1. LNG market overview

- Focus on development of LNG facilities at the Port of Skagen

Conducted for the Port of Skagen as part of the Interreg North Sea Region project, DUAL Ports by GEMBA in 2020

Content

1. Introduction

The objective of the following document is to provide an overview of the current and future market development of LNG-fuelled vessels in the area with relevance for the Port of Skagen. The analysis starts from a global perspective and narrows down the number of relevant vessels that have or will have their operation in the area where it makes sense for the Port of Skagen to be supplier of LNG-bunker.

As the foundation for the number of relevant vessels for the Port of Skagen, the analysis includes both vessels that could bunker in the port and vessels that could bunker via ship-to-ship operations at the Skaw Road or in the strait along the B- and T-route.

2. Executive summary

The analysis has broken down the findings in an outlook for the global development in LNG-fuelled vessels, a regional level that includes ships with routes through or operations in the Kattegat and Skagerrak region and locally, those ships that are expected to bunker in the Port of Skagen.

Global

- The current fleet of LNG-fuelled vessels are 125 and another 136 vessels in the orderbook towards 2026, this means that 261 LNG-fuelled ships are certain.
- Additional vessels will be ordered in the mean time and different estimates suggests around 400 LNG-fuelled vessels in operation in 2020 and 800 in 2025.
- The development in LNG-fuelled ships is considered to grow at a high pace and estimates suggests an annual growth rate of 20% until at least 2030.

Regional

- Approximately 30% of these vessels will either operate in or pass the Kattegat Skagerrak region.
    - This means that by 2020 approx. 54 LNG-fuelled vessels will be of interest to the Port of Skagen and in 2025, the number will be 134.

Local

- Because of existing sailing patterns, competition and bunker opportunities, the market share for the Port of Skagen is estimated to be around 15%.
    - This means that by 2020 approx. 8 LNG-fuelled vessels will be using LNG bunker service from the Port of Skagen (either at Skaw Road or in the port).

- Each vessel is estimated to have 6 bunkering operations with each 500 m^3 LNG per operation
    - This means that by 2020 there is a demand for approx. 30.000 m^3 LNG equalling 13,300 tonnes. In 2025 the demand is 65,500 m^3 equalling 30,000 tonnes.

Infrastructure and competitors

- The LNG infrastructure for ships is currently underdeveloped in the Kattegat and Skagerrak area, but constructions and plans for the expandsion of the LNG infrastructure network is underway.
- In 2018 Port of Gothenburg began LNG-service operation from their LNG import terminal and will be one of the main competitors along with the bunker barges operating in the Kattegat and Skagerrak area.
- Port of Gothenburg has both Ship-to-ship, Jetty-to-ship and Truck-to-ship operations available.
- The Skangas operated bunkering-vessel, Coralius a 5,800 m^3 tank and Shells Cardissa (6,500 m^3) are creating a strong supply-network in the region.
- There are three other bunker barges in Northern Europe (Shells Cardissa (6,500 m^3), ENGIE Zeebrugge (5,000 m^3) and Coral Methane (7,500 m^3))

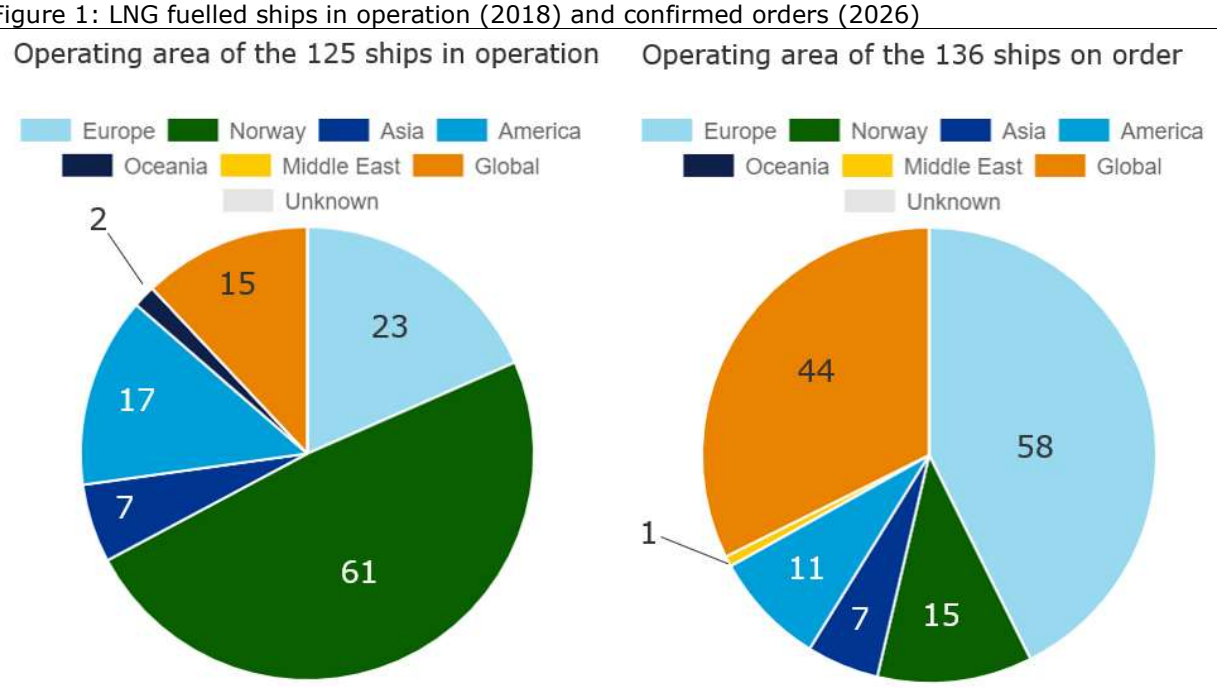
3. LNG vessels with relevance for the Port of Skagen

The current level of ships operating on LNG worldwide is 125 with 136 confirmed ships that will be introduced over the period from 2018-2026.

If nothing changes in the order numbers, this means that there will be a total world-market of 261 vessels by 2026. The 261 vessels cover a large variety of vessel-types, but most are constructed for covering a fixed route in the ro/ro or ro/pax ferry industry.

Figure 1 indicates the geographical operation of the current 125 vessels and the 136 orders. The figure indicates that the greatest expansion in LNG fuelled vessels will be operating in Europe (58 new by 2026) and in global operations (44 new by 2026).

Figure 1: LNG fuelled ships in operation (2018) and confirmed orders (2026)



Source: DNV GL

Besides the pure LNG fuelled vessels there is another 87 LNG-ready ships in operation and another 24 LNG-ready vessels in confirmed orderbooks around the world. This means that by 2026 there is a total of 261 LNG fuelled vessels and 111 LNG-ready fuelled vessels in operation.

On top of the existing and confirmed LNG vessels there will be construction and new orders of additional LNG fuelled vessels. The degree to which these new vessels will be introduced is depending on the success of LNG as a fuel, new competing fuel types and the port capacity and infrastructure for fuelling LNG vessels. An optimistic outlook from DNV GL states that by 2026 there will be around 500 LNG fuelled and LNG-ready fuelled vessels in the world.

It is assumed that the types of vessels that could be of relevance for the Port of Skagen are;

- Bulk (dry and liquid)
- Bunker
- Container
- Cruise
- Gas carrier
- Fishing

The assumption is based on the types of vessels that the Port of Skagen traditionally have received and will receive when the port extension 3 is in place. This does also included vessels that traditionally can be found Off Skaw.

By applying this logic only 36 of the 127 current LNG vessels on the world market can be viewed as being relevant to the Port of Skagen.

Furthermore, it is important to account for current operation pattern of the relevant ship types in current operation and to some extend the nationality of the vessels.

If current ships are not operating in the North Sea or the Baltic Sea they will, as a starting point, not be relevant for the Port of Skagen.

Apart from the ships that call the Port of Skagen there is a short distance to the Skaw Road where several large vessels are moored and waiting for new orders. This segment of vessels should be served off Skaw by bunkering vessels.

The strait is among the busiest waters in the world and more than 70,000 thousand ships pass each year. Table 1 shows the different ship types of relevance at the Port of Skagen, the Skaw Road and the strait

Table 1: Ship types of relevance to the Port of Skagen, off Skaw and at the strait

Port of Skagen	Skaw Road	Strait
• Bulk (dry and liquid) • Bunker • Container • Cruise • Fishing	• Bulk (dry and liquid) • Bunker • Oil/chemical	• Bulk (dry and liquid) • Bunker • Cruise • Container • Fishing • Oil/chemical

The ship in the strait represent the pool of ships that normally passes the Port of Skagen and the Skaw Road during their operations. Most of the ships could potentially enter the Port of Skagen or anchor at Skaw Road should LNG refuelling become an option.

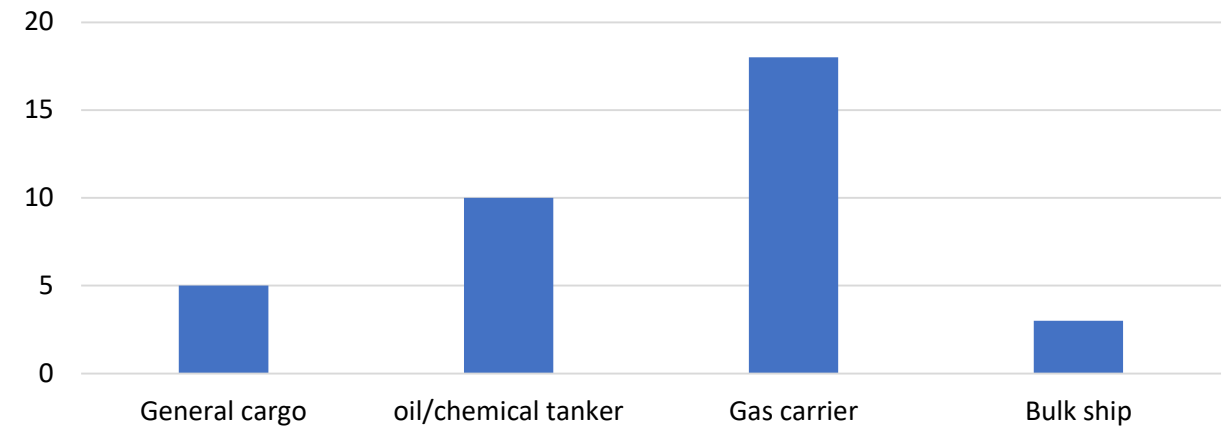
The following segments is a breakdown of the current LNG vessels in use, with focuses on relevant ship types.

