



**CORE LNGas
hive**



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ASSISTANCE CORE LNGAS HIVE PROJECT

LNG Market Study: Bottom Up Analysis

ENAGAS, S.A.

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Objective: The current report comprises the results of the bottom-up analysis of the CORE LNGas HIVE project activities ET2, ET3 and ET4. This delivery contains the results from the bottom-up analysis, as an input to the LNG demand definition.

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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.

The scope of the study of DNV GL is to

- Evaluate the current state and future evolution of demand for LNG as a fuel in harbours and maritime transport, including the evaluation of the existence of ships and equipment suitable for the use of LNG.
- Evaluate current state and future development of the supply infrastructure,
- Defining possible offer scenarios and emphasising on the limitations imposed by the supply logistics chain.
- Provide criteria for the establishment of measures that allow the LNG supply and demand objectives analysed in previous sections to be reached.

DNV GL proposed approach consist of a bottom up analysis of current demand and infrastructure, a top down scenario development and a consolidation and integration part.

The bottom-up approach will deliver semi-quantitative data based on stakeholder interviews, a survey and an analysis of publicly available data such as annual reports of relevant companies. The strength of the Bottom-Up approach is that it can capture non-quantitative aspects like opinions and expectations of key people. More detail on approach and activities are included in the next chapter.

This reports details the results of the bottom up analysis. The results are presented per segment.

2 APPROACH BOTTOM UP ANALYSIS

2.1 Interviews

Interview goals

The main goal of the interviews was to develop insight of the current situation w.r.t. LNG and to what extent main stakeholders consider LNG as an alternative shipping fuel and as a fuel for port operations and intra port transport. Main goal of the interviews was to identify:

- Developments in the maritime market, more specific in lines, cargo, fleet.
- Main enablers and barriers to use and/or to develop LNG
- Main criteria of shipping companies to select a bunkering port
- Best way for shipping companies to adapt to future emission regulations.
- Potential demand for LNG use.
- Main characteristics of future LNG supply chain infrastructure.

The results of the interviews have been used to fine tune an e-survey to all stakeholders.

Interview segmentation

As part of this project, 50 interviews across 6 segments and two countries were planned (see table below). In the segment 'Shipping companies', the focus was on Spanish and Portuguese companies with international operations but main activities in Spain/Portugal. The selected set of interviewees aimed for a good representation of companies with fixed lines who are considered to be first movers, like ferries and cruisers. Fishing companies were excluded from the interviews because of the big share of small companies operating only one vessel. It was considered difficult to convince this target group to be available for an interview during the summer period. For bunkering services, the focus was on companies currently supplying fuel to ships. For port terminal operators, the interviews focussed on the main players in the container terminal market to get a better understanding of the status w.r.t. fuel and electricity consumption, emission reduction and potential of LNG for (on land) port operations.

Executed interviews

45 out of 50 interviews have been executed (90%). In general, it was difficult to plan the interviews for Shipping Companies in Spain because of low availability due to holiday period and (for some segments) limited interest in the subject. 18 companies contacted were not available for an interview. See Table 1 column n.a. (not available) for the distribution of the companies between the segments. Because of the clear picture for shipping companies a new target was set on 9 companies for Spain. In addition, some stakeholders expressed doubts due to the potential commercial character of this research.

Table 1: Overview of the executed and planned interviews

SEGMENTS	Spain			PORTUGAL		
	Target	Done	n.a.*	Target	Done	n.a.*
Port authorities	8	8	1	5	4	1
Shipping companies	12	8	8	6	6	2
Natural gas suppliers	2	2		2	2	
Terminals LNG/Gas	3	3		2	2	
Bunkering suppliers	3	3	5	1	1	
Port and transport Infra	2	2	1	2	2	
Other	1	1		1	1	
	31	27	15	19	18	3

***n.a.: not available: for reasons of availability and/or no interest to participate (no interest in the subject/not willing to participate due to the potential commercial character of the study)**

Coverage of subjects

Except for front runner shipping companies, port authorities and logistic terminals, the interviewed respondents don't see big opportunities and are hardly studying LNG as fuel. Therefore, no specific studies and plans related to LNG are being developed. This lack of plans implies that most shipping companies are not able to give specific (qualitative and/or quantitative) insight in LNG opportunities, best options for the transition, indications of future LNG consumption and specific requirements for LNG infrastructure.

2.2 E-survey

Based on the results of the interviews an e-survey with 12 questions has been defined. Four questions had a generic character: question and answer categories were the same for all segments. Other questions and answer categories are specific for one or two segments. The e-survey was available in Spanish, Portuguese and English. See annex A for an overview of questions and answer categories.

Based on the difficulties to plan interviews and on the provided information during the interview DNV GL proposed to shorten and simplify the survey. Simplification to an e-survey that could be completed within 15 minutes was necessary to get a representative sample of completed surveys per segment. Detailed quantitative questions on subjects like current fuel consumption, transport km/s, average ship age etc. are excluded because answering these questions is time consuming and on a more generic level this information can be derived from other sources. Questions on specific plans for the coming years have been excluded because the recent interviews learned that only a very limited number of respondents have detailed plans and most of them are not willing to share this information.

The e-survey has been sent to over 400 respondents in over 250 companies. Table 2 presents an overview of contacts, targets responses and completed responses.

All contacts received a personal e-mail invitation and a reminder from DNV GL. Finally, DNV GL called 40 companies to get responses on the major questions. These reminders led to 24 extra responses.

Note that the figures in the table below represent unique responses (one per company).

Table 2 Overview of status e-survey

Segment	Overview responses				
	Nr. organisations Invited by mail	Targeted response rate	Nr. Targeted responses	Nr. Completed	% targets Completed
Port Authorities	30	80%	24	24	100%
Shipping companies	120	25%	30	30	100%
Natural Gas Suppliers	16	50%	8	5	62%
LNG & gas terminals	5	80%	4	4	100%
Bunkering services	22	50%	11	5	45%
Port terminals	31	33%	10	13	130%
Total	224		87	81	93%

The share of responses for Port Authorities, Natural Gas suppliers and LNG terminals is high enough to get representative responses. Because we interviewed all main port terminal owners in Spain and Portugal and because of the great similarities in operations the results of Port terminals are also considered to be representative. The sample of bunkering companies was too small for a statistical representative result. But since the results are in line with results of interviews with bunkering companies and with the input from other segments, the results for this segment are considered accurate.

3 MAIN FINDINGS AND ANALYSIS

This chapter contains an overview of the main findings from all the stakeholders. Detailed findings per stakeholders are elaborated in the next chapters (chapter 4 to 9). In general, the tables/figures are based on the results of the e-survey, main findings are based on e-survey/interviews and specific additional clarifications come from the interviews.

Most (shipping) companies are denying the implementation date of new emission regulation

The majority of shipping companies do not expect new emission regulation before 2025. They seem to deny or not be aware that the new EU regulation is final (Directive 2016/806/EU; 0.5% of Sulfur by 2020 in European waters). Based on EU history any delay seems to be unlikely. Intensive information campaigns, and awareness sessions seem to be needed to engage and mobilise shipping companies. According to most stakeholders Spain and Portugal are not expected to be part of ECA-zones before 2025.

Most shipping companies have no specific plans to comply with emission regulations

24% of the shipping companies are already active in LNG. A fair share of this group is only involved in pilots with for example Port Authorities. Most shipping companies are aware of several LNG related pilots of Port Authorities and leading shipping companies. They monitor progress but have no specific LNG related plans yet to become active. 40% of the respondents of the e-survey are assessing opportunities to become active. 20 % has no plans for LNG at all (see Figure 1).

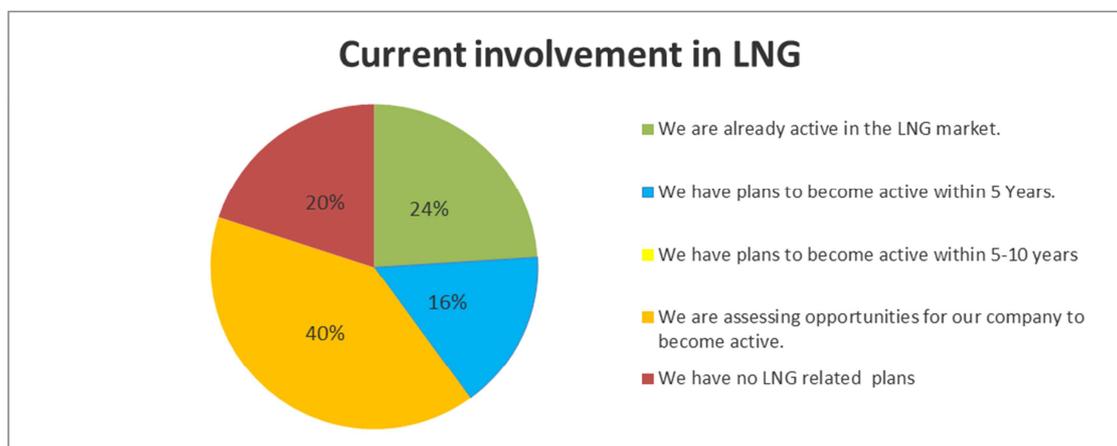


Figure 1 involvement shipping companies in LNG

Other stakeholders seem to be prepared

From the other stakeholder segments, 53% state they are already active in the LNG market. 19% has plans to become active within 5 years (see Figure 2). Most interviewees indicate the current supply infrastructure (regasification plants, storage facilities and trucks) is sufficient to meet the expected demand until 2025. Several interviewees doubt the abilities of the LNG suppliers to develop the infrastructure (barges, jetties, LNG storage capacity) needed for a fast and successful market uptake. Current differences in technical standards (quay design, bunkering systems) and the lack of a clear unified set of safety requirements and procedures lead to a relative long implementation period.

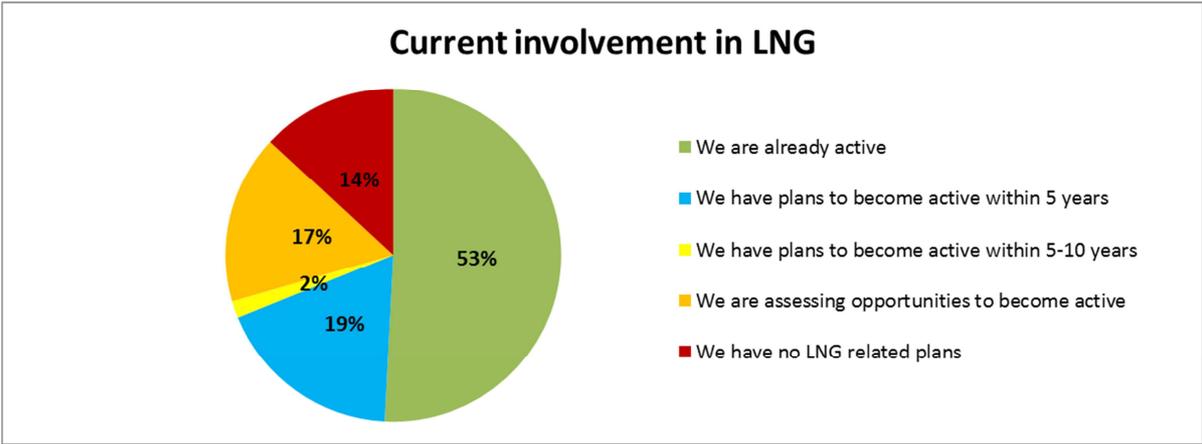


Figure 2 current involvement of other respondents in LNG business

No significant growth of LNG as shipping fuel before 2025

The take-up of LNG is still in an early stage and most stakeholders interviewed expect no significant breakthrough before 2025. Overcapacity in several shipping segments, bad economic situation and low fuel prices will hinder a quick take up.

LNG as a shipping fuel in 2030: 36% expects a market share of 10-25%

All target segments, except logistic terminals, have been asked to indicate their perception of the market share LNG as a maritime fuel in 2030 when emission regulation is in place and ample LNG is available. (See the results in Figure 3). The weighted average results in a LNG market share of approximately 25% in 2030. Several respondents indicate that the market share of LNG could grow fast if the price difference between oil based and gas based fuels will grow or stricter emission regulation come into place. Respondents that expect a relative low LNG market share don't expect strict emission regulation and do expect the availability of high quality low sulphur fuels against competitive prices.

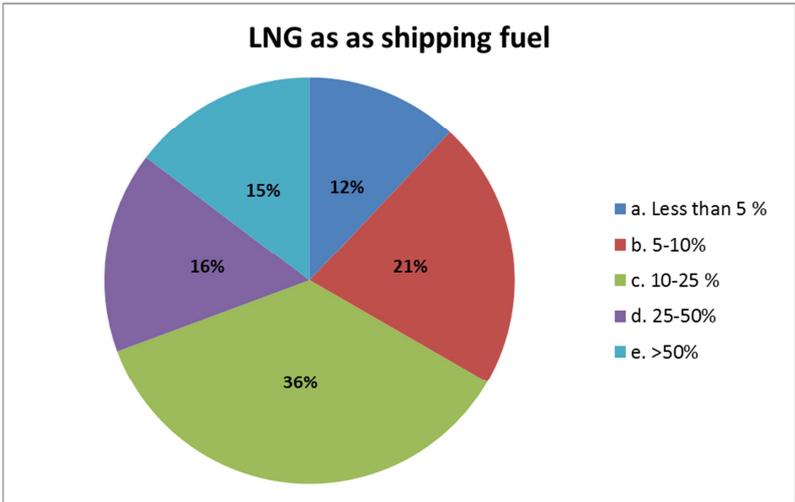


Figure 3 LNG as a shipping fuel

Stakeholders expect stricter regional emission regulation will result in loss of business

Most shipping companies and ports fear the negative impact of emission regulation on ability to compete (on cost) with other shipping companies/ports. Cost is a very important factor in the competition between shipping companies and between ports, especially in the current economic circumstances. The very high cost implications (CAPEX and OPEX) of new emission regulations and clean fuels like LNG

might cause a significant loss of business to ports and shipping companies who don't have to comply with these rules.

Progress of LNG implementation highly depending on new builds and thus economic situation

Retrofitting of current ships is very expensive and often hardly possible. Because of the bad economic situation companies will postpone investments as long as possible. A growing market and a need to expand capacity is a necessary condition for a significant growth of LNG fuelled ships. Because of the current overcapacity in cargo transport it might take a while before new cargo vessels will be ordered.

No positive business case for LNG in current situation

With the limited price difference between LNG and traditional fuels it is almost impossible to come up with a positive business case for LNG as a maritime fuel (only). Other potential consumers like port operations, trucks of logistic companies and even the use of LNG to supply municipalities and local industry seem to be needed to create the demand necessary for a positive business case.

Uncertainty on technical and economic performance of LNG solutions and other clean fuels

Large scale LNG implementation in Northern Europe and small scale tests in Spain and Portugal demonstrated positive results. Nevertheless, most shipping companies and Port Authorities have doubts on the technical performance of LNG as a shipping fuel and or fuel for port machinery. Respondents question amongst others the technical performance at the end of the life time, maintenance costs and the value for reselling on the second hand market.

Significant differences in opinions on best propulsion alternative

Stakeholders differ significantly on their opinion of the best future clean fuel alternative. Over 80% of the interviewed stakeholders clearly state preference for the cheapest solution. If applicable this would be IFo380 + scrubbers. Only a minority took very strict emission regulation and a competitive advantage of an eco-friendly image into account to identify LNG as the most competitive clean fuel. Almost 70% of the shipping companies, participating in the survey, identified dual motors as one of the preferred propulsion alternatives. See Figure 4. Several interviewees see low sulphur fuel as strong competitor that could be able to beat LNG.

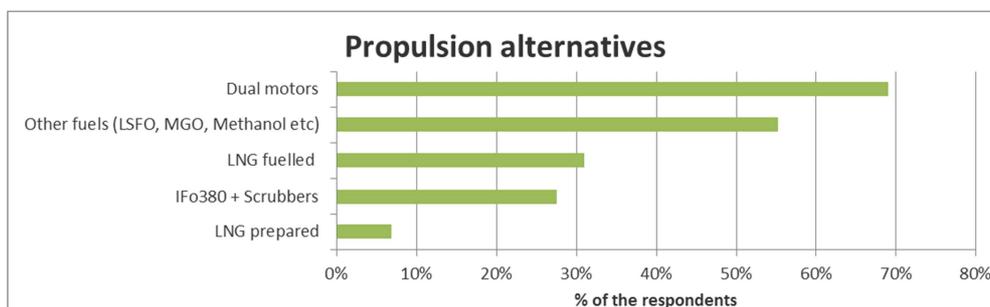


Figure 4 propulsion alternatives

Low/uncertain demand and uncertain prices of LNG are the main barriers

Almost 60% of the respondents indicate uncertainty of the future fuel prices as the main barrier for LNG as a maritime fuel. Interviews revealed that minor differences between prices of alternative fuel and LNG make it almost impossible to develop positive business cases for LNG. A change in price differences and/or strict environmental regulation could lead to a positive business case and thus a higher demand. Port Authorities, bunkering companies and LNG terminals consider the low and uncertain future demand as a

main barrier. Uncertain demand was in the top 3 of 80% of the respondents in these categories. During the interviews the high CAPEX was considered the main barrier. Huge investments in LNG fuelled ships only pay off if there are major differences between prices of alternative fuel and LNG. Uncertainty towards technical performance was in the top 3 of almost 20% of the respondents but it ranked as number 3 for shipping companies and port terminals. This barrier is a top 3 barrier for 28% of the shipping companies and 46% of the port terminals.

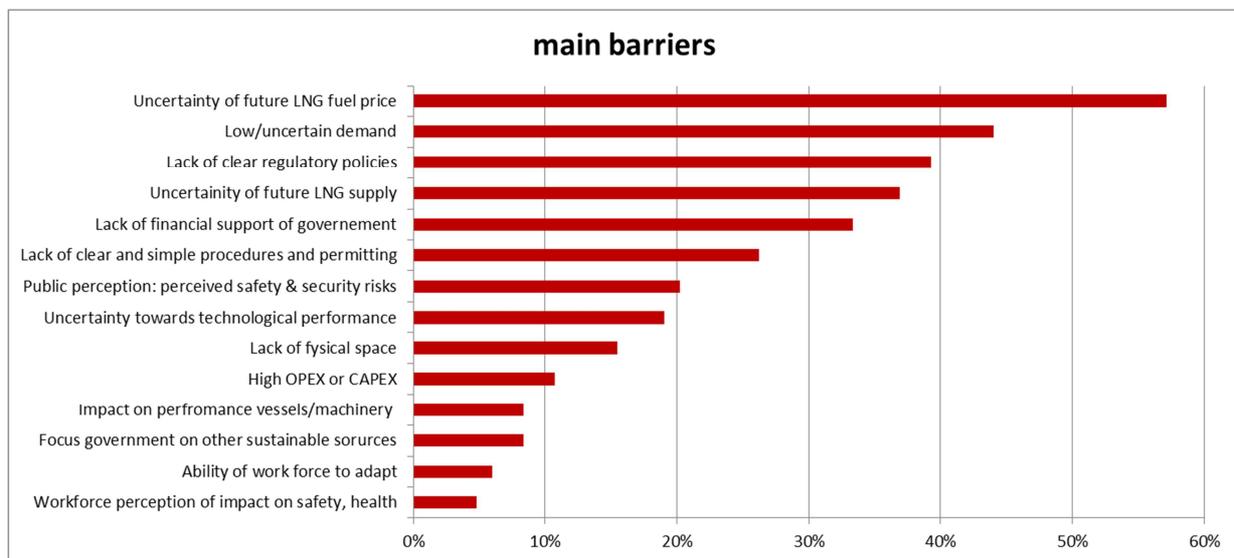


Figure 5 main barriers

Market and emission main drivers to consider LNG

Over 80% of the respondents assess increase market share, making services more attractive and emission reduction % regulation (very) important drivers to consider LNG (See Figure 6).

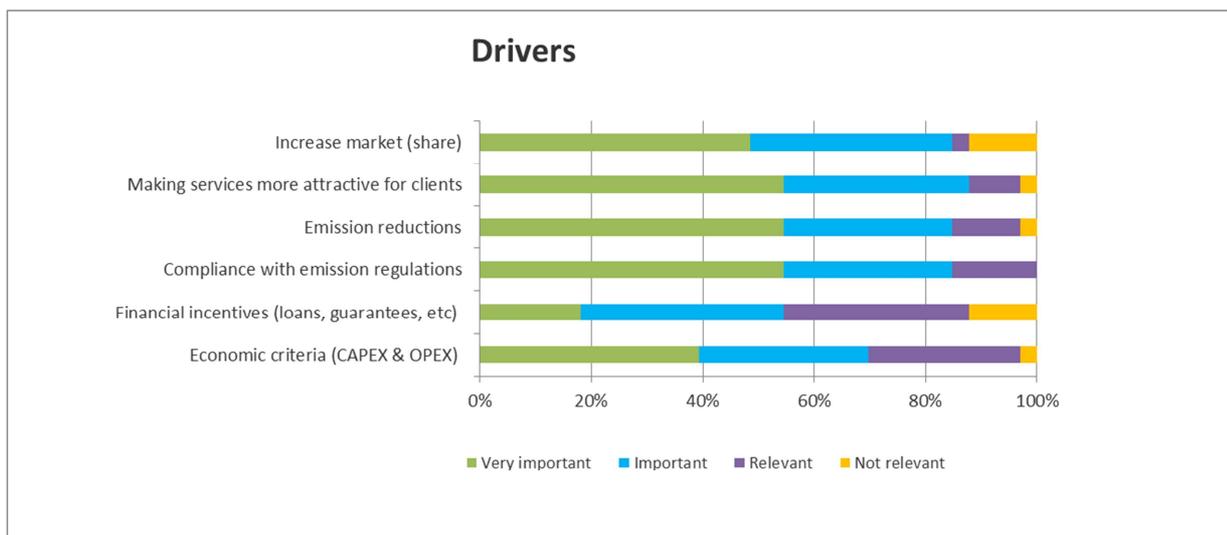


Figure 6 Drivers

Tension between cooperation and competition

In order to move forward in the Peninsula region, Spain and Portugal need one or two full scale demonstration initiatives. The high initial investment cost can only be covered with high demand for LNG. Both for investment and scaling up demand for LNG, cooperation between competing shipping

companies and ports is needed. Investing in such an early phase project is very risky (if you bet on the wrong horse you can lose all) but staying behind is also dangerous (the winners takes all, so if you start too late you might also lose business). Cooperation is also needed to prevent the loss of business to more innovative ports (in for example France) and or cheaper ports (in for example Africa). Currently there is lack of leadership and coordination to drive this pre-competitive development.

