term the possible need to supply the regular passenger line plus some additional traffic.
- In the optimistic scenario in its upper range it would require the existence of more than one supply system. In this case, given the expected volumes the PTS option seems the most appropriate.
- The intermediate scenario would fit in with both STS and PTS, with the study being carried out in phase 3 to ascertain the impact of costs necessary for the installation of the PTS system at the Enagás or Foret in order to determine suitability in this scenario.
- The TTS and iso container systems could be suitable in the transitional until to arrive at any of the three scenarios.
- There are additional opportunities to deepen the LNG demand for use in machinery, equipment and means of transport The port system and the local environment, which could be made compatible with the ship service.

2.4 Analysis of logistics solutions

In this section, an analysis is made of the advantages and disadvantages of each of the alternatives studied, taking into account the investment and operating costs associated with each system. See annex I where you can find all the explanation.

The following is a summary of the recommended optimal volumes, maximum flows, auxiliary operating times, advantages and the drawbacks of each type of bunkering.

Tabla 1 Comparative summary of characteristics by type of bunkering

	TTS	STS	TPS
Volúmenes	<100 m3	>1000 m3 (>100 m3 con barcaza)	>100 m3
Caudal máximo	60 m3/h	2.000 m3/h	400 m3/h (200 m3/h para tanques tipo "C")
Tiempo medio de operaciones aux. (*)	1.5 h	2.5 h	1 h
Ventajas	Flexibilidad	Flexibilidad	
	Bajos costes (inversión y operación)	Gran capacidad de carga	Grandes volúmenes
		Grandes volúmenes	Rapidez del procedimiento de búnkering
		Suministro en mar (expansión del mercado)	
Desventajas	Pequeñas cantidades	Grandes costes (inversión y operación)	Muelles especializados
	Bajas tasas de carga		Ocupación del espacio de la terminal

* Times include auxiliary transfer operations (upstream and downstream operations required for coupling, compliance with safety protocols, etc.)

The above table does not include the CTS option since this method has not yet been applied and the design is yet to be defined by the IGF code. The equipment and facilities for this type of bunker are very similar to those for loading/unloading/ handling standardized containers for transporting goods tanker general.

An analysis of advantages and disadvantages is then made for each of the types of bunkering studied, including the associated costs from a qualitative point of view. Other sections of this study include an estimate of the investment costs associated with the STS and PTS options. For more details see Annex I.

Based on the information provided on the different bunker modes analysed in the study (Annex I), the comparison between them in terms of volumes, flows, operation times and costs, and on the other hand the analysis of advantages and disadvantages of each of them, allows us to conclude the following:

- The STS and TPS modes have the highest capacity and flow rates LNG transfer. In turn, they are best suited to supply a greater number of vessel types or supplies.
- The STS and PTS systems are those that require the greatest initial investment, and in the case of PTS, operating costs are also important. The particularity on the use of existing facilities, necessary adaptations, etc...are described earlier in the study (Annex I). Evaluating for the PTS mode about 3 different options/locations, and for STS the reform of the existing barge and the construction of a new barge.
- The two systems mentioned above have disadvantages from the point of view of operation and possible interference with other operations or with the traffic of other boats.
- The TTS system has a high flexibility of operation and with respect to location. It is also an approved system with regulations specific. But it has the disadvantage of low load capacities due to tank and limitation of operation times due to flow rates reduced.
- The CTS mode is a simplified system that has advantages over interference and intermodal possibilities. However, it is a system not implemented on vessels, pending inclusion in the IGF code.
- As regards the TTS supply as a measure to mitigate the above-mentioned limitation there is the possibility of using a system for coupling several tanks in one device in such a way that the total flow is multiplied by the total number of tanks that can be connected to that device, thus reducing the refuelling operation times. The development of this multi-truck refuelling system is therefore very useful for any demand situation for the refuelling of small or medium sized vessels.

3. Basic design of multi-truck to ship system

3.1 Background

As one of the conclusions of the first study carried out by the Port of Huelva, it was to carry out a conceptual design of a multi-truck to ship system that would allow LNG bunkering operations to be carried out with several tanks at the same time, thus allowing loading times to be reduced and adjusting to demand and ship call times in the Port of Huelva.

3.2 Description of the Multi-truck to Ship (MTTS) System

The basic features of the description of the multi-truck to Ship (MTTS) are defined below:

This system is designed to facilitate the operation of filling LNG fuel tanks on ships of up to 500 m3, from tanker trucks.

The design flow rate for filling the LNG fuel tank on ships will be 200 m3/h. That is to say, it should be possible to reach this flow rate when the system is operating 'at speed'.

All the elements of the installation shall be mounted on a portable open skid or frame of standard "20' container" dimensions.

The ship's fuel tank shall be filled from tankers. Up to three tankers can be unloaded simultaneously. The design will allow for uninterrupted filling operation upon completion of the emptying of each tank. The system will allow the eventual depressurization of a fourth truck at the same time.

The connection to the tanks with the MTTS system will be made by means of 3" hoses equipped with quick coupling and dry closure to avoid the need to perform emptying, inerting, filling and cold start between tanks, thus minimizing connection times.