Existing LNG-fuelled vessels with relevance for the Port of Skagen

Based on the data from DNV GL a sorting of the 125 ships in operation has been made based on the probability of the vessels to operate in the Kattegat and Skagerrak Region. The explanation and deduction of these vessels is presented in the appendix.

Figure 2 shows the relevant vessels for the Port of Skagen. These vessels are considered the gross pool of vessels that the port could attract.

Figure 2: Overview of relevant types of vessels sailing on LNG in 2018



Source: DNV GL and own elaboration

As shown in figure 2 the total amount of relevant vessels for the Port of Skagen is around 36 in 2018. Among these, the most common vessel-types are gas carriers and oil/chemical tankers.

In order to further qualify the number of vessels with relevance for the Port of Skagen the criteria operation history in the North Sea and Baltic Sea were used to sort out companies and vessels from the list that do not do business in these areas.

Ordered LNG vessels with relevance for the Port of Skagen

On top of the 125 existing ships, there is another 136 confirmed orders of new LNG-fuelled vessels that will be in operation by 2026. Of these 136 vessels, 86 vessels are ferries, tugs, dredger, offshore vessels that will not be operating out from or to the Port of Skagen. Another 42 ships will most likely have their operations outside of the Kattegat/Skagerrak and has hence been omitted from the list. In total, this means that 44 new LNG-fuelled ships could be of relevance to the Port of Skagen.

Table 2 shows the condensation of relevant ships to the Port of Skagen and Skaw Road. The numbers in the table goes from total LNG-fuelled vessels in operations and in the orderbooks to the resulting 78 relevant vessels in operation in the area around the Port of Skagen in 2026.

Table 2: overview of the deduction for relevant ships to the Port of Skagen and Off-Skaw				
		In operation in 2018	**Additional vessels in operation by 2026**	**Combined**
	Total	125	136	261
Removed based on vessel type	Ferries and ro-ro/PAX vessels	42	26	68
	Tug	11	6	17
	Dredger	2	7	9
	Car carrier	2	2	4
	Patrol vessel	4	0	4
	offshore oil and GAS	23	9	32
	Part sum	*41*	*86*	*127*
Removed based on vessel operation area	Gas carriers NO only	6	0	6
	oil/chemical tanker CA only	1	2	3
	Bunker ship US only	0	6	6
	Cruise vessels Mediterranean and Caribbean only	0	14	14
	Container Vessels	0	20	20
Vessels with relevance for the Port of Skagen and Skaw Road	***Final sum***	***34***	***44***	***78***
Source: based on DNVGL, sorted by GEMBA				

These 78 LNG-fuelled vessels are those vessels that for certain will be in operation by 2026. However, within the eight years until 2026 additional orders will be placed and the 78 vessels will mainly function as a foundation to illustrate the relevant ship-types that will be in operation.

4. Further deduction of the potential LNG vessels for Skagen

The grand total of relevant LNG-fuelled vessels in the region is considered the foundation from which the Port of Skagen should serve a certain number of. There are several factors that suggest that ships will pass the Port of Skagen because of refuelling elsewhere and the existing and increasing competition that exists in the area. In the following, the 78 relevant LNG-fuelled vessels are further qualified in terms refuelling potential in the Port of Skagen or off Skaw and the share of competition.

Factor: Refuelling or passing by

The 78 relevant LNG-fuelled vessels will not all be served in the Port of Skagen or at the Skaw Road. Most LNG-fuelled vessels can endure a travel time of up to 30 days without refuelling and it is therefore expected that at least half of the relevant vessels will refuel in their destination port.

This means that because of the existing sailing pattern the 78 vessels are reduced to 39 vessels.

Factor: The competition

The LNG infrastructure in the Kattegat region is currently shared by Skangas with the LNG bunker vessel Coralius and the Swedegas 33,000m^3 terminal in the Port of Gothenburg.

Both Skangas and Swedegas, will by the time the Port of Skagen has a functional LNG solution, have had the time to develop the market and their position in the Kattegat region. This will complicate the opportunity for the Port of Skagen to attract customers from the existing oil/chemical segment, which is serviced in the Port of Gothenburg.

Competition for the LNG customers through factors such as price and service level would therefore be a norm, unless either Skangas or Swedegas is brought in as LNG operators in the Port of Skagen. Based on the current situation it is assumed that the Port of Skagen will mainly compete against the Port of Gothenburg.

The creation of an LNG terminal at the Port of Skagen would create a duopoly in the LNG market in the Kattegat region until other LNG infrastructures in e.g. Frederikshavn or Helsingborg is established.

In the initial phase, it is expected that The Port of Gothenburg will serve 85 % of the market which means that around 12 vessels could be considered the foundation for the Port of Skagen by 2026.

These 12 vessels suggest that approx. 15 % of the traffic that operates in the region will use the LNG facilities in the Port of Skagen or at the Skaw Road.

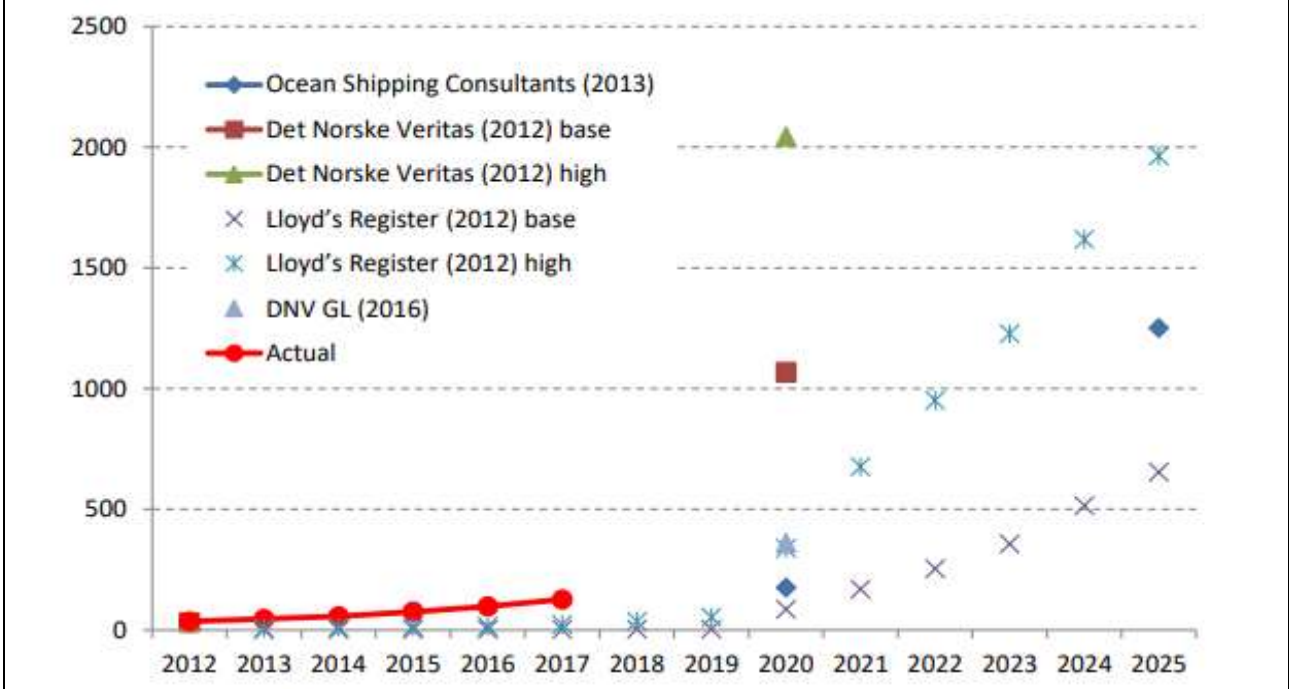
5. Future demand

The future demand for LNG as fuel in the shipping industry is of high importance to a port that wish to enter the LNG market. For some years there has been a lot of discussion and suggestions about how the market will develop in relation to new LNG-fuelled vessels and there are still large discrepancies among the forecasters. The different forecasts suggest widely different annual growth rates and hence shows the difficulties in establishing a safe suggestion about the future.

In the chart in figure 3 there is an overview of different predictions of the development in number of LNG-fuelled vessels from DNV, DNV GL, Lloyds Register and Ocean Shipping Consultants.

As it can be seen in figure 3, the suggested forecasts are almost shaped as an exponential growth. This indicates that when a new technology is embraced in the market, the development is expected to grow at an exponential level. This exponential development has been seen in several other introductions of new technologies (the law of accelerating returns) and is also expected to be the case in the LNG-market. When reaching a level of maturity and certain market share, the curve will flatten hence showing an s-curved shape. The inflection point at which the curve will bend and flatten is beyond the time horizon of this analysis.

Figure 3: Different organisations outlook on the development in LNG-fuelled vessels.