Mix of bunkering systems in a mature market

Most interviewees agreed that for the short term truck-to-ship combined with an occasional barge for cargo ships is the most optimal bunkering solution. In a matured LNG market all bunkering systems will have a position. Trucks are still the best way for small fishing ports and marinas. Barge to ship was the preferred system for the interviewees. Tanker to ship was also identified as a suitable bunkering system by 86% of the respondents of the survey (See Figure 7). Note that interviewed parties were able to address more than one option.

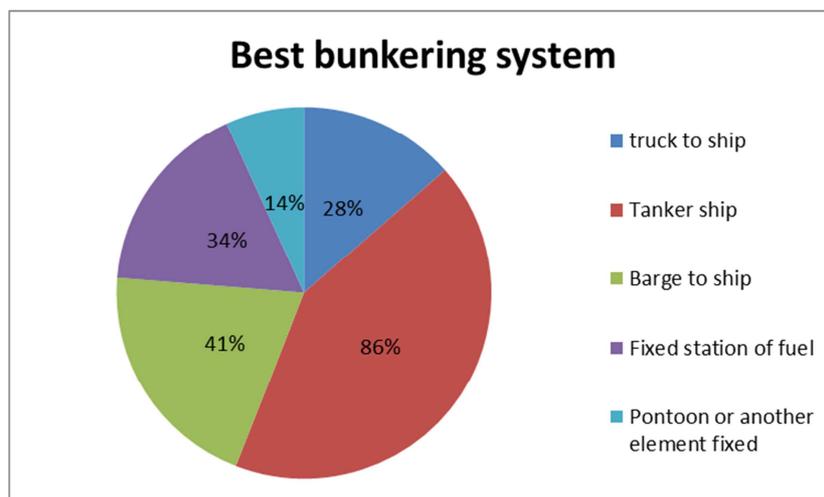


Figure 7 bunkering system

Criteria to select bunkering port

Based on the e-survey the main criteria for selecting a bunkering port are geographic situation (in top 3 of 69% of respondents), fuel prices (in top 3 of 61% of the respondents), and time at the port (in top 3 of almost 27% of the respondents, combined with waiting time for delivery this is 35%). These results are presented in Figure 8. Most interviewees concluded that in general all these bunkering selection criteria are very important but for a specific kind of ship on a specific route it might be possible to identify a top 3.

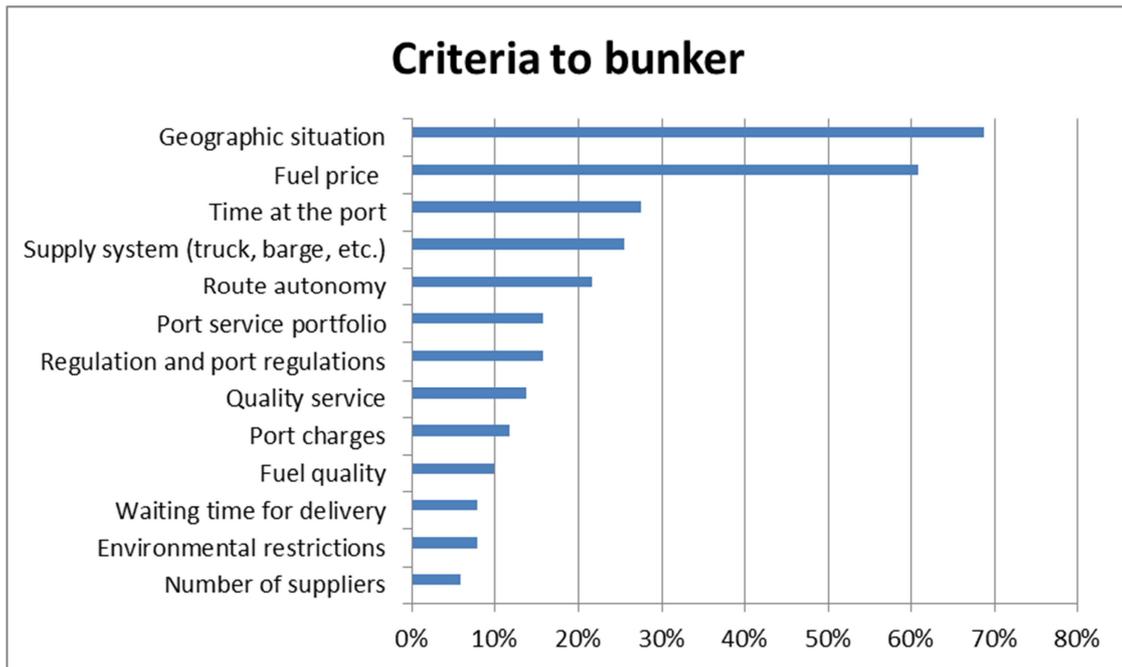


Figure 8 Main criteria to select bunkering port

LNG for Port and terminal operation

LNG for port operation is (very) likely for a specific part of machinery. Over 50% of the respondents (port Authorities and port terminal owners) indicate the use of LNG for trucks, containers trailers, reach stackers and heating and/or cooling of buildings as likely or very likely (see Figure 9). Additional consumption will benefit the overall business case for LNG due to scale advantages. LNG demand could decrease on the long term (15 years or longer) as part of the machinery is expected to be powered by electricity. It is likely that LNG will be more a transition technology towards future clean energy sources like Hydrogen and fuel cells.

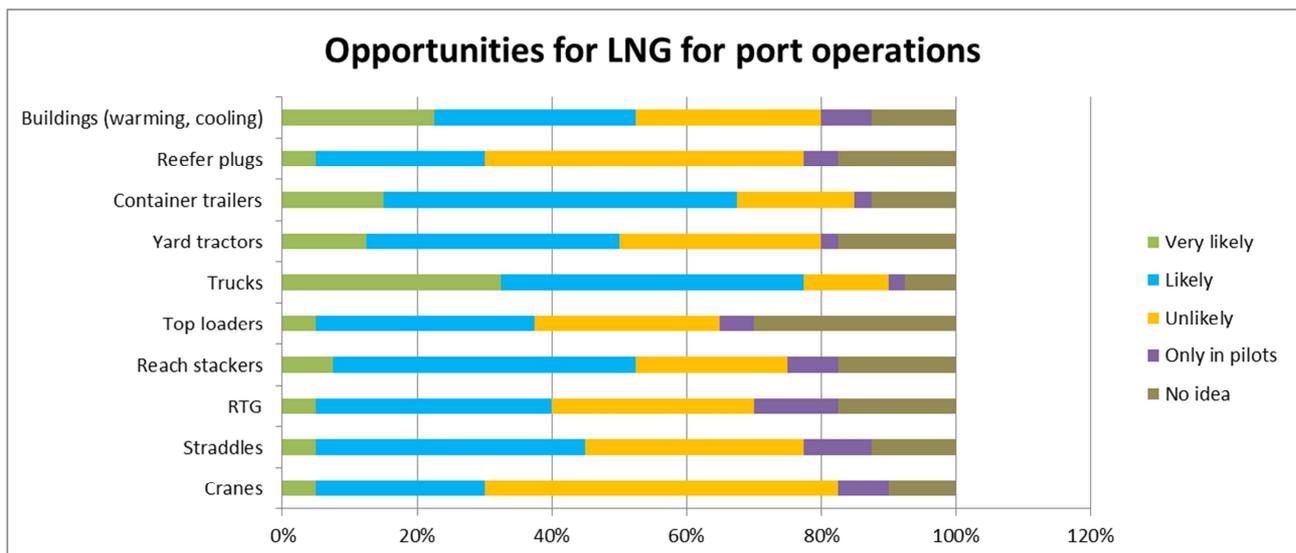


Figure 9 Opportunities for LNG for port operations and machinery

Port electrification

Currently some terminals operators are working on port electrification, they performed feasibility studies, ran pilots and some even have a strategy to replace current machinery (at the end of their life time) with electrical powered machinery. 35% of the responding Port Authorities and operators of (logistic) terminals consider electrification of a substantial part of the port operations is very likely. Another 38% consider this likely (see Figure 10). Terminal operators seem to be more in favour of terminal electrification. 65% consider electrification of a substantial part of the terminal operation likely or very likely.

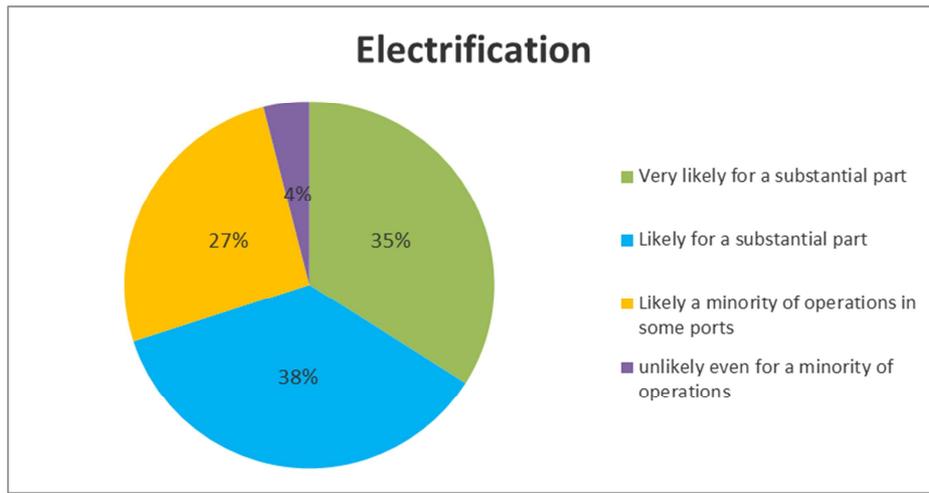


Figure 10 Likelihood of port electrification

4 PORT AUTHORITIES

4.1 Main findings

Decarbonisation policies

Interviewees (except 1) are convinced that Spain/Portugal will not be part of the ECA (Emission Control Area) zone before 2025. Policies on decarbonisation and emission reduction have to be global policies in order to guarantee a global level playing field. One Port Authority stated that new ECAs are inevitable and will reach the South Atlantic and Mediterranean corridor probably before 2025. Over 80% of the respondents to the e-survey do expect that ECA zones and other emission regulation will have a (very) high impact on port operations.

Current situation with respect to LNG as shipping fuel

50% of the Port Authorities are already supplying LNG or are ready to supply LNG to ships this year. 40% have plans to become active within 5 years. Several port authorities performed elaborate demand studies for LNG. Most Port Authorities are still working on internal sensitization and sensitization of the port community in forums and face to face visits. They recognise that several companies seem to be more committed to LNG projects than three years ago.

No significant use of LNG as shipping fuel before 2025

The take-up of LNG is still in an early stage and no significant breakthrough is expected before 2025. First movers will be cruisers and passenger ferries. Fishery vessels and container ships on regular routes are likely to follow. LNG is not likely to be supplied to tugboats as they require special dynamics of motor operation. The investments needed (CAPEX), the remaining life time of assets and the bad economic situation will lead to a slow growth path. Financial support is needed to speed up the transition to LNG. 1/3 of the respondents expect a share of 5-10% LNG as shipping fuel in 2030, 1/3 expects a share of 10-25%.

Bunkering LNG starts with trucks

Bunkering infrastructure will be initially by trucks, but with growing demand will be supplied either by barge and/or via fixed terminals. It is expected that bunkering practices will be similar to other fuels. Fuel price, geographic situation and time at the port are considered the main criteria for shipping companies to select a bunkering port.

LNG for Port operations and transport (very) likely for some machinery

Most Port Authorities participated in studies and pilots on LNG for port operations and transport. A majority of the respondents assess the use of LNG to fuel trucks (70% of the respondents), container trailers (60% of the respondents) and warming & cooling of buildings within 10 years very likely or likely. LNG competes with electrification as the main way to reduce future emissions. Almost 70% of the Port Authorities consider electrification of a substantial part of the terminal operations within 10 years likely or very likely. According to some Port Authorities LNG could be part of the energy mix of these ports. LNG will be a valuable and clean alternative for terminals running on solar and other renewable sources.

Main enablers for LNG demand & supply infra developments

The main enablers for use of LNG are tax discounts, funding for (pilot) projects, awareness campaigns from key industry players and local government, and stringent emission limits.

Main barriers for LNG demand & supply infrastructure developments

The main barriers for uptake of LNG are:

- High CAPEX/OPEX (mentioned in the top 3 of over 70% of the respondents)
- Uncertainty of future LNG fuel price (in top 3 of over 70% of the respondents)
- LNG supply chain is not available (in the top 3 of over 50% of the respondents).
- Lack of clear regulatory policies (mentioned in the top 3 of just over 30% of the respondents)

4.2 Current involvement Port Authorities in LNG business

Over 40% of the Port Authorities involved in the study are already active in the LNG market (see Figure 11). Several ports are already supplying LNG. Others are ready to supply LNG to ships this year or next year. These Port Authorities identified a potential demand, prepared to develop an LNG supply infrastructure, and sometimes even developed procedures and processes. A few port authorities performed elaborate demand studies for LNG. These studies are not limited to LNG as shipping fuel but also including port operations and industry. Port Authorities of several island ports are cooperating with municipalities and the tourist industry. In these cases, households, hotels and industrial companies are expected to be the main users of LNG.

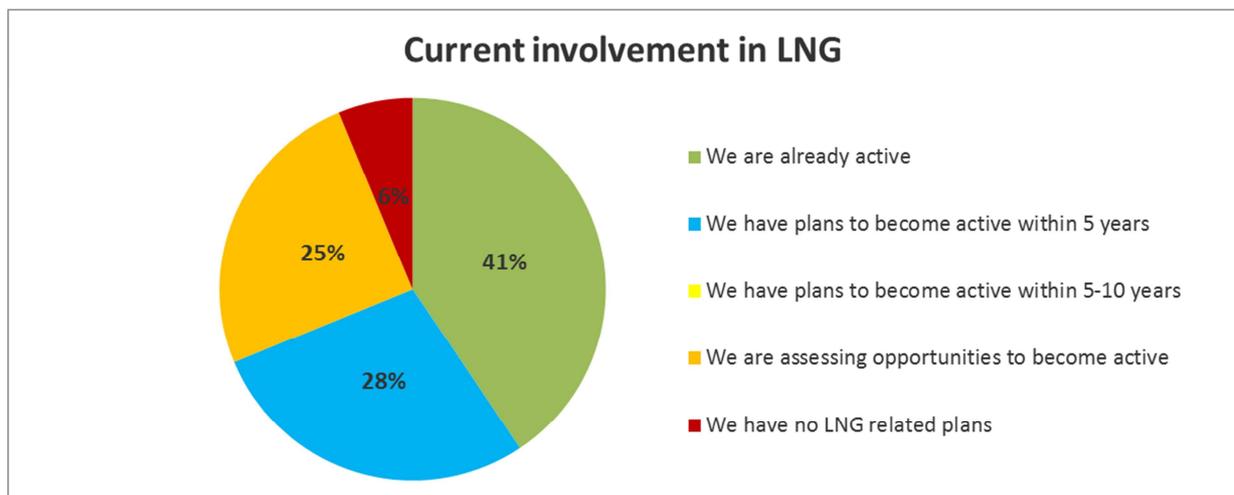


Figure 11 Current involvement port authorities in LNG

4.3 (Inter)national decarbonisation policy frameworks & plans

Spain and Portugal are not expected to be part of an ECA zone. Only one port authority believed that new ECAs are inevitable and will reach the South Atlantic and Mediterranean corridor probably before 2025. IMO has not decided yet when the global Sulphur cap will become effective (2020 or 2025), in case of the latter, the Mediterranean will be divided in two areas: the northern part (using natural gas) and southern part (using HFO). This might imply that most car-carriers or container carriers will move to the south for bunkering purposes. This will lead to a strong pressure on the already vulnerable national economies. Interviewees seem to be convinced that the national governments will be able to block such a devastating implementation. Ports and companies have to compete with cheaper services of ports and companies outside the EU on cost and will lose business. Remaining an attractive location for tourism is a main driver for several cities. This results into ambitious goals of local government and industry (tourism and other).

Emission regulation will have a (very) high impact on port operations

The majority of Port Authorities (85%) expect a high or very high impact of emission regulation on port activities (see Figure 12). Ports will have to consider measures to reduce emissions from trucks and port machinery because trucks are responsible for up to 20% and machinery for up to 30% of the port emissions. This broad perspective is also needed to create the necessary LNG demand for a positive business case.

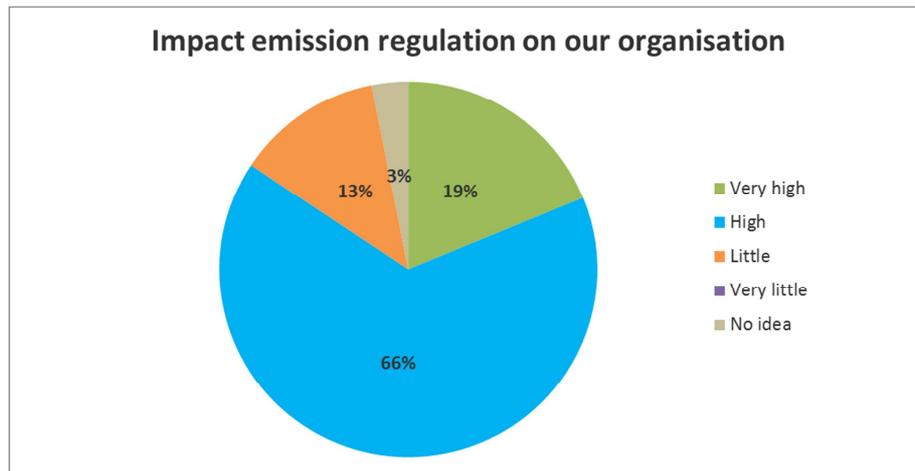


Figure 12 impact of emission regulation

Elaborate set of actions to encourage stakeholders to work on decarbonisation

Port authorities stimulate stakeholders to work on LNG and decarbonisation via multiple activities like: awareness meetings, initiating R&D projects, facilitating innovative pilots (with funds, contribution in kind), developing LNG infrastructure (regasification plants, storage facilities and/or fuel stations for vessels and machinery), reducing port charges, taxers and tolls (like a 50% reduction for LNG fuelled vessels), developing a clear framework of regulations & procedures and the mandatory implementation of good practices as part of the concession requirement for companies.

Example port authority 1 : how to comply to future emission regulations

The port authority needed and still needs to innovate and become more sustainable to hold a good competitive position. Sustainability is since 20 years an issue with the start of ECO-ports and the creation of a working group (of now 22 organizations, mainly terminal operators) to obtain a sustainability certification. 6 companies have an IMS certification, with some of them additionally an ISO 50001 certification. This group has defined voluntary targets and companies can pick suitable targets. Port authorities and port terminal operators have clearly taken advantage of their efforts.

Example port authority 2: how to comply to future emission regulations

The port authority has already started the process of changing the regulation to allow for LNG. In terms of ports' infrastructure, it is prepared to make the shift to LNG, once funds are available to cover the incremental costs to invest on LNG machinery (motors, pumps, forklifts, reach stackers). The port authority issued recently new rules aimed to promote export of goods, attract cruisers, protect the environment and ensure safe operations. There are reductions of port fees and pilotage services for frequent calls. The most likely LNG-option does not require a high fixed investment, since the solution should pass by an LNG supply mobile module based on a container. In addition, the current motors are reaching their end of life (e.g. diesel engine powering cranes installed) so it is the right time to invest. Yet, no effective plans are on top of the table with regard to this subject.

Example port authority 3: how to comply to future emission regulations

Some port equipment is already powered on electricity. If LNG goes ahead it can be used as fuel for new machinery. Every appliance that can contribute to leverage LNG demand is relevant. The next step is a thorough study on the expected demand of LNG in the port, so as to decide what solution best fits these projections.