The transfer of LNG from the tanks will be carried out by pumping. Three centrifugal pumps are supplied, each one aligned with each of the three tanks that are unloaded simultaneously.

During the detailed design phase, depending on the recommendations of the selected pump supplier, the need to provide for pump recirculation from the MTTS system to the tanks will be assessed. If necessary, this will be done by means of 2" hoses equipped with quick coupling and dry closure.

The installation shall have a small atmospheric vaporisation system that allows the operating pressure of the tanks to be increased to keep it within the operating limits as they are emptied.

A manifold will be installed for the return of vapour to the tanks. The connection to the tanks with the MTTS steam manifold will be made using 2" hoses with quick coupling and dry closure to minimise the connection time between tanks.

The transfer of LNG from the MTTS system to the ship shall be carried out by means of a single 4" hose. This hose shall be fitted with a mechanical emergency breaking system (BRS) so that the system is sectored in the event of possible over-elongation and/or hose rupture in the event of the vessel's undocking.

A conventional flow meter shall be installed to measure the LNG transferred to the ship. It is not considered necessary to equip the MTTS system with fiscal measurement elements. It is considered that invoicing will be done by the difference in weight of the unloaded tanks.

The control of the installation will be completely manual under the supervision of an expert LNG transfer operator.

The filling system will also have an instrumented emergency stop system (local PLC) that will interrupt the operation in case of emergency, stopping the pumps and interrupting the LNG supply to the ship by means of an electrically operated valve.

The circuits shall be fitted with connections for nitrogen purging at the start and end of the loading operation.

Electrical elements and instrumentation shall be suitable for explosive atmospheres. The installation will have a single point for the connection of electrical supply from the outside. It will also have a point for grounding.

The lines, hoses and equipment will be cryogenic, suitable for a working temperature of -160 ºC

