CORE LNGas hive

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ASSISTANCE CORE LNGAS HIVE PROJECT

Consolidation Top down and Bottom up Analysis

ENAGAS, S.A.

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Applicable contract(s) governing the provision of this Report:

Objective: The current report comprises the results of the consolidation step between bottom up and top down analysis. The results will serve as input for the supply chain definition of the CORE LNGas HIVE project activities ET2, ET3 and ET4.

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Table of contents

1 INTRODUCTION

More stringent air emission requirements for seagoing vessels are introducing a new challenge for maritime administrations and services. One of the possible solutions for compliance with these requirements for vessels in the sulphur emission control areas (SECAs) is the use of LNG as propulsion fuel for shipping, next to the use of low sulphur fuels and the installation of exhaust gas scrubbers. Except for Norway, the take-up of LNG as ship fuel in Europe is still in an early stage, and key stakeholders typically identify three main barriers: the lack of adequate bunker facilities for LNG, the gaps in the legislative or regulatory framework, and the lack of harmonized standards.

The recently adopted Directive on the deployment of alternative fuels infrastructure 2014/94/EU aims to solve the first barrier by enforcing the Member States to ensure that an appropriate number of LNG refuelling points for maritime and inland waterway transport are provided in maritime ports of the TEN-T Core Network by 31 December 2025 and in inland ports by 31 December 2030.

The CORE-LNGas hive project has been chosen to be co-financed by the European Commission within the CEF-Transport 2014 call. Enagas is coordinating the project, with as main objective to make a series of studies and pilot tests to advance the development of an integrated, safe and efficient logistics chain for the supply of LNG as a marine fuel in the Iberian Peninsula. DNV GL has been chosen to assist Enagas in the execution of a part of the studies in this project, namely the market studies planned in sub-activities ET2, ET3 and ET4.

This reports details the results of a part of the overall scope, namely the consolidation step between the top down and bottom up approach to results in the final LNG forecast.

2 METHODOLOGY

2.1 Introduction

The purpose of this step is to combine the results from the Bottom-Up approach and the Top-Down approach into the study's final LNG demand. This forecast serves as the basis for the planning of the supply chain implementation.

In the top down approach the demand for LNG as marine fuel until 2050 has been forecasted based on general trends which will influence the LNG uptake. General factors that influence the LNG uptake are the type of regulation in place and how strongly this regulation is enforced as well as economic factors such as the oil price development and especially the development of the price difference between HFO and LNG (so-called fuel price spread). Key factors at individual vessel level are the operational profile, e.g. whether the vessel is deployed on global or regional trade, on fixed routes or not, and its share of fuel consumption in ECAs. In addition, soft factors such as green image play a role on segment level, e.g. in the cruise segment. The main drivers of demand for LNG are environmental regulations and the price difference between LNG and other fuels. The main barriers are uncertainty about the availability of LNG in ports, about technical standards, and about the second hand-price of LNG ships.

In that light, 3 scenarios have been developed in the top down analysis:

(1) "Basic scenario"

(2) "Low scenario"

(3) "High scenario"

Finally, by combining AIS shipping data with LNG market penetration for various vessel segments the top down LNG demand can be estimated.

In the bottom up approach, key stakeholders (shipping companies, port authorities, port terminals, bunker suppliers and natural gas suppliers) have been subjected to a market survey by means of an interview or e-survey. The key purpose of this step was to capture non-quantitative aspects like opinions and expectations of key people.

2.2 Methodology

The qualitative and semi-quantitative results from the Bottom-Up approach (interviews/e-survey/specific market information) will be compared with the fully quantitative results of the mathematical Top-Down approach with regards to consistency and completeness. The consolidation is supposed to influence 3 key parameters from the top down analysis.

- LNG uptake rate
- Market share of the ports / geographical spread across Iberian Peninsula
- Overall fleet growth

The assessment will study how the values for the above-mentioned parameters (as defined in the top down analysis) might be influenced by the bottom up results. Additionally, the Gibraltar case and the strategic location of the Iberian Peninsula are discussed. The parameters are discussed in below sections.

3 INFLUENCE ON LNG UPTAKE RATE

3.1 Results interviews/e-survey

3.1.1 Basic information from the bottom up analysis

Given the current limited price difference between LNG and traditional fuels, there is no positive business case for LNG as a maritime fuel (only). Extra user groups like port operations, trucks of logistic companies and use of LNG to supply municipalities and local industry seem to be needed to create the demand necessary for a positive local business case (although impact on the global LNG demand is necessary limited). In addition, there’s uncertainty on technical and economic performance of LNG solutions and other clean fuels.

In general, there is an unfavourable investment climate in the Iberian Peninsula, due to the economic situation. A change in price differences, strict environmental regulation could lead to a positive business case and thus a higher demand. During the interviews the high CAPEX/OPEX was considered the main barrier. Shipping companies don’t expect a major breakthrough before 2025.

It is anticipated that the uptake of LNG will be gradual per shipping segment, with the current fleet of LNG-fuelled vessels concentrated in niche or high specification sectors: the RO-PAX and offshore vessel sector have been the first adopters of LNG as fuel. This is in line with the local trends where -despite the current weak business case- some early adopters will be sailing on LNG and bunkering LNG in the project area by 2020 (Carnival cruises, Balearia ferries, Fred Olsen, …). As most passenger vessels and ro-ro vessels sail on fixed routes, this allows for accurate planning of bunkering, which makes this segment very likely to shift to LNG. The ro-ro and ro-pax segments represent a significant share in in the Spanish and Portuguese shipping market.

The bottom up report aimed at obtaining quantitative data on the % LNG uptake by 2030 by asking the different stakeholders. Despite the -above mentioned- rather pessimistic opinions on the LNG uptake rate, 31% of the correspondents considers >25 of the maritime fuel consumption could be LNG by 2030 and 36% thinks that LNG will be between 10 and 25% of marine fuel consumption. The remaining 33% believes LNG uptake will be below 10%.

From the top down analysis, it can be concluded that the LNG share in the overall energy demand for shipping will only be 3, 6.5 and 11% for the low, basic and high case respectively.

3.1.2 Conclusion

LOW SCENARIO - The rather pessimistic forecast (3% fuel uptake by 2030 in top down) is in line with the opinions from the most sceptical Spanish and Portuguese stakeholders. Stakeholders are not optimistic about LNG uptake due to large Capex investment since the current economic situation implies an unfavourable investment climate in Iberian Peninsula. Based on the semi-quantitative results from the bottom up, this represents 12% of the interviewed parties which believe that the % traditional fuel being replaced by LNG will be lower than 5%. The future low scenario is in line with the perception of the most pessimistic correspondents, so for the low scenario no modifications on the top down LNG uptake rate were done based on the bottom up results.

BASIC SCENARIO- Based on the results of the top down, the % traditional fuel being replaced by LNG will be lower than 7% in 2030. This forecast is significantly lower than what the bulk of the (bottom up) correspondents believe (average is 10-25%). Since the top down report mentions that the error margin on LNG uptake is 50%, consolidation of the results might lead to a 50% increase of the top down LNG forecast (table 15 from the top down report) based on the bottom up results.

HIGH SCENARIO - Based on the results of the top down, the % traditional fuel being replaced by LNG will be about 11% in 2030 whereas 31% of the correspondents in the bottom up believe this will be above 25%. Since the qualitative opinions (economic downtimes, low oil price, …) are not in line with the semi-quantitative opinions, it is suggested to only use the same factor, 50% increase of the top down LNG forecast (table 17 from the top down report).

3.1.3 Main actions to overcome the barriers

In order to achieve at least the basic forecast, the criteria of table 14 of the top down report need to be fulfilled. This is also linked with the main barriers identified in the bottom up report per segment.

LNG price in non-regulated markets like LNG bunkering - The main factors that impact LNG prices, LNG price developments and prices of traditional fuels are global and can hardly be influenced by national authorities. Despite this, Spanish/Portuguese authorities may develop supply contract mechanisms to develop a reasonable long term fixed LNG prices. This includes a gradual migration from oil-linked pricing to spot or hub-based pricing. In addition, authorities may develop a transparent and effective fiscal system for LNG.