4.4 LNG as a (shipping) fuel

Current situation with respect to LNG as shipping fuel

Most Port Authorities identify a growing interest of stakeholders discussing or inquiring for opportunities of LNG as a shipping fuel. Three years ago, using LNG as shipping fuel was unthinkable but nowadays things are changing. Most Port Authorities have no doubt that LNG is going to be the future. Most Port Authorities are still working on internal sensitization and the sensitization of the port community in forums and face to face visits. Some ports seem to have stopped working on LNG because lack of support of local government or lack of success (lack of positive responses from shipping companies).

No significant use of LNG as shipping fuel before 2025

Some shipping companies are starting to use LNG, but no significant breakthrough is expected before 2025. Port Authorities expect a slow growth path because of the huge investments needed for LNG, the long remaining life time of current vessels, and the bad economic situation. Financial support and stricter regulations are needed to speed up the transition to LNG.

Cruisers and ferries and are likely to lead the transition

First movers in Spain will be cruisers and ferries. Most shipping companies are waiting for results of the new LNG-fuelled Balearia vessel. First movers in Portugal to adopt LNG would be ships operating on longer routes connecting to northern Europe, where stricter environmental rules and ECA zones are in place. Most likely first movers are cruise liners and container ships active on regular lines in designated ECA zones. Significant difference in fuel prices (high price of oil/diesel) might lead to a positive business case for LNG.

Fast uptake for container ships possible but not likely

LNG uptake can go very fast if the economic growth and or international trade is going to lead to new investments in container ships. Since a huge number of container ships are passing the strait of Gibraltar, a small percentage of these ships converting to LNG can lead to a relevant market share of LNG as a marine fuel.

LNG best alternative?

Some Port Authorities are expecting significant opportunities for LNG as a clean fuel and consider it the best alternative to meet future emission regulations. Others are less optimistic and consider HFO + scrubbers, methanol and LPG and low sulphur fuels as better alternatives. Ship owners will choose for the least expensive alternative. High investments and operational costs will weaken the competitive position of ships and ports. In this competition, market share is lost to competitors active in regions without strict emission targets. Figure 13 shows the differences in expectations in the use of LNG as

shipping fuel in 2030. A significant minority of respondents (44%) expect an LNG market share of 10-25% in 2030. 25% expect a market share of 5-10%.

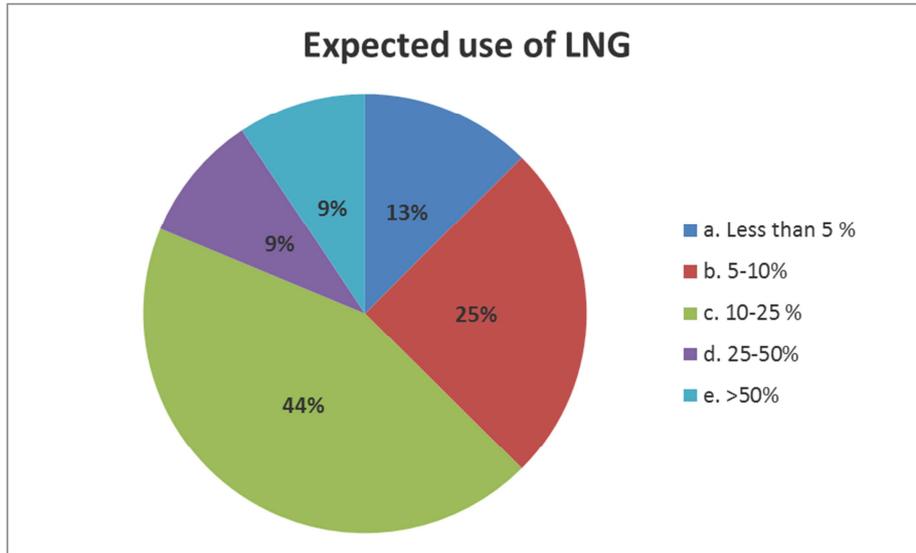


Figure 13 Expected % of ships using LNG in 2030

Main barriers for LNG as shipping fuel: high CAPEX and OPEX

According to Port Authorities the main barriers for shipping companies to use LNG as a shipping fuel are (see Figure 14):

- High CAPEX/OPEX (mentioned in the top 3 of almost 80% of the respondents)
- Uncertainty of future LNG fuel price (in top 3 of over 60% of the respondents)
- LNG supply chain is not available (in the top 3 of over 50% of the respondents). For ships not using fixed route a ship should be able to bunker LNG every 500-600 miles.

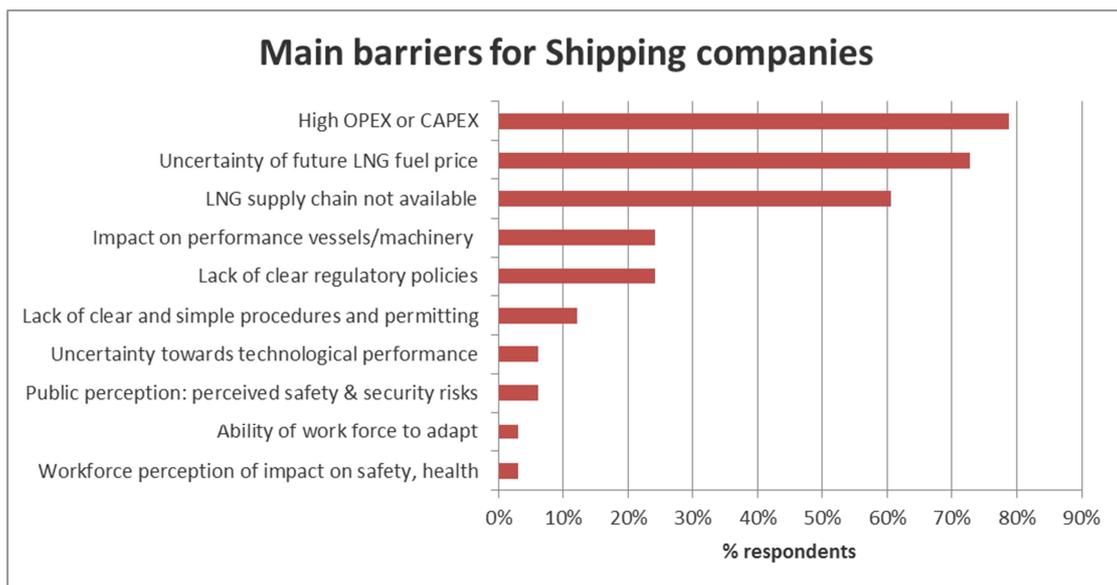


Figure 14 main barriers for shipping companies to use LNG

4.5 LNG Bunkering

LNG Bunkering initially by truck

Slow take up of LNG demand, will mean most ports will initially bunker LNG by trucks. Bigger ports might start with a combination of trucks and barges. Fixed infrastructure will only be feasible when the LNG demand demonstrates sustainable growth.

Requirements and challenges for LNG bunkering

LNG bunkering hardly differs from bunkering of other fuels. Currently safety issues or better lack of knowledge on demonstrated safety of LNG operations is a challenge. Most Port Authorities are not expecting that lack of operational and security procedures regarding LNG will be a significant barrier for the initial growth. The main challenge is the (low) speed of bunkering and the fact that bunkering during operations is not allowed (yet). Qualification and training of current staff dedicated to bunkering services might be a challenge. Some Port Authorities however had positive results with fairly simply awareness campaigns and training courses.

The implementation of the required LNG infrastructure on time and against acceptable cost is challenging as well. The broad range of different supply systems and equipment and the lack of standardisation amongst other Southern European ports is a problem.

Criteria to select a bunkering port

Fuel price and geographic situation are considered the main criteria for shipping companies to select a bunkering port (see Figure 15). Over 60% of the respondents of the e-survey selected these 2 criteria in their top 3. Time at the port is mentioned by almost 40% as a main criterion. The majority of the other criteria are selected in 15-25% of the respondent's top 3. Only fuel quality, number of suppliers and environmental restriction seem to be of less importance. The interviews of Port Authorities revealed that all criteria are important although for a specific kind of vessel on a specific route some criteria would have more impact than others. This makes it difficult for Port Authorities to identify a top 3.

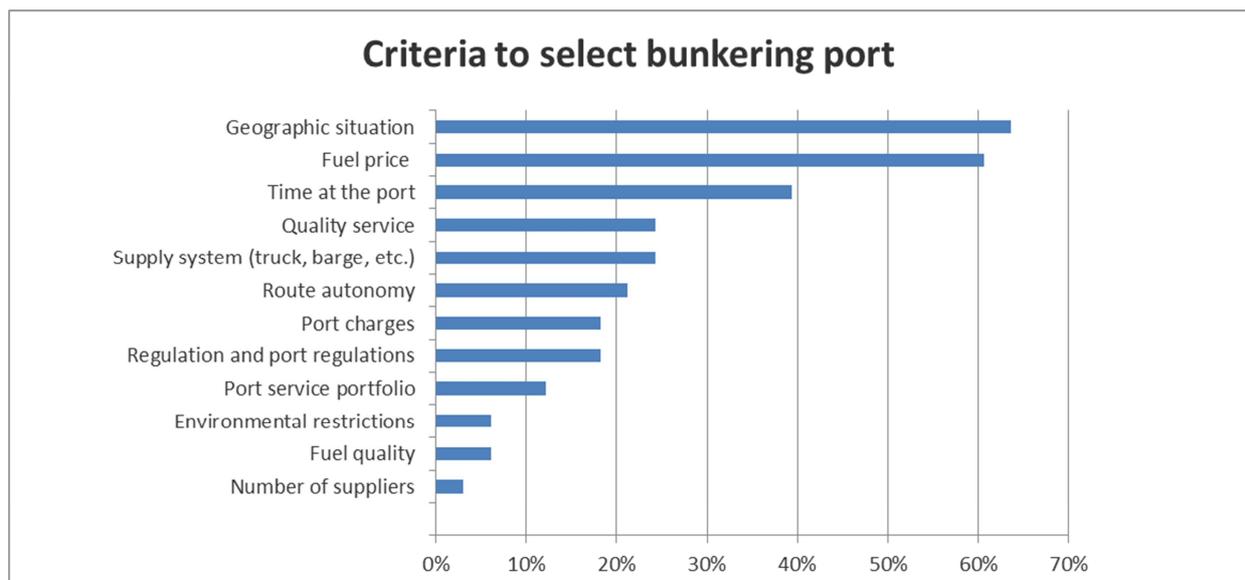


Figure 15 criteria to select a bunkering port

4.6 LNG for Port operations and transport

Several Port Authorities have been involved in studies and pilots on LNG for port operations and transport. They are looking for funds and forming consortia. All island ports and/or municipalities consider LNG for industry and heavy transport. Most islands ports have concrete plans/contracts for next steps. The main opportunities for LNG for port operation and transport are (see Figure 16):

- Trucks: Over 70% of the respondents do think that this use of LNG is very likely or likely within 10 years from now.
- Container trailers: Very likely or likely according to 65% of the respondents
- Heating and cooling of buildings: Very likely or likely according to 50% of the respondents. Interviewees see also possibilities to use LNG to heat pipelines.

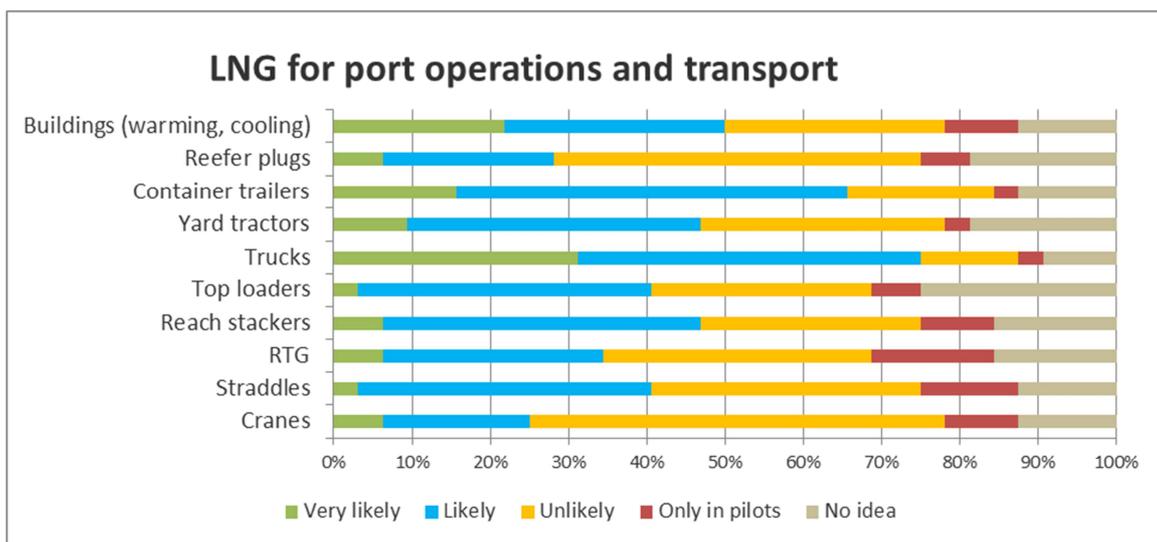


Figure 16 Likelihood LNG use for port operation and transport

Investments in new infrastructure and machinery are not easy for container terminals. The bad economic circumstances lead to shortage of internal and external funds for investments. Investments are postponed. If terminals renew machinery they will seriously consider buying cheaper second hand equipment.

For Port Authorities/terminal owners LNG competes with electrification as the main way to reduce future emissions. Some terminal owners seem to bet on LNG as main fuel, others on a combination of electrification and renewables. LNG could have a place in the energy mix of the electrification. If the financial support is available and clear directions regarding LNG are in place, the terminals will replace current motors and pumps by dual-fuel engines using LNG. The implementation might be rather slow because of the extensive economic and technical life time of port machinery. 76% of the Port Authorities consider electrification of a substantial part of the terminal operations within 10 years likely or very likely (see Figure 17).

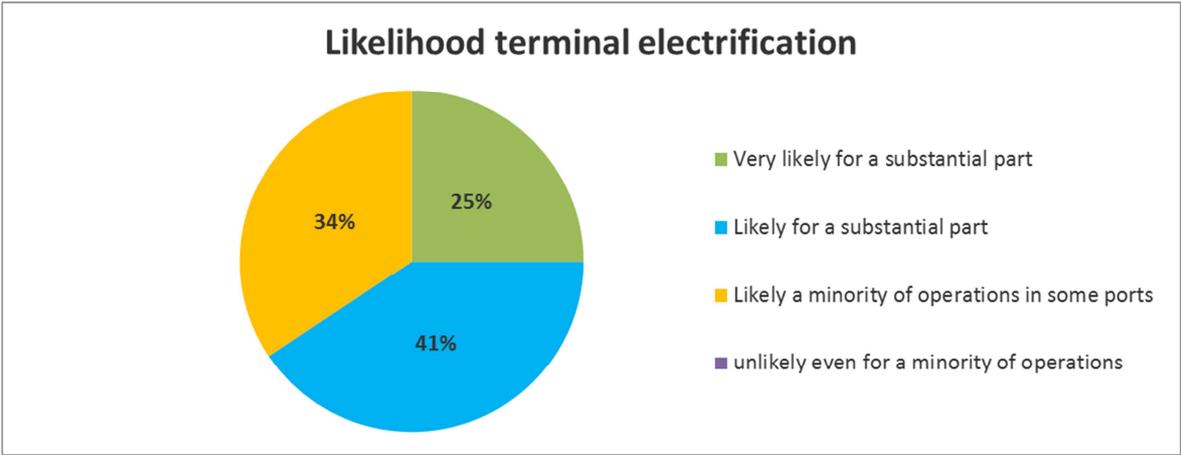


Figure 17 Likelihood terminal electrification

4.7 Drivers, enablers & barriers

Main drivers: increase in market share and attractive services for clients

Over 80% of the respondents to the e-survey indicate market share, attractive services for clients, emission reduction and compliance with emission reduction as a very important or important driver (see Figure 18). Some Port Authorities feel pressure from local authorities demanding improved air quality and to create new market opportunities. Specific drivers for Port Authorities at islands are energy costs and sustainability. Islands use a lot of oil and want to become independent of oil since transportation of oil is expensive. Cities and industries are looking for cheaper alternatives. Tourist industry is emphasizing the negative impact of polluting factories on the city's image.

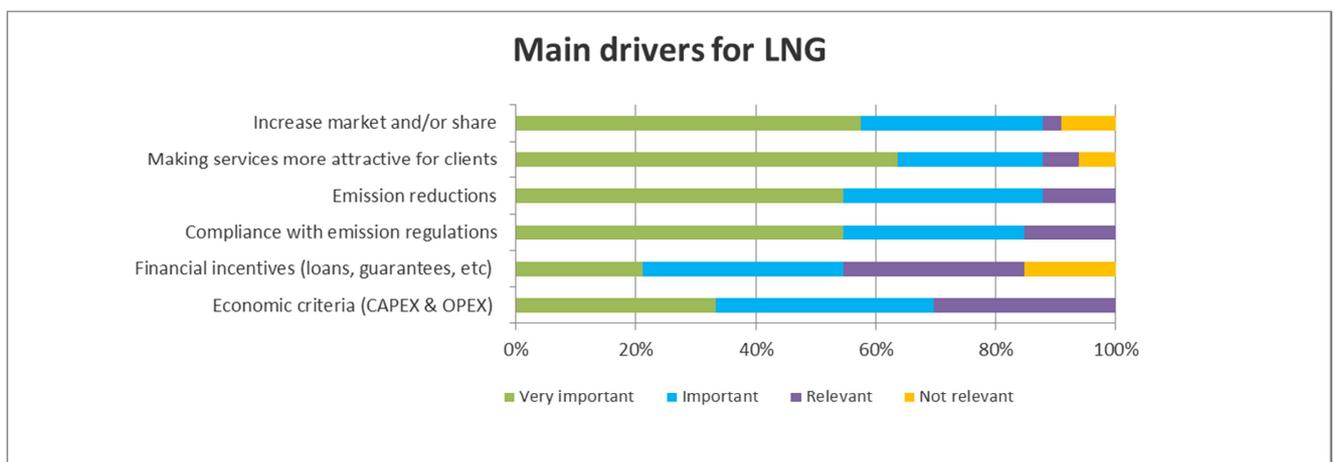


Figure 18 main drivers for LNG

Main enablers

- Economic growth leading to new builds/new investments
- Competitive prices and reduced OPEX for shipping companies;
- Tax discounts and financial support for innovative pilots. It should be possible to obtain discounts up to 20-40%. Several ports already have implemented these sizes of tax discounts. Support of 'project economics', pilot programs or co-financed projects are important for materializing a breakthrough;
- Public awareness and positive mind set. This starts with the need for cleaner air following with the public awareness of clean and safe character of LNG;
- Good geographical position to provide bunkering services for example containerships operating on international routes passing by ECA zones;
- Additional demand for LNG by industry, hotels, terminals and of course new LNG demand initiated by increased traffic of cruisers and passenger ferries);
- Stringent limits for greenhouse gas (GHG) and sulphur emission and/or new ECA zones.

Main barriers

According to the e-survey the main barriers for Port Authorities to develop LNG services and infrastructure are (see Figure 19):

- Lack of demand/market resulting in a negative impact of the LNG business case (in top 3 of barriers almost 70% of the respondents);
- Uncertainty on future LNG prices ((in top 3 of barriers of 40% of the respondents);
- Absence of policies defining the regulations towards the future of LNG (in top 3 of barriers of 40% of the respondents);

- Lack of support financial support of local government (top 3 of almost 40% of respondents). High Taxation, Port taxes, bunkering taxes and tolls for “small scale” nowadays are very high (around 50%).
- Sometimes local government is even actively opposing LNG initiatives or not including all stakeholders in the process. Arguments from local government for not supporting the LNG business case are: safety risk and the opinion that the support of gas will stop renewables;
- Stakeholder perception. Managers, crew, general public managers are concerned about the safety risks of the installation. Additional safety standards, processes and requirements are needed. Some Port Authorities lack the data (evidence) to assist in implementing safety (criteria) and safety management in general.

Several interviewees did mention the significant differences in supply systems & standards, procedures and equipment used in Southern Europe to fuel ships as a main barrier.

