LNG Opportunities For Harbor Development

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Abstract. Today a "Green" vision of the Port becomes fundamental and LNG is more environmental friendly than any other fuel for its reduced emissions (nitrogen oxide, sulfur oxide and particulate matter). In the Mediterranean Sea, the environmental legislation has not yet imposed strict limits as it happened in the ECA / SECA zones. However, starting from 2020 or in any case by 2025, new regulations are planned to come into force. The distance of the LNG suppliers from the terminals and the LNG demand itself strongly affect the whole supply chain. One key point to consider for competitive planning and development of the LNG supply chain is that LNG carriers can supply connected harbors thus reducing the number of vessels involved and optimizing the quantity of LNG carried. The choice of using LNG as a fuel is growing because it reduces pollution and operative costs. The technology is ready to be used, but the port infrastructures have to face new challenges in the days to come. This study shows the possible scenarios (LNG supply system and pollution reduction) if using LNG in four different types of port.

Keywords. LNG, Harbor, Terminal

1. Introduction

LNG is becoming a more popular fuel choice for shipping and transportation on oceans and inland waterways, both in terms of reduced emissions (nitrogen oxide, sulfur oxide and particulate matter) compared to heavy bunker oil and even low-sulfur marine diesel, and in terms of operative costs. The technology is ready to be used on board of ships, but what will the change in port infrastructures be, in terms of bunkering vessels, tugs, etc.? For this type of ships, the challenges will grow in the days to come.
The study [1] considers a development of a fleet of ships to cover the needs of the improvement of the LNG chain.

The intent of the study is to identify 4 different port types which can resemble an existing harbor scenario. This study suggests how the logistic chain will work when the LNG demand increases (two are the cases taken into consideration: what the logistic chain should be if 20% of the ships in port use LNG as fuel and what it should be if 60% of the ships in port use LNG as fuel).

In order to compare the four different types, the study has considered the following points:

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- distance from Harbour to LNG Terminal (within 150 miles or farther than 150 miles)
- percentage of the ships in port using LNG as fuel (20% or 60%)
- total amount of ships calling the port

According to the percentage of ships using LNG as fuel, considering the distance from the closest LNG terminal, the study shows what are the investments needed for each port type.

The list includes the following support vessels:

1. LNG Tugs
2. LNG Storage Barges
3. LNG Bunkering Tankers
4. LNG Small Scale Carriers for the filling of the LNG facilities of the port

The distances from terminals and LNG demand strongly influence the LNG supply chain. For example, a small/medium size harbor could have advantages if the LNG supply chain is made by means of the same LNG bunkering tankers used for the refueling. On the other hand, a large type harbor has the necessity of planning the investments according to the development of LNG supply chain made by small LNG carriers.

Anyway, a detailed analysis must be done for each port to determine better the LNG supply fleet according to the specific needs. Five different ports were studied and the conclusions of the time domain simulations of four of them are presented in the following Chapters.

Moreover, at the end of the study, it clearly emerged that a network of harbors can be more competitive in terms of planning and development of the LNG supply chain. Linked harbors can benefit from the streamlining of the LNG supply by means of LNG carrier reducing the number of the vessel and at the same time optimizing the quantity of the carried LNG.

A knowledge of the specific harbor (or harbors network) is essential to take proper actions for planning of the investments. A systematic development can occur and the initial investment can be increased later according to the LNG demand grow. However, in some cases a bigger initial investment is more advantageous for it allows setting up the logistics of the harbor in a way that only little investments are needed in the future when the LNG demand increases.

2. Definitions

In the LNG scenarios, the following definitions are used:

LNG bunkering ship/tanker: a ship that stores and transfers refueling media to the ship.

LNG on shore facility: a tank or a group of tanks with an aggregate capacity of not more than 400 m^3.

LNG in-port facility: a LNG store barge moored in the port area with a group of tanks with different capacities (for example 5000 or 10000 m^3).

LNG filling ship/carrier: a ship that stores and transfers LNG to bunkering ships, storage barges or onshore/in-port storage facilities.

LNG filling voyages: course made to restore the LNG refueling capacity of the port.

LNG supply chain: all the ships, barges, stores and trucks that contribute to the supply of the LNG to the ships in-port.

LNG Terminal: a facility where a LNG filling ship can load LNG.