Uncertainty of supply – Spain/Portugal have sufficient large import terminals and is starting initiatives to boost the development of small scale infrastructure (e.g. bunker vessels under development). Once the demand increases, local ports may assess the feasibility of storage and bunkering infrastructure. No specific additional actions are defined. The recently adopted Directive on the deployment of alternative fuels infrastructure 2014/94/EU aims to further solve this barrier by enforcing the Member States to ensure that an appropriate number of LNG refueling points for maritime and inland waterway transport are provided in maritime ports of the TEN-T Core Network. The possibilities for authorities in these non-regulated, competition based markets are mainly in provision of transparent and simple to manage framework conditions.

Regulation – The International Maritime Organization’s (IMO) Marine Environment Protection Committee (MEPC) has decided in October 2016, that a global sulphur cap to 0.5 % shall be implemented starting with 1st of January 2020. This Sulphur cap is defined in the amendment MEPC.176(58) to the Annex VI of the MARPOL convention, defining the maximum Sulphur content of any fuel oil used on board ships. So, no additional actions need to be defined.

Access to capital/uptake of new technology - Spanish and Portuguese authorities should consider to develop a national funding framework, complementary to EC TEN-T or CEF instruments, to provide seed investment in LNG in order to stimulate development of both the supply and demand side.

3.2 LNG ships on order – market information

3.2.1 Relevant market information

In this paragraph, some specific market information is added. It relates to project area specific information that may have a significant impact on general forecast (so called game changers). This market information will be used as an add-on to the mathematically calculated forecast.

3.2.1.1 Cruise ships

Carnival Corporation has signed a new agreement (September 2016) with leading German and Finnish shipbuilders to deliver two new cruise ships for Carnival Cruise Line (with delivery dates expected in 2020 and 2022) and one new cruise ship for P&O Cruises UK (with delivery date expected in 2020). The new ships will be powered by LNG.

In total, the company now has agreements in place to build seven LNG-powered cruise ships across four of its 10 global cruise brands in coming years. As previously announced, the first of these ships is expected to be in service for AIDA Cruises and Costa Cruises in 2019.

AIDA Cruises has ferry lines with potential stops in Barcelona, Valencia, Mallorca and/or Ibiza. Costa cruises has a ferry line with potential stops in Barcelona and Mallorca.

These cruise vessels have 3500m^3 of LNG stored on board (3 storage tanks) and are expected to bunker each 14 days, leading to circa 90 000 m^3 (41 kton) LNG bunkered per vessel per year. It is likely that competitors will follow as from 2023.

Recently, Shell Western LNG has signed a deal with Carnival to supply LNG in northwest Europe and the Mediterranean to their 2 new LNG-powered cruise ships, with effect from 2019. Shell will refuel one Carnival cruise ship from the 6,500m^3 dedicated LNG-bunker supply ship that it will base from next September at Gate Terminal, Rotterdam. The second ship is expected to refuel at one of the ports in the western Mediterranean, most likely Gibraltar or Barcelona.

3.2.1.2 United Arab Shipping Company

The series of innovative 14,500 TEU (eleven vessels) and 18,800 TEU (six vessels) container ships are under construction at Hyundai Heavy Industries for United Arab shipping company (UASC). These 17 vessels are intended to be converted to globally operate using LNG as ship fuel and the Approval In Principle has been prepared as part of DNV GL's "LNG Ready" service – demonstrating that the designs will enable a cost and time efficient conversion for LNG fuel operation.

These vessels are on global trade, passing the project area. It is not very likely that these ships will bunker in the project area (since this is only 20% of the distance of a full round trip). If such a large containership would be sailing on LNG (8000m^3 LNG storage), it potentially bunkers every 8 weeks in the area, thus a potential demand of 25 kton per year.

3.2.1.3 Balearia ferries

Balearia confirmed that they have 2 ferries on order fuelled by LNG. The first ferry is expected to be in operation in 2019, and will have dual fuel engines, capable of running on marine diesel oil or natural gas. The ferry, with a length of 232 meters and a beam of 30 meters, will be the first LNG fuelled passenger ferry operating in the Mediterranean. The ferries have 800 m^3 LNG on board (2 storage tanks of 400 m^3). It is assumed that the ferries bunker twice a week, 1500m^3 per vessel, leading to an annual consumption of circa 35 kton per year per vessel.

Looking at today's situation, Balearia offers trips from the mainland ports (mainly Barcelona and Valencia) to the Balearic Islands, and connections between the different Balearic Islands. As the LNG fuelled ferries will be operating in the project area, they will also fuel in this area.

3.2.1.4 Fred Olsen

Mid 2016 the GAINN4SHIP INNOVATION project was announced. This project deals with the conversion of a high speed ferry operating in the Canary archipelago.

The vessel to be retrofitted is the Fred Olsen HSC ropax Bencomo Express, which is 95.47 metres in length and able to carry a maximum of 871 passengers and 27 trailers or 271 cars. The Bencomo Express vessel was first put into action in October 1999 on the route between Santa Cruz de Tenerife (Tenerife Island) and Agaete (Gran Canaria Island).

A second-hand sister engine (same engine manufacturer and type -CAT3618-) from the four engines that the HSC Bencomo Express has installed on board will be purchased and modified to become an LNG dual-fuel engine. This sister engine will be tested in dual-fuel operation on a test bench to obtain the approval for the modified dual-fuel engine by the chosen classification society. The vessel's systems will also be adapted using new eco-efficient technologies, the LNG tank and control system will be installed and the bunkering system will be replaced.

Real-life trials for the validation of the pilot will be carried out from different perspectives. An analysis of the technical solutions implemented will be carried out as this vessel will be the first HSC case; regulatory validation compliance with the regulation in force; validation of the safety and operational procedures developed during the training for the crew and port workers to become proficient in LNG operations; and finally, a financial feasibility of the prototype developed will be performed.

If the pilot results are promising and Fred Olsen would decide to equip more of its Canaries HSC ferry fleet (currently 5 vessels) with similar engines, this could result in a potential demand of about 20 kton per year by 2025 - 2030.

3.2.1.5 Partnership Qatargas, Maersk, Shell and United Arab Shipping Company

Qatargas (largest LNG producer in the world), the Maersk Group (world's largest shipping container company) and Shell signed a Memorandum of Understanding (MOU) to explore the development of LNG as a marine fuel in the Middle East region. Through the joint relationship the partners plan to explore the development of new markets for LNG to be used as propulsion fuel for merchant vessels. The final ambition is to create a regional hub.

3.2.2 Conclusion

The impact of the above aspects will be assessed on the forecast scenarios. The results are presented in below text and in Table 1.

LOW SCENARIO – Developments like Carnival cruises and UASC are not bunkering in the project area. Both Balearia vessels are supposed to bunker LNG in the area as from 2020 (EU sulphur emission limit). This would lead to a yearly bunkering of 70 kton LNG in the project area. As the main routes start from Valencia or Barcelona, it is likely that one of these ports will supply LNG. It is assumed - based on information from the bottom up - that as from 2020, 70 kton LNG/y will be bunkered in Barcelona. The Fred Olsen Canary ferries do not yield an additional demand.

BASIC SCENARIO – There is a high likelihood that at least one of the Carnival cruise vessels will bunker in the project area. It is assumed that Barcelona will be the preferred bunker location to supply an extra 90 000 m^3 (circa 41 kton) LNG per year as from 2021 (on top of the 70 kton LNG per year from the low scenario). The Fred Olsen Canary ferries results in an additional demand of 20 kton/year from 2030 onwards, added to the Las Palmas forecast.

HIGH SCENARIO - It is assumed that Barcelona will be the preferred bunker location to supply an extra 150 kton LNG per year as from 2021 for LNG ferries calling the port (assuming 2 Carnival cruise vessels and 2 Balearia vessels). We additionally assume that one large container vessel will be converted to LNG and will bunker in Algeciras, leading to an extra demand of (8000m³ each 8 weeks) 25 kton of LNG per year. The Fred Olsen Canary ferries results in an additional demand of 20 kton/year from 2025 onwards.

Table 1 - overview of potential additional LNG demand based on current market information

company	type of vessel	Number of vessels	Starting year	Expected yearly bunkering in the project area
Carnival	cruise	2 (7 long term)	2020	Low – 0 Basic – 41kton High – 80 kton
Balearia	ferry	2	2020	Low – 70 kton Basic – 70 kton High – 70 kton
Fred Olsen	ferry	1 trial (5 long term)	2030 2025	Low – 0 Basic – 20 kton High – 20 kton
UASC	container	17 LNG ready, assumption 1 bunkers in project area	2020	Low – 0 Basic – 0 High – 25 kton

3.3 Fishing and smaller fleet

3.3.1 Introduction

Not all small vessels will be captured in the AIS analysis from the top down approach as the IMO regulations only require AIS to be fitted aboard all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size.