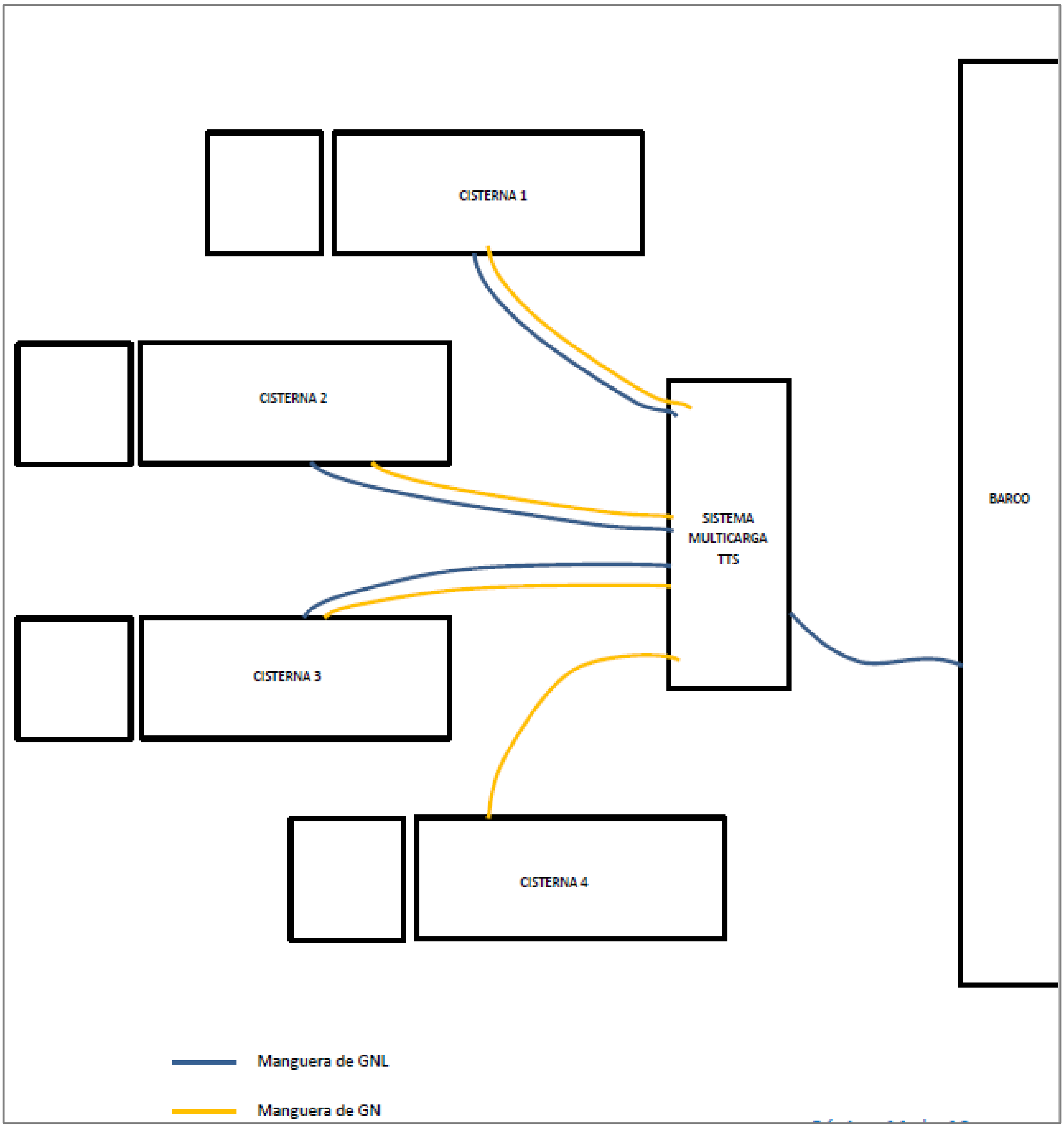

Ilustración 1 Example of tank, skid and vessel layout

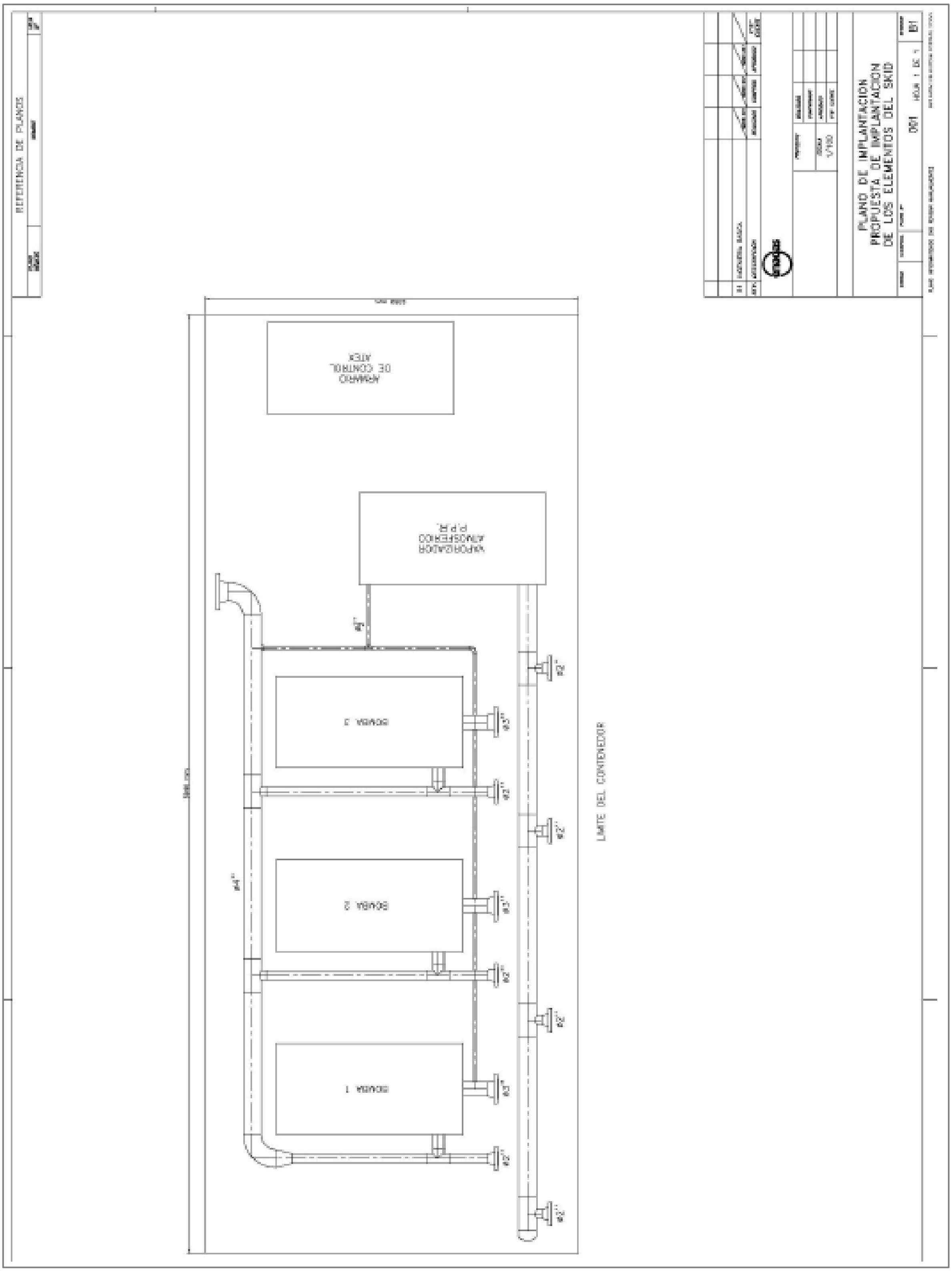

Ilustración 2 Proposal for the implementation of the main elements of the MTTS skid. Enagás

4. Smallscale ship loading facilities project

4.1. Scope

The purpose of this document is to describe the actions planned in the project "LOADING OF SMALL CAPACITY VESSELS" in the facilities of the regasification plant of Enagás in Palos de la Frontera, Huelva, designed in accordance with current applicable regulations, to namely, the standard UNE-EN1473 "Installations and equipment for liquefied natural gas. Design of the facilities" as well as the UNE-EN-ISO 28460 "Facilities and equipment for liquefied natural gas. Shipping interface and port operations"

4.2. Project description

The new facility is designed to carry out LNG loading on small capacity ships, ranging from 600 to 5,000 m3. The design ranges of the flow rate and loading pressure will be 140-400 m3/h and 1-4 barg. It will be carried out in the existing jetty and the operation cannot be simultaneous with the unloading of LNG from methane tankers.