Systematic investment: initial assets investment followed by continuous proportional investments

3. Basis of conceptual study

This study considered five types of harbor that are representative of the situation along Italy's coast. Each port type has its own characteristics, needs, infrastructures and a geographic position that influence the availability of the LNG. The LNG terminal distance from the reference Port was set as follows:

- Less than 150nm: port's LNG Bunkering tankers can make the refueling of storage facilities.
- More than 150nm: LNG Carriers shall make the refueling of the storage facilities.

The ships' landings per week considered in this study for each port's type are listed in **Table 1**.

PORT TYPE	SHIPS' LANDINGS PER WEEK						
	RO-RO	FAST RO-RO PAX	SMALL FERRY	TANKER	CONTAINER	CRUISE	AVAILABLE TUG
PORT TYPE A	14	-	-	-	8	1	6
PORT TYPE B	-	4	56	-	-	-	2
PORT TYPE C	-	-	-	10	-	-	4
PORT TYPE D	-	10	-	7	25	15	10
PORT TYPE E	10	20	-	15	50	8	10

Table 1. Ships' landings for each port

In this study, we considered two theoretical stages of the development of LNG as fuel. This two different phases are set as below:

- First stage: 20% of landing ships are LNG fueled (at the beginning);
- Second stage: 60% of landing ships are LNG fueled (in a second step).

The port type C is a tanker ships terminal, and it is not mentioned in the present study. In fact tankers will not be involved in the LNG conversion or in new buildings as other types of ships. A cold ironing solution made by means of LNG power barge could be an option to reduce the pollution from tankers during their time spent in-port.

The standardization of the ships, considered in the study, reflects the medium size of the ships that land in each type of harbor. The **Table 2** summarizes the different type of ships and their characteristics:

SHIP CLASS	SHIP CHARACTERISTICS			
	Length [m]	Beam [m]	Draft [m]	Estimated LNG Tank [m^3]
RO-RO	190	26	7.5	400
FAST RO-RO PAX	200	26	6.75	500
SMALL FERRY	100	20	4	50
TANKER	250	43	14	-
CONTAINER	200	30	9.5	800
CRUISE	290	32	8	1500
TUG	33	13	4.2	35

Table 2. Main Ship characteristics

4. Port Type A – Small Size Port with 30 Landings Per Week

The port type A, as per Table 1, is a small size port with an average traffic of less than 30 ships per week. The traffic is not so various in terms of typology of landing vessels. Anyway, one Cruise ship calls weekly.

The LNG demand per week at first step, 20% of landing ships, will be 2900 m^3 and will grow up to 9250 m^3 when 60% of landing ships will be LNG fueled.

4.1. Port Type A Conclusion: LNG Terminal Distances From Harbour Less Than 150 Nautical Miles

The little distance from the LNG Terminal allows to a systematic development with the progression of the LNG demand. A LNG on shore facility and one bunkering tanker are sufficient at the beginning. In the future as the LNG demand increases, the supply will be covered by adding more bunkering tankers. The **Figure 1** summarizes the development of the bunkering facilities in port type A needed for the supply of the LNG amount at first step, 2900 m^3 per week, to a second step, 9250 m^3 per week.

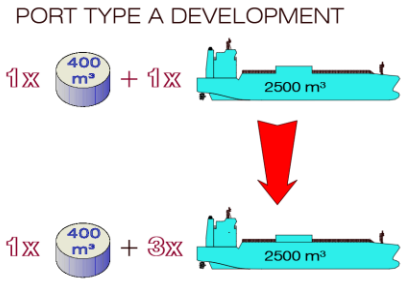

Figure 1. LNG bunkering facilities development for Port Type A: Distance less than 150 nautical miles

4.2. Port Type A Conclusion: LNG Terminal Distances More Than 150 Nautical Miles

The grow of the demand of the LNG leads to an increase of the necessary storage capacity. From the beginning, what changes in the LNG supply chain is the volume of the stored capacity, from 5000 m^3 to 10000 m^3, and the number of voyages made by the

LNG carrier. In this scenario, it becomes fundamental to consider the development of the LNG demand to plan the necessary investment to the port facilities. The best option could be planning directly the large volume of storage capacity.. **Figure 2** summarizes the development of the bunkering facilities in port type A if the LNG Terminal distance is more than 150 NM.