Many feasibility studies focus on larger seagoing vessels as these larger vessels will result in the highest gains w.r.t. emission reductions. There is however also a potential case for smaller, short range vessels, vessels that stay in the port area and inland vessels. This is confirmed on the market by e.g. the platform supply vessels already in operation in Norway, several tugs and some inland tankers in operation in Northern Europe today, and several ferries in operation or announced.

The Iberian Peninsula has a relatively large fleet of smaller vessels that are operational within the harbours and its direct vicinity.

From a technical point of view, there is no reason why smaller vessels cannot sail on LNG. To achieve the same range as with traditional fuels however, the LNG system will need more space, potentially limiting its use in very small vessels. Although currently no conversions or new builds are announced, it is technically possible to design engines, tanks and associated LNG equipment for ships in this smaller size range.

Three main restrictions apply, besides general considerations regarding technology maturity:

1. Minimum engine power

Gas engines for maritime use are available from some 700kW upward. Smaller engines are not available as per today. Gas engines for road use are available from some 300kW upward. Those engines are not developed for maritime operational profiles and need adaptation to maritime requirements (environment, safety, motions).

2. Minimum vessel size

Established technology for LNG storage for the use as fuel are pressurized cryogenic tanks, IMO Type C tanks. These tanks are purpose made. Smallest sizes for maritime use are currently about 29m^3 liquid volume.

3. Use profile of vessel

Idle times, times of vessels being not in operation, maintenance carried out by the crew and others are factors that are of particular relevance for smaller vessels using LNG as fuel and need particular consideration.

In 2014, DNV GL revealed a concept of a LNG-fuelled fishing vessel named 'Catchy', designed primarily for fishing with purse seine and pelagic trawling. The vessel is 60m long, this is a larger fishing vessel than most of the fishing vessels operating in the Iberian estuaries and a case for smaller fishing vessels has not yet been made.

Figure 1: DNG GL concept LNG-fuelled fishing vessel "Catchy"

In a 2013 report from Panteia for the European Commission on "contribution to impact assessment of measures for reducing emissions of inland navigation" it is estimated that for all new inland vessels in the vessel class from 110 meter onwards and operating on Dual Fuel LNG, there are positive impacts for ship owners in terms of the operational costs, in addition to an increase in the performance regarding emissions.

Iberia, with its large fishing fleet and good potential access to LNG for bunkering has the opportunity to play a pioneering role in introducing LNG as fuel in the fishing sector. However, the potential LNG demand from the fishing and smaller fleet is perceived as limited. The main reason is the current economic circumstances in this sector, being unfavorable towards making the necessary investments: this fleet is mainly in the hands of smaller companies lacking the access to capital.

This is also supported by the findings from the bottom up survey. Additionally, there are technical restrictions for the smallest vessels. Moreover, since these vessels are rather small, the potential LNG demand is per definition limited and not influencing the overall demand significantly.

3.3.2 LNG uptake fishing fleet

In the following paragraphs, a LNG demand forecast case is made for this part of the fleet anyway, under the assumption that the current main barrier (access to capital) would be lifted in the years to come. Note that currently DNV GL does not believe this to be likely, we therefore refer to this additional demand as hypothetical.

Hypothetical LNG demand for small fishing fleet

In 2015, in numbers of vessels, the Iberian fishing fleet represented 21% of the total EU fishing fleet (source: Eurostat – fishery statistics in detail). From the year-on-year data, given in Table 2, it can however be noted that notably the Iberian fleet is shrinking, in Spain even with 30% over the last decade (see Figure 2).

Table 2 - number of fishing vessels in EU, Spain and Portugal

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
European Union	86856	88374	85441	84181	83374	81791	80374	86818	85989	84356
Spain	13363	13013	11424	11129	10855	10510	10121	9873	9632	9408
Portugal	8696	8610	8571	8514	8425	8333	8245	8200	8157	8054

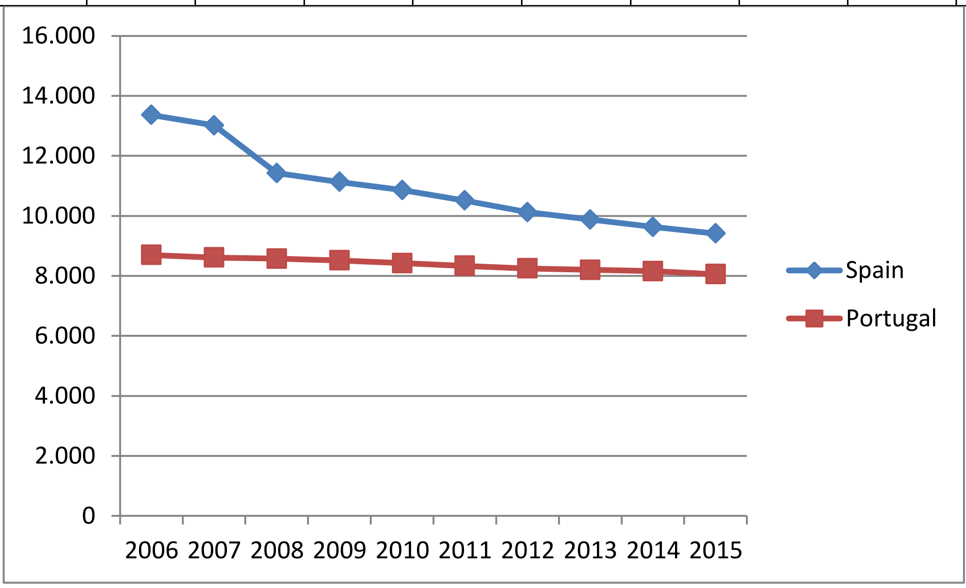

Figure 2 – Evolution of Iberian fishing fleet (number of vessels)

Still, Galicia is a main hub for fishery, and the Port of Vigo remains the biggest fishing port in the world. The bigger fishing vessels are already accounted for in the AIS analysis, in this section we aim at forecasting potential LNG demand specifically for the smaller part of the fishing fleet. Eurostat data on numbers of vessels in the different engine power categories are given in Table 3.

Table 3 – Number of fishing vessels in Iberia, per engine power class (2015 Eurostat data)

engine power	Spain	Portugal
<25kW	4866	4600
25-74kW	2465	2618
75-149kW	837	408
150-349 kW	807	233
350-499kW	236	116
500-749kW	101	52
750-999kW	26	9
1000-1999kW	46	11
2000-2999kW	5	7
3000-3999kW	6	0
>4000kW	13	0
total	9408	8054

Based on the argumentation above, we have excluded the smallest vessels (engine power <350 kW).

For the remaining vessels, we have made the following assumptions with regards to their operational profile and specific fuel consumption (aligned with the assumptions of the "LNG hub in the northwest of the Iberian Peninsula" report)

- operating days: 240 days per year
- operating hours: 10 hours per day
- average specific fuel oil consumption: 240 g/kWh
- equivalent average LNG consumption for substituting gas engines: 160 g/kWh
- the fleet will not grow in number over the years
- per power range the average power was used for calculations (e.g. 425 kW for all vessels in the range 350-499kW).

The resulting maximum potential demand is given in Table 4.