4.3. Elements of the installation

Loading circuit

Smallscale ships can be loaded from any of the tanks existing in the installation. For this purpose, the LNG will be driven from the primary pump delivery manifold to the LNG line (where it will perform the pitting of the new installation) connecting the 30'' and 20'' discharge manifolds on the dock.
The ship's BOG return will be conducted through the new installation to the boiloff manifold located in the berthing area of ships from 70,000 to 180,000 m3.

New LNG filling installation

- ### Filling line

The new line for bunkering of 6'' nominal diameter bites into the line that connects the 30'' and 20'' collectors in the berthing area. This line extends to the point of connection to the ship located at dock level. The line has: a pneumatically actuated isolation valve with a 1'' by-pass valve for the cold maintenance of the new installation at a minimum distance from the pitting to the LNG line; two temperature transmitters, a fiscal flow meter type Coriolis flanged to the line, a flow control, a check valve that prevents the flow two pressure transmitters and an automatic LNG shut-off valve Pneumatic actuation.

The line is protected by three new thermal expansion valves for avoid overpressure in case of LNG containment.

• Recirculation line

In the new line for bunkering, a bifurcation is included that connects to the existing cold maintenance line that goes to the reliquefier. This branch is upstream of the control valve, and at a distance to ensure a temperature of around -160ºC in the fiscal flow meter during the bunkering operation. At this temperature, the current is in single-phase (liquid) mode, thus avoiding the presence of gas in the fiscal flow meter.

This line has: a manual valve with internal vent of 2'' (0107V32) with detector of Limit switches (closed) on request of the tax measuring system and a thermal expansion (PSV-3224) to avoid overpressure in case of LNG confinement.

• Fiscal Meter

It consists of a Coriolis type mass flow meter (FE-3225), and all its associated installation and necessary to obtain the certificates by the NMi as "Custody Transfer" according to MID, required by the new functionality of the terminal.

• Filling flow control

A flow control valve is installed at a minimum distance from the bunkering connection to maintain pressure in the load line. This prevents vaporization of the LNG, especially at the fiscal measurement point. The flow control loop uses the signal from the fiscal flow meter.

The valve has a drain and a by-pass with a 1" manual valve for the cold start prior to the load operation of the downstream line section of that valve.

• Sectioning system

The new installation has a pneumatically actuated ball switching valve (0n-off) (XV-3222) and the line size to ensure the integrity of the installation and to sectorize the terminal in case of emergency events. In this way, the fixed elements, which are inside the terminal, would be isolated from the elements subject to movement of the ship.

This valve, actuated from the emergency shutdown system (ESD), has associated the necessary process interlocks to guarantee a safe operation of the installation at all times.

In addition to acting on this valve, the ESD (as explained later) will also act on the flow control valve by actuating its solenoid valve and on the other valve.

The system is also automatically switched off by the active safety system (F&G) when there is a risk in the area due to the presence of gas or fire.

LNG Hose, the ship-to-shore interconnection shall be made for LNG by using 6" in diameter. The handling of the hoses, as well as their interconnection to the ship and the use of saddles and hose fall arresters will be carried out by using a crane.

The hoses, support elements and anti-fall elements shall be provided by the boat and shall be designed, as well as properly maintained, to ensure the integrity of the installation.

• Emergency release system

To minimize the consequences in case of tension that could cause the rupture of the discharge hoses or the flanges that fasten them, a disconnection system is installed (BRC) that allows quick and safe disconnection by isolating the hoses and thus avoiding the LNG spill.

This emergency rupture system is part of the hoses and will also be provided by the boat, which should ensure that it is designed, as well as with the correct maintenance, to guarantee the integrity of the installation.

• Gas and fire detection system

Three flame detectors and three gas detectors are used in the bunkering area to meet the demands of the new facility.

• Fire fighting system (ICS)

The existing control post in the bunkering area is used to cover the demands of the new facility.

• Spillage collection system

Included is the design of a spill containment basin that will also be protected by a foam system.

• Drainage system

After the loading operation, the LNG will be drained through the LNG line which connects to the existing line GNL which collects the drains from the unloading arms of the berth from 70.000 to 180.00 m3. This new line has a 1" manual shut-off valve with limit switch (closed) for requirement of the fiscal measurement system; and a check valve for avoid reverse flow. Drainage will be done by nitrogen injection from the N-line.