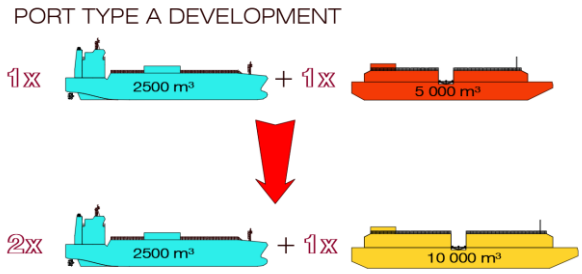

Figure 2. LNG bunkering facilities development for Port Type A: Distance more than 150 nautical miles

5. Port Type B –Ferries Port with A Seasonal Increase of Ship's Traffic

The port type B is a small size port with a seasonal increase in ship's traffic. The traffic is not so various in terms of typology of landing vessels.

The LNG demand will be 1150 m^3 per week at the first stage and will raise up to 3300 m^3 in the further steps.

5.1. Port Type B Conclusion: LNG Terminal Distances Less Than 150 Nautical Miles From Harbor

The number of the ships that land in-port mainly influences the development of the logistic chain for the port type B. The short distance from the LNG Terminal allows a systematic development as the LNG demand grows, like it happens in the port type A. In order to cover the LNG demand in this scenario, as shown in **Figure 3**, the initial configuration features one on shore storage facility of abt. 400 m^3 plus one bunkering tanker. As the demand increases, it will be sufficient to add more bunkering tankers and increase the number of voyages per week to the LNG terminal.

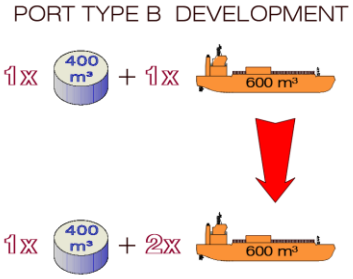

Figure 3. LNG bunkering facilities development for Port Type B: Distance less than 150 nautical miles

5.2. Port Type B Conclusion: LNG Terminal Distances More Than 150 Nautical Miles From Harbor

A systematic approach can still be used in the development of the port type B for distances over 150 nautical miles from the LNG Terminal. The increase of the LNG demand can be covered by the appropriate number of LNG bunkering tankers and the necessary landings of the LNG carrier to fill the in-port facility of 5000 m^3, see **Figure 4**.

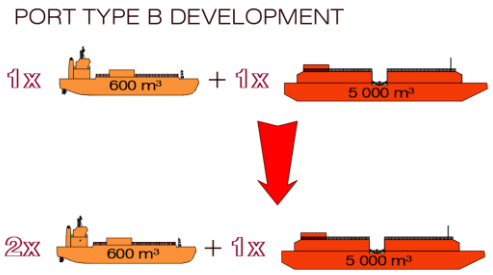

Figure 4. LNG bunkering facilities development for Port Type B: Distance more than 150 nautical miles

6. Port Type D – Medium Size Port with Big Cruise Traffic

The port type D is a Medium Size port with big cruise traffic and a medium size oil terminal. The traffic is various in terms of typology of landing vessels. A large amount of Cruise vessels requires a large amount of LNG supply, i.e. 9600 m^3 per week at the beginning and 28750 m^3 when 60 % of landing ships are LNG fueled.

6.1. Port Type D Conclusion: LNG Terminal Distances Less Than 150 Nautical Miles From Harbor

The development of port type D leads to a special consideration. When 20% of the ships are LNG fueled, the use of three bunkering ships and one in-port storage facility grant an operational convenience in the refueling operations. Nevertheless, with the growth of the LNG demand, a systematic development does not guarantee the correct approach to the logistics. With the increase of the LNG demand, the in-port facility of 5000 m^3 becomes inadequate. In the planning of the Port development, special considerations have to be taken in order to reduce the possibility of wasting resources and not having facilities that will get obsolete/insufficient in a short time. It becomes clear that a market survey is essential to decide if an investment towards the 10000 m^3 storage barge leads to a better result than other type of investments, see **Figure 5**.