Table 4 - maximum potential LNG demand for current fishing fleet

	number of vessels		**annual maximum potential LNG consumption [kton LNG/a]**	
engine power	**Spain**	**Portugal**	**Spain**	**Portugal**
350-499kW	236	116	38,52	18,93
500-749kW	101	52	24,24	12,48

	number of vessels		annual maximum potential LNG consumption [kton LNG/a]	
engine power	**Spain**	**Portugal**	**Spain**	**Portugal**
750-999kW	26	9	8,74	3,02
1000-1999kW	46	11	26,50	6,34
2000-2999kW	5	7	4,80	6,72
3000-3999kW	6	0	8,06	
>4000kW	13	0	22,46	
total	433	195	133,32	47,49

To create forecast from these values, we have assumed the following:

- From the AIS analysis, we know the distribution of fishing vessels with AIS signal (= large shipping vessels) over the different ports. To be able to allocate the total demand for Spain and Portugal over the different ports, it is assumed that the distribution of small fishing vessels per port is the same as these large shipping vessels. This distribution is shown in **¡Error! No se encuentra el origen de la referencia.**. Subsequently, we have assumed that the smaller ports' demands will be clustered to other main ports; we have therefore selected the main fishing ports base on the vessel call data (the ports in bold in **¡Error! No se encuentra el origen de la referencia.**) and recalibrated the distribution over these main ports only, in **¡Error! No se encuentra el origen de la referencia.**.
- For the LNG uptake %, the values of the category "other" (table 15-17 top down analysis report) have been used. These are summarized in Table .
- Regarding vessel replacement, we have assumed an overall replacement age of 25 years and have furthermore assumed a uniform distribution for the current fleet's age.

With these assumptions, combining the maximum potential demand based on the estimated specific LNG fuel consumption from Table 4 with the assumed LNG uptake percentages from Table , we have calculated the forecasts per country, and per corridor in Table , Table and

Table . Note that other smaller ports exist where fishing is a key activity, but this will not influence the overall demand.

Table 5 - assumed LNG uptake % for fishing fleet

LNG uptake%	2020	2025	2030	2035	>2035
low	2	2	4	6	10
basic	4	5	8	10	15
high	5	8	10	13	18

Table 6 - LNG demand forecast for Spanish small fishing fleet [kton LNG/a]

Spain	2020	2025	2030	2035	2050
low	0,533	1,067	2,133	3,733	9,065
basic	1,067	2,400	4,533	7,199	15,198
high	1,333	3,466	6,132	9,599	19,197

Table 7 - LNG demand forecast for Portuguese small fishing fleet [kton LNG/a]

Portugal	2020	2025	2030	2035	2050
low	0,190	0,380	0,760	1,330	3,229
basic	0,380	0,855	1,615	2,565	5,414
high	0,475	1,235	2,185	3,419	6,839

Table 8 - LNG demand forecast for Iberian small fishing fleet [kton LNG/a], per corridor

Atlantic	2020	2025	2030	2035	2050
low	0,514	1,028	2,055	3,596	8,734
basic	1,028	2,312	4,367	6,936	14,642
high	1,284	3,339	5,908	9,248	18,495

Gibraltar & Islands	2020	2025	2030	2035	2050
low	0,209	0,419	0,838	1,466	3,561
basic	0,419	0,943	1,781	2,828	5,970
high	0,524	1,362	2,409	3,771	7,541

3.3.3 Conclusion

Summarizing:

- We see no clear trend for LNG conversion in this sector.
- Conversion is technically feasible (although no proven concepts for smaller engine sizes, and no precedents). Galicia will have to play a pioneering role showing strong leadership in order for the fuel switch to LNG happening in this segment.
- The impact on demand is negligibly small compared to the demand from other vessels in the near future, we see the main growth potential from 2030 onwards (heavily depending on future technological developments for small LNG vessels, specific port efforts and incentives from (local) authorities).

4 MARKET SHARE OF PORTS/GEOGRAPHICAL DISTRIBUTION

4.1 Results interviews/e-survey

Since sufficient LNG terminals (underused) are present in the project area LNG availability is not perceived a problem. Current terminals are able to supply LNG to trucks and this will in the future be the case for bunker barges. Following aspects are resulting from the bottom up analysis:

a. **Mediterranean:** Valencia and Barcelona port authorities and Balearia Ferries (shipping company) believe 'the winner takes it all', i.e. there is only place for one LNG supplier in Mediterranean, the port who decides to supply LNG as fuel can have a big benefit in the future. In the current situation, it looks like Barcelona is the most realistic port to win, Valencia did lots of efforts in the past for LNG but they didn't materialize for some reason (related to difficulties in permitting, …).

b. **Gibraltar/Algeciras**: Due to the limited space available in Gibraltar, they have strong limitations on growth. If the fleet of shipping companies is growing, they might consider to leave Gibraltar with all their ships. Algeciras sees this as an opportunity for them.

c. **Biscay Region**: This region has different regular lines and cargo lines: regular lines are by definition a favourable condition for change to another fuel. If they can be convinced to shift to LNG, then this region may have the critical mass to come very fast to break-even point. When LNG becomes relevant in Spain, the Biscay region (port of Bilbao) believes they are in a good position for providing LNG bunkering services.

d. **Portugal:** Port authorities Sines & Lisbon: open for new opportunities, but will not be the first movers, rather the first followers.

4.2 Conclusion

One of the assumptions underlying the mathematical model of the top down analysis is the so-called fair share principle implicating that current bunkering behaviour will not change and the proportional shift to LNG will be equally felt in all ports under study. This is a viable assumption for making the demand calculations, but it cannot be upheld in a realistic bunker market development scenario as it would imply installing micro-scale land based LNG bunkering facilities in all ports concerned. Nevertheless, the local demand in these locations is likely to be supplied by LNG trucks or bunker barges being loaded from a nearby LNG hub. This supply (LNG demand) is thus originating from a nearby larger hub but the effective bunkering might be in the smaller port.

Therefore, realistically, the calculated demand in all ports will be clustered and redistributed to a limited number of ports serving as a bunkering hub for the region, making sure that there is enough demand to justify the initial CAPEX investments in these hubs. This will be detailed in the supply chain report.

Based on the bottom up results (limited number of Hubs) and the top down results (exclusion of small bunker ports), one can conclude on the following:

ATLANTIC CORRIDOR – In the Atlantic corridor, due to the geographical spread, one could assume three such hubs to develop, one in Portugal, (f.e. Sines) and two in Spain (one in the Galician region and one in the Biscay region).

MEDITERRANEAN CORRIDOR – In the Mediterranean corridor, based on current trade and bunker patterns and LNG availability, we assume two hubs to develop, in Valencia and Barcelona.

GS and ISLAND CORRIDOR – In the GS and ISLANDS corridor, based on current trade and bunker patterns and LNG availability, we assume three hubs to develop, in Algeciras and Las Palmas, and Tenerife.

As stated above, the final decision on LNG Hubs will be further detailed in the supply chain part of this study.

5 OVERALL FLEET GROWTH

Fleet growth is influenced by other macro-economic parameters (economic activity, GDP, transport demand); historically there has been a strong correlation between growth in GDP and shipping. However, analysts indicate that the recent greater emphasis on sustainability supports a steadier (lower) level of growth in shipping demand in the future[1]. The Baltic Dry Index (measuring the demand for shipping capacity versus the supply of dry bulk carriers, indirectly measures global supply and demand for the commodities shipped aboard dry bulk carriers, considered as a leading economic indicator because it predicts future economic activity) reached the all-time-low level at 290 on 11 February 2016.

5.1 Results from e-survey/interviews

In the top down report we have assumed a fixed growth factor, specific per shipping segment, ranging from 0.1 to 1.9% growth. Concerning the specific fleet growth values, the survey and interview answers do not give quantitative results but only qualitative trends: survey responses indicate a rather pessimistic view of the ship owners regarding future fleet growth and associated investments.

Other studies like f.e. the EU LNG Lot 3 study assume an overall average year on year future fleet growth between 0.95% and 1.55% for transportation of cargo; and 0% for fleet growth in the passenger transport segment.

5.2 Conclusion

Based on the above results and background information and knowing that fleet growth is not a key influencer in the final LNG demand calculations, we have opted not to adapt our fixed growth percentages, used across all scenarios in the top down analysis.

6 GIBRALTAR AND TANGER

6.1 Market insights Tanger

The port of Tanger Med possesses a large oil terminal (total capacity of 532.000 m³) in 19 above ground storage tanks. Since the terminal has been in exploitation, bunkering activity in the port and the anchorage areas has developed tremendously with an annual volume of 2.25 million tonnes in 2014. A steady growth is expected due to special conditions applicable for bunker calls only. No plans are known with respect to LNG developments.

[1] https://www.bimco.org/Reports/Market_Analysis/2016/0104_Reflections2016.aspx: "a "new normal" has arrived, lowering the GDP-to-trade multiplier generated by global economic activity"

6.2 Market insights Gibraltar

Gibraltar is the largest bunkering port in the Mediterranean with bunkering volume of around 4 million metric tonnes in 2014. Bunkering continues to be the main activity within the Port of Gibraltar. Bunkers are normally delivered by barge while the vessel is at anchor in Gibraltar Bay and can also be delivered alongside.