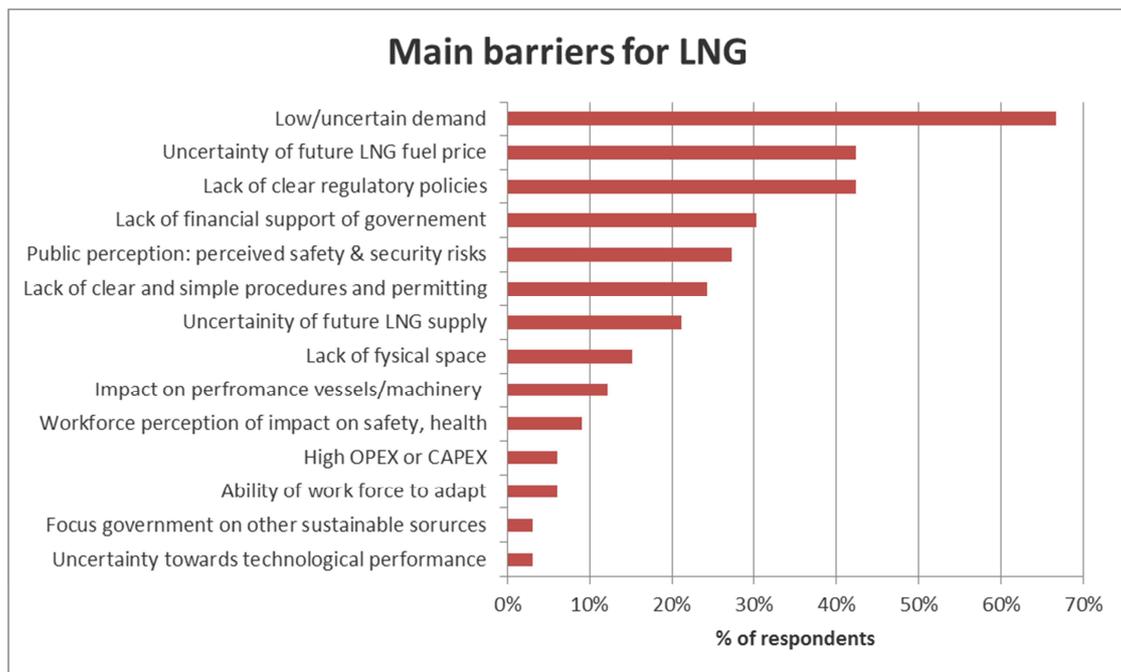


Figure 19 Main barriers for LNG

Main actions for governments to facilitate market growth

- Create a dedicated governmental department to handle LNG shipping issues. This could boost the investment and visibility of the LNG in Portugal or in Spain, as already happening in Italy.
- Positive discriminatory tariffs (discounts) and/or incentives by the national authority for LNG propelled ships or LNG bunkering services;
- The authorities will need to make substantial steps in defining a clear way forward. This needs to be translated into specific actions not harming current players and ensuring safe and operable LNG infrastructure. A homogenous (international) regulatory framework is very important to stimulate the use of LNG. Authorities should involve all stakeholders to discuss their views on LNG for the maritime sector, understand their difficulties, the challenges posed and the potential impact of LNG to their businesses.

5 SHIPPING COMPANIES

5.1 Main Findings

Sustainable Profit Margin

None of the involved respondents were confident with the feasibility of a business case for a LNG new build or retrofitting investment under the current economic circumstances. A lot of uncertainties have impact on this business case. The bottom line for not investing in LNG today is the lack of confidence in a minimum sustainable profit margin during the life cycle of an LNG powered ship.

Stricter Emission Regulation

Emission Regulations in combination with specific regulations for LNG as transport fuel and LNG infrastructure is perceived as the most important trigger or requirement to give an impulse to the use of LNG as shipping fuel. Success of this regulatory framework will depend on level of detail how emission levels will evolve in time and the region (coast-line) to which the regulation applies. Most Shipping companies expect stricter emission regulation will be implemented with a realistic 'transition' time, long enough to adapt to the new circumstances. This is a remarkable finding as the date for European emission regulation to come into force has been defined (Directive 2016/806/EU) but apparently, awareness and sense of urgency among several shipping companies seems to be limited.

Economic circumstances

There are concerns how realistic stricter emission regulations are, given the current economic circumstances in shipping. The market is dealing with a surplus of available ships while the demand is still falling.

Risk of market disturbance

The paradox is that shipping companies are expecting stricter emission regulations in Europe and the Iberian Peninsula in specific. However they do not expect the emission regulations to be so strict that it will significantly disturb current global shipping market equilibrium. This combination makes Shipping companies less confident that LNG investment will be profitable in the next 10 years.

Public Perception and Reputation

Shipping companies are actively improving their carbon footprint and environmental impact with 'low cost - high impact' initiatives, like energy usage reduction and using low resistant marine coating. Cruise ship operators emphasize the importance of an environmental friendly image or reputation and perceive this as an important unique selling proposition to attract customers.

Main enablers for LNG as a shipping fuel

The main enablers for uptake of LNG are financial incentives like lower cost because of significant price difference between LNG and other (clean) fuels, compliance with global or local emission regulation, public opinion and opinion of customers on environmental and sustainability issues and availability of LNG infrastructure at the ports;

Main Barriers for LNG as shipping fuel

The main barriers for uptake of LNG are uncertainty of LNG supply (in top 3 of barriers for more than 60%

of the respondents) and uncertain future LNG prices compared to alternative clean propulsion variants (in top 3 of barriers for 60% of the respondents).

5.2 (Inter)National Policy Framework

Emission regulation will have (very) high impact on Shipping operations

Despite the uncertainty when and what emission regulations come into force, most Shipping Companies (87%) expect (very) high impact on their operation. Only a small number of shipping companies (13%) claim that emission regulation will have (very) little impact on their business. The general results of the interviews with Shipping Companies support this outcome. However, it should be mentioned that most of the shipping companies expect a step-by-step tightening of the emission regulation allowing time to adapt and prevent market disturbance.

Awareness and Sense of urgency

The European emission regulation (Directive 2016/806/EU) defines that as of 2020, sulphur limit of 0.5% will apply across all EU waters (and the 0.1% limit will continue to apply in the ECA zones). In line with the timing and coverage set by this regulation, the step by step approach mentioned above must be part of a national policy framework for the market development of alternative fuels and their infrastructure (Directive 2014/94/EU, part of the EU Clean Power for Transport package). Shipping companies who must act to meet the 0,5% limit before 2020 should be targeted with awareness campaigns and support needed to understand the sense of urgency.

Public Awareness for LNG

The National Policy framework should also address communication campaigns to increase public awareness about the benefits of LNG and its safety risks. Biases on LNG safety and environmental benefits can become a barrier in the near future when faster take up is needed. Municipalities and local stakeholders for example can play a pivotal role in the further development of LNG infrastructure if they are involved early in the process. Shipping Companies involved in the interviews expect the government to coordinate promotion and awareness campaigns.

National Policy Framework Expectation

Other opinions about the expectation of a policy framework for LNG and LNG infrastructure addressed during the interviews with Shipping Companies are:

- The Government should act as the coordinating actor for defining rules and regulations for all stakeholders involved (e.g. harmonize safety rules; at this moment, each Spanish port implements different procedures). Lack of leadership and absence of a coordinating actor is mentioned as a barrier;
- Shipping companies and owners are against subsidies from the government as it can distort the market (importance of common rules and framework for all);
- Unclear if European Commission will apply ECA requirements to all European waters;
- In Spain, bunkering fuel is treated as a "commercial" service. In the latest EC regulation, bunkering fuels is specified as a "Port Service" and hence different requirements. To align to European or global guideline, current gaps between the national and European regulation need to be identified and aligned;
- Present LNG Ship Load tax is a barrier to use LNG as fuel. Ministry of Industry should adapt this policy;
- Only at the end of 2020, when the limit of the 0.5% Sulphur in European waters will be in force (and possibly globally, if IMO decides so), the estimated number of new builds will be more accurate and result in a more reliable forecast towards 2025.

5.3 LNG as Shipping Fuel

Current situation with respect to LNG as shipping fuel

About 24% of the involved Shipping Companies indicate to have LNG fuelled ships in operation and a few (16%) indicate to have plans for the next 5 years. Four shipping companies already have LNG (prepared) ships in operation. Several LNG powered vessels are currently under construction (passenger ship & Cruise ship), one LNG powered tug-boat is piloted and two feasibility studies are in progress. The decision for LNG new build or retrofiting were predominantly made based on 1) available external funding (subsidy) and 2) significant price difference between LNG and HFO at the time the final investment decision was approved.

As an alternative to new build, retrofitting existing ships and the use of LNG auxiliary engines has been mentioned as currently being the most economical option to adopt LNG for current fleet. Nevertheless, most Interviewees indicate retrofitting existing ships is not always possible due to technical constrains e.g. level of automation, available hull space and incompatibility with legacy technical standards.

The majority (60%) of the shipping companies have no LNG related plans or are in a very early assessment phase. With the current economic circumstances, respondents claim not to be able to develop a positive LNG business case during the expected lifetime of a vessel. Nevertheless, LNG is on the agenda and shipping companies seem to be interested be up to date regarding the latest developments. Compared to the level of activity in LNG as displayed in Figure 20, most business cases for LNG investments are not expected to be feasible and materialized within the next 5 years.

Interviewed Shipping Companies expect a very slow increase of LNG propelled ships for the period until 2030.

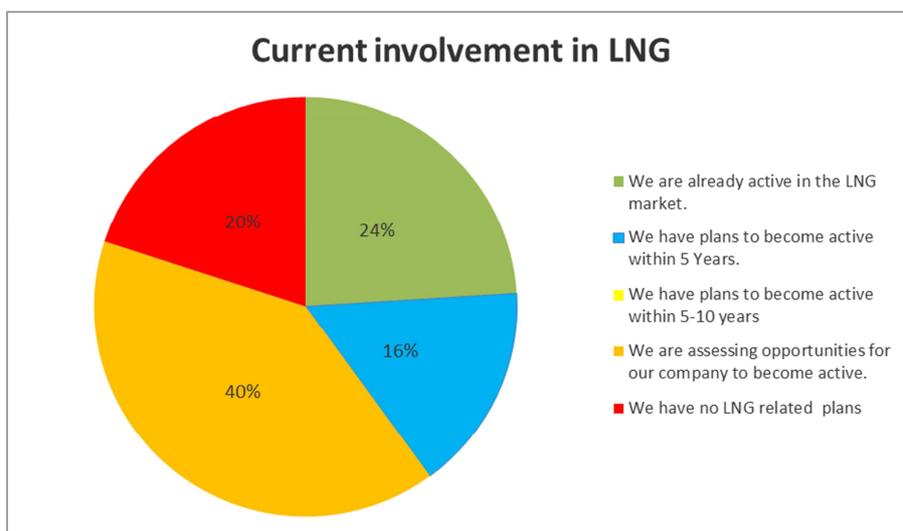


Figure 20 Current activity of Shipping Companies in LNG

LNG consideration for future ships

Most shipping companies aim to maintain the number of vessels in operation today, at least for the upcoming 5-10 years (the fleet in the project area is rather young). Looking beyond this period, it is expected that ships reaching 'end-of-life' will continue to be replaced by new builds. For existing ships, MGO, HFO + scrubbers and retrofitting options are considered to meet emission regulation. With the current market circumstances, new builds ships are likely to be dual fuelled. Some interviewed shipping

companies have indicated to 'prepare' new builds with LNG or dual engines to be more flexible in future propulsion fuel (long term). For the long-term LNG is most likely the best clean propulsion alternative to comply with stricter emission regulation.

The e-survey results on clean propulsion variants (Figure 21) contradict the interview findings to some extent. LNG "ready" was mentioned by multiple interviewees as a serious option to maintain energy sourcing flexibility. Dual engines are perceived as inefficient due to the extra weight and potential vessel design limitations. As dual fuel engines are indicated as the most favoured option following the results of the e-survey, we might conclude the energy sourcing flexibility is an important factor for a ship in operation as well.

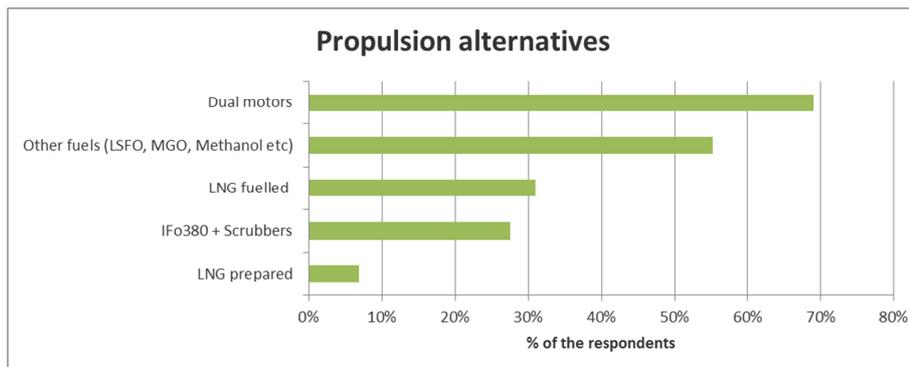


Figure 21 Propulsion Alternatives

LNG as transition technology

In the far future, hydrogen and fuel cell technology is perceived as a promising breakthrough technology to challenge the position of LNG. Although a breakthrough seems not to be likely before 2030, hydrogen and fuel cells could be an important future clean fuel alternative.

Adopting LNG to adapt to future emission regulation

To comply with stricter future emission regulation, the majority (61%) of the respondents indicate new build is the best way to adapt to LNG. None of the e-survey respondent indicated retrofitting existing fleet is the single approach to adapt to LNG. Main arguments against retrofitting are the technical constrains and relative high costs. Nevertheless a few respondents (26 %) indicate retrofitting existing ship is feasible for example when the expected life time of a vessel is long enough to cover the investment and new build is not on option. A minority (13%) has no idea how best to adopt LNG to meet future emission regulation.

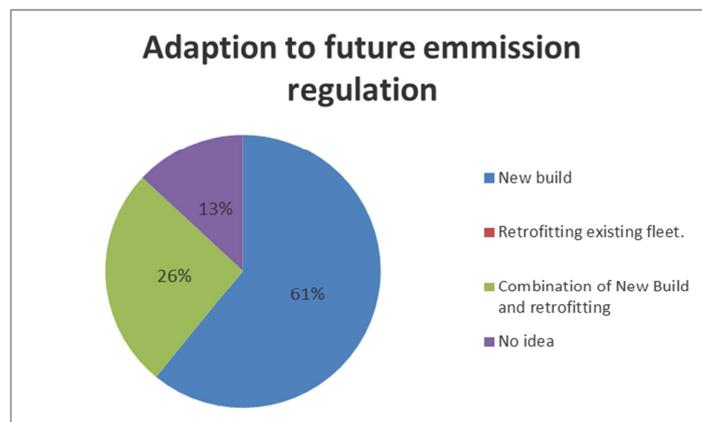


Figure 22 Adaptation to future emission regulation

Expected use of LNG in 2030

In the e-survey Shipping Companies were asked to estimate the market share of LNG as propulsion fuel in 2030 when emission regulation is in place and ample LNG supply points are available. 26 % indicate more than 50% of the maritime energy consumption to be LNG. Another 22% indicate 25-50% of the maritime fuel consumption in 2030 could be LNG (see Figure 23).

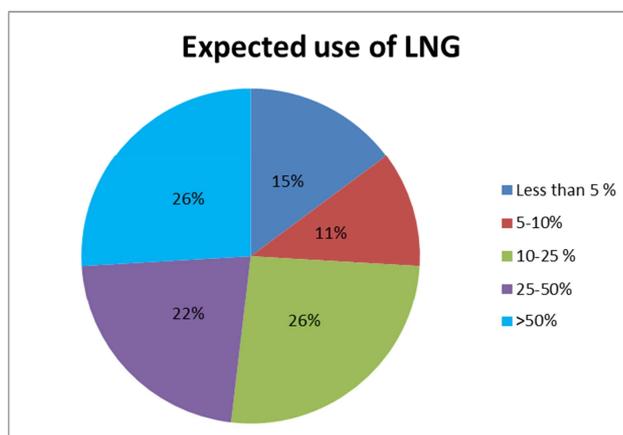


Figure 23 Expected use of LNG

Expected use of LNG in 2030 per shipping segment

According to the interviewed Shipping Companies the order of future uptake of LNG by different shipping categories could look like (form first mover to (late) follower):

- Short Sea shipping regular lines: cruise-liners, passenger ferries, ro-ro's, feeders. Specially those involved in SECA areas;
- Short Sea Shipping in tramp traffic: small sized product tankers and LPG's. Specially those involved in SECA areas;
- Ocean going regular liners with high involvement in SECAS;
- Other type of ships operating in high predictable lines (time, location, available bunkering capacity).

The expected use of LNG in 2030 within the Shipping segments indicated in the e-survey is displayed in Figure 24. These results are less reliable due to the limited sample and the fact that companies active in two or more segments (8 respondents) could only indicate an overall LNG market share. More than 60% of the container shipping companies (6 respondents) indicate the market share of LNG in 2030 could be more than 50%. This is higher than expected probably due to the strong representation (3 respondents) of innovative international players with destinations in ECA zones. For cargo companies (12 respondents) a normal spread was expected: companies with vessels on regular lines within Europe are expecting a high share of LNG use and companies needing to be flexible in a global market are expecting a low share of LNG. Only a few tanker shipping companies expect a significant uptake of LNG, but a significant part is expecting LNG market share of 10%-25% (6 respondents). For Ferry / Ro-Ro / Cruise shipping companies (13 respondents) more than 40 % expect an LNG market share of 50 % or more. As cruise liners and passenger ferries are expected to be the first movers (based on the interviews) this figure is in line with our expectations.

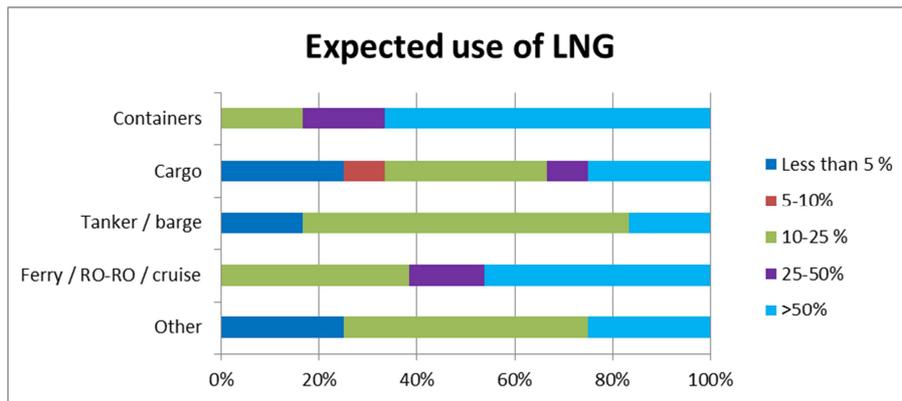


Figure 24 Expected use of LNG per shipping segment

Main drivers for LNG

Economic Criteria (OPEX and CAPEX) are relatively strong drivers for LNG based on the results of both the e-survey as the interviews. According to the interviewees, customers are very sensitive to price and any increase of cost to accommodate LNG investments may lead to the loss of contracts; other important drivers are compliance with regulation and aspects related to shipping economics: energy sourcing flexibility, fuel price and availability of LNG supply (Figure 25). Some interviewees expect an increased attention to environmental and sustainability issues from the public opinion and companies and increased regulatory pressure due to operating in (S)ECA areas.

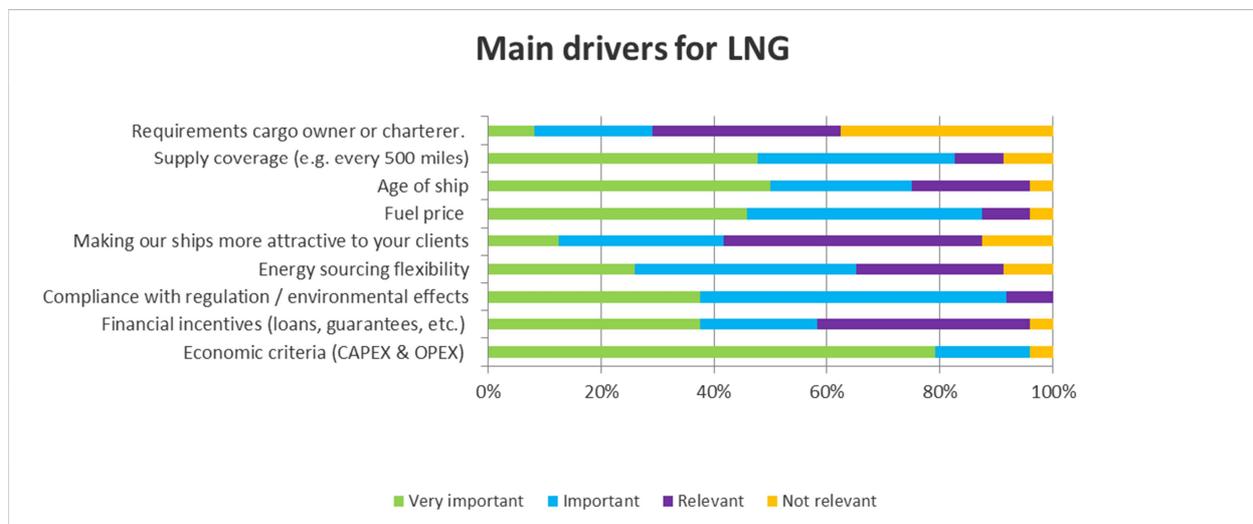


Figure 25 Main Drivers for LNG

5.4 Bunkering

LNG Bunkering

Regarding LNG bunkering, shipping companies shared the following considerations during the interviews:

- Most shipping Companies associate LNG logistics with high cost (e.g. €100.000 CAPEX for a 40 ft. LNG container and OPEX cost (e.g. to maintain a constant low temperature of -162°C));
- There are concerns of environmental impact and perceived safety risks of inland LNG logistic;

- Bunkering time at the port is essential: It is necessary to address in an early phase (Design phase) how to minimize this dead time required for bunkering;
- Some suppliers consider a system where 4 or 5 parallel connected trucks are used to bunker a vessel. This would be a big improvement, however still not enough to bunker bigger vessels;
- Bunkering procedures have improved. Although concerns are raised on consistency per Port and allowing bunkering while port operations are carried out (so-called simultaneous operations – SIMOPS).
- Fixed LNG refuelling infrastructures are not likely to be possible within 10 years because quays, quay infrastructure and fuelling facilities are not standardized. This is a big difference with quays in Northern European ports;
- In most ports, bunkering is part of the port services. LNG bunkering would need an additional cost / fee structure to charge the ship owners using these services.