5. Study "SELECTION OF ALTERNATIVES FOR THE EXTENSION OF THE ENAGÁS BERTH IN THE PORT OF HUELVA"

5.1. Background

According to different studies, on the actual and potential LNG demand for maritime transport and port services and the evolution of LNG efficient, secure and strong supply logistic chains in the Spanish and Portuguese core network with particular emphasis in the Atlantic and Mediterranean core corridors, including the extension to peripheral regions and third countries bye means an specific approach to the Gibraltar strait, carried out by consulting agencies in the activities Studies ET2, ET3, ET4, as DNVGL and SBC, significant grows in demand for the use of LNG as fuel for ships are expected in ports in the geography of southern Spain, like Cádiz, Algeciras, Gibraltar, Tánger, Ceuta and Canary Islands, also Huelva itself, among others.

Due to the fact of its geographic location, its characteristic, and especially because of having a virtual unlimited source of LNG – a Regasification Terminal - , the port of Huelva represents an ideal hub to serve such a demand.

Despite the aforementioned, nowadays the port of Huelva capacity to face referenced demand, it is limited, in turn, to the capabilities of its Regasification Terminal, which actually features a single berthing of vessels.

This single berthing has been initially dimensioned to serve methane tankers (large scale operations); as the number of transferring operations of LNG as fuel for ships (or small scale) increases, the existing berth could become saturated, reaching the moment in time when it would not be able to cope with all the expected requests: a combination of large scale and small scale operations.

As a solution to the aforementioned problem, it is proposed to unfold the existing berth, through the construction of a brand new dedicated berth for small-scale operations, which will operate independently from the existing one at present. As a consequence of this, considerably increasing the capacity of the Port of Huelva in supplying LNG as fuel for ships, providing wide coverage for any demand scenario.

The purpose of this document is to gather the analysis and reflections carried out during the conceptual design phase in the study of the different alternatives to provide a solution to the problem posed.

The study of alternatives analyses the different solutions for port infrastructure and the layout of LNG lines for ship loading. The process aspects have been taken into account in order to plan the interconnection points and to foresee the space requirements on the platform, although the dimensioning of the loading equipment has not been analysed in detail at this stage.

5.2. Study of the fleet

Which considers mainly the operation of small-capacity methane carriers at the terminal.

Consequently, the design fleet only includes small-capacity LNG carriers dedicated to transporting LNG either for bunkering operations or for delivery to other terminals (feeder). These vessels range from 30,000 m3 to 600m3 LNG capacity, and has been completed with both atmospheric and Type C tanks.

In the elaboration of the list included below, both the fleet of this type of ships in operation and the typical fleet included in different publications have been taken into account. Some of the ships analysed are still in the project phase.

Tabla 2 Fleet

BUQUES DE DISEÑO										
BUQUE	CAPACIDAD GNL	CAPACIDAD GNL	NOMBRE BUQUE	TPM	Δ pc	L (m)	Lpp (m)	B (m)	T (m)	D|max (m)
1	BUQUE MAXIMO	30.000	30.000 M3 LNG FEEDER VESSEL (TIPICO)	17.600	26.400	184,60	175,20	27,60	18,50	8,80
2	BUQUE MEDIO	16.500	CORAL ENERGY	12.345	18.518	155,00	146,00	22,70	14,95	8,19
3		10.000	UNNAMED (WARTSILA)	7.200	10.800	124,90	117,20	22,40	11,80	6,60
4		6.500	CARDISSA. (Shell BV)	5.320	7.980	119,90	112,93	19,40	10,21	5,80
5		6.500	CORAL ANTHELIA	6.221	9.332	115,00	108,80	16,80	9,80	7,00
6		4.000	4000 BUNKER VESSEL	2.820	4.230	90,00	86,77	15,70	9,40	5,10
7	BUQUE MININO	2.200	CLEAN JACKSONVILLE-GTT (PROYECTO)	1.130	1.695	64,62	60,87	14,79	4,78	2,60
8		2.000	2000 BUNKER VESSEL	1.707	2.561	70,00	66,90	14,80	8,10	4,06
9		800	SPABUNKER CUARENTA	4.200	6.300	73,90	69,61	16,25	7,60	6,20
10		800	FKLAB L1 (PROYECTO)	850	1.275	67,60	61,00	11,60	4,80	3,50
11		600	OIZMENDI	3.200	4.800	73,50	69,23	15,00	4,20	3,10

TPM = toneladas de peso muerto
ΔPC = desplazamiento máximo del buque (plena carga). A partir de la ROM
L = eslora total del buque

Lpp = eslora entre perpend
B =manga del buque
T = puntal del buque
D= Calado del buque

En azul, valores estimados a partir de otros buques similares

5.3. Location options

In order to analyze the different location alternatives, it is necessary to know the draught requirements and the manoeuvring circle, for which reason the following are calculated such needs.

- ### Terminal draught

The draught of the berth (ha) must allow all the vessels of the fleet to stay expected at berth in the expected load situations, with a certain level of operation.

The necessary draught in the berth line with respect to the reference level is a function of the maximum vessel draught including under-keel shelter taking into consideration the aspects of trimming, swell, etc.

In simple terms, the mooring draught can be estimated by formulating the ROM 2.0-11 which, for vessels of 10,000 t or more.