Source: OECD (2017)

The most optimistic predictions show that by 2020 up to 2,000 vessels would be in operations. The more recent and perhaps more realistic forecast suggests around 400 LNG-fuelled ships in 2020 and around 800 ships in 2025. This means that there are three reference points from which an annual growth rate may be calculated.

Table 3: Reference point, number of vessels and calculated annual growth rate over various periods	
Year	Number of vessels
2018	125
2020	400
2025	800

Based on these reference points it is possible to calculate an average annual growth rate for three periods.

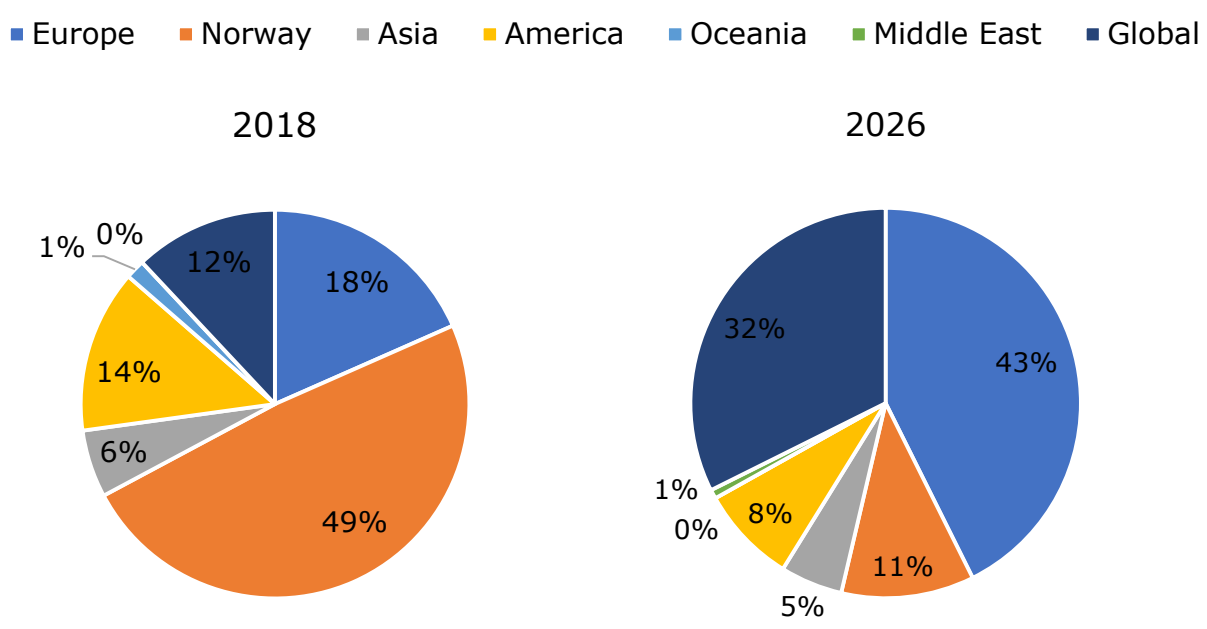
Table 4: annual growth rates based on the three reference points.	
Average annual growth rate period	Average annual growth rate %
2018 - 2020	78
2018 – 2025	30
2020 – 2025	15

Table 4 shows that there are differences in the AAGR over the three reference points measured. The AAGR for the short period of 2018 to 2020 is very sensitive to the short period and is therefore not taken further into consideration.

For the purpose of forecasting the development in LNG-fuelled vessels in this study, we rely on an average growth rate of 20 %. Sensitivity scenarios using an annual growth rate of 15 % and 25 % will be illustrated to show the variations this may course.

Based on the current fleet and the orderbooks it is possible to illustrate where the future vessels will operate. Figure 4 shows the percentage of the entire LNG-fuelled fleet in 2018 and in 2026 (based on the orderbooks).

Figure 4: operation area of existing (2018) LNG-fuelled vessels and LNG-fuelled vessels in the orderbook (2026).



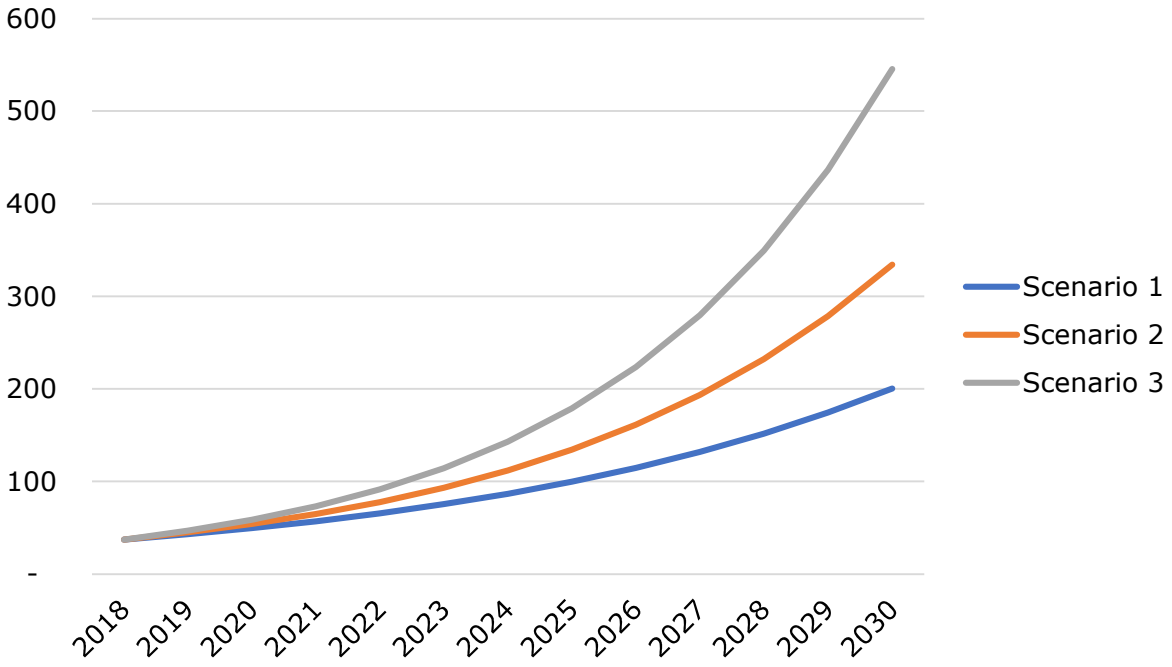
Based on DNV GL

According to DNV GL 49 % of the current LNG-fuelled fleet operates in Norway and 18 % in Europe while 43 % of the ships in the orderbook towards 2026 are expected to operate in Europe, 11 % in Norway and 32 % at global routes.

The tendency towards increasing LNG-fuelled ship traffic in Europe suggests that the demand will be larger in Europe than in the rest of the world. It may therefore be safe to use the annual growth rate of 20 % also on this forecast.

Figure 5 illustrates the development in number of relevant ships operating in the region around Skagerrak and Kattegat from 2018 to 2030 based on the average annual growth rate of 20 % and two alternatives of 15 % and 25 %.

Figure 5: Development in number of relevant ships operating in the region around Skagerrak and Kattegat from 2018 to 2030 based on the average annual growth rate of 20 % and two alternatives of 15 % and 25 %.



Source: GEMBA, based on DNV GL

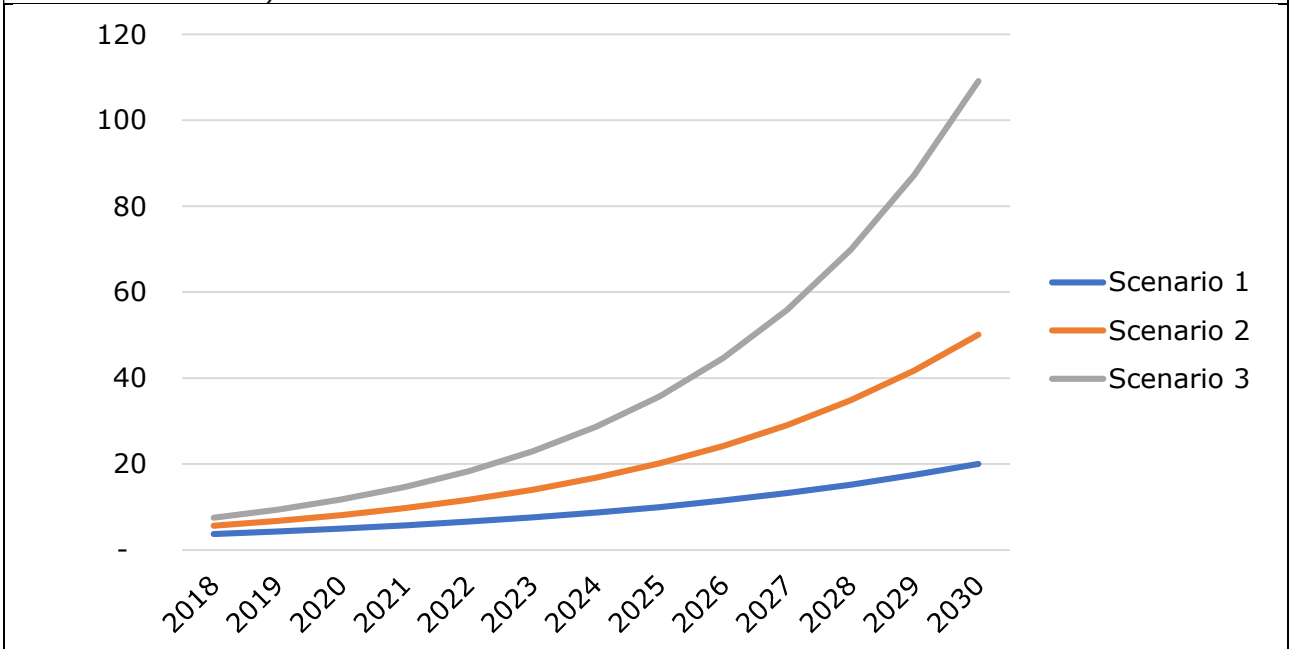
Figure 5 shows that by 2030 the most optimistic scenario (AAGR 25 %) suggests that there will be 546 relevant vessels, the scenario based on the average annual growth rate of 20 % suggests 334 vessels in 2030 and the least optimistic scenario (AAGR 15 %) suggests 201 vessels.

