Flexible LNG bunkering value chain in the Spanish Mediterranean Coast
BunkerLogix project objectives
Natural gas is an attractive alternative to traditional liquid fuels in maritime transport

Regulatory, economic and environmental factors are driving the use of alternative energy in transport, and natural gas represents an attractive alternative

Maritime transport is experiencing regulatory changes with the establishment of ECAs (Emission Control Areas) and international limitations of emissions.

Sulphur emission levels were limited to 0.1% in 2015 in ECAs and will be limited to 0.5% globally in 2020, which will require adapting the existing fleet. LNG is being considered as one of the alternatives to current fuels in maritime transport, as it reduces emissions considerably, complying with regulation limits and at a reasonable cost.

In the case of Spain, these limits are ratified through the Directive 2012/33/EU, where it is said that the member states will take all necessary measures to guarantee that in its territories, no fuel with a sulphur content higher than 0.5% will be used for maritime transport from 1st January 2020.

Emission limits in ECAs and globally

Source: AEC Maritime

ECA globally

Source: DNV GL
The project objective was to overcome the existing barriers for the establishment of a LNG bunker supply chain in the Mediterranean.

The main objective was to identify the requirements to overcome the existing barriers for the development of a LNG bunkering value chain, giving security of supply to ships in the Spanish Mediterranean Coast, managing the LNG bunkering technical, operational, economic and legal aspects in the medium term.

The specific objectives of the project included:

- **Design a supply chain** based in a LNG bunker vessel and existing gas infrastructure
- Analyze in detail the operational implications of the LNG bunkering activities in the main Spanish ports in the Mediterranean coast
- Contribute to the definition of the LNG bunkering regulation in Spain, harmonizing it with current practices in the North and Baltic Sea and developments at European level
- To develop the roadmap for obtaining the necessary permits in order to be able to carry out the LNG bunkering activity
- To quantify the necessary demand to make viable the investments needed for the future LNG facilities and analysis of the best suited logistic solution
Thanks to the collaboration of different companies and synergies between them the objectives were successfully achieved.
The LNG bunker vessel was designed compatible with the existing gas and port infrastructure in Spain

Main activities of technical analysis

- Interaction with ports and LNG terminals
- Evaluation of the potential bunkering areas
- LNG bunker vessel engineering
The procedures and other studies were developed under the operational analysis, in order to guarantee safety in operation.

**Main activities of operational analysis**

- Design of the *custody transfer and measurement system*
- Development of *loading and supply procedures*
- Maneuverability studies
- Shipping model
- Quality and HSSE studies

Seakeeping and hull forms optimization

Safety studies
The main objective of the legal analysis was the development of a roadmap for obtaining the necessary permits.

Main activities of legal analysis

- Analysis of current legislation at regional, national and international level
- Necessary permits identification and development of roadmap
- Development of port terms and conditions
Potential and minimum critical demand, and best suited logistic solution, which makes viable the LNG bunkering activity

Main activities of business model

- Market test to evaluate the potential demand in the different ports
- Development of an economic model to calculate the minimum critical demand to make viable the project

Example of results from the market test - 35 Companies (1,836 ships)

Regular routes (%)
- No: 29%
- Si: 71%

Plans to order new vessels 2014-2020 (% of companies)
- No: 43%
- Si: 57%

Plans to convert or order LNG ships in the medium-long term (% of companies)
- No: 29%
- Si: 71%
WP1&2: Technical and operative activities
The planning and execution of the engineering phases have been designed with the aim to achieve “ad-hoc” ships.

Engineering phase involves 3 blocks: Preliminary Studies (Technical Matrix, Ports analysis and Supply Strategy), Pre-FEED and FEED.