Future bunkering system

Following the e-survey’s outcome for Shipping Companies, future bunkering systems are expected to be a combination of fixed infrastructure and barge to ship facilities (Figure 26). Despite the easy logistics of trucks, the limited volumes and slow bunkering speeds are significant constrains.

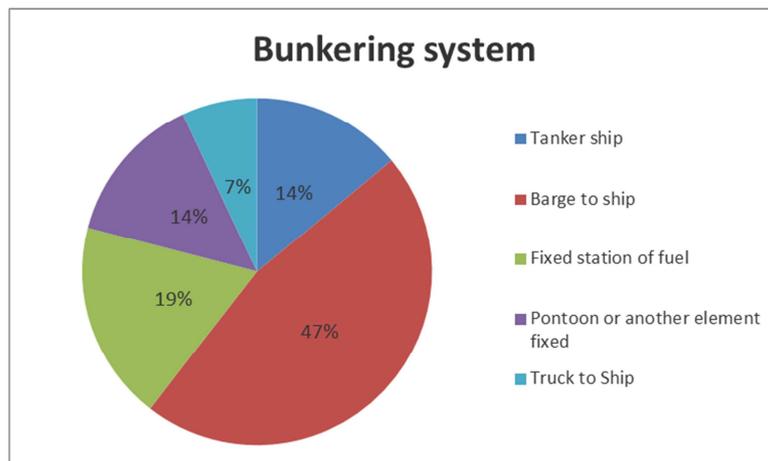


Figure 26 Best long term bunkering systems

Bunkering Criteria

The criteria Shipping Companies indicate to select bunkering ports have both been addressed during the interviews as the e-survey. Based on the e-survey, the most important criteria to select a port for bunkering are: geographic situation, fuel prices and waiting time for delivery (Figure 27).

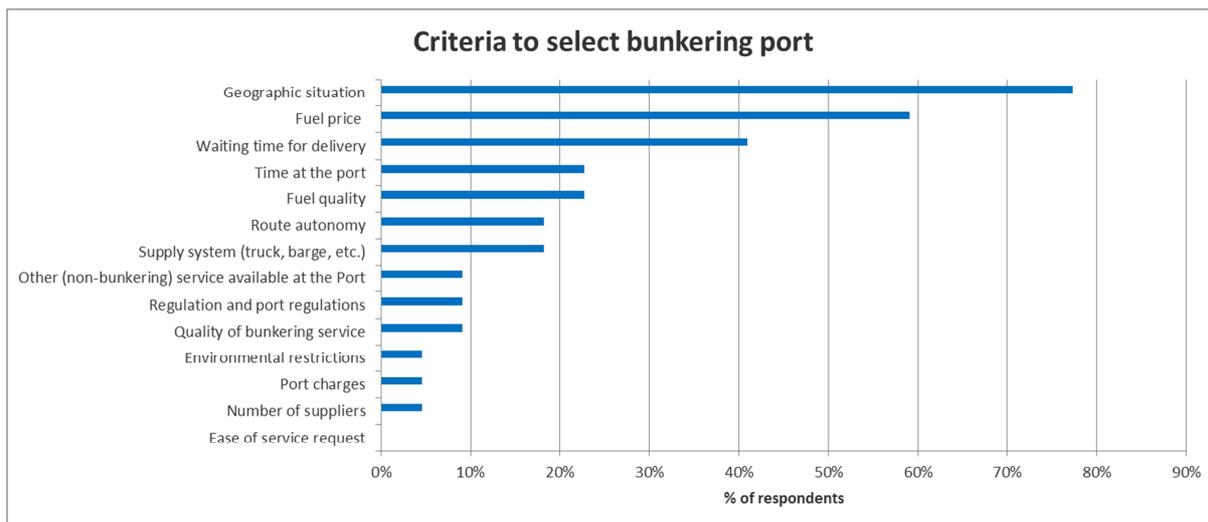


Figure 27 Criteria to select a bunkering port

5.5 Enablers & Barriers

Enablers for LNG as Shipping Fuel

Following the interviews with Shipping Companies, the most important enablers for adapting LNG as a Shipping fuel are listed below:

- Increased attention to environmental and sustainability issues from the *public opinion*, LNG is seen as a *strategic differentiator*: Reputational effect of low carbon emission and environmental friendly operations are indicated as a selling point for customers to pay a premium. Cleaner working circumstances and consciousness of the environment friendly imago will benefit *employee attractiveness*.
- Being LNG prepared increases flexibility in case future operations include ECA zones and/or alternative fuels are becoming less attractive (cost, availability). Next to flexibility, predictability of lines and related bunkering requirements (amount, location, time) and the likelihood of future operations *ECA zones* are important factors to consider LNG.
- Significant *price difference* between LNG and other (clean) fuel alternatives prove not to be a reliable factor. The ability to maintain a certain level of energy sourcing flexibility is important for shipping companies. New innovative energy contracts could reduce price uncertainty which allows more reliable investment decision for LNG.
- *Financial incentives* to support LNG Ship investment and LNG supply chain development. A more matured *carbon emission trading market* will also be an incentive to further develop a positive business case for LNG.
- Global / Local policies and *emission regulation* and National policies and procedures allowing safe, environmental friendly and 'flexible' LNG *bunkering practices* e.g. bunkering during operation, which is already a common practice in some Norwegian ports (SIMOPS);
- Quality of LNG and availability of LNG *infrastructure* at the ports; Availability of alternative clean fuels (e.g. low sulphur fuel) is expected to be a constraint as well which is potentially beneficial for LNG;

Barriers for LNG as Shipping Fuel

According to the e-survey the main barriers for Shipping Companies to use LNG as shipping fuel are (see Figure 28):

- Uncertainty of LNG supply (in top 3 of barriers for more than 60% of the respondents);
- Uncertain future LNG prices compared to alternative clean propulsion variants (in top 3 of barriers for 60% of the respondents); Because of this uncertain prices shipping companies are

worried about a sustainable profit margin during the complete lifecycle of the vessel given the *age of existing ships* and their remaining lifetime and value

Other important barriers, in the top 3 of around 25% of the respondents, are:

- Lack of financial support of the government.
- Uncertainty towards technical performance. Limited *Ship performance* (propulsion power, autonomy of navigation), Impact on sensitive ship *design requirements* (centre of gravity, acoustic profile etc.).
- Lack of clear regulatory policies. Uncertainty of *legislative developments* for 1) emission level regulation and 2) the date for entry into force and 3) the applicable area (global/EC water/local). The fact that the current Spanish / Portuguese coast is no SECA, makes a less urgent feeling among the ship-owners to adopt LNG;
- Lack of physical space for LNG infrastructure, available size versus size needed for LNG tank.

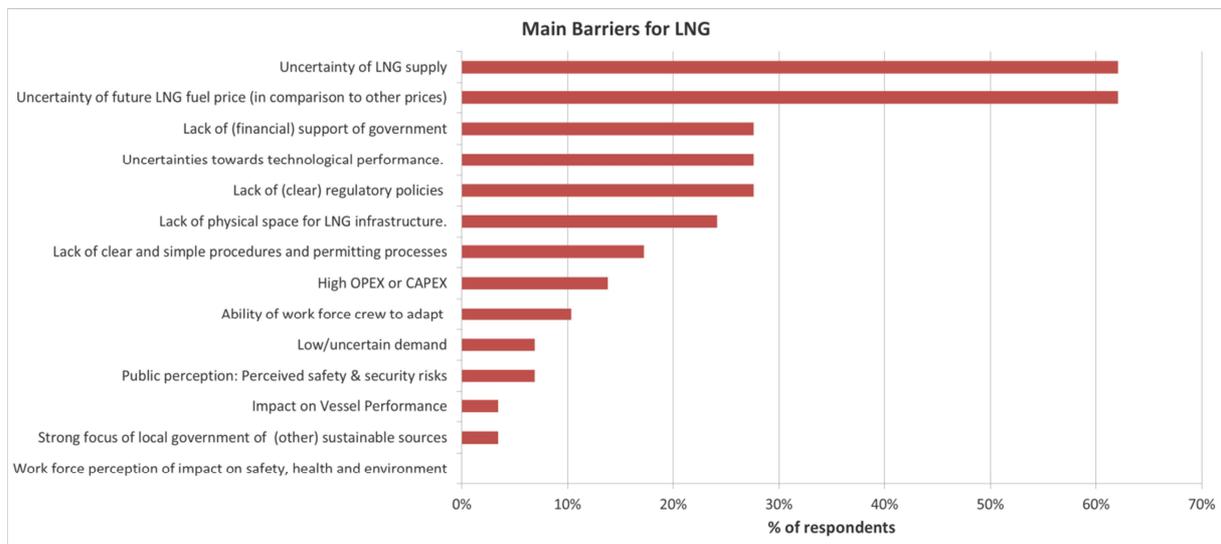


Figure 28 Barriers for LNG as Shipping Fuel

Interviewees also mentioned the following constraints:

- In short time, there are other mandatory rules that will also imply an investment effort (even if at a lower order of magnitude, approximately 10% of the investment needed to shift to LNG bunkering) which is the compliance with the new Ballast Water Treatment plans. This might have an influence to ship owners in *prioritizing investments*. Shipping companies have ample alternative *measures* (low cost, high impact) *to reduce carbon footprint / environmental impact* of shipping operation;
- Lack of *port design standards*, procedures (e.g. quay infrastructure) in Northern European ports and amongst Spanish ports. Without standards, significant investment in fixed LNG refuelling infrastructure is not likely to happen before 2025. Especially for oceanic vessels lack of global LNG supply chain and available logistics to bring LNG on board limits the navigation range.
- LNG being 'substituted' by alternative clean power sources sooner than expected (e.g. electrification, *hydrogen fuel cell*); Current alternative clean propulsion fuels are available for acceptable prices on short term (MGO and HFO 0,5%). However, on the long-term availability and prices are very uncertain as well;
- Bunkering is managed by charterers instead of the ship owner. Lack of incentives for *Charterers* to pay a premium for a long-term investment in LNG instead of using low sulphur fuels;

6 LNG AND GAS TERMINALS

6.1 Main Findings

In this paragraph the main findings of the e-survey and interviews conducted with LNG and Gas Terminals are listed:

- Nowadays only 20% of the total capacity of the LNG tanks are in use;
- In Portugal 80 UAGs (Unidade Autónoma de Gás - satellite units) are operated in the mainland. The LNG terminal in Sines is the main entrance for natural gas in Portugal, along with the pipeline entry point at Campo Maior;
- During the golden years, the LNG terminal contributed with 60% to the natural gas consumed in the country. Presently, it only supplies 30% of the internal demand. As a result, only +/- 30% of the potential storage and logistic capacity is used today;
- Currently LNG terminals are more focused on the regasification business, but this already has reached its full potential;
- The main natural gas demand in Portugal is the electricity sector. However, the primary future source of electricity will be more and more renewables instead of gas / coal fired power plants.

6.2 (Inter)national policy framework/decarbonization plans

Emission regulation key driver

Introduction of ECA zones inside the Mediterranean will push LNG use substantially. Most respondents do not expect the Mediterranean coast to be part of an ECA zone on the medium / short term. Most LNG & gas terminal operators involved in the e-survey (80%) expect a (very) high impact of emission regulation on their terminal operations (see Figure 29).

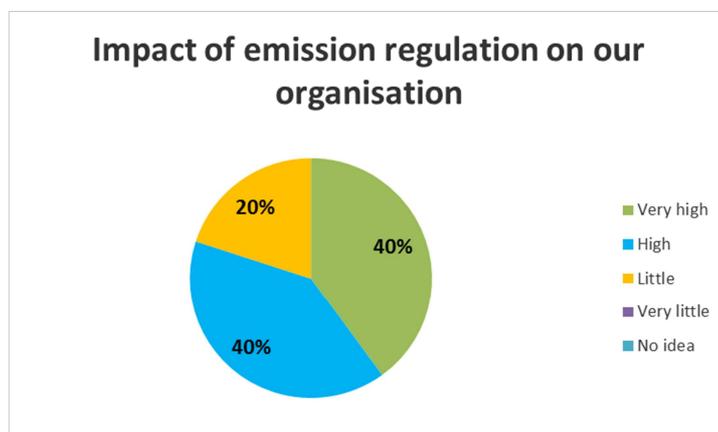


Figure 29 impact of emission regulation on LNG & gas terminal operations

Safety and standard operating procedures

Even if demand for LNG for shipping would increase, a lot of technical and logistic challenges related to national LNG policies need to be solved. Safety standards and regulation for bunkering LNG during operation are key aspects to reduce dead time. Note: dead time of a regular sized ship can be +/- € 100.000, - a day.

Regulation for Port Tariffs

Storage tariffs in Portugal are calculated per ship. Smaller ships are charged the same tariff as bigger ships. In order to make LNG bunkering more attractive for smaller ships, a new tariff method is being piloted now. In the end, tariff models need to be part of national regulation on Ports tariffs.

6.3 LNG as a Shipping fuel

This paragraph summarizes the perception LNG & Gas terminal operators have about shipping companies adapting to LNG as propulsion fuel.

Main barriers for LNG as Shipping Fuel according to LNG & Gas terminals

According to LNG & gas terminal operators the main barriers for shipping companies to use LNG as shipping fuel are (see Figure 30):

- High OPEX or CAPEX (mentioned in the top 3 of all (100%) of the respondents)
- LNG supply chain not available (mentioned in the top 3 of 80% of the respondents)
- Uncertainty of future LNG fuel price (mentioned in the top 3 of all 60% of the respondents)

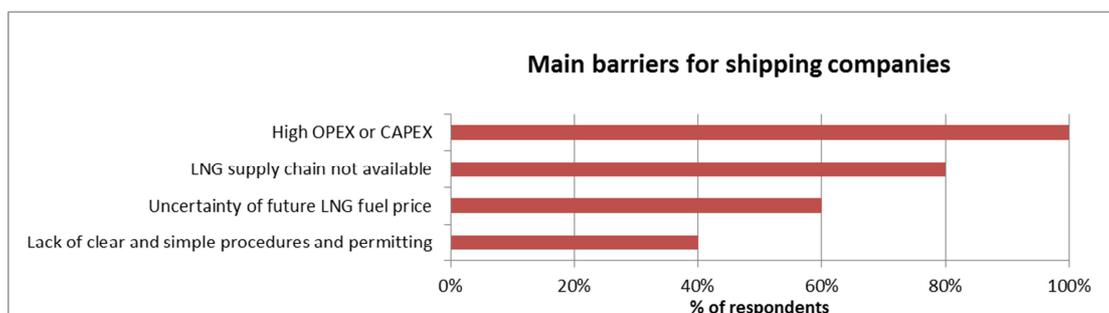


Figure 30 main barriers for shipping companies to use LNG

LNG demand in 2030

In the e-survey LNG & gas terminal operators were asked to indicate the expected LNG consumption as part of the total maritime energy usage (Figure 31). The majority (80%) of the respondents expect 10-25% or even 25-50% of the energy usage will be covered by LNG.

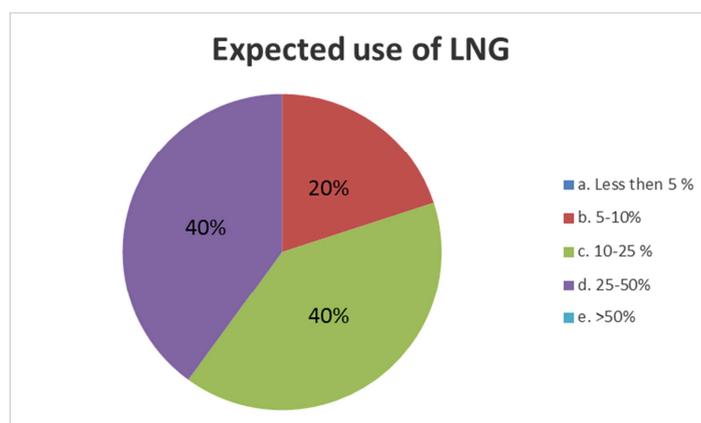


Figure 31 Expected LNG share in 2030' maritime energy consumption

6.4 Opportunities for LNG and LNG infrastructure

Current level of LNG related activity

LNG & gas terminal operators are naturally active in the LNG business. All participants in the e-survey indicated to be pro-actively exploring opportunities for LNG demand. However, the number of 'demand' side opportunities are limited now.

LNG for Port Infrastructure

Port machinery like cranes, stackers, trucks and loaders to load and unload cargo can be powered by LNG. Contradictory to this, port terminal operators are not convinced using LNG. LNG requires larger engines to produce the equivalent amount of power. Electrification seems to be a more promising alternative for Port Terminal operators to reduce GHG and particle emissions. In contradiction to port terminal operators, almost 60 % of the LNG & gas terminal respondents involved in the e-survey are positive about the potential use of LNG for port infrastructure (see Figure 32).

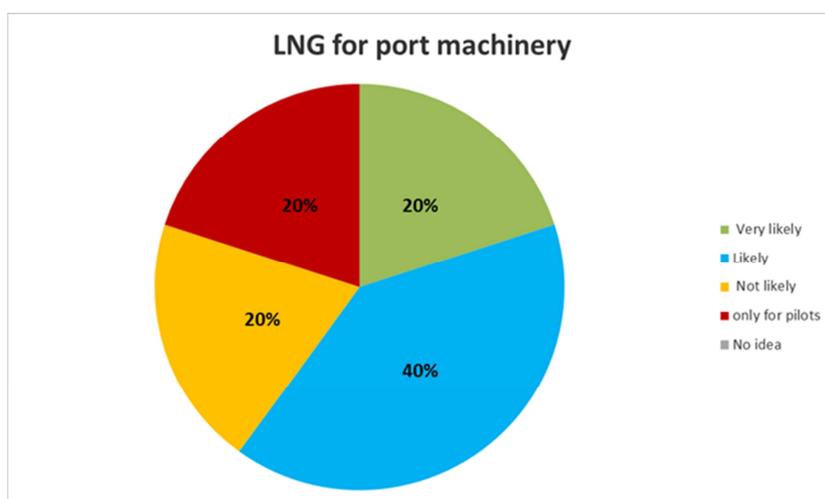


Figure 32 Feasibility of LNG for port machinery

Main opportunities for LNG:

- Current focus is predominantly on LNG supply for the Maritime Sector, however other sectors of interest are land based heavy transportation industry and electric power plants;
- Current plans in Portugal are to invest 2M Euros in the terminal to retrofit the jetty, which is currently unable to fill small LNG carriers mainly due to non-suitability of the loading arms (operational envelope not able to reach the lower manifolds). If small LNG ships can load at the terminal it is expected that new shippers (eg. GoldEnergy) will come in (at least once per year) and current local clients such as EDP Gas, ENDESA and Galp may also use this loading system. It enables refill of barges to supply bunker LNG to big carriers;
- Another opportunity for LNG supply is the inland transport system. In Portugal, public transportation and heavy duty trucks can be fuelled with LNG. Along with aviation they represent approximately 20% of primary energy consumption. The heavy road vehicles can play a crucial role. However, the development of electric vehicles and availability of electrical supply stations is a rapid developing alternative to LNG;
- The strategic geographic location of the terminal in Sines can be used to become a global broker of bigger supplies of LNG from Africa (Nigeria). Recently the feasibility to provide containerized LNG to locations such as Italy, through existing liners was assessed;

- The table below gives an overview of opportunities and expected infrastructure development

LNG as fuel		
Opportunities	2020	Demand is covered until 2020. Currently only 20%-35% of the production capacity is used. First vessels are supplied with LNG.
	(2025)	Supply to local fleet (small scale)
	2030	Current capacity should be enough to cover the demand until 2030.
Expected infrastructure for LNG	2020	Current LNG infrastructure is suitable to cover the demand Fishing vessels supply will be covered by Truck to Ship or small scale terminals No major action plans: study of the dock adaptation for LNG bunkering to ships, small modifications
	(2025)	More modifications to the terminal will be done if evidence of an increase of the demand is proven. (second jetty and additional storage tank)
	2030	More flexibility to storage will be needed

6.5 Drivers, enablers & barriers

This paragraph summarizes the enablers and barriers for LNG demand and supply infrastructure according to the interviews with LNG and Gas Terminals.

Main drivers: increase in market share and economic criteria

80% of the respondents to the e-survey indicate increase in market share and economic criteria will be the most important drivers for sustainable growth of LNG demand & supply. 60% of the respondents indicate supply of LNG will increase the attractiveness of their services to clients (see Figure 33).