Depending on the attractiveness of the bunker solution (STS, simultaneous operations (SIMOPS), truck, pipe, etc.), competitiveness and other parameters the Port of Skagen will be able to attract and service a different number of vessels.

As described in the section above, approx. 15 % of the vessels that operates in the region will apply the LNG facility from the Port of Skagen

Based on the same annual growth rates as in figure 5, figure 6 shows the development in realistic LNG-operation for the Port of Skagen from 2018 to 2030.

Figure 6: The development in realistic ships that may be serviced by the Port of Skagen (either in port or at the Skaw Road)



Source: GEMBA, based on DNV GL

Figure 6 shows that by 2030 the most optimistic scenario (AAGR 25 %) suggests that there will be 109 bunkering ships at the Port of Skagen, the scenario based on the 20 % annual growth rate suggests 50 bunkering vessels in 2030 and the least optimistic scenario (AAGR 15 %) suggests 20 bunkering vessels.

6. Number and volume of refuel operations

It is expected that each ship will have 6 refuel operations pr. Year and that each refuel operation will have an average volume of 500m^3. With these assumptions it is possible to generate an outlook of the total volume that the will be demanded at the Port of Skagen.

7. Inland demand

Because of the highly developed gas pipe net in Denmark there have not been a high demand for inland LNG applications for industry or transport purposes. However, there are several plans and wishes to transform the other parts of the transport sector to increased use of LNG.

The only large-scale LNG using project today is the ferry that serves the island of Samsø that runs on LNG. When in full operation the ferry uses approx. 5.000m^3 per year. The LNG is today transported in 50m^3 tanks from the Port of Rotterdam, meaning that approx. 100 truckloads drives the 850km distance in each direction from Rotterdam to the Port of Hou, where the ferry departs, each year. This means that the LNG-fuelling operation requires 170,000 km trucking each year.

These 5.000m^3 could be supplied from the Port of Skagen Rather than from Rotterdam. The distance from the Port of Skagen to the Port of Hou is 270km in each direction. This means that with LNG supplied from the Port of Skagen, the bunkering operation would be 54,000km which is 116,000km less than the current travel distance each year.

LNG-supply from the Port of Skagen would hence decrease the transportation costs considerably and leading to lower CO^2 emissions.

It is assumed that the Port of Skagen could supply the 5,000m^3 to the Samsø-ferry operation and the volume is hence included in the future

8. Demand and port throughput of LNG

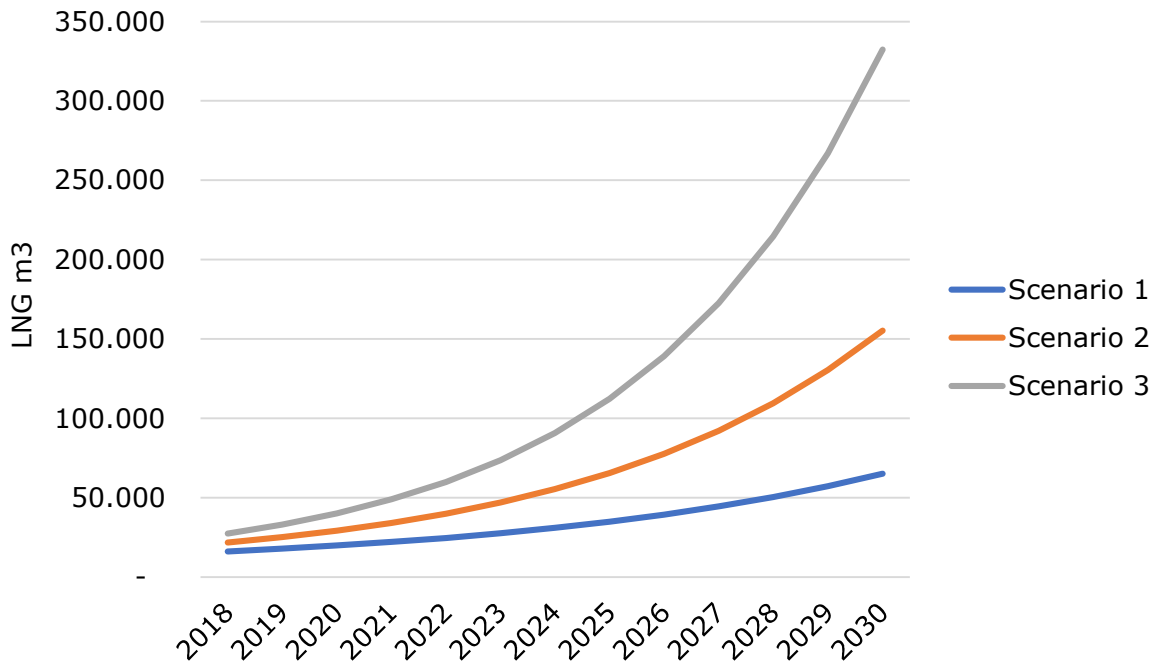
Based on the above analyses it is possible to make a qualified estimation of the future demand for LNG-throughput both in the region in total and realistic LNG-operations at the Port of Skagen. Table 5 shows the parameters that have been applied to create three different scenarios:

Table 5: parameters and value in each of the three scenarios			
	Scenario 1	Scenario 2	Scenario 3
Number of vessels of interest to the Port of Skagen in year 1	3	5	7
Annual growth rate of additional LNG-fuelled vessels (%)	15	20	25
Number of refuels per vessel	6	6	6
Volume per refuel (m^3)	500	500	500
Market share by Port of Skagen	10	15	20
Inland demand (m^3)	5,000	5,000	5,000

Based on the above assumptions the development may be plotted and the volume of LNG-throughput can be identified.

Based on the number of potential LNG-fuelled ships that will use the Port of Skagen or bunker at the Skaw Road and knowledge about how many bunkering operations and volume per bunkering, the demand in terms of square meters can be identified. Figure 7 shows the volume that is needed based on the above-mentioned assumptions.

Figure 7: Projected LNG-demand at the Port of Skagen from 2018 to 2030



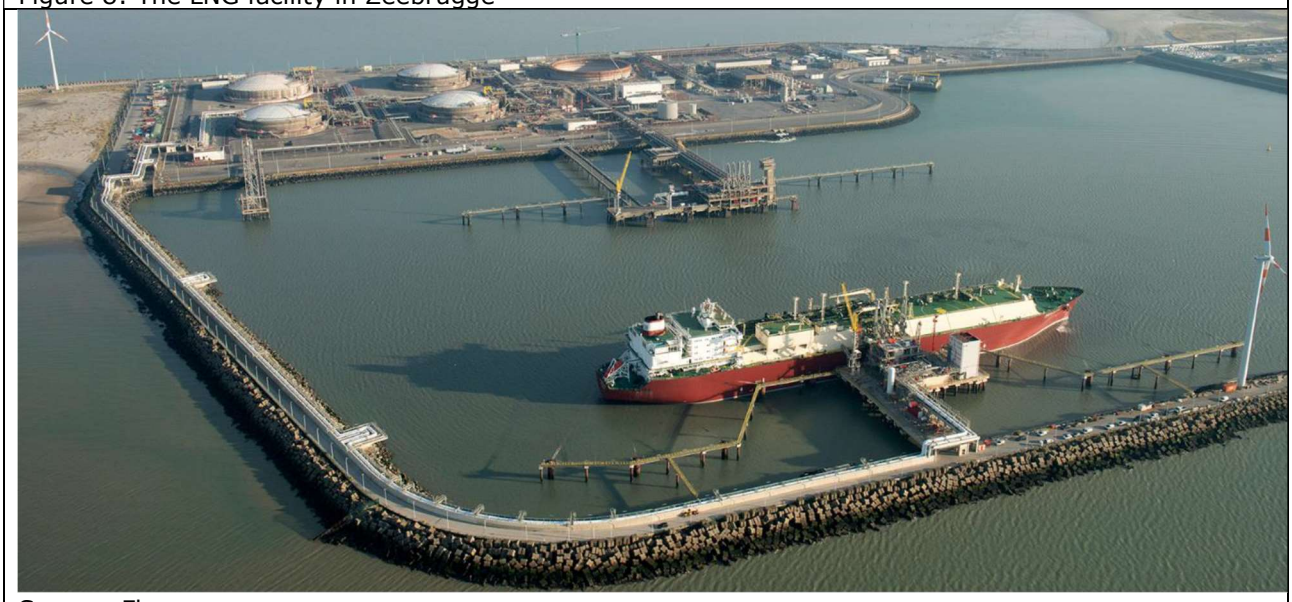
As it can be seen from figure 7 the scenario 2, where the annual growth rate is set to 20% and the Port of Skagen-market share is 15% shows that an expected demand in 2020 will be at approx. 29,300m^3 and 155,500m^3 in 2030.

9. LNG Infrastructure in the North Sea and the Baltic Sea

The LNG infrastructure for ships in the North Sea and Baltic Sea is currently limited to handling large import and export operations for LNG feeder and bunker vessels since these have been the most numerus for the last decades.

The largest LNG hub to date is found in the Port of Zeebrugge. The LNG facility in Zeebrugge is capable of storing 380,000 m^3 LNG, conduct regasification and unloading/loading two ships simultaneously. The terminal in Zeebrugge handles around 15 million tons LNG per year.