- Technical Matrix (compatibility envelope with regasification terminals)
- Supply strategy (conversion Vs. new built)
- Conceptual engineering
- Basic engineering (and complementary studies)
- Operability
- Flexibility
- Optimization

Vessel Capacities:
- 5,000 m³ Vessel
- 10,000 m³ Vessel
Specific studies prior to engineering phases had added value to ship design in technical, operational and compatibility terms.

**Ports**
1. **Infraestructure**
   Characterization of Ports and their potential permanent and dedicated berthing points
2. **LNG Bunkering**
   Identification and first dimensioning of susceptible and optimal areas for LNG bunkering operations

**LNG Terminals**

Geometric compatibility characterization of all the interaction elements between the LNG Terminal and the LNG Tanker to implement and guarantee their compatibility during the Engineering phases

**Strategy**

1. **Construction**
   Assessment of the most optimal strategy of construction: Conversion or New Building?
2. **Shipyards**
   Preliminary assessment of the most suitable shipyards to accomplish the construction
A essential milestone prior to the engineering phases was the analysis of terminals due to its influence on the naval design.
The results of the compatibility envelop matrix laid the foundations of naval design from first steps of the Pre-FEED

The aim was to achieve a common envelopment matrix that characterizes the interaction of the elements and facilities of all the LNG loading jetties considered (regasification Terminals) with the LNG Bunker Vessel.

- **Loading arms** (loading arms)
- **Mooring system** (mooring)
- **Fendering system** (fendering)
- **Gangway** (gangway)

Sources:
- nautic expo
- Ship technology
- Fender team
- gurskoy
A Port assessment was performed to characterize the marine facilities, infrastructure, anchorage areas & metocean data

The study of the maritime infrastructure involved to all ports under study in the project BunkerLogix

The assessment of the ports involved a deep analysis that covers the characterization of the maritime infrastructure, study of the anchorage areas and a specific metocean analysis of the conditions where the vessel has to perform its operational profile

Maritime-port infrastructure

- Permanent berthing points capable to serve as Base Port dedicated to the LNG Bunker Vessel

Anchorage areas

Metocean analysis

- Wind
- Swell
- Current
- Tides
- Visibility (Port Authority)

Cartagena Port

Barcelona Port

Valencia Port

Algeciras Port
Construction strategy procured the best solution to achieve the most flexible and optimized LNG Bunker Vessel, although specific services shall be subject to different optimization strategies.

**Conversion/New built**

The following alternatives were assessed, looking for the best solution, based on technical feasibility, cost and delivery time:

- **Conversions studied**
  - Product Tanker
  - LPG Tanker
  - Feeder/Bunker Tanker (HFO, MDO, MGO)
  - Multipurpose
  - General Cargo

- **New Building**

**Shipyards availability and delivery time (preliminary)**

A first assessment of potential shipyards able to build the ship (technology, experience, term and cost) was carried out:

Large, medium and small shipyards were analysed:

- Spanish shipyards
- European shipyards
- International shipyards

**Conclusion:**

A new building is the best solution.
The Pre-FEED studies lay the basis of the LNGBV* design to be completely defined, optimized and improved during the FEED

**Pre-FEED: Scope of the work**

<table>
<thead>
<tr>
<th>Cargo capacity (BoD)</th>
<th>Power plant</th>
</tr>
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<tbody>
<tr>
<td>- LNG Bunker Vessel: 5.000 m³</td>
<td>- Alternatives: DF-DE, ME-GI y PG</td>
</tr>
<tr>
<td>- LNG Bunker Vessel: 10.000 m³</td>
<td>- Power-Speed-SPC curve</td>
</tr>
<tr>
<td>- Specific operational profiles</td>
<td>- Preliminary configuration (EE)</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Cargo containment system</th>
<th>Cargo handling (NG/LNG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Number of cargo tanks and capacities</td>
<td>- Assessment (engines/consumers)</td>
</tr>
<tr>
<td>- Containment technology</td>
<td>- Operative condition (scenario)</td>
</tr>
<tr>
<td>- Isolation and BOR (%/day)</td>
<td>- Consumptions (BOG)</td>
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<thead>
<tr>
<th>Basic dimensioning</th>
<th>Vessel specification</th>
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</thead>
<tbody>
<tr>
<td>- Selected technology for the Cargo Containment System</td>
<td>- LNG Bunker Vessel (5.000 m³)</td>
</tr>
<tr>
<td>- Compatibility with LNG Terminals</td>
<td>- LNG Bunker Vessel (10.000 m³)</td>
</tr>
<tr>
<td>- Preliminary drawings and calculations</td>
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* LNG Bunker Vessel
Two different capacities were analysed in parallel, with different operational profiles