The port of Gibraltar has managed getting this position because of:

- Competitive market because of high turnover
- Low costs because of unique tax-free status within European Union
- Competitive port dues
- Located near main shipping lanes
- Market is continuously monitored by the Government of Gibraltar to ensure competitiveness

Gibraltar has taken some steps toward making supply of liquefied natural gas (LNG) as a fuel to ships at anchor a reality in the key Mediterranean bunkering hub, with some feasibility studies etc. That said, Gibraltar has no large-scale LNG import terminal and hence today no easy access to LNG supply.

However, Shell is planning the construction of an LNG small scale storage terminal in Gibraltar. The LNG will be used to supply the nearby power station. (As of 26 August, 2016, HM Government of Gibraltar and the Gibraltar Port Authority (GPA) have signed a bunker market development agreement with Shell. It follows an agreement signed earlier in August between her Majesty's Government of Gibraltar and Shell, for the supply of LNG for use in power generation in Gibraltar. Under this agreement, a small regasification unit will be constructed in Gibraltar, which will be operated by Gasnor, a 100% Shell-owned subsidiary).

The Port of Gibraltar is also looking at developing their LNG bunker market: they are looking at creating an LNG hub in Gibraltar and developing an LNG bunker vessel to serve both Gibraltar and the neighbouring Algeciras. These LNG bunkering plans are still under discussion.

However, Brexit is now potentially putting the Gibraltar tax free regime at risk, and this could severely damage the peninsula's current position in shipping trade and bunkering, potentially leading to big market shifts. On the political domain, Spain has submitted a proposal to the UN for sharing sovereignty over Gibraltar with the UK after Brexit.

6.3 LNG forecast

Based on the above-mentioned bunker volumes for 2014, a rough forecast has been made for both ports. This is presented in the table below.

Table 9 - LNG demand forecast for ports of Gibraltar and Tanger [kton LNG/a]

kton LNG	**2020**	**2025**	**2030**	**2050**
Gibraltar	17	70	190	880
Tanger	10	40	105	495

6.4 Conclusion

Due to the limited space available in Gibraltar, there is a strong limitation on growth. It is further unclear how LNG small scale infrastructure will develop in Gibraltar and Tanger Med. This may lead to market opportunities (potential extra demand) for Spanish terminals supplying LNG to these areas. This will be further highlighted in the supply chain report.

7 GEOSTRATEGIC LOCATION

7.1 Introduction

The area under study is a geo-strategical location being at the entrance of the Mediterranean Sea and therefore connecting countries in Europe, Africa and the Americas. This implies that a high number of vessels are passing and/or bunkering in the area.

The coast line is dotted with a high number of ports with an important share in the overall European bunkering of traditional fuels.

In addition, Spain and Portugal have easy access to LNG with a significant number of LNG import terminals spread over the coast line.

7.2 Conclusion

No extra factor has been included the strategic position of Spain and Portugal since this factor is already accounted for in the top down report where an extrapolation of the results has been performed based on actual bunkering. Analysis of the bunker data has shown that important local variations exist (e.g. due to bunker attractiveness of specific locations and the fact that some ports have specific anchorage areas where bunkering is performed).

8 CONSOLIDATED LNG DEMAND

8.1 Consolidated forecast per corridor per segment

Table , Table 1 and show the consolidated figures detailed for the reference years 2020, 2025, 2030 and 2050 for the 3 corridors differentiated by segment. Estimation results show for the basic scenario the highest demand of LNG in the GS & Islands corridor with 2.54 million tonnes of LNG in the year 2050, followed by the Mediterranean corridor with 0.75 million tonnes of LNG in the year 2050 and finally the Atlantic corridor with 0.38 million tonnes of LNG in the year 2050.

The low scenario forecast is about half the basic scenario forecast with the demand in the GS & Islands corridor about 1.13 million tonnes of LNG in the year 2050, followed by the Mediterranean corridor with 0.36 million tonnes of LNG in the year 2050 and finally the Atlantic corridor with 0.18 million tonnes of LNG in the year 2050.

For the high scenario following results are obtained, the highest demand of LNG in the GS & Islands corridor with 3.32 million tonnes of LNG in the year 2050, followed by the Mediterranean corridor with 1 million tonnes of LNG in the year 2050 and finally the Atlantic corridor with 0.51 million tonnes of LNG in the year 2050.

8.2 Development over time

The development over time is presented in Figure 3-Figure 5. Across all scenarios there is a significant increase in LNG demand to be noted. Comparing the three corridors and their LNG demand over time, it appears that the GS & Islands corridor with the highest LNG demand stays largely ahead over the other two corridors in all scenarios.

As the deployed fleet is very young in some segments, e.g. with an average age per vessel of just about 10 years for the tanker segment in all corridors in scope, for the bulker segment in the Atlantic and in the Mediterranean corridor, or for the Ro-Ro segment in the Atlantic corridor, the replacement of existing tonnage takes a significant amount of time and therefore the uptake of LNG demand is starting slowly.

8.3 Conclusion

The confrontation of the bottom-up and the top-down analysis has resulted in an updated forecast for the different scenarios. The scenarios from the top-down analysis are mainly the results of an independent and mostly objective analysis, but also largely theoretical in nature. Those scenarios were improved to reflect a more realistic development of the LNG uptake as the top-down analysis does not uncover step changes that may be expected in the early stages of developing small-scale LNG supply chain. In addition, LNG demand for small fleet and port operations has been accounted for.

These results will serve as input to identify the required infrastructure and modalities (e.g. ship-to-ship, truck-to-ship, and intermediate storage) given the evolution of LNG demand as predicted by the analysis.