Figure 8: The LNG facility in Zeebrugge



Source: Fluxys

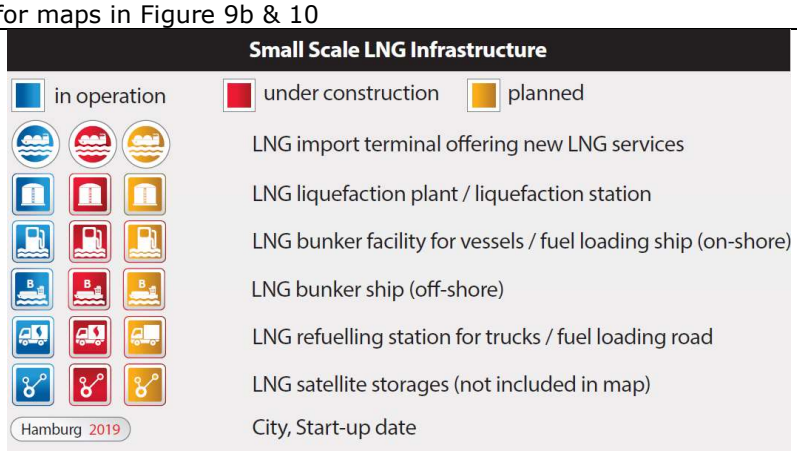
The most notable trait of current LNG hubs is that they are situated in ports with strong attachments to the gas grid in the EU and that they have frequent and fixed shipping or ferry connections. Another trait is that current LNG storages are situated in locations where the hinterland have a limited access to gas.

However, with the implementation of the new SEAC areas in the North Sea and Baltic Sea and development in ship fuel technology a greater LNG infrastructure network is needed to service the maritime industry moving forward.

Currently one of the main aspects that have held investment back in regard to new LNG ships is the lack refuelling options for medium to small scale vessels that does not have fixed routes.

Figure 9b shows the current LNG infrastructure network in the North Sea and Baltic Sea

Figure 9a: Ledger for maps in Figure 9b & 10



Source: GIE

Figure 9b: Current and planned LNG infrastructure in the North Sea and Baltic Sea

Source: GIE

The map of Figure 10 shows that fixed LNG infrastructure in the area of Kattegat and Skagerrak is limited to service any potential influx of new LNG Ships in the area.

Figure 10: current and planned LNG infrastructure in the area surrounding the Port of Skagen

Source: GIE

To limit the perspective of this market overview, the analyse will focused on the infrastructure and import of LNG in the following ports:

- Frederikstad
- Lysekil
- Gothenburg
- Frederikshavn
- Copenhagen
- Helsingborg

Furthermore, the survey will focus on uncovering the modes of LNG services and the LNG storage capacity of these ports. Regarding modes of LNG services, there will be focus on uncovering the infrastructure regarding three of the modes:

- LNG bunker facility for vessels onshore
- LNG bunker vessels for offshore STS operation
- LNG refuelling through truck.

Infrastructure for the last two modes, included as secondary parameters as the Port of Skagen does not have theses modes of services as a strategic concern for the port.

The LNG infrastructure in Frederikstad and Lysekil

The LNG facility in Frederikstad in Norway is known as the Øra terminal and is owned by the Norwegian gas company Skangas. The facility at Øra is focused on being an import terminal to supply the inland industry with LNG. The mode of service is primarily oriented towards import terminal and liquidation. The capacity of the Øra terminal is 6.400 m^3 divided over nine smaller tanks at the terminal.

The LNG infrastructure at Øra is also geared towards providing ships with LNG as a refuelling option. But most of the logged refuelling have been done by Skangas own LNG bunker vessels, the Coralius, which primarily carries out STS operations in the Gothenburg area.

The LNG facility in Lysekil is also owned by Skangas and is capable of servicing both the inland industry and shipping industry with LNG. But primary customer for the Lysekil terminal is the inland customer. The single tank at Lysekil can store 30.000 m^3 of LNG.

While the facilities at Øra and Lysekil are well-developed and capable of servicing the shipping industry, most of the LNG imported at these sites are distributed to inland customers.

The refuelling that does happen at these sites are primarily for Skangas own LNG bunker vessels, which then provides its service in Gothenburg. This seems to indicate that the sites are located inconveniently for the growing LNG shipping market that passes through Kattegat and Skagerrak.

Fact box on Skangas	
SkanGas	Skangas is a Norwegian company focused on Skangas operates an LNG portfolio that consists of the purchase of feed gas, LNG liquefaction, distribution of LNG by trucks and ships through receiving terminals, to customer facilities where LNG is regasified to natural gas or delivered as fuel to the end-user. Skangas supplies LNG in; • Nordic industry markets • North European ECA for marine
Source: Skangas	

The LNG infrastructure in Gothenburg

The LNG infrastructure in Gothenburg port is the most built out in the Kattegat region in regard to LNG bunker service of maritime industry.

Skangas have since 2017 been present in the Gothenburg area with the LNG bunker vessel, which has a bunker capacity of 5,400 m^3.

Table 6 shows the LNG STS operations that LNG operator Skangas have carried out in the period September to December 2017. It should be noted that all the operations are carried out for just two shipping companies Terntank and Furetank.

Table 6: overview of LNG STS operations at Gothenburg Sep to Dec 2017.

Customer	**Vessel**	**Port**	**Date**
Furetank	Fure West	Intl water Swe/Dk	19.9.2017
Neot OY	Ternsund	Gothenburg, 519	3.10.2017
Preem	Tern Ocean	Gothenburg, Danafjord	5.10.2017
Navigator Gas	Navigator Aurora	Gothenburg, Danafjord	8.10.2017
Neot OY	Ternsund	Gothenburg, Ruta C	23.10.2017
Neot AS	Tern Sea	Gothenburg, Ruta C	23.10.2017
Preem	Tern Ocean	Gothenburg, 521	27.10.2017
Furetank	Fure West	Gothenburg, Ruta C	28.10.2017
Neot Oy	Ternsund	Gothenburg / Ruta C	22.11.2017
Preem	Tern Ocean	Gothenburg / Ruta C	20.11.2017
Neot AS	Tern Sea	Gothenburg / Ruta C	21.11.2017
Preem	Tern Ocean	Gothenburg	7.12.2017
Neot OY	Ternsund	Gothenburg / Ruta C	17-19.12.2017
Neot AS	Tern Sea	Gothenburg, 511	11.12.2017

Source: Skangas

Five of the eight oil/chemicals tankers shown in table 6 is also mentioned in figure 2 on page 6. This seems to indicate that there currently is a limited, but stable marked in the area around Skagen for LNG STS operations.

Figure 11: STS operations carried out by Skangas in Gothenburg

Source: Skangas

Beside the STS operation there is also a new LNG import facility emerging in the Port of Gothenburg. This LNG facility is being developed and operated by the Swedish national gas provider Swedegas.

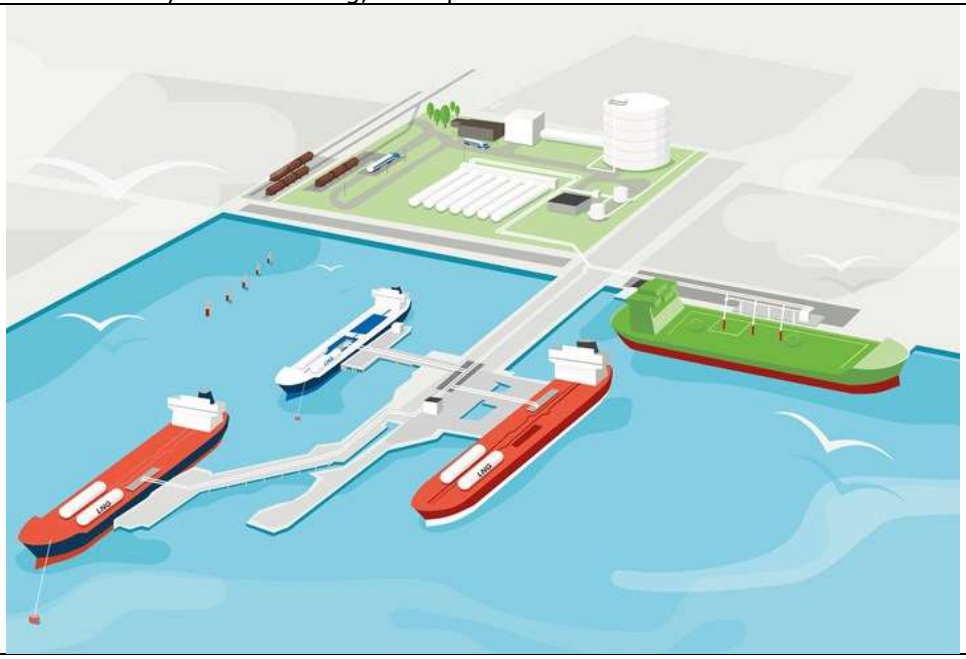
The capacity of this new LNG bunkering terminal in Gothenburg is set to be scale up to 33,000 m^3 and can provide LNG for the shipping industry both through STS operations and QTS operations. The main focus for the facility is however to provide LNG for the inland industry with LNG.

The LNG facility is set to be operational in late 2018 and Skangas will most likely still carry out their STS operations in the area both inside and outside of the port.

The scale of the new facility and volume of the operators in the port, makes Gothenburg port the current market leader for LNG bunker services in the area.

A concept of the new facility is shown in figure 12.

Figure 12: The LNG facility in Gothenburg, concept



Source: Port of Gothenburg

LNG Infrastructure in Frederikshavn Havn

The planned LNG facility in Frederikshavn is a liquefaction plant and bunkering facility meant for service for the maritime traffic in the area and most likely the existing ferry connection to Oslo and Gothenburg seeing as Stena line the operator of these connections are investing in newbuilt LNG ferries and RORO vessels.