Capacity (LNG volume) and operative profiles

Capacity (LNG volume). Two different capacities were analysed in parallel:
- LNG Bunker Vessel: 5,000 m³
- LNG Bunker Vessel: 10,000 m³

Operational profile of the LNG Bunker Vessel:
Different operating profiles were assigned to each one of the vessels, assuming different modes of operation:

- Part of the time, they will be operating at port and designated areas for LNG supply
- The rest of the time, they will be operating as LNG supply vessel in wider range and also including small scale operations, to supply the total (or partial) capacity of the cargo in a terminal onshore

Source: CryoStar

Source: Tekna
The cargo containment system is one of the parameters with more influence over design and the ship operational profile.

Cargo Containment System (CCS)

Comparative study between CCS: membrane vs. type C tanks
- Properties and hazards of LNG as cargo
- Characteristics of membrane tanks: TGZ Mark III, GT No.96, CS1
- Features IMO type C tanks: bilobe or cylindrical type

Matrix of results derived from the comparative study (membrane-IMO C)
- Advantages and drawbacks of each system
- The optimal system for the ship’s operating profile (Holding Time concept)
- Dimensional comparison of each technology solution (membrane-IMO type C)
- Recommended solution (operational referrals from other similar vessels)

Cargo Containment System selected as best solution: IMO type C tanks
- Features of IMO type C tanks: cylindrical type or bilobe type
- Technical solution: IMO type C tanks (operational referrals from other similar vessels)
The study assessed all operative conditions, power demands, their consumptions and EE for different plant arrangements

Power plant and propulsion configuration

Preliminary disposal and configuration: power plant/propulsion

• Basis of Design (operational profile of the LNG Bunker Vessel)

• Comparative assessment of power demand/consumption in function of the possible scenarios (power balance):
  • Dual Fuel
  • Pure Gas

Proposal for the power plant and propulsion configuration

Different solutions were assessed for each one of the vessels (5,000m³ and 10,000m³) based on its operational profile and characteristics
The SoW covered the basic engineering design and the analysis of the operational implications

FEED: Scope of work (Basic Engineering and Operational Analysis)

TECHNICAL SPECIFICATION

EQUIPMENT LIST

TIC, O&M and TIC ESTIMATE REPORT

OVERAL PROJECT SCHEDULE

APPROVAL IN PRINCIPLE (DNV-GL)

NAVAL ARCHITECTURE

- General Arrangement
- Deck GA (manifold, crane, masts, etc.)
- Body Plan
- Bonjean Curves
- Hydrostatic Calculations
- Stability Cross Curves
- Lightship Weight Distribution
- Preliminary Intact Stability
- Preliminary Damage Stability
- Tonnage Calculation
- Freeboard Calculation
- Capacity Plan
- Body Plan Development
- CFD Hull Form Analysis
- Power-Speed Curve Prediction

POWER PLANT (MACHINERY)