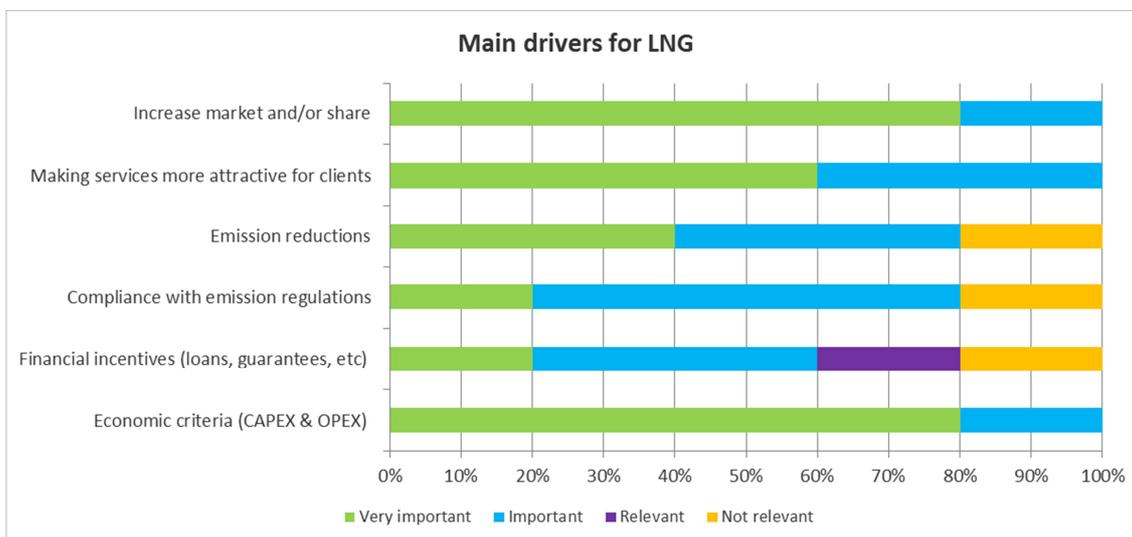


Figure 33 Main drivers for LNG

Main enablers mentioned during the interviews are:

- Full scale EU co-financed demonstration projects are needed to mature the LNG infrastructure.;
- More attractive storage- and port rates for end users;
- Promoting of LNG sector by Port Authorities;
- Reduction of taxes and tolls;
- Reconversion to use LNG for conventional coal-fired and oil-fired thermal power plants;
- Development of an inland gas hub in the Iberia peninsula to improve the transparency of the LNG market;

Main Barriers

According to the e-survey the main barriers for LNG & Gas Terminals to develop LNG related services and infrastructure are (see Figure 34):

- Lack of clear regulatory policies (in top 3 barriers of all (100%) the respondents).
- Low/uncertain demand (in top 3 barriers of 80% of the respondents)
- Lack of financial support of government (in top 3 barriers of 40% of the respondents)

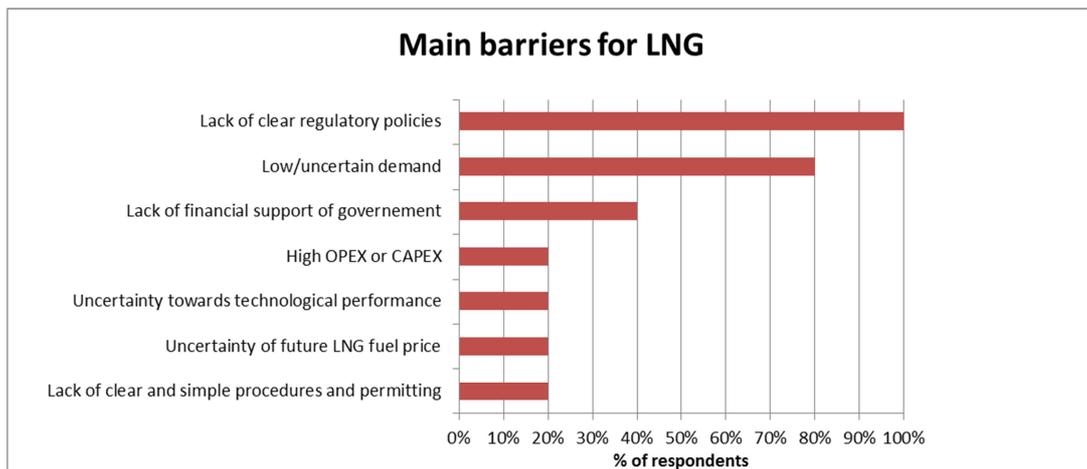


Figure 34 Main barriers

Other barriers mentioned during the interviews are:

- Current overcapacity;
- Uncertainty due to recent national energy plans being put on-hold;
- Low oil prices;
- Lack of standard port regulation and LNG operating / safety procedures;
- Current storage tariffs lack incentives to LNG storage for small shipments;

7 NATURAL GAS SUPPLIERS

7.1 Main Findings

In this paragraph the main findings of the e-survey and interviews conducted with Natural Gas Suppliers are listed:

- Natural Gas Suppliers continue to develop new business to residential and industrial clients;
- The Impact of emission regulation in the North and Baltic seas is an example for the Spanish and Portuguese situation. There is a strong believe ECA zones will come into force globally. It might take some time and will cause temporal market unbalances;
- Both Spanish and Portuguese regions face a situation of oversupply of natural gas (in stock). Demand is not expected to level the supply capacity for the next 10 years.

7.2 Current Involvement of Natural Gas Suppliers in LNG

Of course Natural Gas Suppliers are active in the LNG business. All participants in the e-survey indicated to be actively exploring opportunities for LNG demand.

7.3 (Inter)national policy framework/decarbonisation plans

General opinion

The tendency is to have new ECAs spread worldwide (in Southeast Asia, US, Europe and even Africa). Temporarily, some imbalances may exist as enforcements to comply with stringent rules may lead to higher investment costs for ship owners (CAPEX). However, in the long run there will be efficiency gains as fuel prices decrease and maintenance costs of LNG powered engines are lower. The public is more aware about of the impact of pollution caused by inland and port navigation. This is one of the reasons why cruisers and ferries are looking for alternative solutions to reduce emissions and be greener. New emission restrictions will pose a burden mainly on the shipping companies. They will need to adopt technologies such as scrubbers, cleaner fuels and LNG (single or as dual fuel engines). ECA's are the way to move forward for cleaner fuels such as LNG. Restrictions must be in place to force companies to adjust.

How to comply?

Suppliers are committed to ensure port operations and port infrastructures comply with international safety rules and best practices for handling LNG. Some companies are promoting the current studies that are being undertaken by the port authorities regarding safe operations with LNG ships. Some companies already adjust their fleet to international standards in the absence of local legislation. They are waiting for the introduction of legislation that requires the use of cleaner fuels.

Main drivers to work on emission reductions

- Environmental concerns translated into new set of 'future' rules and regulation for the use of LNG as maritime fuel;
- Current studies identifying policy and regulatory requirements for the development of the LNG value chain.

Main governmental actions

From the perspective of the Natural Gas Suppliers, the main actions to be taken by the government on the short term are:

- Transpose EU directive;
- Increase awareness for upcoming emission regulation by hosting discussion forums bringing together all the parties involved on the LNG value chain – create working groups;
- Organise and prioritise funds available;
- Introduce new restrictions regarding emissions.

Impact of emission regulation on Natural Gas Suppliers

Natural Gas Suppliers are expecting a very high (71%) impact of new emission regulation on their operations. The rest (29%) is expecting a high impact which is just a difference in nuance. New emission regulation is likely to boost the demand for LNG which will have a positive impact on the business performance of natural gas suppliers.

7.4 LNG as a shipping fuel

Current situation with respect to LNG as shipping fuel

LNG is an opportunity, driven by legislation and public claim for clean air. For the medium term, LNG is likely to be used by ships with well-defined and predictable routes. Most the current fleet will use clean fuel alternatives, e.g. HFO 0.5% Sulphur. Modification of existing vessel is often not possible due to space constraints.

Currently there is an oversupply of natural gas (in stock) and demand is not expected to level the supply for the next 10 years. Nowadays significant demand is coming from Asia, China and Europe. To amplify the difference between oil and gas prices, long term contracts need to be signed.

Expected use of LNG as shipping fuel

Figure 35 shows the differences in expectations for the use of LNG as shipping fuel in 2030 according to natural gas suppliers. The majority (43%) of the respondents expect 10-25% of the propulsion energy consumption will be LNG.

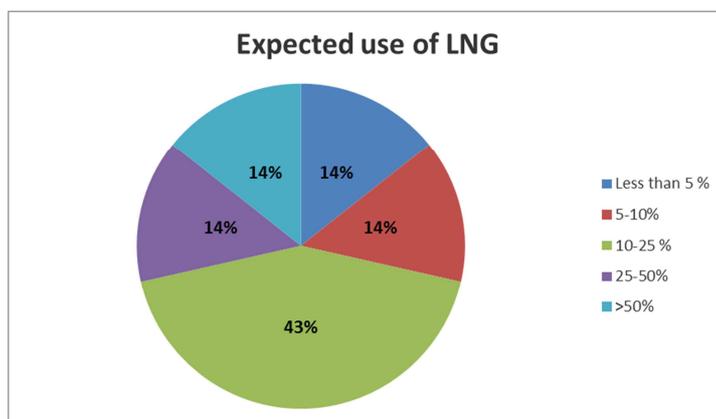


Figure 35 % LNG of total maritime energy consumption in 2030

Main barriers for LNG as Shipping Fuel according to Natural Gas Suppliers

According to Natural Gas Suppliers the main barriers for shipping companies to use LNG as shipping fuel are (see Figure 36):

- Higher operating cost (OPEX) or initial investment (CAPEX) (mentioned in the top 3 of 100% of the respondents).
- Bunkering logistics, LNG supply chain not available (mentioned in the top 3 of 85 % of the respondents).
- Uncertainty of future LNG fuel price and/or LNG supply (mentioned in the top 3 of 45 % of the respondents).

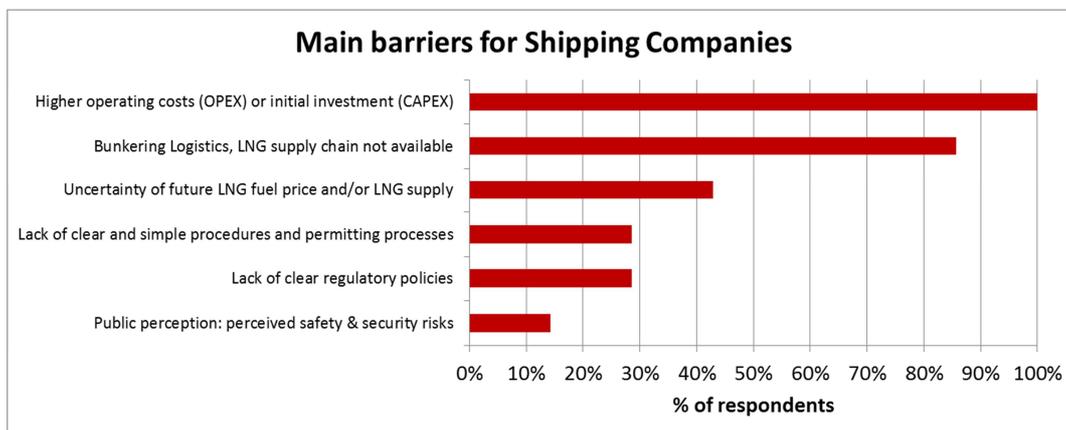


Figure 36 Main barriers for shipping companies to use LNG according

7.5 Characteristics of future LNG supply chain & infrastructure

The future LNG infrastructure until 2020 shall be small-scale with refilling points in the main ports. The first clients using LNG as maritime fuel shall be the international cruisers and river ships. It is important that national port authorities have a tariff that encourages the loading of small LNG vessels. Currently, the discrimination on volume is a limitation to a more intensive use of the LNG terminal. LNG fuelled ships will appear once the environmental restrictions to use cleaner fuels are fully implemented. The necessary infrastructure will then appear naturally. Until 2025, companies involved in short-sea routes and inland navigation will gradually be offered LNG bunkering facilities. With a local market in development, it will be possible to start offering LNG bunkering services to bigger LNG vessels doing international lines. It shall be similar to what is happening on the LNG truck market. However, it is not clear yet, if the bunkering model will be based on a barge supplying LNG or bunkering from the terminal. The easiest way of bunkering gas is by truck but for ships it is the worst option due to the extensive bunkering times.

LNG for Port Infrastructure

Port machinery like cranes, stackers, trucks and loaders to load and unload cargo can be powered by LNG. Port terminal operators are not convinced. LNG requires larger engines to produce the equivalent amount of power. Electrification seems to be a more promising alternative for Port Terminal operators to reduce their GHG and particle emissions. In contradiction to port terminal operators, almost 60 % of the natural gas suppliers involved in the e-survey, are positive about the potential use of LNG for port infrastructure (see Figure 37).

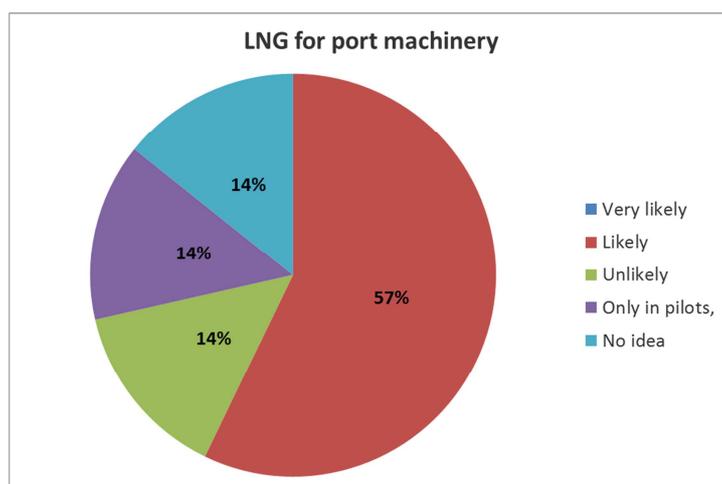


Figure 37 Feasibility of LNG for port machinery

7.6 Drivers, enablers & barriers

In this paragraph the most important arguments or conditions that would limit (barriers) or stimulate (enablers) the use of LNG as perceived by the interviewed natural gas suppliers are listed.

Main drivers: compliance with emission regulation.

Over 70% of the respondents to the e-survey indicate emission regulation will be the most important driver for sustainable growth of LNG demand & supply. The effect, emission reduction, and the enabling condition: economic criteria (CAPEX & OPEX) are equally rated by 55% of the respondents as being important (Figure 38)

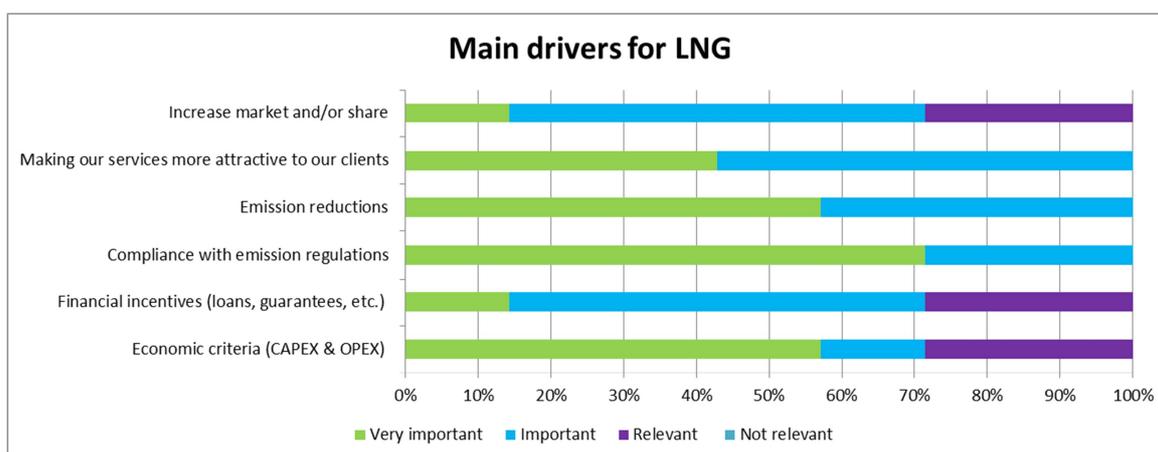


Figure 38 Main drivers LNG demand & supply according to natural gas suppliers.

Main enablers

Other enablers mentioned by Natural Gas Suppliers during the interviews are:

- EU directive for the implementation of an infrastructure for alternative fuels;
- Forums and meetings engaging all the relevant stakeholders (government, regulators, port; authorities, shipping companies, gas suppliers);
- Environmental awareness;
- Lower operating costs on the long-run;
- EU studies and initiatives such as Blue Corridors or CORE LNGas Hive.

Main barriers to develop LNG

According to Natural Gas Suppliers the main barriers developing LNG supply and related services are (Figure 39):

- Low/uncertain demand (mentioned in top 3 of more than 40 % of the respondents)
- Lack of (clear) regulatory policies (mentioned in top 3 of more than 40 % of the respondents)
- Uncertainty of future LNG fuel price (in comparison to other prices) (mentioned in top 3 of more than 40 % of the respondents)

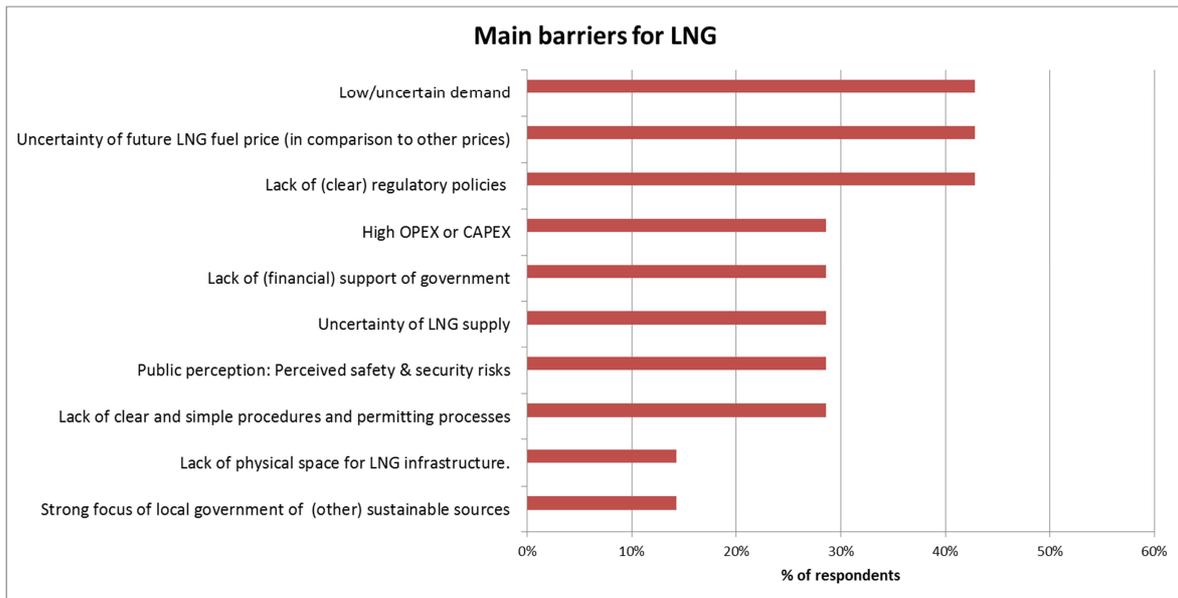


Figure 39 Main barriers for developing LNG supply and related services

Other barriers mentioned during interviews with Natural Gas Suppliers:

- Lack of legislation enforcing the use of alternative fuels such as LNG. Government should help small scale fleet (grants and subsidies). New regulations should be finished: Port Authorities are working on it;
- Uncertainty about future consumption of LNG;
- Misinformation and lack of information;
- Volatility of crude oil prices;
- Presence of alternative solutions for retrofitting the existing fleet, notably scrubbers, requiring much lower investment;
- High port taxes and tolls.

8 BUNKERING SERVICES

8.1 Current involvement in LNG business

Most bunkering companies (67%) are prepared to get involved in the LNG business (Figure 40). Some did a few operations, performed (feasibility) studies and/or designed processes and infrastructure (equipment and storage facilities). The main (international) companies are already supplying LNG for heavy road transportation and industry and are operating small regasification units.

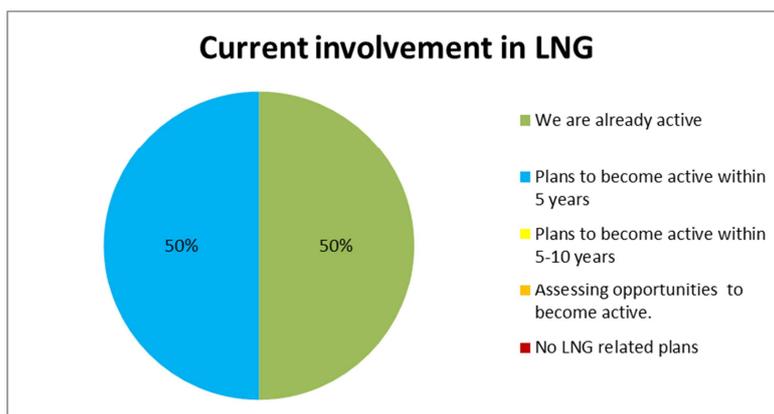


Figure 40 current involvement in LNG

8.2 Expected bunkering product mix

Next 5 and next 10 years: no imminent plans

There are no imminent plans to expand the current fleet of barges or invest in new storage facilities. Once the market for LNG bunkering grows, it will be added to the bunkering mix gradually. LNG is considered as a significant opportunity; however, development of a LNG bunkering facility will only be initiated when the demand is there. According to several bunkering companies, shipping companies are still struggling with the LNG business case and most shipping companies do not 'demonstrate' a firm belief in LNG on the short term. The Maritime business world is a traditional world, with limited innovation. They repeat what works. Due to this and the very high CAPEX of LNG there will be a very long lead time/implementation time of LNG. Main opportunity for growth is to create an easy (fast) and cost competitive LNG alternative for big tankers and container ships to and from ECA zones. Until 2020 the LNG market in Portugal will be relatively small and LNG bunkering services are not expected to be profitable. Nevertheless, it is perceived as an interesting opportunity.