It should be noted however that the news a liquefaction plant in Frederikshavn was first announced in 2016. Here the plant where scheduled for completion in late 2017 to spring 2018. There has so far been very little news on plans for the LNG plant and no indication that work have started on the construction.

The latest statement from the Port of Frederikshavn on the LNG project was in December 2017. Here it was announced that the coming year, 2018, would see the continuation of the planes for the new LNG project. Sources have indicated that the project is currently in the financing phase, but with is facing limited interest from investors and operators.

LNG Infrastructure in Helsingborg

The plans for an LNG refuelling station in the Port of Helsingborg is to date still underway with no sign of actual construction.

The envisioned purpose of the refuelling station is that is should service a multitude of business segment – truck, ferries and shipping industry. The Port of Helsingborg is currently participation in an EU programme called Ten-T in which the port together with the Lithuanian company Klaipedos Nafta have signed a deal to cooperate on in a project group called the HEKLA. There has so far been no statement on either operators, capacity or final customer groups that the Port of Helsingborg wants to focus on.

But it seemed like that the Port of Helsingborg where moving towards investing in an LNG bunker vessels solution that can handle STS operation in The Sound rather than an onshore LNG terminal solution. The reason for this swift in concept seems to be the ship owner's preference for STS operations at sea rather than having to enter the port.

Different ship designs for this LNG bunker vessels have been put forward as of 2016 with a custom ship design being recommend as the other types of LNG bunker vessels where concluded to be too expensive:

"A self-propelled barge/vessel with one or two LNG tank(s) with a total volume of 500 m3 on the deck or in hull depending on design (assumed to be type-C) and a number of ISO 40" LNG containers as space allows" (final report HELGA II, page: 14)

Table 7: Cost of LNG Bunker vessels

Ship concept	Types of fuel	Tank capacity m^3	Investment cost (mio. SEK)
Retrofitting existing bunker ship	LNG, MGO, HFO	2,000-3,000	50 - 70
Retrofitting existing bunker ship, LNG propulsion	LNG, MGO, HFO	2,000-3,000	70 – 90
New bunker ship	LNG, MGO, HFO	2,000-3,000	210- 220
New self-propelled bunker barge	LNG, MGO	N/a	130 – 140
Retrofitting an existing bunker barge	LNG, MGO	500	72 - 75
2nd hand transport barge	LNG	N/a	63 – 65

Source: HELGA

LNG Infrastructure in Port of Copenhagen

The LNG bunkering plans for Copenhagen is so far undisclosed with the current intention being to have LNG facilities before 2025. This initiative is a part of overall climate strategy plan for the city of Copenhagen, which has as its aim to be carbon neutral.

It is known that Copenhagen through their alliance with the Port of Malmö does have some LNG operations, but that these are carried out through LNG trucks. The LNG trucks are operated by Skangas.

LNG Bunker vessels

A new trend in northern Europe in regards to LNG transportation and distribution the emerges of LNG bunker barges. This is due to bunker barges being able to transport LNG for around 37 euro/mWh, while LNG by trucks is transported for around 39 euro/mWh.

Currently there are only a few LNG bunker barges in operation in Northern Europe as seen in table 8.

Table 8: Overview of the LNG bunker barges in Northern Europe

Ship name	**LNG bunker capacity m^3**
Coral Methane	7,500
ENGIE Zeebrugge	5,000
Skangas Coralius	5,400
Shells Cardissa	6,500

Source: Skanges, Shell, ENGIE and Anthony Veder

The bunker barges present the LNG infrastructure in the Kattegat region with a large flexibility in terms of meeting the ship owner's preference for STS, but does included a higher price for the LNG due to the OPEX and logistic cost than a on-site LNG liquefaction plant.

LNG infrastructure sum up

The survey of the LNG infrastructure in the Kattegat region makes it is clear that the current LNG infrastructure for service of the maritime sector is limited.

With the exception of the Port of Gothenburg and to some extent the terminals in Øra and Lysekil, there are few LNG options in the area.

While Ports of Helsingborg and Copenhagen have expressed interest in developing LNG capabilities for the shipping industry no such initiatives have been realize. The Port of Frederikshavn are also in the planning process, but no actual construction work has commenced, despite the previous announcement of a start to LNG activities in 2018.

This is a positive for the Port of Skagen as the current lack of competition limits the competition to the Port of Gothenburg in the short term.

This is however a challenge as the LNG facilities in the Port of Gothenburg are set to be scaled up in their capacity with a storage of 33,000 m^3 and are in the process of establishing a reputation as a competent LNG refuelling port following the STS operations by Skangas.

The LNG Bunker vessels of Coralius and Cardissa presents a further challenge for any land-based LNG activity in the Port of Skagen.

Table 9 shows the ports and their LNG operators with the LNG storage capacity.

Table 9 overview of the LNG storage capacity in the ports of the Kattegat region

Operator and port	**LNG bunker capacity m^3**
Swedegas LNG bunker terminal Port of Gothenburg	33,000
Skangas Coralius, Port of Gothenburg	5,400
Shells Cadissa	6,500
Skangas, Terminal at Øra, Frederikstad	6,400
Skangas, Terminal at Lysekil	30,000
Port of Frederikshavn,	n/a
Port of Copenhagen	n/a
Port of Helsingborg	n/a

Source: GEMBA

Due to the currently limited market in LNG ships and the current supply chains, a large LNG terminal system is therefore not advised to the Port of Skagen due to the establishing cost and currently limited demand.

A general trend in the infrastructure is however that the LNG terminals in the area are focused on importing LNG and not producing it themselves via a liquification plant. This will drive prices up as operators in these ports will have to factor in cost of importing LNG in their price structure. The LNG bunker vessels are also liable to the same trend as the OPEX and logistics cost of providing LNG at sea though STS will have to be factored in to their pricing structure as well.

This opens up a window of opportunity for the Port of Skagen if they can attract an operator that manage a smaller LNG liquefaction system on site. The reasoning behind this is that a small-scale liquidation plant could compete on price with the large import terminals without running into diseconomies of scale due to a lack in the demand from the LNG ship market.

10. Bibliography

OECD/ITF (2018) Fuelling Maritime Shipping with Liquefied Natural Gas - The Case of Japan.

Danish Maritime Authority (2012): North European LNG Infrastructure Project. A feasibility study for an LNG filling station infrastructure and test of recommendations

DNV GL (2018): LNGi status update 01 august 2018: Comprehensive insights on worldwide LNG bunkering availability and market data on LNG as fuel for ships

TNO (2017): Study on the Completion of an EU Framework on LNG-fuelled Ships and its Relevant Fuel Provision Infrastructure

Appendix

Gas carriers

12 of the 16 ships are owned by Norwegian shipping companies. Half of which are gas carriers that are primarily tasked with supplying the Norwegian gas infrastructure with LNG for industry and private consumption. This means that it is unlikely that these six vessels will enter the Baltic Sea and they are therefore omitted from the further analysis.

Of the remaining twelve gas carriers eight are owned by the Danish company Evergas, which operates worldwide, but are primarily used to carry gas from the US to the EU.

1 Evergas Gas Carrier powered by LNG

The gas from Evergas is primarily imported at major hubs in England, Germany and the Netherlands. This makes their operations in the Baltic sea limited, which may prove to be a negative for the Port of Skagen.

Gas carriers have traditionally been located Off Skaw, while waiting for new orders or when taking on provisions. The vessels are therefore expected to prefer refuelling while at sea trough STS, rather than entering port.

Oil/chemical tankers

One of the ten oil/chemical tankers are owned by Canadian Groupe Desgagnés which primary international operations are along the eastern US coast. This makes it unlikely that this vessel will be operating in the North Sea or Baltic sea.

Eight of the remaining nine oil/chemical tankers are owned by Furetank ship company (three vessels) and Terntank (four vessels).

These two companies are both Danish companies that has their primary business activities in the North Sea and the Baltic Sea and are expanding their fleet with new LNG ships in 2021. This expansion will be covered further in the section on ordered LNG ships.

The tank capacity and LNG consumption per day of these LNG vessels from Furetank rederi and Terntank can be seen in table 10.

Table 10: Tank capacity and LNG consumption				
Owner	**Ship**	**LNG consumption tonnes/day**	**Tank size m3**	**Max days without refuelling**
Terntank	Tern sund	8,9	630	33
Terntank	Tern ocean	8,9	630	33
Terntank	Tern Sea	8,9	630	33
Furetank	Fure west	11,2	580	26
Terntank	Tern Fjord	8,9	630	33
Furetank	Fure Nord	11,2	580	26
Source: Terntank and Furetank rederi, calculations by GEMBA				

The table shows that the vessels from Furetank rederi and Terntank can operate on a roughly a monthly basis when on a full tank of LNG. This means that in theory the vessels will be refuelling LNG twelve times a year if the tank capacity allows for a full return. The need of refuelling is however lowered because all the vessels sail with a duel engine that can alternate between LNG and MGO. The tank size of the MGO tanks are the same as the LNG tanks.

Interview with informants from the two companies also made it clear that they prefer and actively seek out refuelling services that can be completed STS and without the need to enter port.

The last LNG oil/chemical tanker vessels is owned by the Swedish shipping company Tarbit shipping, which have a its primary business in the North Sea and the Baltic Sea.

Conclusion on the current level of LNG vessels in operation

Table 11 sums up the number of operational vessels that are of interest to the Port of Skagen.

Table 11: overview of operational vessels and their operations in the North Sea or Baltic sea and preference for LNG refuelling.