- Engine room GA
- Aft Azimuth Thrusters Room GA
- Fwd Tunnel Thruster Room GA

STRUCTURAL ANALYSIS

- Midship Section
- WT Transversal Bulkheads

- Forward Sections
- Aft Sections
- Shell Expansion
- Main Deck
- Longitudinal Sections
- Hull Welding Table
- Superstructure-Front & Back B.
- Superstructure-Longitudinal S.
- Superstructure-Decks
- Superstructure-Wheelhouse
- Mast on Bridge
- Material Specification
- LNG Tank Structural Design
- LNG Cargo Tank Supports
- Midship Structure Calculations
- Long. Strength Hull ( Loads )
- Mooring Arrangement (Eq. number)
- Mooring equipment GA drawing

SERVICES AND SYSTEMS (PIDs)

- Bilge and Ballast System Concept D.
- Ballast System
- Aft and Fwd Bilge System
- Hold Space Bilge System
- Firefighting System Concept D.
- Fire SW System
- Fire System in Cargo Area-Water Spray
- Fire System in Cargo Area-Dry Powder

- Water Cooling System
- Fuel Oil System
- Lube Oil System
- Compressed Air System
- Exhaust Gas System
- CO2 System (or FM200)
- Air Vent System
- Sounding System
- Drain System
- Engine Room Ventilation
- GRU Room Ventilation
- Fwd Thruster Room Ventilation
- Aft Thruster Room Ventilation
- Accommodation General Arrangement
- Potable and FW (Hot-Cold)
- Sanitary Discharge Black Water
- Sanitary Discharge Grey Water

OPERATION & PROCEDURES

- Seakeeping and Station Keeping
- Maneuverability
- Mooring Dynamic Analysis (Terminals)
- Loading rate and BOG management
- LNG Transfer Solution
- LNG Transfer Procedure
- Crew Training Design
- Measurement System (CTMS)
- Logistic Model

SAFETY

- Spaces category: Bulkheads Fire Divis.
- Spaces category: Deck Fire division
- Electric One-Line Diagram
- Electric Load Calculation
- Life Saving Equipment Plan
- Fire Fighting Equipment Plan
- Escape Route Plan
- Dangerous area plan

CARGO HANDLING

- Cargo System General Arrangement
- Cargo Hold Ventilation
- Gas Detection in Cargo Area
- Insulation System
- LNG Loading and Discharge System
- Fuel Gas Supply Concept Description
- Fuel Gas Supply System
- Inert Gas System

HSSE: HAZID, HAZOP, QRA
The basic engineering studies were done for two vessels, 5,000 m$^3$ and 10,000 m$^3$ capacity.
The design of the vessel has obtained the “Approval in Principle” from DNV-GL

“Approval in Principle” - DNV-GL

BASIC ENGINEERING
- LNG Tanker (5.000 m³)
- LNG Tanker (10.000 m³)

INTEGRAL REVISION
- LNG Tanker (5.000 m³)
- LNG Tanker (10.000 m³)

IMPLEMENTATION
- LNG Tanker (5.000 m³)
- LNG Tanker (10.000 m³)

AiP CERTIFICATE
- LNG Tanker (5.000 m³)
- LNG Tanker (10.000 m³)

LNG Bunker Vessel (5.000 m³)

LNG Bunker Vessel (10.000 m³)
The Basic engineering was complemented with several specific studies oriented to the operation of the vessel.

**Technical studies (vessel)**
- Marine dynamics: Station keeping and Sea keeping
- Maneuverability
- Mooring system

**Operational procedures**
- Loading procedure at the regasification terminal
- LNG supply (bunkering procedure)
- Loading rate, pressure and BOG management
- Crew training

**Complementary studies**
- Logistic model
- CTMS system (Custody Transfer Measurement System)
- Health, Safety, Security and Environment (HSSE) studies – HAZID, HAZOP and QRA
WP3: Permits and regulation
Objectives of the legal analysis

This activity included, on one side, a thorough legal analysis taking into account international, European and national regulations and standards as well as industry best practices for the LNG bunkering activity.

In addition, a regulatory roadmap was developed for obtaining the necessary permits in order to be able to carry out the LNG bunkering operation in the ports under study.