According to these criteria, the nominal draught required for the design ship, from a berth (h1) located in sheltered waters, taking into account ship-related factors, would be 9.50 m, sufficient for the maximum loaded draught type ship, equal to 8.80 m.

• Maneuverability

As a preliminary measure and in order to detect possible interference during the approach and return maneuvre to the berth, in accordance with ROM 3.1-99. Maritime configuration ports, the following values of the maneuvering circle of the largest vessel are established

Tabla 3 Dimensions of the manoeuvring circle for a 30.000 m3 ship.

CIRCULO DE MANIOBRA BUQUE 30.000 m^3	
Dimensiones	(m)
L	184,60
R_{cr}	147,68
L_G	64,61
B_G	18,46
2 x L_G =	129,22
2 x L_G x 1,6 x L	424,58
2 x B_G x 1,6 x L	332,28

5.4. Location options

Two possible alternatives have been considered for the location of the berth terminal, considering the aspects mentioned in previous sections, the needs of draught and requirements for maneuvering. In both cases, berthing is planned outside the navigation channel so that there is no interference with the normal operation of the existing terminal.

Its orientation, significantly parallel to the channel, is justified by the lesser effect of the currents, which in the absence of waves is the most important hydrodynamic action.

The ROM also recommends safety guards for goods berths the shipowner, the shipowner's agent or the shipowner's representative, shall be responsible for the safety of the ship and for the safety of the ship distances of 50-150 m. The value of 50 meters is met for each of the alternatives of dimensions that are raised in the following sections.

- ### Option U.1. Close to the coast

The first option proposes a terminal further away from the navigation channel, with access to the platform at a distance of approximately 250 m from the coast line.

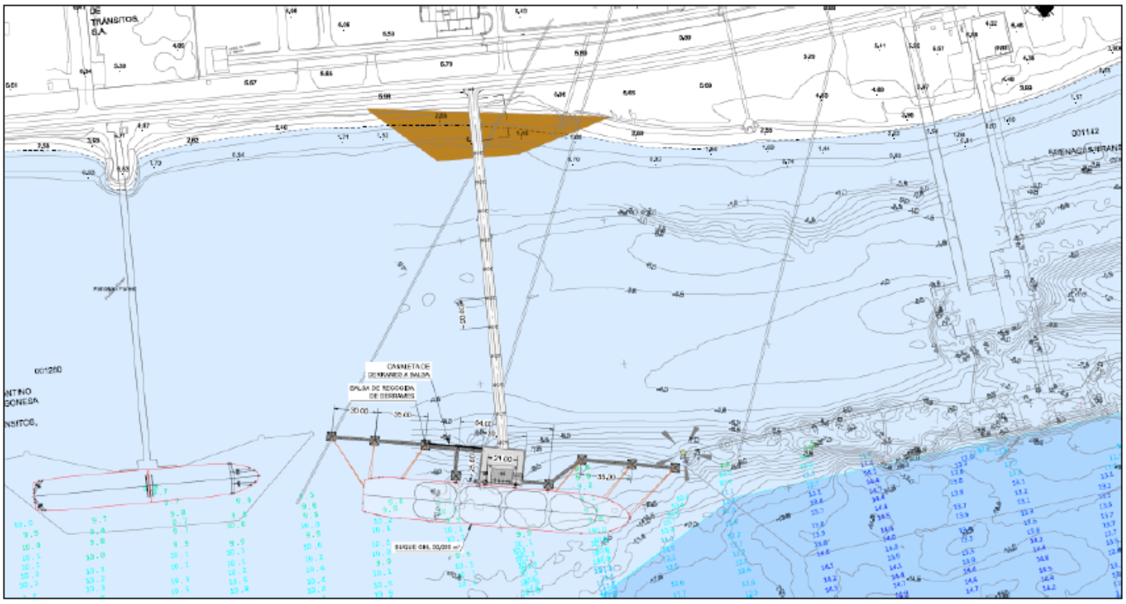

Ilustración 3 Location of the terminal with bathymetry OP1

As can be seen in the image below, this location ensures the maneuverability of the larger design vessel, without interfering with adjacent berths.