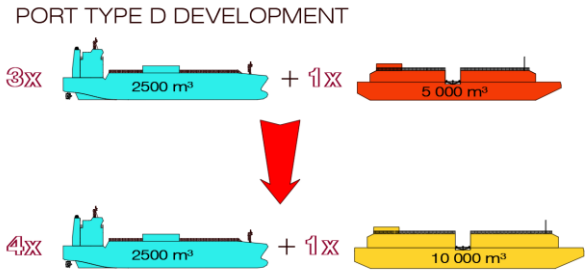

Figure 5. LNG bunkering facilities development for Port Type D: Distance less than 150 nautical miles

6.2. Port Type D Conclusion: LNG Terminal Distances More Than 150 Nautical Miles From Harbor

A systematic approach can be used in the development of the port type D for distances over 150 nautical miles from the LNG Terminal. The increase of the LNG demand can be covered by the appropriate number of LNG bunkering tankers and by the necessary landings of the LNG carrier to fill the in-port facility of 10000 m^3, see **Figure 6**.

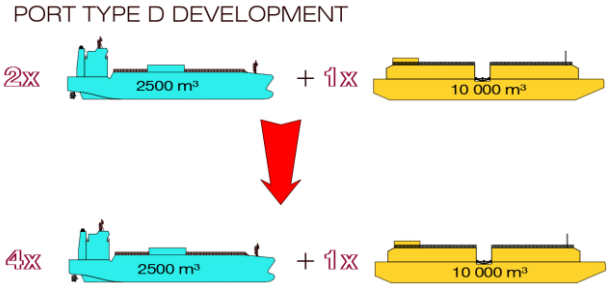

Figure 6. LNG bunkering facilities development for Port Type D: Distance more than 150 nautical miles

7. Port Type E – Large Size Port with Medium Cruise Traffic

The port type E is a large size port with big oil terminal and medium sized cruise traffic. The traffic is various in terms of typology of landing vessels. A large number of different vessels requires a large amount of LNG to supply, 13900 m^3 to 40200 m^3 per week.

7.1. Port Type E Conclusion: LNG Terminal Distances Less Than 150 Nautical Miles

The development of port type E leads to a special consideration. During the first stages, the use of three bunkering ships and one in-port storage facility grant an operational convenience in the refueling operations. Nevertheless, in case of growth of LNG demand, a systematic development does not guarantee the correct approach to the logistics. With the increase of the LNG demand, the in-port facility of 5000 m^3 becomes inadequate. n the planning of the Port development, special considerations

have to be taken in order to reduce the possibility of wasting resources and not having facilities that will get obsolete/insufficient in a short time., as shown in **Figure 7**. It becomes clear that a market survey is essential to decide if an investment towards the 10000 m^3 storage barge leads to a better result than other type of investments.

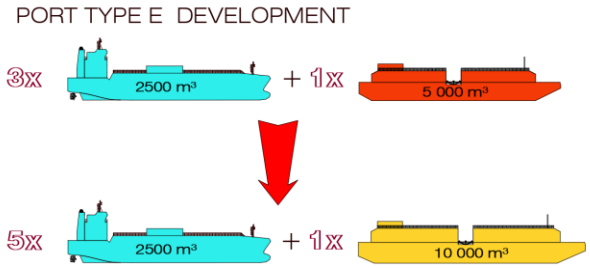

Figure 7. LNG bunkering facilities development for Port Type E: Distance less than 150 nautical miles

7.2. Port Type E Conclusion: LNG Terminal Distances More Than 150 Nautical Miles

A systematic approach can still be used in the development of the port type E for distances over 150 nautical miles from the LNG Terminal. he increase of the LNG demand can be covered by the appropriate number of LNG bunkering tankers and by the necessary landings of the LNG carrier to fill the in-port facility of 10000 m^3, see **Figure 8**.

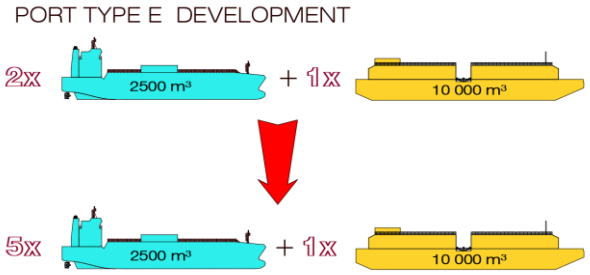

Figure 8. LNG bunkering facilities development for Port Type E: Distance more than 150 nautical miles

References

[1] O.P. /L.D.Z., *Environmental Friendly Supply Fleet for Harbor Services*, Navalprogetti, Conceptual study, 2017.