Next 10 years: no imminent plans

Expected to be the same as the first 5 years.

2030 and beyond

In the far future LNG is likely to become an important clean fuel, also part of the bunkering mix in the region. The current examples and global development demonstrate LNG is an important clean shipping fuel of the future. New cleaner fuels like (ultra) low Sulphur variants are considered a strong competitor for LNG. Also for this type of fuels, the supplier specifications for storage and bunkering are strict and require modification of current infrastructure. Most of the volume will come from the spot market and the remainder will be associated with the supply of local ships (tug boats, river ferries and fishing boats).

First movers will be passenger and ferries companies

First movers will be passenger and ferries companies. Other potential LNG users will be tug boats. Only 15% is passengers and RO-RO. 85% of bunkering volume (in the world) is cargo (containers, dry and bulk cargo). Growth of LNG in this segment is only possible if a global supply infrastructure is available. Tankers and container ships on regular international routes are also potential clients if services can be provided fast against cost competitive prices. Nevertheless, bunkering companies expect only a market share for LNG as a maritime fuel of 5-10%, as shown in figure 41.

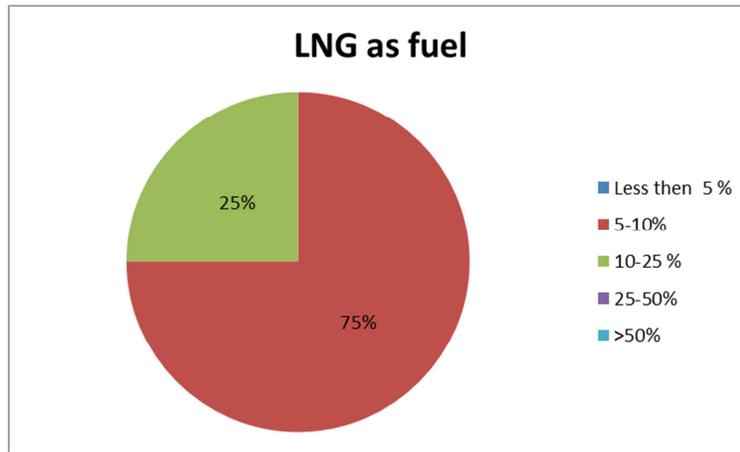


Figure 41 LNG as fuel

8.3 (inter)National policy framework/decarbonisation plans

Collaboration across the value chain

Port authorities and LNG suppliers are already executing LNG feasibility studies about safety and operational procedures for storage and transfer of LNG. This collaboration across the value chain is key to accelerate the development of small-scale LNG infrastructure.

Storage Facility

A challenge for LNG supply is to find out the most appropriate storage facility to serve the demand. The COSTA project triggered several feasibility studies. At the moment, several bunkering companies are studying options how the bunkering market can evolve.

8.4 Characteristics future LNG supply chain & infrastructure

The future supply infrastructure and practices for LNG will be the same as for traditional fuels. Most of the bigger ships will use barges to bunker. Small ships in small ports will be supplied by truck. Ships will bunker in port during operation, in berth or on sea if conditions allow.

Main ports will have a small-scale storage facility. These ports will be supplied by feeders loaded at the LNG terminals or via existing regasification plants. The current regasification plants have enough capacity to provide the necessary volume. One interviewee emphasized that a medium regasification plant is also necessary at the main islands groups. The bunkering can be done by barges, directly from the terminal, truck-to-ship or a combination of both.

Another interviewee stated that FSRU or other floating storage systems are not likely to be feasible due to sensitivity and corresponding safety regulations.

8.5 Criteria to select port/bunkering services

The criteria to select a port based on available bunkering services, from the perspective of the bunkering services are port service portfolio (in top 3 of 80% of the respondents), fuel quality and the location (both in the top 3 of 60% of the respondents). See Figure 42.

The most important criteria mentioned during the interviews are:

- *Cost competitive prices and a positive business case.* This includes fuel prices, prices to bunker and port taxes. Evolution of the Crude Oil Brent prices during recent years has been a game changer. What was a competitive option in the past may no longer be valid at present;
- *Time at the port.* Simple and clear legislation on LNG transport and bunkering should contribute to shorter lead times and shorter times at a port.
- *Availability any time, any place.* The current regional gas market is still evolving. Liquidity of supply needs to be improved. Physically, LNG is available, but the logistic costs and other transaction costs can hamper this liquidity per region or need. One way to tackle this issue is by developing financial instruments like swaps. It will take some time to have a liquid market functioning (up to 10 years). Availability any time, any place also means that ports need to have enough storage capacity and enough barges to fuel several ships a day.
- *(port) regulation: simple and clear.* Legislation for ports is lacking. For traditional fuels this is a simple piece of paper. For LNG, general security rules are lacking. Of course, there will be some differences between port rules because of differences in location (in or outside port) and kind of ships/terminals.

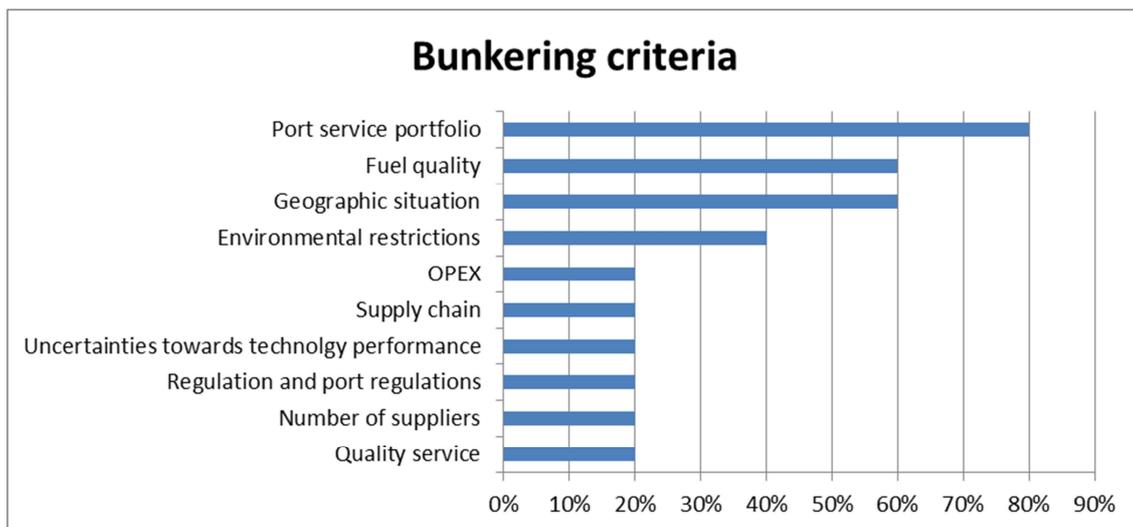


Figure 42 main criteria to select bunkering port

8.6 Drivers, enablers & barriers for LNG

Demand is the main driver to invest LNG bunkering services

The main driver to invest in LNG bunkering services is economics. Bunkering companies will only invest if there is a proven demand/market. According to most interviewees the demand will be triggered by stricter emission regulations. Bigger companies have the financial capacity and resources to invest in LNG. 80% of the respondents of the survey also assess compliance to future emission regulations and making services more attractive to clients as very important. See Figure 43.

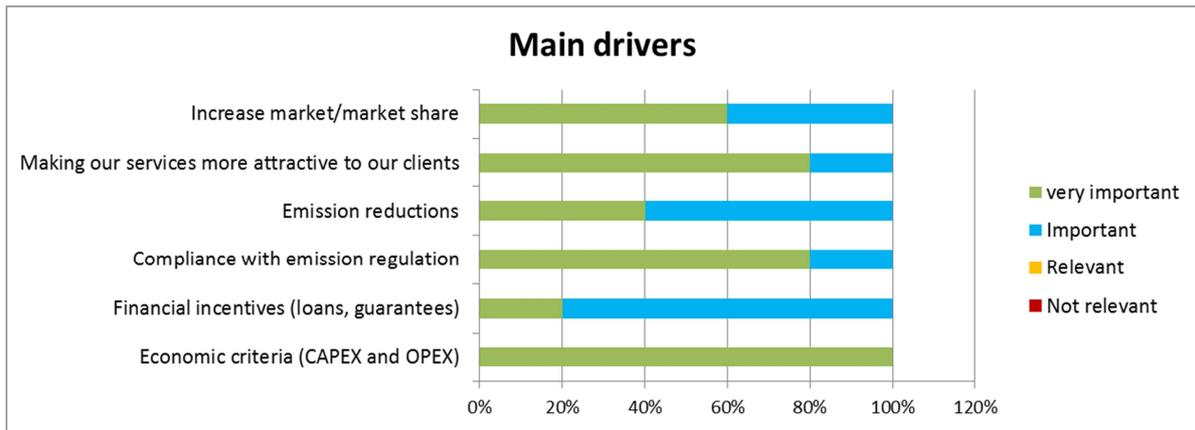


Figure 43 main drivers to invest in LNG

Main enablers

- Customer demand;
- Perception of clients and public. People living in cities near the riversides and harbours are more and more concerned with the potential risk of air pollution. This has already been a significant driver for LNG adoption by cruise lines;
- Availability of LNG as a commodity (with price liquidity);
- EU funded programs;
- EU directive 2014/94/UE;
- New ECAs.

Main barriers

- Low and uncertain demand (in top 3 barriers of 80% of respondents)
- Uncertainty on future LNG price (in top 3 barriers of 60% of the respondents). Traditional fuels are a day even minute (spot) market. According to one interviewee customers considering LNG are requesting long year contracts to mitigate cost risks.
- Lacking supply and supply infrastructure (in top 3 barriers of 60% of the respondents and mentioned in all the interviews.

Other important barriers mentioned during the interviews are:

- Public perception (in top 3 barriers of 2/3 of the respondents). People living in cities near the riversides and harbours are more and more concerned with the potential risk of air pollution. This has already been a significant driver for current LNG initiatives.
- Lack of positive mind-set amongst ship-owner for LNG. Currently they are not 'believers'
- Lack of clear and simple procedures and processes. The sector needs harmonisation of port regulations

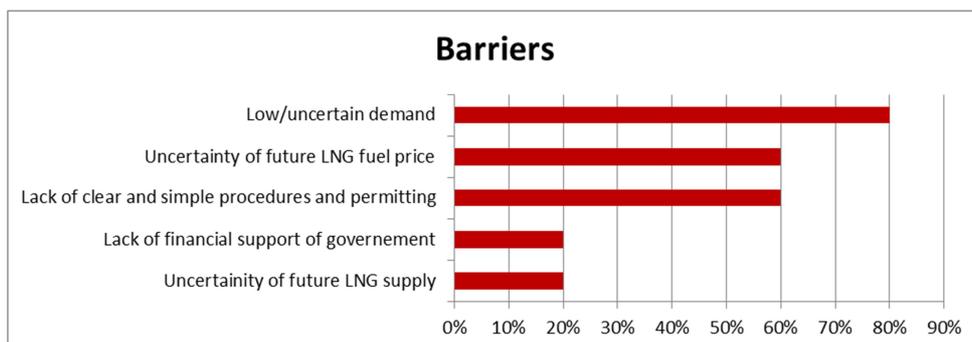


Figure 44 main barriers



Main actions

- To raise awareness about the LNG for the maritime sector. Engagement of relevant stakeholders is of the utmost importance to create healthy conditions for LNG investments in the Maritime sector. The port authorities and customs have an important role to promote LNG. They shall positively discriminate LNG traffic and LNG operations over the traditional HFO powered shipping;
- Develop simple and clear legislation as legislation for ports is lacking. For traditional fuels this is a simple piece of paper. For LNG, general security rules are lacking. Puertos des Estados and some core ports are already working together on some rules.

9 PORT TERMINALS

9.1 (Inter)national policy framework/decarbonisation plans

75 % expects (very) high impact of emission regulations on terminal operations

It makes sense to set a limit on emissions of existing consumers. In an ideal world regulation needs to be applied globally to have a balanced effect. Regulation will become active per region and at different moments. An ECA might be in place in Portugal or Spain in the future, but Africa will be lacking any regulation for a long period and continues to be the scrapyards from Europe. Legislation is and will be limited to new machinery, so there is no need to speed up replacements. No stricter regulations are expected for the coming years so there is no need for extra actions to comply. On the long term the impact of emission regulation is high (see Figure 45).

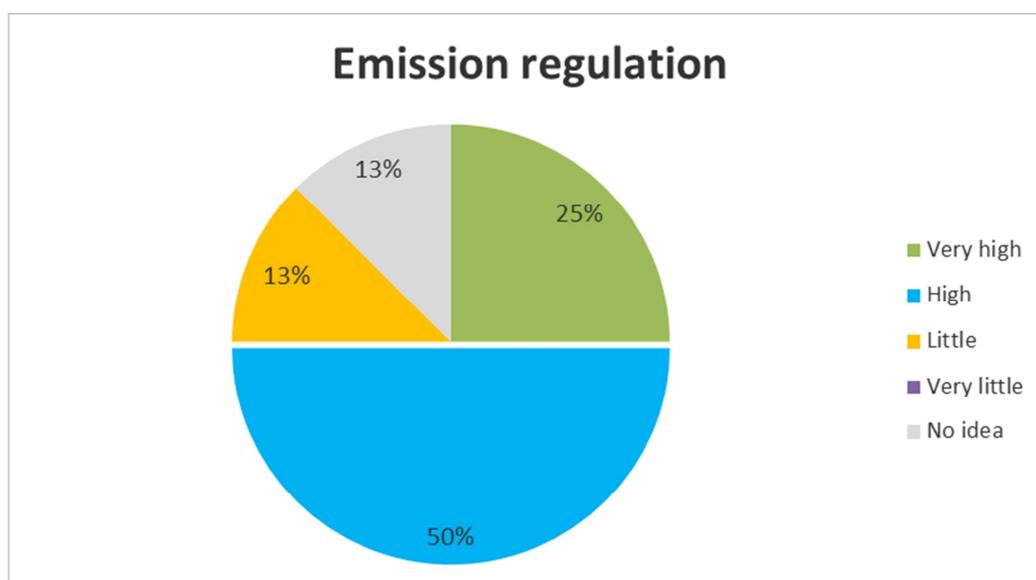


Figure 45 Impact of emission regulation

How to comply with emission reduction policies?

For most of the port terminals, emission reduction is not an issue. Some terminal owners/operators are working on environmental issues, as their terminals are located near densely populated areas. Driven by either municipalities or Port Authorities, these terminal operators are working on energy efficiency and emission reduction and are participating in Research & Development or other innovative pilots. Innovators on environmental issues studied the potential of LNG or electrification but most do not have a specific plan for large scale transition within the coming years. Emission restriction is expected to be predominantly an issue for big container terminals. For bulk terminals dust is the main problem.

9.2 Current and expected terminal and transport infra

The companies interviewed do not expect major new innovative changes in terminal and port infrastructure although some are sensitive to environmental issues and have strategies to replace a part of the current machinery by LNG or electricity fuelled machinery.

9.3 LNG for port and terminal operations and transport

In general

Terminal owners/operators will only replace machinery at end of the economic lifetime. Replacement could be done by cheap available second hand equipment, although the intention/strategy is to replace with electric driven vehicles or other eco-friendly solutions. Terminals with an electrification strategy do not have plans to adopt LNG as fuel for terminal equipment. Other terminals might consider gradually replacing machineries that needs a lot of power, like vessels, tug boats and some trucks with LNG. These decisions depend on a positive business case (both CAPEX and OPEX). For a positive OPEX, minimum availability of small LNG refuelling infrastructure is required. Currently available small terminals are not expected to be able to reach this critical mass. For these terminals LNG is not viable an option.

Over 40% of the respondents assess the use of LNG for most machinery likely or very likely (see Figure 46). The majority is only sceptical about the future use of LNG for reefer plugs (majority is already powered by electricity) and cranes (already powered by electricity), straddles and top loaders.

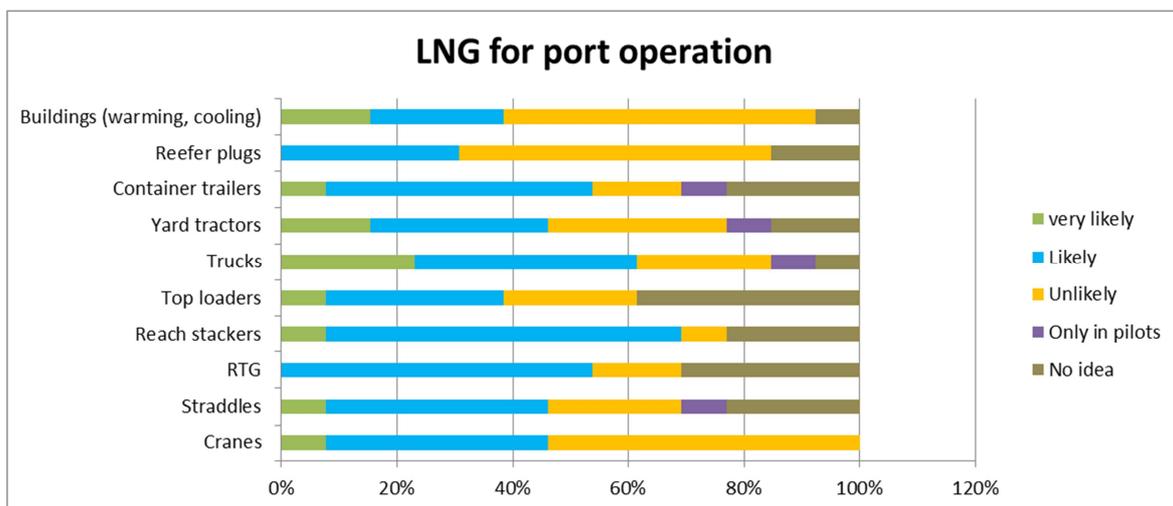


Figure 46 LNG for port operation and transport

Terminal operators consider electrification of port machinery as an important option to reduce emissions. 65% of the respondents consider terminal electrification likely for a substantial part of the terminal operations (see Figure 47). For several port terminals, electricity is the preferred option because of the possibility to recover energy (via batteries, fly wheels etc.). According to some respondents they are not aware of equipment suppliers, supplying (standard) LNG fuelled terminal equipment. Equipment suppliers focus on hybrid solutions, batteries and fly wheels. This lack of attention and supply might prevent terminal operators to consider LNG fuelled machinery.

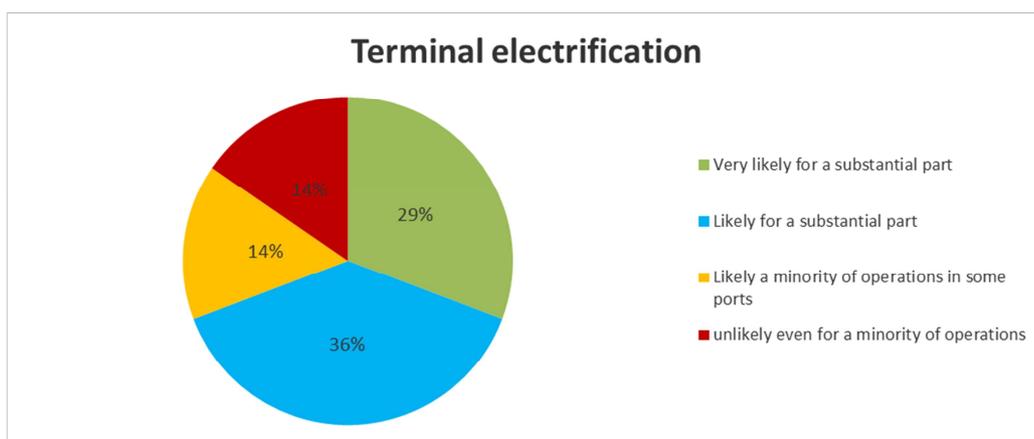


Figure 47 Likelihood terminal electrification

Best ways to bunkering LNG

Over 60% of the respondents assess tanker to ship as the best way to bunker LNG. This is a remarkable response rate because the interviews in all segments showed barge to ship at the best way. Tanker to ship is of course a suitable solution for the biggest container and bulk carriers on international routes. See Figure 48.

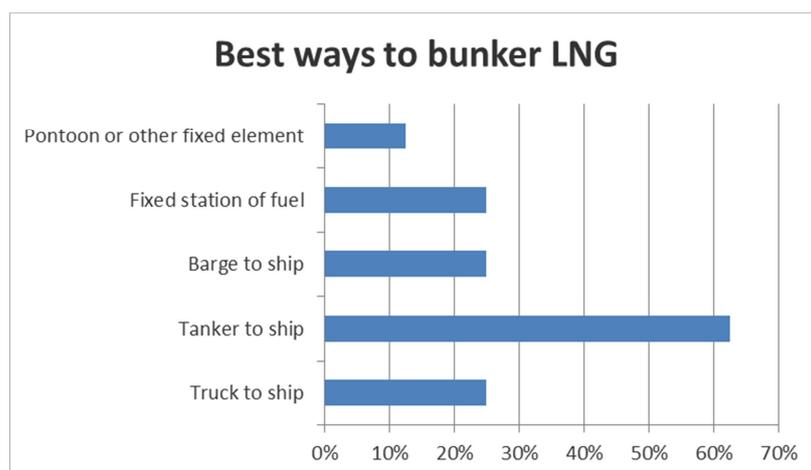


Figure 48 best ways to bunker LNG

9.4 Drivers, Enablers & barriers for LNG

Main driver: lower cost

Over 50% of the respondents of the e-survey did assess all drivers to invest in LNG as very important or important. See Figure 49. Compliance with emission reduction is leading the list with over 80% assessing this as very important or important. The main and most important driver for port terminals is lower cost. Building a green image and anticipating on future emission regulation are relevant but not the most relevant drivers. Energy consumption is only 3-5% of the total operational cost of most trucks and tractors, so this is a minor factor in decision making. In the long-term, most new machineries will be preferably powered by electricity. Machinery moving a lot might be using hybrid/dual fuel options. But that is expensive especially during low energy prices and low usage. Gradual replacement of conventional powered (vessels, tug boats, some trucks with) to LNG alternatives is expected, but on the long term.