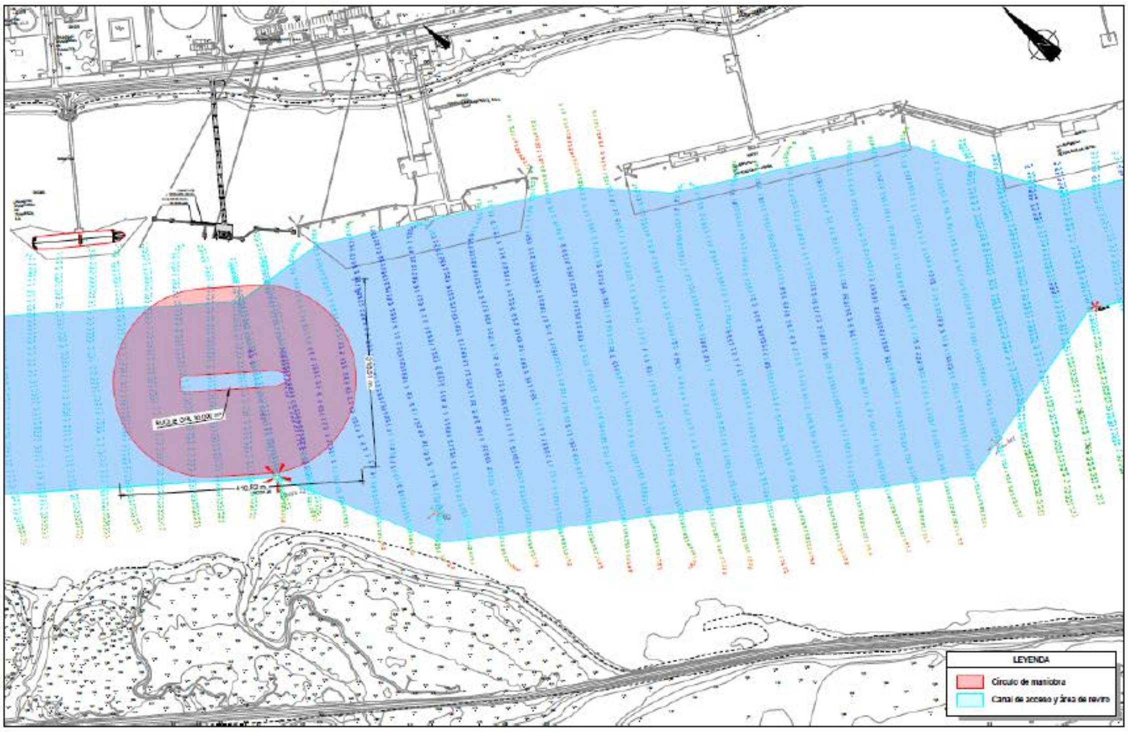

Ilustración 4 Maneuvering circle.

The main drawback would be, with the information available, the interference that would would produce with at least one of the existing emissaries. If Enagas were to opt for this possibility, consideration should be given to the likely need to shorten This would involve, in addition to the cost, interference with the operation of the plant during construction, the need for detailed studies to obtain new permits, such as environmental and dilution studies to process a new discharge authorization, or a possible modification of the Environmental Impact Statement.

The estimated volume of dredging at this location is very small, as there are only areas located with a bathymetric level of more than -9.5 m. It might be advisable to analyze the areas of erosion/sedimentation due to piles in order to estimate the maintenance dredging requirements, although these are considered negligible due to not to be a serious piece of work.

In this option, the area in which dredging must be kept at the -9.50 with respect to the alternative presented below. In any case, dredging at is not very important, since you already have the draft necessary.

The dredging to reach the -9.5 m level, without counting the overdredging, is estimated at about 3,225 m3 , which means a cost of 50,000 €, if you take advantage of a dredging work that is performing in the area.

This location is considered technically feasible but would require a further analysis of the impact it may have on the aspects related to the emissaries and the management of environmental permits.

In view of this situation, which at first sight may seem complex, the following section analyzes another option that allows to save the inconveniences found in this location.

• Option U.2. Further from the coast

In this case, the mooring line is moved forward and turned slightly to avoid interference with the existing outfalls and to separate from the channel slopes and the current mooring, with better draughts. The mooring line is approximately -10 bathymetric and the length of the access bridge is increased by about 40m with respect to the solution proposed in the previous section.