Type of Vessel	Port of Skagen	Off Skaw	Strait	No operation in the North Sea or Baltic sea	In total operation worldwide
General Cargo	3*	3	3	0	3
Oil/chemical tanker	0	9	9	1	10
Gas carrier	0	12	12	6	18
Bulk	3*	3	3	0	3

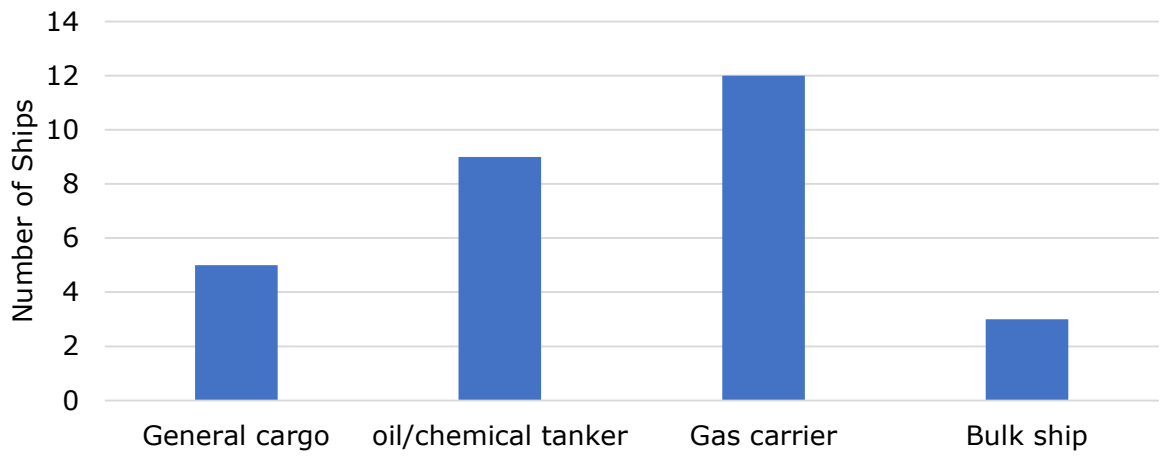
Source: DNV:GL, sorting by GEMBA Seafood Consulting A/S
* May enter the Port of Skagen

With the vessels from Evergas included a total of 29 vessels currently in operation could benefit from an LNG bunkering solution while being at Off Skaw.

Only the bulk and bunker vessels might enter the Port of Skagen to refuel as these vessels are unloading or loading cargo.

The distribution based on type and operation in the North Sea or the Baltic Sea is shown in figure 13.

Figure 13: Overview of relevant types of vessels sailing on LNG in 2018 sourced for operational history in the North Sea or the Baltic Sea



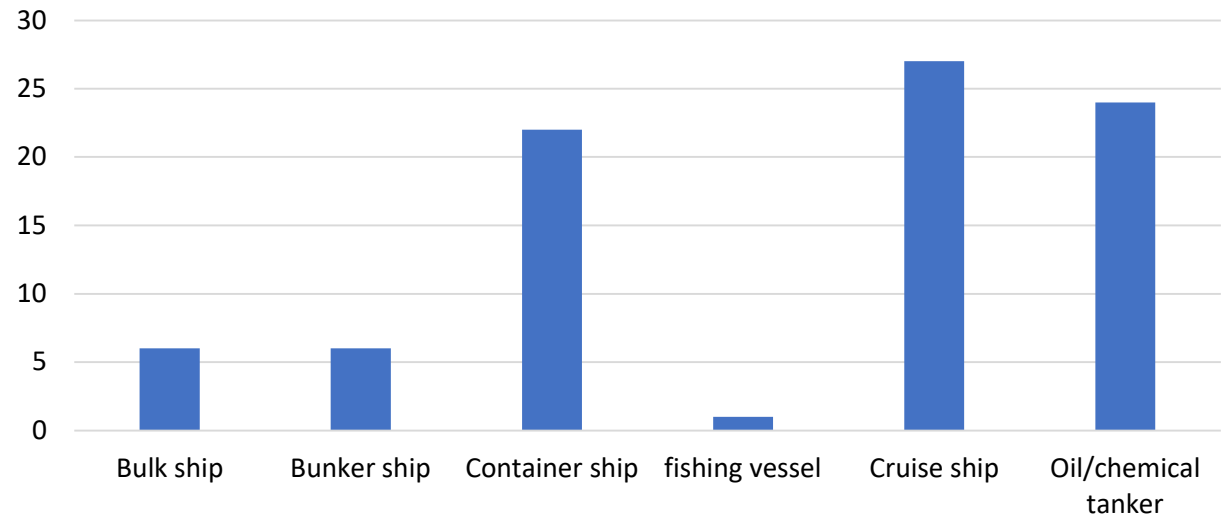
Source: DNVGL, sourced by GEMBA

Ordered LNG vessels with relevance for the Port of Skagen

Looking at the 136 confirmed orders of new LNG vessels for 2026 there are 86 ships with relevance for the Port of Skagen. This section will analyse the development in the segments:

- Fishing vessels
- Container vessels
- Cruise ships
- Oil/chemical tanker
- Bulk and tanker off skaw

Figure 14: overview of relevant types of confirmed newbuilt of LNG vessels in 2018



Source: DNVGL

As shown in figure 14 the largest uptake in new orders for LNG vessels are in the container ship, oil/chemical tanker and cruise ship segment, while bulk, bunker and fishing vessels only make up a small part.

Based on this positive outlook for the LNG market, the following sections will attempt to qualify the data and source the ordered into either a relevant or not relevant category for the Port of Skagen.

Bulk Ships

Four out the six ordered LNG bulk ships are by the Finish company ESL Shipping. ESL Shipping have their operations in the entire Baltic Sea area.

The ships ordered by ESL Shipping have a rather small LNG tank located on the back of the ship meaning that the operational range is somewhat limited. It is therefore an uncertainty if the ships will enter the Kattegat region as the LNG infrastructure in this area in more spars than in the Baltic Sea.

M/S Haaga

The next-generation bulk carrier *Haaga* was on the 20th of August 2018 delivered to ESL Shipping from Jinling Shipyard in Nanjing, China.

The 25,600 dwt, LNG-fueled vessel generates less than 50% of the carbon dioxide emissions of the previous generation of vessels. The vessel can also be fueled by completely carbon-free biogas, once the availability of carbon-free biogas improves over time.

Specifications
Length: 160 meters
Width: 26 meters
Draft: 10 meters
LNG capacity: 600 m^3

The last two LNG bulk ships are ordered by the Swedish company Erik Thun which already operates two LNG bulk ships in the Baltic Sea.

Therefore, all six bulk ships are potential ship for the Port of Skagen or at the Skaw Road.

Bunker Ships

The orders for the new LNG bunker ship are placed by the American company Harley Marine Services. The company primarily operates on the US market and the international operations that company do carry out are to the neighbouring countries of Canada and Mexico.

It is however assumed that some of the new bunker vessels will be allocated to Harley Marine Services international subsidiary Harley Marine International Holdings Pte. Ltd., which operates in the area surrounding Singapore.

It is therefore highly unlikely that the bunker vessels will enter European waters. This means that of the six bunker vessels in the orderbook, zero will be counted as potential vessels for the Port of Skagen.

Fishing vessels

The first newbuild fishing vessel is being produced in Norway and ordered by the Norwegian fishing company Liegruppen. The vessel is co-founded by the Norwegian NOx fund, which support projects that can contribute to decrease NOx emissions.

The NOx fund may provide up to 80 % of the investment and the fishing vessels segment might be considers to be a developing phase where very few orders are expected in the nearest future. The current lack of interest may be explained by a lack in positive operational cost for the vessels.

Source: Liegruppen

Worlds first LNG fishing vessel Libras.

Specifications
Length: 86 meters
Width: 17,80 meters
LNG capacity: 350 m^3

Catch method
purse seiner, and for both single and double purse seines

The current concerns regarding LNG as ship fuel for fishing vessels is the price, operation cost and the space it will take up on the vessels.

Interviews with ship owners revealed that there is interest in the LNG technology, but with no current best in class examples for fishing vessels owners to look to actual investment is yet to made in new LNG assets. It is therefore interesting to see if the newbuilt for Liegruppen can provide the fishing industry with a positive example of the commercial viability of LNG as a ship fuel.

For now, it must be stated that one of the main business segments for the Port of Skagen is seeing little to no development in volume, which is a negative in regard to the market outlook.

Container Ships

There are currently 22 container ships in order with the first ships set to arrive in late 2018.

Container ships are a new segment to the Port of Skagen following the expansion of the port with the stage 3 plans. The expansion lead to the creation of Skagen Stevedore A/S, which is a subsidiary of the fishmeal and fish oil producer FF Skagen. Skagen Stevedore A/S is overseeing the container operations in the Port of Skagen.

However, the container activity at the Port of Skagen is currently limited and there is only one container ship operator is MSC that is arriving weekly to the port.

Container ships are not traditionally known for being anchored Off Skaw or doing refuelling operation outside of port. This limits the numbers of LNG container vessels that might visits the Port of Skagen for LNG refuelling.

While it is likely that the container activity in the Port of Skagen could as a result for the industry in the hinterland diverting their containers to Skagen instead of Aarhus, it is still uncertain if this would bring more LNG container ships to the Port of Skagen.

New LNG Container vessels

Specifications
Length: 163,6 meters
Width: 23,80 meters
LNG Capacity: 1.200 m^3

A new design by Croatian Brodosplit, of a coverless dual fuel feeder container vessel, emphasizing environmentally friendly approach and fuel efficiency, simultaneously aiming to achieve EEDI lower than IMO required for the year 2025

Of the 22 container ships in order, zero of them are by the current operator MSC. This means that the segment container vessel will not generate any additional revenue in regard to a refuelling LNG facility.