Table 10 - Consolidated forecast per segment - Basic scenario

Corridor	Port	Top Down - post regional share (kton/a)				Consolidated forecast (kton/a)				Consolidated forecast (10^3 m^3/a)				Consolidated forecast (MJ/a)			
		2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050
Atlantic	Container ships	1,04	5,75	16,09	57,77	1,56	8,63	24,14	86,66	3,47	19,17	53,65	192,58	8,6E+07	4,7E+08	1,3E+09	4,8E+09
	Tankers	0,69	2,83	11,86	58,33	1,04	4,24	17,79	87,50	2,31	9,43	39,53	194,44	5,7E+07	2,3E+08	9,8E+08	4,8E+09
	Bulk carriers	0,60	2,21	5,69	44,11	0,90	3,31	8,54	66,16	1,99	7,35	18,97	147,03	4,9E+07	1,8E+08	4,7E+08	3,6E+09
	General cargo	0,39	1,91	4,45	20,12	0,59	2,86	6,68	30,18	1,31	6,36	14,83	67,07	3,2E+07	1,6E+08	3,7E+08	1,7E+09
	Car carriers	0,21	1,26	2,43	10,62	0,31	1,89	3,64	15,93	0,69	4,20	8,10	35,41	1,7E+07	1,0E+08	2,0E+08	8,8E+08
	Passenger ship	0,98	4,21	8,91	33,79	1,47	6,31	13,37	50,68	3,27	14,02	29,71	112,62	8,1E+07	3,5E+08	7,3E+08	2,8E+09
	Ro-Ro	0,07	0,55	2,34	7,32	0,10	0,83	3,51	10,99	0,22	1,83	7,81	24,41	5,4E+06	4,5E+07	1,9E+08	6,0E+08
	Ro-Pax	0,02	0,07	0,42	2,41	0,03	0,11	0,64	3,61	0,06	0,25	1,42	8,03	1,6E+06	6,1E+06	3,5E+07	2,0E+08
	Other	0,61	1,45	2,40	8,97	0,91	2,17	3,60	13,45	2,03	4,82	8,01	29,89	5,0E+07	1,2E+08	2,0E+08	7,4E+08
	Fishing fleet	0,00	0,00	0,00	0,00	1,03	2,31	4,37	14,64	2,28	5,14	9,70	32,54	5,6E+07	1,3E+08	2,4E+08	8,0E+08
	Port operations	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Mediterranean	Container ships	1,95	9,33	27,89	123,07	2,93	13,99	41,84	184,61	6,51	31,09	92,98	410,24	1,6E+08	7,7E+08	2,3E+09	1,0E+10
	Tankers	0,81	3,45	13,83	70,96	1,21	5,18	20,75	106,44	2,69	11,51	46,10	236,54	6,7E+07	2,8E+08	1,1E+09	5,9E+09
	Bulk carriers	0,39	1,50	3,85	26,98	0,59	2,25	5,78	40,47	1,31	4,99	12,84	89,94	3,3E+07	1,2E+08	3,2E+08	2,2E+09
	General cargo	0,34	1,30	2,57	10,87	0,52	1,95	3,85	16,30	1,15	4,33	8,56	36,22	2,8E+07	1,1E+08	2,1E+08	9,0E+08
	Car carriers	0,43	2,18	5,30	24,65	0,65	3,27	7,95	36,98	1,44	7,27	17,68	82,17	3,6E+07	1,8E+08	4,4E+08	2,0E+09
	Passenger ship	1,88	7,68	16,67	77,34	43,82	52,52	66,01	157,01	97,38	116,70	146,68	348,92	2,4E+09	2,9E+09	3,6E+09	8,6E+09
	Ro-Ro	0,30	1,55	2,73	18,30	0,45	2,33	4,10	27,44	1,00	5,18	9,11	60,98	2,5E+07	1,3E+08	2,3E+08	1,5E+09
	Ro-Pax	1,02	6,22	17,79	65,26	71,53	79,33	96,68	167,89	158,95	176,30	214,85	373,09	3,9E+09	4,4E+09	5,3E+09	9,2E+09
	Other	0,38	1,11	1,65	7,30	0,57	1,66	2,48	10,94	1,26	3,69	5,51	24,32	3,1E+07	9,1E+07	1,4E+08	6,0E+08
	Fishing fleet	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
	Port operations	0,00	0,00	0,00	0,00	2,80	2,80	0,00	0,00	6,22	6,22	0,00	0,00	1,5E+08	1,5E+08	0,0E+00	0,0E+00
GS & Islands	Container ships	8,59	34,66	92,73	535,45	12,89	51,99	139,09	803,18	28,64	115,53	309,09	1784,84	7,1E+08	2,9E+09	7,6E+09	4,4E+10
	Tankers	3,40	13,40	60,49	286,09	5,09	20,10	90,73	429,13	11,32	44,66	201,62	953,62	2,8E+08	1,1E+09	5,0E+09	2,4E+10
	Bulk carriers	0,61	2,13	5,20	27,03	0,92	3,19	7,79	40,55	2,04	7,09	17,32	90,10	5,1E+07	1,8E+08	4,3E+08	2,2E+09
	General cargo	1,93	8,77	18,77	76,76	2,90	13,16	28,15	115,15	6,44	29,25	62,55	255,88	1,6E+08	7,2E+08	1,5E+09	6,3E+09
	Car carriers	0,17	1,69	4,48	12,35	0,25	2,54	6,72	18,52	0,56	5,63	14,94	41,16	1,4E+07	1,4E+08	3,7E+08	1,0E+09
	Passenger ship	4,29	17,49	35,61	158,18	6,43	26,24	53,41	237,28	14,29	58,32	118,70	527,28	3,5E+08	1,4E+09	2,9E+09	1,3E+10
	Ro-Ro	0,93	4,53	7,74	51,32	1,40	6,80	11,61	76,98	3,11	15,11	25,81	171,06	7,7E+07	3,7E+08	6,4E+08	4,2E+09
	Ro-Pax	4,09	24,45	85,71	319,18	6,13	36,67	148,56	498,77	13,63	81,50	330,13	1108,38	3,4E+08	2,0E+09	8,2E+09	2,7E+10
	Other	12,50	30,34	45,05	209,75	18,75	45,50	67,58	314,63	41,67	101,12	150,17	699,18	1,0E+09	2,5E+09	3,7E+09	1,7E+10
	Fishing fleet	0,00	0,00	0,00	0,00	0,42	0,94	1,78	5,97	0,93	2,09	3,96	13,27	2,3E+07	5,2E+07	9,8E+07	3,3E+08
	Port operations	0,00	0,00	0,00	0,00	2,00	2,00	0,00	0,00	4,44	4,44	0,00	0,00	1,1E+08	1,1E+08	0,0E+00	0,0E+00

Table 11 - Consolidated forecast per segment - Low scenario

Corridor	Port	Top Down - post regional share (kton/a)				Consolidated forecast (kton/a)				Consolidated forecast (10^3 m^3/a)				Consolidated forecast (MJ/a)			
		2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050
Atlantic	Container ships	0,36	2,32	8,06	38,42	0,36	2,32	8,06	38,42	0,81	5,16	17,91	85,37	2,0E+07	1,3E+08	4,4E+08	2,1E+09
	Tankers	0,33	1,64	5,73	46,76	0,33	1,64	5,73	46,76	0,72	3,64	12,74	103,90	1,8E+07	9,0E+07	3,2E+08	2,6E+09
	Bulk carriers	0,29	1,05	3,00	33,13	0,29	1,05	3,00	33,13	0,64	2,32	6,66	73,63	1,6E+07	5,7E+07	1,6E+08	1,8E+09
	General cargo	0,13	0,82	2,10	13,86	0,13	0,82	2,10	13,86	0,29	1,82	4,66	30,80	7,2E+06	4,5E+07	1,2E+08	7,6E+08
	Car carriers	0,10	0,52	1,39	6,84	0,10	0,52	1,39	6,84	0,21	1,15	3,08	15,19	5,3E+06	2,8E+07	7,6E+07	3,8E+08
	Passenger ship	0,45	1,51	3,65	19,67	0,45	1,51	3,65	19,67	0,99	3,36	8,11	43,71	2,5E+07	8,3E+07	2,0E+08	1,1E+09
	Ro-Ro	0,03	0,15	1,00	4,19	0,03	0,15	1,00	4,19	0,07	0,32	2,23	9,31	1,7E+06	8,0E+06	5,5E+07	2,3E+08
	Ro-Pax	0,01	0,03	0,06	1,42	0,01	0,03	0,06	1,42	0,02	0,07	0,14	3,15	5,2E+05	1,7E+06	3,5E+06	7,8E+07
	Other	0,30	0,58	1,01	5,24	0,30	0,58	1,01	5,24	0,66	1,28	2,24	11,65	1,6E+07	3,2E+07	5,6E+07	2,9E+08
	Fishing fleet	0,00	0,00	0,00	0,00	0,51	1,03	2,06	8,73	1,14	2,28	4,57	19,41	2,8E+07	5,6E+07	1,1E+08	4,8E+08
	Port operations	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Mediterranean	Container ships	0,67	4,14	13,01	86,12	0,67	4,14	13,01	86,12	1,48	9,21	28,91	191,37	3,7E+07	2,3E+08	7,2E+08	4,7E+09
	Tankers	0,38	2,04	6,45	56,80	0,38	2,04	6,45	56,80	0,84	4,53	14,33	126,23	2,1E+07	1,1E+08	3,5E+08	3,1E+09
	Bulk carriers	0,18	0,71	2,02	20,15	0,18	0,71	2,02	20,15	0,41	1,58	4,48	44,77	1,0E+07	3,9E+07	1,1E+08	1,1E+09
	General cargo	0,11	0,60	1,28	7,46	0,11	0,60	1,28	7,46	0,24	1,33	2,84	16,58	6,0E+06	3,3E+07	7,0E+07	4,1E+08
	Car carriers	0,20	0,97	2,69	16,62	0,20	0,97	2,69	16,62	0,44	2,17	5,98	36,93	1,1E+07	5,4E+07	1,5E+08	9,1E+08
	Passenger ship	0,90	2,83	6,72	45,71	0,90	2,83	6,72	45,71	2,00	6,29	14,92	101,58	4,9E+07	1,6E+08	3,7E+08	2,5E+09
	Ro-Ro	0,14	0,49	1,19	10,88	0,14	0,49	1,19	10,88	0,31	1,09	2,63	24,18	7,8E+06	2,7E+07	6,5E+07	6,0E+08
	Ro-Pax	0,51	2,06	6,58	37,43	70,51	72,06	76,58	107,43	156,69	160,13	170,18	238,73	3,9E+09	4,0E+09	4,2E+09	5,9E+09
	Other	0,18	0,37	0,81	4,18	0,18	0,37	0,81	4,18	0,41	0,81	1,80	9,29	1,0E+07	2,0E+07	4,5E+07	2,3E+08
	Fishing fleet	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
	Port operations	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
GS & Islands	Container ships	3,19	16,21	46,33	378,78	3,19	16,21	46,33	378,78	7,08	36,03	102,95	841,74	1,8E+08	8,9E+08	2,5E+09	2,1E+10
	Tankers	1,52	8,06	26,46	231,01	1,52	8,06	26,46	231,01	3,38	17,92	58,81	513,36	8,4E+07	4,4E+08	1,5E+09	1,3E+10
	Bulk carriers	0,30	0,93	2,66	20,10	0,30	0,93	2,66	20,10	0,66	2,07	5,91	44,66	1,6E+07	5,1E+07	1,5E+08	1,1E+09
	General cargo	0,66	4,02	8,70	52,37	0,66	4,02	8,70	52,37	1,47	8,94	19,34	116,38	3,6E+07	2,2E+08	4,8E+08	2,9E+09
	Car carriers	0,06	0,52	2,98	6,79	0,06	0,52	2,98	6,79	0,12	1,16	6,62	15,10	3,0E+06	2,9E+07	1,6E+08	3,7E+08
	Passenger ship	1,87	6,47	14,78	92,69	1,87	6,47	14,78	92,69	4,15	14,37	32,85	205,98	1,0E+08	3,6E+08	8,1E+08	5,1E+09
	Ro-Ro	0,50	1,39	2,93	30,26	0,50	1,39	2,93	30,26	1,11	3,09	6,50	67,25	2,7E+07	7,6E+07	1,6E+08	1,7E+09
	Ro-Pax	2,15	7,58	29,83	186,20	2,15	7,58	29,83	186,20	4,78	16,86	66,30	413,79	1,2E+08	4,2E+08	1,6E+09	1,0E+10
	Other	6,57	11,44	20,72	125,30	6,57	11,44	20,72	125,30	14,61	25,42	46,05	278,43	3,6E+08	6,3E+08	1,1E+09	6,9E+09
	Fishing fleet	0,00	0,00	0,00	0,00	0,21	0,42	0,84	3,56	0,47	0,93	1,86	7,91	1,2E+07	2,3E+07	4,6E+07	2,0E+08
	Port operations	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00