- **Standards and regulation**
  - Compilation and analysis of existing regulations and standards that must be taken into account in the LNG bunkering supply chain:
    - Regional
    - National
    - International

- **Permits**
  - Evaluation and development of the **Regulatory Roadmap** for obtaining the necessary permits in order to be able to carry out the LNG bunkering operation:
    - From the LNG bunker vessel side
    - From the port side
Ship Roadmap

Methodology

- Review of documents and recommendations listed in study of existing permits and regulation

- Evaluation of the phases that should form the permitting roadmap for the vessel.

- Evaluation of the necessary requirements in each of the phases.

- Discussion of the document (Repsol and FVP)
The main objective was to answer to the following questions:

What requirements must be met by a company that wants to launch a LNG bunkering supply vessel?

To answer to this, the document was divided in three parts:

• Documents and certificates needed to leave the shipyard

• Vessel crew composition, training and certificates needed

• Paperwork to perform in order to
  • Load the LNG into the vessel
  • Perform a LNG bunker operation
Port terms and conditions

Methodology

Analysis of different port terms and conditions for conventional bunkering services ship-to-ship from different Port Authorities and supply of LNG by truck.

Analysis and study of the port terms and conditions in force for fuel supply in the Port Authority of Valencia

Adapt that port terms and conditions for the supply of LNG ship-to-ship

Discussion of the document (Repsol, Port Authorities participating in the project and the Directorate General of Merchant Marine (DGMM))
Port terms and conditions

Content and objectives

The Port terms and conditions for this project is the regulation of the supply service of LNG as fuel for ships using another tanker or barge in ports.

The document has been divided in the following parts:

- **Clauses 1st-10th** → Sets out the general conditions for giving the service specifying timing, authorizations, supply area, product to be supplied and responsibilities.

- **Clauses 11th-22nd** → Sets out the characteristics of the supply vessel, taxes and guarantees, complying the law and regulation and security conditions.

- **Clauses 23rd – 26th** → Sets out the mandatory requirements for giving the service object of the authorization such as schedule, vessels, technical elements of the operation, incidents, etc.

- **Clauses 27th – 31st Annexes** → Detailing items such as termination of the authorization, claims, and collects other applicable applicable rules and sets the entry into force date of the terms and conditions.

- **Annexes** → In the Annex I, the requirements and procedure to do the authoritarian request for giving the service, is broken down, and the security checklist is developed in Annex II.
Checklist- Annex

The Checklist is a document that both the supplier and the vessel to be supplied fill together and reflects and checks the operation before, during and after.

Additionally, technical information about the LNG transfer is gathered, agreed for that operation between both parties.

The checklist selected and approved is that developed by the IAPH.
WP4: Business model
1. Market test
The aim was to characterize the future demand for LNG as marine fuel. The following aspects in particular were described:

- **Fleet specifications**: average age, sizes, fuels used, main types of vessels.
- **Operation of regular routes**, percentages of transit in emission control areas (ECAs).
- Plans for **retiring vessels and building new ones**.
- Forecasts for the **conversion of the fleet to LNG** or for the ordering of vessels with an LNG engine.
- **Fuels** that will mostly be replaced.
- Development of **Pilot Projects** for LNG-powered vessels.
- **Expected discounts on LNG** compared to the fuels currently being used.
- **Bunkering frequencies** at the different ports.
- **Average time spent in ports**.
- **Average consumptions** per vessel.

The conclusions allowed to determine the commercial viability of the project and evaluate if the future sales will justify the necessary investments.
Telephone interviews were conducted with senior managers of companies of interest in the industry

The methodology applied to the drafting of this report has involved the following stages:

- Preparation of a **semi-structured questionnaire** lasting around 20 minutes, which served as the basis for the fieldwork.