If MSC where to order an LNG Container ship or if Skagen Stevedore A/S where to attract a shipping company with LNG container ships, it could mean that one or maybe two container ships would visit the Port of Skagen. If it is assumed that these visits would be on a weekly basis, it would be a clear positive for the LNG fuelling business case.

Cruise Ships

Another relevant vessel segment for the Port of Skagen cruise ship is growing with 27 new LNG cruises planned. The cruise industry is therefore one of the clear early adopters of the new fuel technology.

This is a positive for the Port of Skagen since the cruise segment have grown into primary business segment of the port and the city in the hinterland. But an in depth look at the list of cruise companies is required to see how many of the new LNG ship might potentially visit the Port of Skagen on their route.

14 of the planned LNG cruise vessels are ordered by Hurtigruten, Ponant, Disney Cruise Lines and TUI Cruises have little to no current activity in the Skagerrak area. It should be noted that TUI Cruises is owned by Royal Caribbean Cruises Ltd. and TUI Cruises itself owns Marella Cruises, both of which already have cruise ships visiting the Port of Skagen.

While it is likely that these cruise companies might create new cruise routes as facilities are established to accommodate the ships in the Port of Skagen, it is not a certainty and therefore are these 10 of these 14 LNG Cruises not expected to visit the Port of Skagen.

New Cruise ships on LNG

The Carnival Corporation first LNG cruise ship *AIDAnova* is set to arrive in late 2018 and will be used for service in the German cruise line AIDA Cruises. *AIDAnova* begin cruising around the Canary Islands.

The tank specification for *AIDAnova* is 3.500 m^3 for LNG storage, which will power four dual-fuel motors capable of producing a 17-knot service speed.

The cruise ship needs to refuel at 3.000 m^3, which requires the vessel to refuel every 14 day. This means a consumption rate of 214 m^3/day or 98 tons/day.

Of the 17 planned LNG cruise vessels left, 11 are order by the American company Carnival Corporation and 2 are order by Royal Caribbean Cruises Ltd. Both companies operate worldwide which makes it difficult to estimate where the new LNG ships will sail.

This creates different scenarios in regard to how many LNG cruise can be estimated will visit the Port of Skagen.

Carnival Corporation is the owner of the cruise companies Princess Cruises, Cunnard Line, Seabourn and P&O cruise. All four cruise companies are visiting Skagen in the 2019 season and the companies Cunnard Line, Seabourn and P&O cruise have been entering the Port of Skagen since the 2016 season.

In addition, Royal Caribbean Cruises Ltd. have also started to visit the Port of Skagen in 2018 and is set to return in 2019. In total these companies are visiting the Port of Skagen with eight unique cruise ships in 2019.

If the majority of the new LNG cruise are being built for the SECA area in the North Sea and the Baltic Sea, it could potentially mean that a high of 6-8 LNG cruise ship might visit the Port of Skagen in 2021.

However, if the new LNG cruise ship are meant for other cruise route, like the AIDAnova, it could mean that the Port of Skagen will see few new LNG cruise ship visiting the port. One scenario would therefore be 2 to 3 LNG Cruise ships.

Furthermore, the majority of relevant new cruise ships from Carnival Corporation and Royal Caribbean Cruises Ltd. are scheduled to lunch in period 2019-2021 meaning that the potential demand for LNG supply could increase significantly in this period.

It should also be noted that the other cruise lines Ponant, Disney Cruise Lines and TUI Cruises are unrealized customers to the Port of Skagen and that attracting these companies to include the Port of Skagen in one of their already established routes could bring additional LNG cruise vessel to the Port of Skagen.

The development in the cruise industry is seen as current positive for the Port of Skagen, but the actual business potential depends on if the current cruise companies will use the new LNG cruise ship on the routes connected to the Port of Skagen.

Oil/chemical tanker

There is a total of 24 new LNG oil/chemical tanker vessels currently on order, with the first vessels expected to arrive in late 2018.

11 of the 24 Oil/chemical tankers are ordered by the Russian companies SCF and Rosneft. Both companies operate on a worldwide scale and is known to have had operations to and from the Baltic Sea.

Lomonosov Prospect

New LNG oil tanker set for delivery on the 29th of September 2018.

Length: 250 meters
Width: 44 meters
LNG Capacity: 800 m^3

2 of the 24 oil/chemical tankers are owned by Canadian Groupe Desgagnés, which primarily are known for operating in Canada and along the US eastern coast. While Groupe Desgagnés also have other international operations, it does not include overseas operations

In general, 22 of the 24 Oil/chemical tankers are owned by companies that are known for either having global operations or operations in the Baltic Sea and the North Sea.

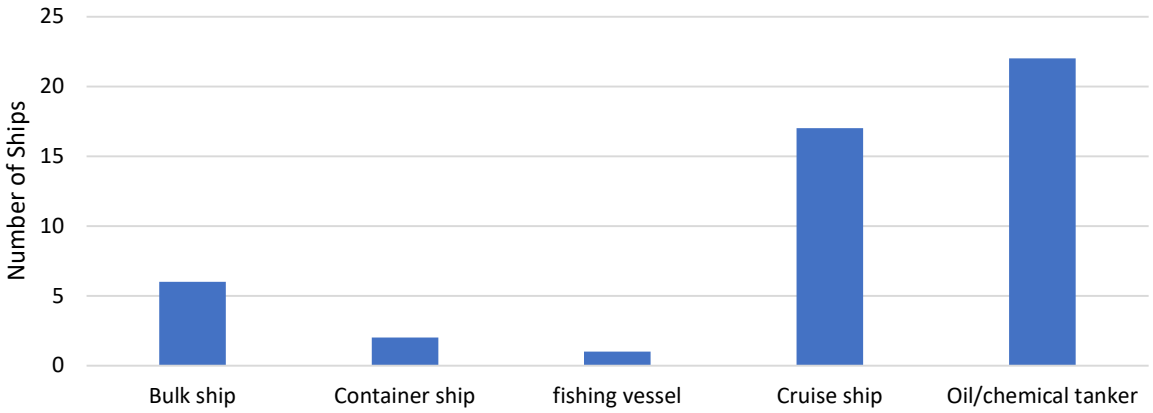
- Thun Tankers, Sweden: 5
- Älvtank, Sweden: 2
- Furetank rederi, Denmark: 2
- SCF, Russia: 6
- Rosneft, Russia: 5
- AET, Republic of Singapore: 2

This means that there are 22 new potential oil/chemical tankers that either will be passing the strait or need stevedore options Off Skaw, which is a positive for the Port of Skagen in regard to LNG refuelling through STS.

Other vessel segments and sourcing the numbers.

The breakdown is based on if the companies have a tradition of operating in the North Sea or the Baltic Sea. Table 12 and Figure 15 shows the spread of over the different relevant vessels based on operation in the North Sea or the Baltic Sea.

Figure 15: Overview of relevant types of vessels sailing on LNG in 2018 sourced for operation in the North Sea or the Baltic Sea



Source: DNVGL, sourced by GEMBA

Table 12: Overview of ordered LNG vessels and their operations in the North Sea or Baltic sea and preference for LNG refuelling

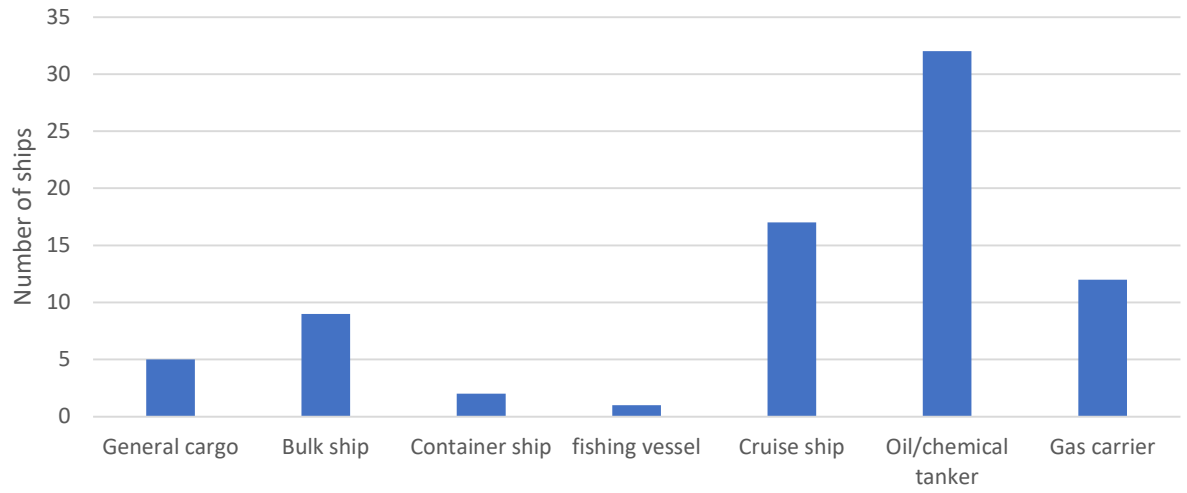
Type of Vessel	Port of Skagen	Off Skaw	Strait	No operation in the North Sea or Baltic sea	In orderbook worldwide
Bulk	6*	6	6	0	6
Bunker vessel	0	0	0	6	6
Container	4*	0	22	0	22
Cruise	13	0	17	25	27
Fishing vessel	1	0	1	0	1
Oil/chemical tanker	0	22	22	2	24

Source: DNV:GL, data sourced by GEMBA

The breakdown shows that of the potential new LNG vessels operating in areas with relevance for the Port of Skagen is 48 vessels.

Combining the currently relevant in use LNG vessels with the relevant ordered LNG vessels up 2026 gives a total of 78 relevant LNG vessels that could benefit from LNG facilities in the Port of Skagen as shown in the figure below.

Figure 16: Potential amount of LNG vessels visiting the Port of Skagen in 2026



Source: DNVGL, sorted by GEMBA