Table 12 - Consolidated forecast per segment - Low scenario

Corridor	Port	Top Down - post regional share (kton/a)				Consolidated forecast (kton/a)				Consolidated forecast (10^3 m^3/a)				Consolidated forecast (MJ/a)			
		2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050	2020	2025	2030	2050
Atlantic	Container ships	2,55	11,46	26,21	76,26	3,82	17,19	39,32	114,40	8,49	38,20	87,37	254,22	2,1E+08	9,5E+08	2,2E+09	6,3E+09
	Tankers	1,07	5,33	20,62	79,20	1,60	7,99	30,93	118,79	3,56	17,76	68,73	263,98	8,8E+07	4,4E+08	1,7E+09	6,5E+09
	Bulk carriers	0,87	3,85	8,74	58,49	1,30	5,77	13,10	87,73	2,89	12,82	29,12	194,96	7,2E+07	3,2E+08	7,2E+08	4,8E+09
	General cargo	1,09	3,71	8,79	26,58	1,63	5,57	13,19	39,87	3,63	12,38	29,31	88,59	9,0E+07	3,1E+08	7,3E+08	2,2E+09
	Car carriers	0,53	2,42	4,21	14,08	0,80	3,63	6,32	21,11	1,77	8,06	14,04	46,92	4,4E+07	2,0E+08	3,5E+08	1,2E+09
	Passenger ship	1,74	6,53	13,56	45,01	2,61	9,80	20,35	67,52	5,81	21,78	45,21	150,05	1,4E+08	5,4E+08	1,1E+09	3,7E+09
	Ro-Ro	0,14	1,57	3,12	10,17	0,21	2,35	4,69	15,25	0,47	5,22	10,41	33,89	1,2E+07	1,3E+08	2,6E+08	8,4E+08
	Ro-Pax	0,03	0,11	1,42	3,12	0,05	0,16	2,13	4,68	0,11	0,35	4,72	10,39	2,8E+06	8,7E+06	1,2E+08	2,6E+08
	Other	0,92	2,48	3,74	11,84	1,38	3,71	5,61	17,76	3,07	8,25	12,46	39,47	7,6E+07	2,0E+08	3,1E+08	9,8E+08
	Fishing fleet	0,00	0,00	0,00	0,00	1,28	3,34	5,91	18,50	2,85	7,42	13,13	41,10	7,1E+07	1,8E+08	3,2E+08	1,0E+09
	Port operations	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
Mediterranean	Container ships	4,73	18,23	49,75	160,22	7,09	27,34	74,63	240,33	15,76	60,76	165,85	534,06	3,9E+08	1,5E+09	4,1E+09	1,3E+10
	Tankers	1,31	6,06	24,25	96,09	1,97	9,09	36,38	144,14	4,37	20,21	80,85	320,31	1,1E+08	5,0E+08	2,0E+09	7,9E+09
	Bulk carriers	0,61	2,61	5,78	35,94	0,92	3,91	8,67	53,91	2,05	8,68	19,26	119,80	5,1E+07	2,1E+08	4,8E+08	3,0E+09
	General cargo	0,85	2,39	4,81	14,49	1,27	3,58	7,22	21,74	2,82	7,96	16,04	48,30	7,0E+07	2,0E+08	4,0E+08	1,2E+09
	Car carriers	1,10	4,40	9,47	32,79	1,65	6,60	14,21	49,18	3,68	14,67	31,58	109,29	9,1E+07	3,6E+08	7,8E+08	2,7E+09
	Passenger ship	3,28	12,17	26,36	101,87	84,93	98,26	119,54	232,80	188,73	218,35	265,64	517,33	4,7E+09	5,4E+09	6,6E+09	1,3E+10
	Ro-Ro	0,57	2,36	4,25	23,87	0,85	3,54	6,38	35,81	1,89	7,86	14,17	79,57	4,7E+07	1,9E+08	3,5E+08	2,0E+09
	Ro-Pax	2,28	11,80	28,46	87,10	73,42	87,70	112,69	200,65	163,15	194,89	250,42	445,89	4,0E+09	4,8E+09	6,2E+09	1,1E+10
	Other	0,53	1,95	2,69	9,45	0,80	2,93	4,04	14,17	1,77	6,50	8,98	31,50	4,4E+07	1,6E+08	2,2E+08	7,8E+08
	Fishing fleet	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0E+00	0,0E+00	0,0E+00	0,0E+00
	Port operations	0,00	0,00	0,00	0,00	5,60	5,60	0,00	0,00	12,44	12,44	0,00	0,00	3,1E+08	3,1E+08	0,0E+00	0,0E+00
GS & Islands	Container ships	19,11	66,33	171,82	672,19	53,67	124,49	282,72	1033,28	119,26	276,65	628,28	2296,19	3,0E+09	6,8E+09	1,6E+10	5,7E+10
	Tankers	5,36	24,36	108,69	385,05	8,04	36,54	163,04	577,57	17,87	81,21	362,30	1283,50	4,4E+08	2,0E+09	9,0E+09	3,2E+10
	Bulk carriers	0,83	3,86	7,82	36,81	1,24	5,79	11,72	55,22	2,76	12,86	26,05	122,70	6,8E+07	3,2E+08	6,4E+08	3,0E+09
	General cargo	5,40	16,05	37,56	102,50	8,10	24,08	56,35	153,76	18,01	53,51	125,21	341,68	4,5E+08	1,3E+09	3,1E+09	8,5E+09
	Car carriers	0,53	4,88	5,72	17,23	0,80	7,32	8,58	25,84	1,77	16,26	19,07	57,42	4,4E+07	4,0E+08	4,7E+08	1,4E+09
	Passenger ship	7,50	26,49	52,39	209,95	11,24	39,73	78,58	314,93	24,98	88,29	174,63	699,85	6,2E+08	2,2E+09	4,3E+09	1,7E+10
	Ro-Ro	1,46	6,59	21,08	67,00	2,19	9,89	31,61	100,50	4,88	21,97	70,25	223,34	1,2E+08	5,4E+08	1,7E+09	5,5E+09
	Ro-Pax	8,36	49,54	131,64	421,61	12,54	94,31	217,46	652,42	27,87	209,58	483,25	1449,81	6,9E+08	5,2E+09	1,2E+10	3,6E+10
	Other	17,93	52,15	70,92	268,65	26,89	78,23	106,38	402,97	59,76	173,84	236,41	895,50	1,5E+09	4,3E+09	5,8E+09	2,2E+10
	Fishing fleet	0,00	0,00	0,00	0,00	0,52	1,36	2,41	7,54	1,16	3,03	5,35	16,76	2,9E+07	7,5E+07	1,3E+08	4,1E+08
	Port operations	0,00	0,00	0,00	0,00	4,00	4,00	0,00	0,00	8,89	8,89	0,00	0,00	2,2E+08	2,2E+08	0,0E+00	0,0E+00