- Holding of **35 telephone interviews** with senior managers from the corresponding number of shipping companies and international charterers operating in **Barcelona, Valencia, Cartagena and Algeciras**, with an overall estimated universe of 80 companies. The fieldwork has been undertaken between February and May 2014. The 35 companies involved in the preparation of this report, which together operate **1,836 vessels**

- **Continuous liaising and progress meetings** with the persons involved in the BunkerLogix project responsible for the study

- **Quality control, verification and cross-checking of the data** gathered through the interviews.

- **Drafting of the final report** after analysing, structuring and integrating the information gathered.

All stages in the work have been undertaken by **DBK, S.A.**, the leading Spanish company specialising in the drafting of studies on business and competitive analysis.
Main conclusions

- The type of service offered is associated with the type of route
- 71% of the sample explodes regular routes, mainly companies with a fleet of cruise-ferries, container and Ro-Ro / Ro-Pax

![Regular routes (%)](image)

- Between 2014 and 2020, companies that foresee the construction of new vessels represent around 60% of the total. They plan to build more than 170 boats.

![Plans to order new vessels 2014-2020 (% of companies)](image)

- Around a 30% affirm their intention to convert or build LNG vessels in the medium-long term, if there is security of supply
- In all cases, they will be dual fuel, most of them porta containers and general cargo tanks

![Plans to convert or order LNG ships in the medium-long term (% of companies)](image)

Note: - A summary of the outputs of the market test was sent to the participating companies, which included, in addition to this 3 results highlighted here, another 18 more that were obtained
2. Economic analysis
   Minimum critical demand and logistic model
The objective was to calculate the minimum critical demand to supply LNG as marine fuel, in different scenarios.

1. Selection of base cases
2. Characterization of the LNG bunkering supply chain
3. Analysis of logistic implications
4. Characterization of the demand profile
5. Calculation of the minimum critical demand
The available bunkering areas, have been facilitated by the port authorities.

Bunkering areas (external area)

- **Cartagena**
  - Average distance to the bunkering area: 4.5 nm

- **Cartagena - Algeciras**
  - Cartagena-Algeciras: 248 nm // Algeciras to bunkering area: 4.8 nm

- **Sagunto - Valencia**
  - Sagunto-Valencia: 17 nm
  - Valencia to bunkering area: 4.8 nm

Distance to bunkering area: 2.5 nm
The available bunkering areas, have been facilitated by the port authorities.

**Bunkering areas (external area)**

- **Cartagena**
  - Average distance to the bunkering area: 4.5 nm

- **Huelva - Algeciras**
  - Huelva-Algeciras: 134 nm // Algeciras to bunkering area: 4.8 nm

- **Sagunto - Valencia**
  - Sagunto-Valencia: 17 nm // Valencia to bunkering area: 4.8 nm

- **Distance to bunkering area**: 2.5 nm
As part of the project, the logistic implications to supply in different ports were analyzed.

The logistic implications of different supply configurations were analyzed, allowing to determine its economic implications, and to study the best suited logistic solutions and the vessel’s potential capacity of supply.

As part of the project, the potential logistic flexibility of only one vessel was analyzed, in its two configurations (5,000 m³ y 10,000 m³) in order to offer supply services in more than one port.

For that purpose, 3 different supply scenarios were defined, including ship-to-ship bunkering and supply to terminal onshore. The best efficient supply scheme was then developed, in order to maximize the energy delivered in each of the ports, assuming several restrictions, consumptions and service speed given in the bases of design.

From that analysis, the maximum demand to deliver in each one of the ports was determined, as well as time and consumption for each mode of operation.

Finally, the potential LNG selling price was analyzed, as a price discount to the MGO 0.1%. Its sensitivity to different Brent scenarios was analyzed.
The objective was to calculate the associated costs to different logistic scenarios.