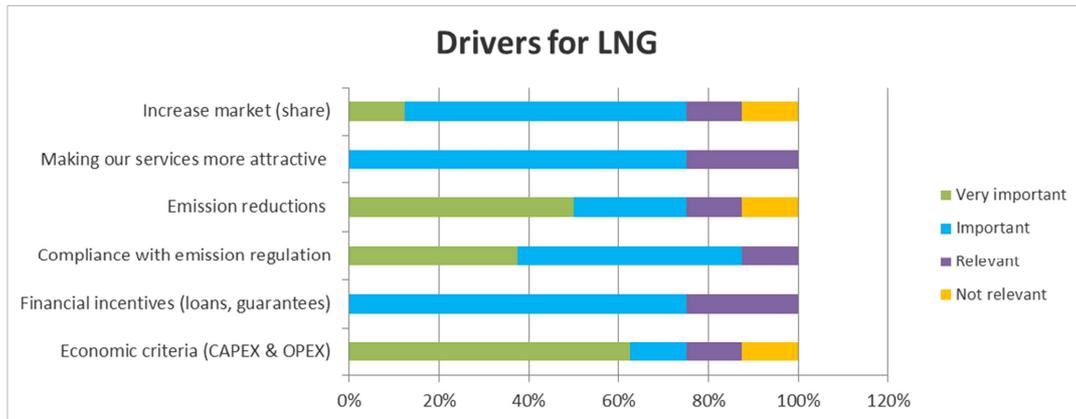


Figure 49 Drivers for LNG

Main enablers

The main enabler is regulation as response on the global concern for the impact of pollution on health and safety.

Main barriers

The most important barriers, appearing in more than 40% of the responses, according to the e-survey (Figure 50) results are:

- *Uncertainty on future LNG prices.* A substantial price gap between LNG fuel prices and other fuel prices is needed to justify the 30-40% higher CAPEX for LNG fuelled machinery. Over 60% of the respondents assess this uncertainty as a major barrier.
- *Uncertainty towards technical performance of the equipment.* Over 40% of the respondents assess this uncertainty as a major barrier. Technical limits and uncertainties may exist. Several pilots did touch on the technical boundary of LNG technologies for terminal machinery and operations. LNG fuelled cranes, trucks and tractors did work perfectly although they have 30-40% less power than the diesel alternative. Compensating this power loss by using a bigger engine, eliminates all cost savings and emission reductions. There are still some uncertainties related to the performance of LNG in the long run/at the end of life time. This uncertainty is a problem because of the impact on the total terminal logistics (truck stops → crane stops → terminal stop). Other weak points are the larger size of the engine and technical difficulties to retrofit terminal equipment.
- *Lack of financial support of government.* Almost 40% of the respondents assess this uncertainty as a major barrier. Compensations, higher CO2 prices and/or taxes on polluting fuels are also needed to create a positive business case.

Other barriers mentioned during the interviews are:

- *Lack of clear and simple permitting processes.* The permitting process was a concern during the innovation phase since compliance to legislation and procedures needed considerable more effort than expected.
- *Low and uncertain demand.* Declining demand for port terminals makes it difficult to reach critical mass needed to trigger a transition towards LNG. The current replacement rate of terminal machinery is low. Life time of most mobile machinery is 10 years, for Cranes this is 40

years. It could easily take another 5-10 years for a terminal owner to invest in new terminal machinery. So for next 10 years, LNG infrastructure is not likely to gain from demand from port terminal machinery. With low demand, limited space for investments, investments are postponed as long as possible. Terminal owners will consider to buy second-hand equipment instead of innovative new equipment

- For most machinery, the pay-back period is far above 8 years, while 5 years is required for LNG investments in current circumstances. With the very low energy prices, return on LNG fuelled solutions will not be enough to reach this pay back-period.
- Operational people perceived LNG to be dangerous. 2 hours of individual training to get familiar with the facts and the new working environment was enough to solve this problem.

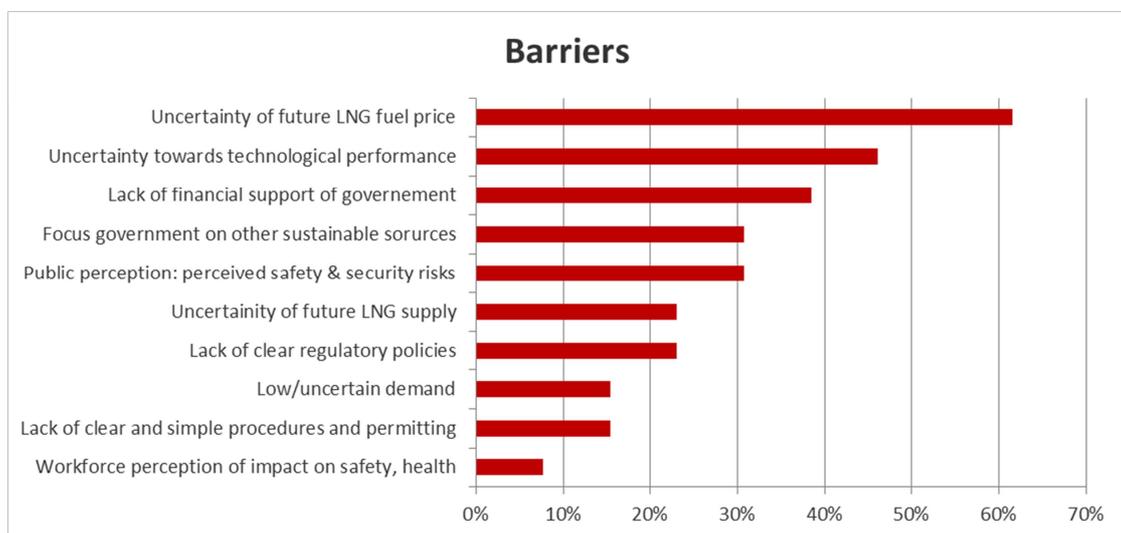


Figure 50 Barriers

Main governmental actions

From the perspective of the Port Terminals, the main actions to be taken by the government on the short term are:

- Account for potential harm for current players and provide funding for reconversion
- Clear goals and legislation forcing terminals to act ('level playing field')
- Develop a clear and easy permitting process

10 DNV GL ANALYSIS OF RESULTS

From the overall study results one can conclude that compliance with emission regulation is the main motivation to consider LNG as fuel. The development of LNG fuelled shipping so far has been encouraged by a lower price of LNG compensating for the added cost for installation of the LNG fuel equipment. In this environment, it has seemed obvious that LNG would be the logical solution to meet the more stringent requirements.

As a consequence, the industry has taken steps to prepare for an increase in LNG fuelled shipping;

- ISO and IMO have initiated projects to standardise the bunkering systems and procedures
- LNG suppliers are positioning themselves for supply of LNG in important ports
- Ship builders and equipment manufacturers are responding by improving technology and solutions for LNG fuelled propulsion.
- Authorities are proposing political incentives to stimulate the conversion to cleaner shipping

However, the recent significant drop in oil price has raised the concern that cheaper oil combined with scrubbers and SCR could be the preferred option compared to LNG. The uncertain financial aspect is the main barrier for LNG uptake (current fuel price spread and the high CAPEX investment, not leading to profitable business models especially in shipping). This situation is region specific, e.g. in US cheap oil is counterbalanced by cheap gas.

Stakeholders further identify as barriers differences in technical standards (quay design, bunkering systems) and the lack of a clear unified set of (safety) requirements and procedures. They emphasise that this might cause a relatively long implementation period. To overcome this barrier, initiatives have been set up by ISO, IMO, EU and EMSA (standardisation of bunker systems and procedures), IAPH, SGMF and IACS (bunker procedures) followed by local initiatives (Dutch PGS 33 guidelines covering design requirements for various LNG bunkering configurations), National LNG platforms (the Netherlands, Germany and Flanders) (platforms to share best practices and information between all LNG stakeholders). This indicates that relevant international bodies are aware of this remaining barrier and are currently doing important efforts to close the remaining gaps.

A remaining barrier as expressed by the stakeholders is the uncertainty in the demand, delaying infrastructure investments, the so called "chicken-and-egg problem".

Future oil and gas prices and harmonisation of international standards and procedures cannot or only to a limited extent be influenced by Spanish and Portuguese stakeholders. What can be influenced locally is the demand uncertainty, which can be overcome by intensive collaboration between all local stakeholders (shipping lines, gas suppliers, terminal operators and port authorities). Moreover, the areas subject to emission control legislation are now being implemented or considered for many more areas (Hong Kong, Japan, Mediterranean, inland Europe), which may lead to a significant LNG demand in Spanish/Portuguese ports.

Below some key aspect for different stakeholder groups are discussed:

SHIPPING COMPANIES – Future plans with regard to LNG, differ amongst ship owners and in general a positive business case is their key decision criteria. This trend is in line with other stakeholder analysis exercises like f.e. EU LOT 2 study "Creating Awareness on LNG Risks and Opportunities". In this report one of the key conclusions is that *'the majority of ship owners are generally in favour of LNG but the barriers regarding financing and harmonized standards are difficult to overcome'*.



In a position paper for the EU (LOT 1 Position Paper: Implications of drop in oil price on LNG uptake) DNV GL stated that: *“All new ships need to be prepared to enter areas where emission controls are implemented, and currently the following solutions are realistic: LNG propulsion, Low sulphur MGO combined with SCR, HFO with scrubbers and SCR. In all cases, additional investments are needed and these need to be depreciated over the lifetime of the ship. The impact of the recent drop in oil price on the natural gas prices will most likely stabilise fairly quickly and will have limited effect on the depreciation on the additional equipment. Based on this assessment it is concluded that there are no indications that the current low oil price will have long term negative impact on the deployment of LNG as a fuel.”*

The majority of shipping companies identified dual motors as one of the preferred propulsion alternatives. This is in line with the current portfolio of LNG ships on order, where about 90% of the confirmed order book are dual fuel ships. This solution offers the possibility to satisfy legislative requirements in emission control areas, and to use the cheapest energy (natural gas or oil) during oceans crossing.

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. As most of the 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.

PORT AUTHORITIES – The current Spanish bunker market is a major bunkering hub with several ports supplying significant bunker volumes (representing about 20% of the bunker market in EU, which is a more than double share compared to Spanish GDP that is about 10% of EU overall GDP). Due to its strategic position, it also has a huge potential for LNG. The ports with the ambition to become a maritime LNG hub will need to provide adequate LNG refuelling infrastructure, able to bunker both smaller and larger vessels.

Spanish Port authorities can be categorised as LNG believers and are ready or will soon be ready to supply LNG. LNG is abundantly available as 8 import terminals are present in the area. In addition, 4 LNG bunker vessels are planned/under study.

Several ports are defined as core port by Directive 2014/94/EU of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, which sets out minimum requirements for the building-up of alternative fuels infrastructure. In terms of maritime transport, Member States shall ensure, by means of their national policy frameworks, that an appropriate number of refuelling points for LNG are put in place at maritime ports, to enable LNG seagoing ships to circulate throughout the entire TEN-T Core Network by 31 December 2025. It is expected that by 2030, 1 or 2 main multimodal LNG Hubs per corridor will be in place.

The “chicken-and-egg problem” (high investment cost versus uncertain demand) can only be overcome by intensive collaboration between shipping lines, gas suppliers and port authorities. This in order not to lose business to more innovative ports or cheaper ports. This also necessitates a stable and efficient permitting climate.



TERMINAL OPERATORS - Port terminal operators are neutral towards LNG developments and will on the long term rather choose for electrification for their equipment (port cranes, already on electricity today). However, if LNG would be available, they would consider it. Some terminal operators have done pilots on LNG. LNG demand for terminal operations is negligible compared to the potential demand for shipping, although it might be very relevant towards the business case for a local small scale installation.

LNG TERMINAL OPERATORS AND GAS SUPPLIERS - In Spain and Portugal, seven LNG import terminals are in operation (as the El Musel terminal has been mothballed) and at least two other terminals are under construction or consideration. Looking at the existing LNG bunkering infrastructure in the ports, all large-scale LNG terminals in operation in Spain have truck loading facilities. Furthermore, several terminals can load smaller LNG carriers.

In recent years, the utilization rates of European LNG import terminals have been low and the Spanish terminals are no exception to this. The Spanish terminals are all operationally underutilised against total regasification capacity and each of Spain's LNG terminals has spare capacity available. This implies that Spanish and Portuguese terminals are actively exploring LNG opportunities, mainly in the maritime sector, however other sectors of interest are land based heavy transportation industry and electric power plants. Terminals are studying possibilities to adapt their jetties for (un)loading of bunker vessels/small LNG carriers and to adapt their tariffs accordingly.

BUNKERING SERVICES - The bulk of the bunker suppliers claim to be ready to be involved in LNG, although do not expect significant opportunities in the next 10 years. This claimed readiness is not in line with overall DNV GL experience but might be caused by the limited response rate from this segment. Although DNV GL believes that, once the demand is established, LNG will be added to the bunkering mix gradually. As per DNV GL's insights the bunker supply market will also change with the entrance of LNG in the fuel mix: DNV GL anticipates a shift to major oil and gas companies rather than local small players.

Current bunker suppliers are reluctant to take the investment risk initiative of going for LNG as marine fuel at an early stage with uncertain demand. Although as specified above, 2 concrete plans for bunker barges are in place.

The overall results of the bottom up analysis will serve as input to the consolidation step with the top down results.

ANNEX A: E-SURVEY

This annex starts with an overview of the core questions of the e-survey. On a meta level we have 3 types of questions:

- Generic question to be asked to all companies in all segments regarding their own position and role.
- Questions about shipping companies and their LNG use, to be asked to the companies in the segments that merely provide services to shipping clients.
- Questions specific for 1 or 2 segments.

After this overview we provide for each question the possible answers.

Questions	Port Authority	Shipping company	LNG gas terminal	Gas supplier	Bunkering supplier	Port Terminal
1 Impact emission regulations. What would be the impact of new emissions regulation (for example, ECA zones) on your organisation (impact on port attractiveness, cost, calls)?	X	X	X	X	X	X
2 Current involvement in LNG. Does your organisation have plans to develop LNG infrastructure/services or to use LNG.	X	X	X	X	X	X
3 Main drivers. What are for your organization the main drivers to develop a LNG infrastructure (to deliver LNG services). Select the top 3 criteria	X	X	X	X	X	X
4 Main barriers. What are for your organisation the main barriers for further developing the LNG market?	X	X	X	X	X	X
5 Main barriers for shipping companies. What are in your opinion the main barriers for shipping companies to use LNG as maritime fuel? Select the top 3 criteria	X	X	X	X	X	
6 Criteria to select bunkering ports. What are in your opinion the main criteria of shipping companies to select a bunkering port. Select the top 3 criteria	X	X	X	X	X	
7 LNG fuelled vessels. what % fuel do you expect to be LNG if propulsion fuel in 2030 if emission regulations and LNG supply points are in place.	X	X			X	
8 Bunkering system. What is according to you in the long term the best bunkering system in your terminals in order to meet the needs of your customers. (multiple answers possible)	X	X		X	X	X
9 Alternative propulsion variants. In order to adapt to future emission regulation, do you expect alternative propulsion variants for new build or the existing fleet		X				
10 LNG for port and terminal infra. What is in your opinion the likelihood of the use of LNG by the following port machinery and transport infrastructure within the coming 10 years in your port/for your terminals	X		X	X		X
11 Electification of ports & terminals. To what extend do ports or terminals consider the electrifications (of their operations)	X			X		X



1 Impact emission regulations. What would be the impact of new emissions regulation (for example, ECA zones) on your organisation (impact on port attractiveness, cost, calls)?	
Very high	
High	
Little	
Very little	

2 Current involvement in LNG. Does your organisation have plans to develop LNG infrastructure/services or to use LNG.	
We are already active	
We have plan to become active within 5 years	
We have plan to become active within 5-10 years	
We are assessing opportunities to become active	
We have no plans	

3 a Main drivers. What are for your organization the main drivers to develop a LNG infrastructure (to deliver LNG services). Select the top 3 criteria	
a. Economic criteria (CAPEX & OPEX)	
b. Financial incentives (loans, guarantees, etc.)	
c. Compliance with emission regulations	
d. Emission reductions	
e. Making our services more attractive to our clients	
f. Increase market and/or share	
g. Other, namely	

3 b Main drivers. What is for your organization the importance of the following drivers to develop a LNG infrastructure (to deliver LNG services).					
Answer Options	Very Important	Important	Relevant	Irrelevant	No idea
Economic criteria (CAPEX & OPEX)					
Financial incentives (loans, guarantees, etc.)					
Compliance with emission regulations					
Emission reductions					
Making our services more attractive to our clients					
Increase market and/or share					
Other, namely					



4. Main barriers for your company to use LNG for Port machinery and operation. Select the 3 most important barriers for your company	
a. Lack of clear regulatory policies	
b. Lack of clear and simple procedures and permitting	
c. Public perception: perceived safety & security risks	
d. Uncertainty of future LNG fuel price	
e. Uncertainty of future LNG supply	
f. Uncertainty towards technological performance	
g. Workforce perception of impact on safety, health	
h. Ability of work force to adapt	
i. Low/uncertain demand	
j. Lack of financial support of government	
k. Focus government on other sustainable sources	
l. Lack of physical space	

5. Main barriers for shipping companies. What are in your opinion the main barriers for shipping companies to use LNG as maritime fuel? Select the top 3 criteria	
a. Lack of clear regulatory policies	
b. Lack of clear and simple procedures and permitting	
c. Public perception: perceived safety & security risks	
d. Uncertainty of future LNG fuel price	
e. Impact on performance vessels/machinery	
f. High OPEX or CAPEX	
g. Uncertainty towards technological performance	
h. Workforce perception of impact on safety, health	
i. Ability of work force to adapt	
j. LNG supply chain not available	

6. Criteria to select bunkering ports. What are in your opinion the main criteria of shipping companies to select a bunkering port. Select the top 3 criteria	
a. Fuel price	
b. Geographic situation	
c. Supply system (truck, barge, etc.)	
d. Fuel quality	
e. Quality service	
f. Number of suppliers	
g. Regulation and port regulations	
h. Port charges	



7 LNG fuelled vessels: What % of ships in Spain and Portugal do you expect to use LNG as propulsion fuel *in 2030*, if emission regulations and LNG supply points are in place?

Less than 5%	
5-10%	
10-25%	
25-50%	
>50 %	

8 Bunkering system. What is according to you in the long term the best bunkering system in your terminals in order to meet the needs of your customers. (multiple answers possible)

Tanker ship	
Barge to ship	
Fixed station of fuel	
Pontoon or another element fixed	
Truck to Ship	

9 Alternative propulsion variants. In order to adapt to future emission regulation, do you expect alternative propulsion variants for new build or the existing fleet

LNG fuelled	
LNG prepared	
Dual motors	
IFo380 + Scrubbers	
Other fuels (LSFO, MGO, Methanol etc)	

10. Use of LNG for port machinery and operation. What is in your opinion the likelihood of the use of LNG by the following port machinery and transport infrastructure within the coming 10 years in your port/for your terminals

Answer Options	Very likely	Likely	Unlikely	Only pilots	No idea
Cranes					
Straddles					
RTG					
Reach stackers					
Top loaders					
Trucks					
Yard tractors					
Container trailers					
Reefer plugs					
Buildings (warming, cooling)					

10b. Use of LNG for port machinery and operation. What is in your opinion the likelihood of the use of LNG by the following port machinery and transport infrastructure within the coming 10 years in your port/for your terminals

Very likely	
Likely	
Unlikely	
Only in pilots	
No idea	

11. Expectation w.r.t electrification of terminal in 2030. To what extent do you expect the electrifications of port and terminal operations by 2030

Possible answers	Answer
a. Very likely for a substantial part of the port operations	
b. Likely for a substantial part of the port operations	
c. Likely a minority of operations in some ports	
d. unlikely even for a minority of operations in some ports	

4. Main barriers for your company to use LNG for Port machinery and operation. Select 3 most important barriers for your company

a. Lack of clear regulatory policies	
b. Lack of clear and simple procedures and permitting	
c. Public perception: perceived safety & security risks	
d. Uncertainty of future LNG fuel price	
e. Uncertainty of future LNG supply	
f. Uncertainty towards technological performance	
g. Workforce perception of impact on safety, health	
h. Ability of work force to adapt	
i. Low/uncertain demand	
j. Lack of financial support of government	
k. Focus government on other sustainable sources	
l. Lack of physical space	



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