Table 13 - Consolidated forecast per corridor

	Basic scenario			
	2020	2025	2030	2050
Atlantic	17,64	72,58	193,2	843,99
Mediterranean	277,9	367,28	554,31	1662,14
GS & Islands	127,09	464,74	1234,3	5644,79
Total	422,63	904,6	1981,81	8150,92

	Low scenario			
	2020	2025	2030	2050
Atlantic	5,57	21,41	62,34	396,14
Mediterranean	162,83	187,15	246,09	785,67
GS & Islands	37,84	126,79	347,21	2504,6
Total	206,24	335,35	655,64	3686,41

	High scenario			
	2020	2025	2030	2050
Atlantic	32,64	132,2	314,53	1123,55
Mediterranean	396,65	552,31	852,8	2206,07
GS & Islands	287,184	946,07	2130,81	7386,74
Total	716,474	1630,58	3298,14	10716,36

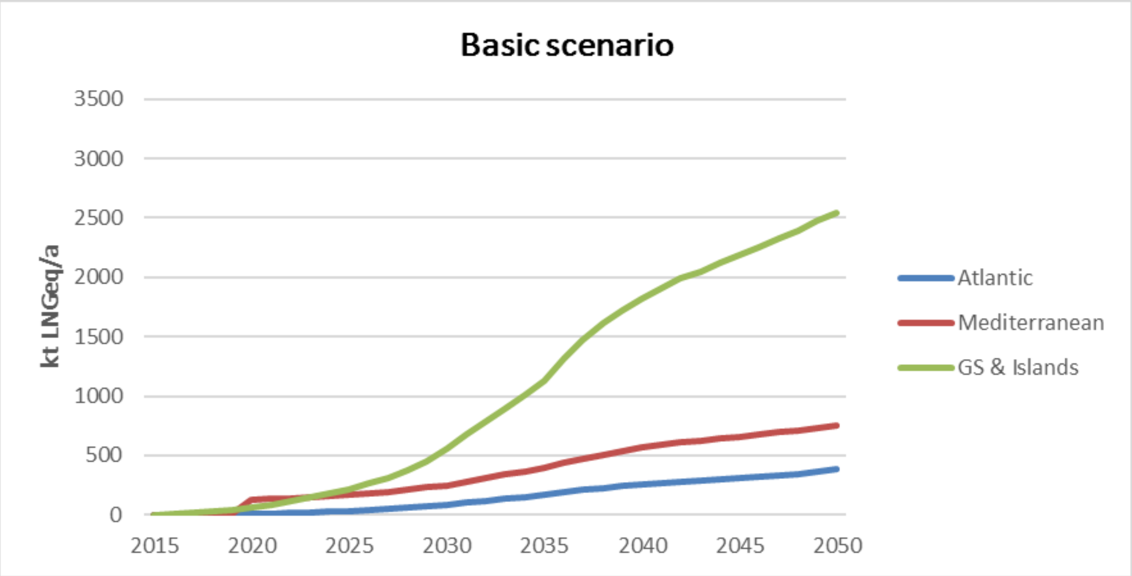

Figure 3: Consolidated forecast - Basic scenario

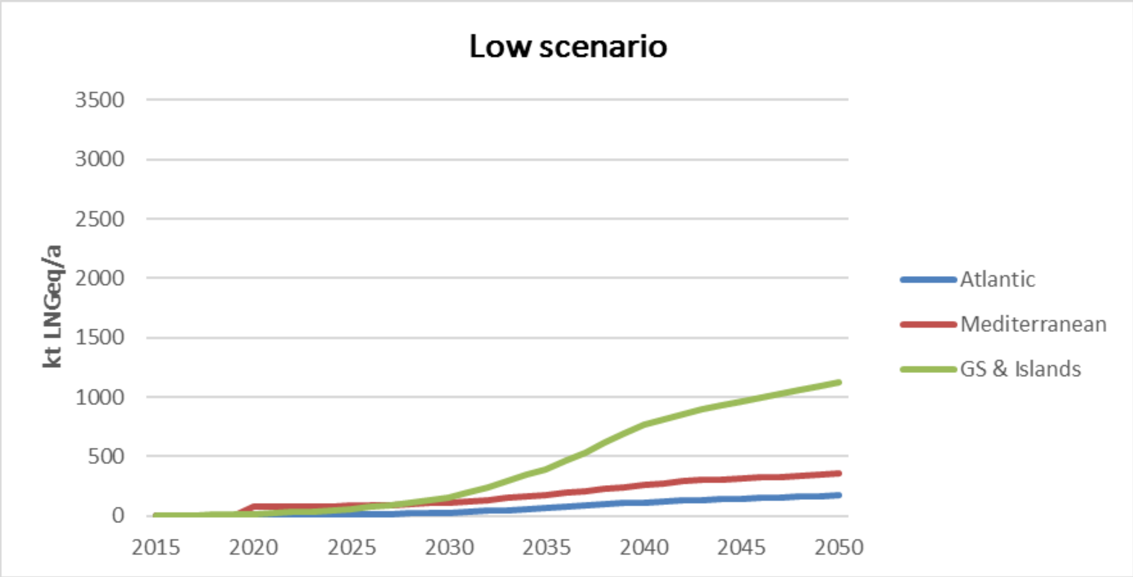

Figure 4: Consolidated forecast - Low scenario

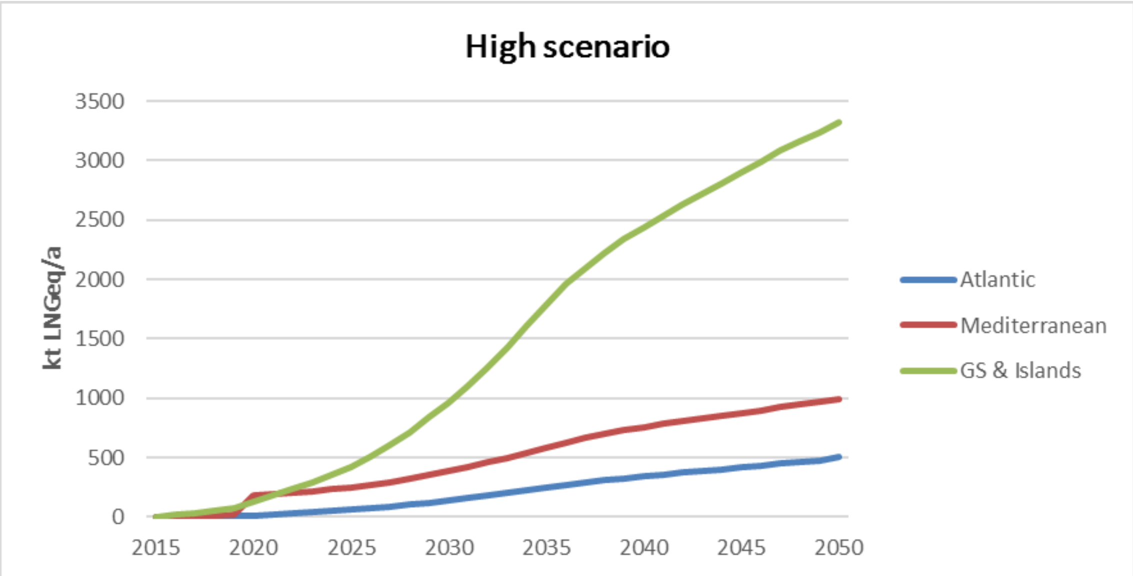

Figure 5: Consolidated forecast - High scenario

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Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.