1. Definition of the bases of design
2. Selection of base cases
3. Analysis of logistic implications
4. Characterization of associated costs
5. Economic implications
The logistical scenarios on which to apply the BOD and get the outputs, cover any operational casuistry

**Selection of base cases**

**Caso 1**
- Loading Barcelona // Bunker
  - Barcelona(50%); Valencia(50%)

**Caso 2**
- Loading Sagunto // Bunker
  - Barcelona(50%); Valencia(50%); Cartagena(1/week)

**Caso 3**
- Loading Huelva // Bunker Algeciras/
  - Small scale 2/month – Las Palmas(50%); Tenerife(50%)

**Legend**
- Loading port
- Bunkering port
- LNG supply port – Small Scale

**Hypothesis:**
- A **specific quantity** of LNG was taken as reference for ship-to-ship bunkering supply in the ports of **Barcelona, Valencia, Cartagena** and **Algeciras**
- In the **Canary Islands**, the vessel is **fully unloaded** (subtracting the BOG produced and minimum heel to come back cold)
Conclusions of the initiative and pending challenges
A consistent design has been carried out, compatible with the existing terminals and able to operate at different ports.

**TECHNICAL ANALYSIS**

- LNG bunkering vessel sourcing strategy: conversion vs new built, and shipyard availability and vessel delivery
- Study of the interaction of the vessel with the marine infrastructures and LNG loading terminals
- Vessel engineering - FEED
- *Approval in principal* by DNVGL
- BOG (boil-off gas) management
- LNG Terminal compatibility studies
- Bunker areas evaluation

**Challenges**

- **Optimize the vessel design** according to final supply scheme and ship-owner requirements
- **Time** until the final investment decision could affect either on the design due to regulation changes

A flexible LNG supply chain in the Mediterranean Coast of Spain is technically feasible.
Once the port is identified, a more detailed study of the specific operation and its interaction with other activities, will be necessary.

OPERATIONAL ANALYSIS

- Development of the bunkering procedures: LNG transfer procedure, LNG loading procedure, crew training and custody transfer by DNVGL
- Study of operational feasibility: transfer solution; sea keeping and station keeping studies; maneuverability envelope; and mooring system configuration
- Logistics: shipping model definition
- Quality and HSSE studies by DNVGL:
  - QRA, HAZID and HAZOP

Challenges

- Necessary to develop a specific safety study for each type of operation on each port, and considering the type of vessel and simultaneous operations
- It is also necessary to develop an operations manual for each specific type of operation
- For the development of the procedures, it is essential to involve AAPP, regasification terminal operators and responsible of the ship operation

The operational procedures have been developed to perform the operation safely and efficiently.
Establishing a common legal framework agreed between different partners is key for the development of LNG as fuel

Legal Analysis

- Development of the regulations to apply in the ports covered in the study
- Analysis of the regulations and standards in LNG bunkering supply at different levels:
  - Internacional;
  - Nacional; and
  - Local
- Permitting in LNG bunkering: road map to obtain the permits for the vessel and to perform the operations, critical paths and schedule

Challenges

- The development of regulation goes in line with the BunkerLogix provisions, and does not involve unanticipated changes
- Unified regulation is required across countries and Port Authorities within Spain
- Specifications developed within BunkerLogix to be taken as reference in the rest of Spain

A legal framework on which the LNG bunker vessel will be able to operate has been established
A minimum demand with longer term contracts is the main challenge for the next steps for implementation

**BUSINESS MODEL**

- A demand pattern analysis: development of a market test involving actual bunker clients from the different ports involved in the project
- Logistic implications of existing and future demand taking into account different scenarios to supply the several ports with one vessel
- Complete economic model to quantify the minimum critical demand for each port and with different size of the supply vessel
- Sensibility analysis with different price scenarios taking into account each port supply chain and different sizes of the bunker vessel

**Challenges**

- To define, together with the final client, the purchasing mechanism of the LNG as bunker fuel
- Supplier and final client need to work together, in order to define the most efficient supply solution according to the demand needs

The main variables that can affect the development of LNG as bunker have been identified
THANK YOU