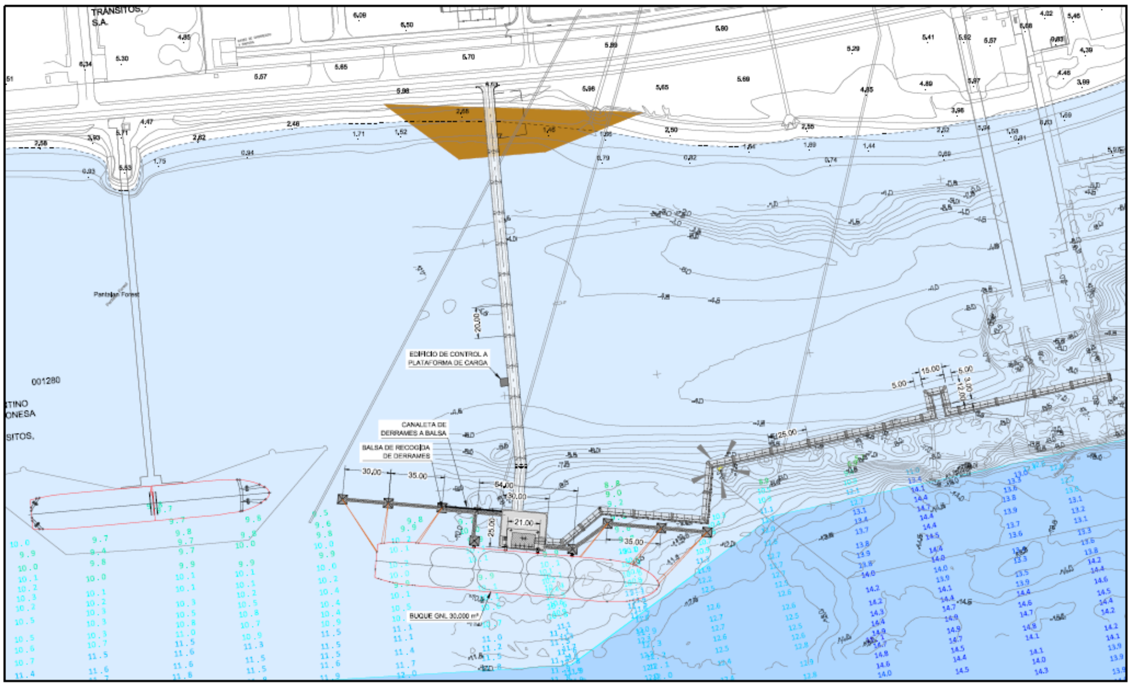

Ilustración 5 Location of the terminal with bathymetry OP2

Maneuverability should be studied in detail, although, as can be seen in the The following figure shows that the manoeuvring circle can be made safely within the channel and the space available to the berth, deserving special consideration how the operation and manoeuvres on the jetty of Foret.

In any of the proposed alternatives and in order to optimize the joint exploitation of the future moorings of the terminal will study the manoeuvres on both piers of Enagás when you have boats in both terminals and in the neighboring Foret's dock.

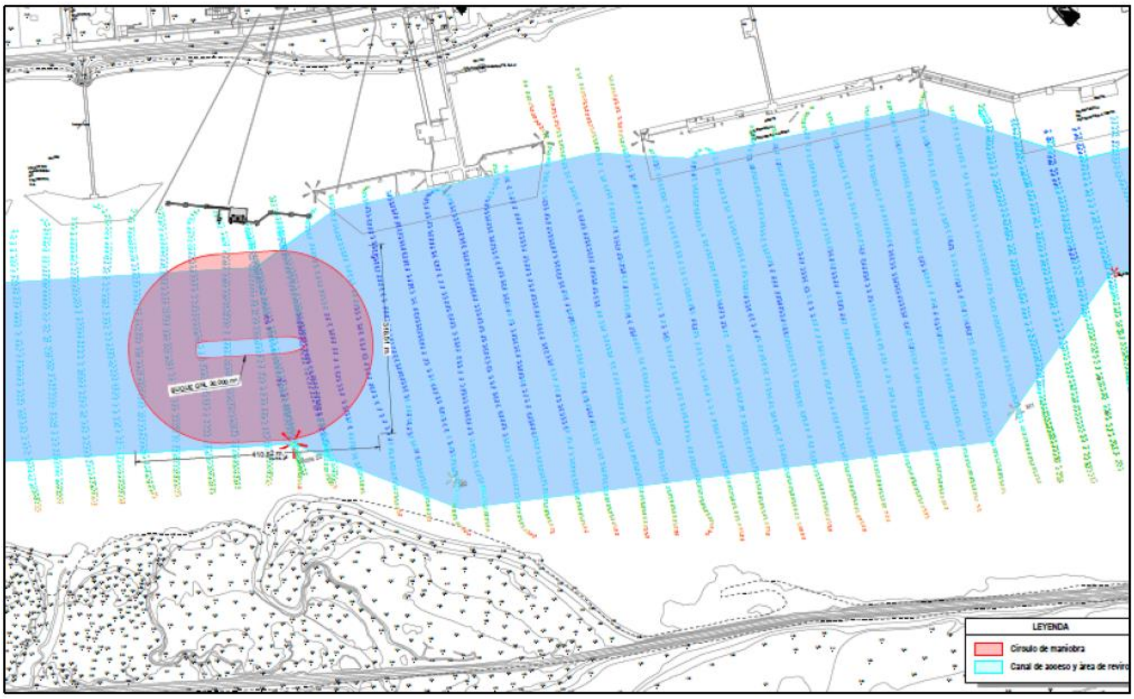

Ilustración 6 Maneuvering circle

The main advantages of this location are, as mentioned, the possibility of avoiding interference with existing emitters as well as less need of maintenance dredging.

As disadvantages we found the need to study in detail a possible condition to the manoeuvre on the Foret pontoon, a longer length of the access pontoon and the lines of interconnections (40m approximately).

This location is also considered viable and a priori, it seems to have a lesser complexity of administrative processing.

Taking into account the criteria for the estimation of costs followed in sections of this same study, since the only difference between the two options is the distance to the coast, it could be estimated that the cost increase in the construction of this second one with respect to the first one would be about 320,000€ This saving from the more The fact that the number of people in the area is closer to the coast than further away could be cancelled out by the possible need to modification of existing outfalls, increased dredging requirements and a more complex administrative management. The assessment of these aspects is not the subject of this studio.

In terms of time, this second option could require about 2 more months' construction work which is estimated to be unrepresentative of the total time required in the project from its conception to its completion.

As with economic aspects, it should also be borne in mind that the modifications of the emissaries required in the first option, would have an important impact on project planning, mainly due to the need to process special permits.

ANNEX I "Feasibility study for new logistics services offered”