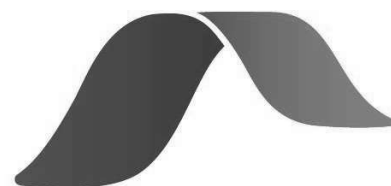


2. Business cases for LNG on the Port of Skagen



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

Interreg
North Sea Region
DUAL Ports
European Regional Development Fund



SKAGEN HAVN

Indhold

1.	Introduction	1
2.	Different solutions.....	1
	Solution 1: LNG ad hoc	2
	Solution 2: LNG stationary tanks	3
	Solution 3: Liquefaction	4
	Solution 4: LNG ship-ship concept.....	5
3.	Bunkering logistics – relevant solutions	6
4.	Profiles on LNG operators	8

1. Introduction

The introduction of LNG at the Port of Skagen is described on four different levels:

1. Concept
2. Cost
3. Demand from Port of Skagen
4. Potential providers

This document will present four solutions, which are based on the background research and analysis conducted in the LNG market overview. Each solution presented will describe how to introduce and develop the LNG opportunities on the Port of Skagen based on the four analytical levels.

This document also includes a section on the LNG operators and providers in the Skagerrak and Kattegat region that could be relevant as an LNG operator for the Port of Skagen.

The described business cases can be read in combination with the separate report: LNG market overview – Focus on development of LNG facilities at the Port of Skagen.

2. Different solutions

The development of LNG at the Port of Skagen will be divided into four different steps that builds on top of each other.

This means that the potential LNG provider could start with step 1 and when a certain level of LNG throughput has been reached, move on to step number 2 and so on.

The different solutions presented stepwise are only guidelines as to how LNG could be developed at the Port of Skagen and it is off course up to the potential LNG provider to make the decisions on which models they see as the best solutions.

Solution 1: LNG ad hoc

Concept: Based on the demand from shipping lines that operate in the area and would like to bunker LNG. The Port of Skagen should ensure and enable that an external operator could deliver LNG to the ships via truck. LNG could be delivered by different gas-providers by one or more trucks. The gas-providers has an y-piece that enables them to combine two tanks and hence double the bunkering speed.

The LNG will most likely have to come from Rotterdam in trucks and a delivery time of app. 4-6 days must be expected. Each truck will only be able to carry around 16 tonnes LNG corresponding to app. 35 m³. This means that in order to fill 70 % of the tank in a 11,300 GT tankship with an LNG-tank capacity of 630 m³, 13 trucks are needed.

The reason why each truckload is limited to around 16 tonnes is due to requirements about maximum load on the German roads and because the trucks also need to carry pumps to fill the ships. If the pumps are available at the port the trucks will be able to carry app. 20 tonnes and hence fewer trucks are needed.

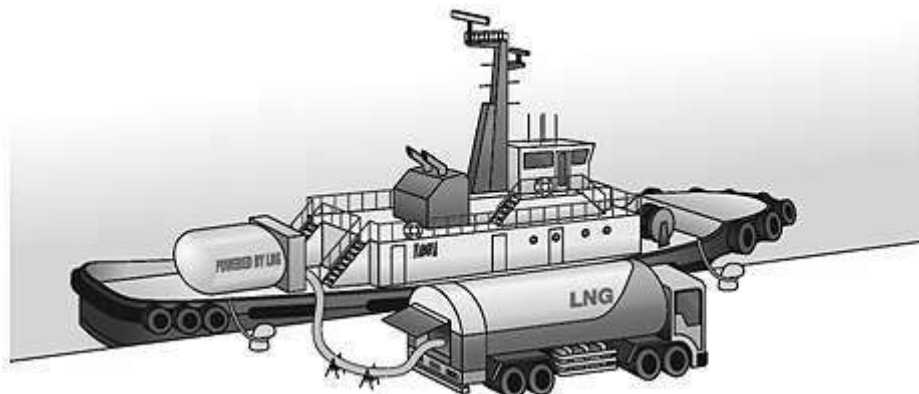
The LNG ad hoc solution will mainly be relevant as a logic first step to show that there are LNG bunkering opportunities at the port.

Costs: The solution only requires that a dialogue with the local fire brigade is initiated.

Demand from Port of Skagen: establish the legal foundations for the LNG operations. This entails dialogue with the local fire brigade and development of simple guidelines.

Bunkering from land is not subject to port dues and there will not be large economic incentives for the Port of Skagen

Potential providers: Q8, Scangas, TitanLNG, AGA



Solution 2: LNG stationary tanks

Concept: Establishing one or two stationary tanks with a capacity of 1,000 m³ and a bunker assisted crane. This could be combined with a license agreement or ownership of a truck to deliver the LNG to other quays at the Port of Skagen. The tanks may be filled by ship or by trucks.

It is expected that a minimum of 1,000 m³ should be established to have the size to be filled by ship. It will most likely be too expensive to bring LNG by truck to Skagen and in order to be able to scale the LNG business, a certain capacity need to be established.

A tank capacity of 1,000 m³ requires a certain level of demand for LNG as the tanks and LNG exhibits some boil-off where the tank pressure increases and the holding time of the LNG decreases. The actual holding time varies depending on the insulation of the tanks, the tank-volume and how much LNG there is left in the tanks.

The 1,000m³ tanks will be suitable to cater for filling approx. two of the 11,300 GT beforementioned tankships each month. This means that the solution with one 1,000 m³ tank (or two 500m³) will be suitable in the start-up phase.

The LNG stationary tank solution could be expanded continuously to additional and larger units as the demand increases.

Costs: There are various attempts to assess the costs of tanks in different sizes. The gas equipment provider, Kosan Crisplant has a turnkey solution consisting of 5x700 m³ (3.500 m³) tanks including a regasification opportunity at the price of 10 million Euro. This correspond to a m³-price of 2.860 €/m³.

Larger LNG tanks will have a lower cost pr. m³, with e.g. 20,000 m³ the cost pr. m³ is approx. 2,000€ pr. m³ and with a 50,000 m³, the cost pr. m³ is 1,600€ pr. m³.

Demand from Port of Skagen: An investment in preparing the quays for receiving LNG carriers and LNG bunkering vessels.

Potential providers: Kosan Crisplant, TitanLNG, Liquiline



Solution 3: Liquefaction

Concept: With Denmark being well-connected gas country there is an obvious opportunity to liquify the natural gas most places in Denmark. The most obvious places for liquefaction would hence be in connection to where the LNG could be used and potentially shipped and stored. The Port of Skagen has a suitable location to service the Skaw road and the future demand in the port of Skagen.

Across the Kattegat in Sweden two large LNG terminals are in operation – Gothenburg and Lysekil. The Swedish LNG terminals are receiving LNG from Rotterdam and Norway but could, if produced in Denmark, be supplied by the Port of Skagen.

The terminal in Gothenburg has a capacity of 33,000 m³ and the terminal in Lysekil has a capacity of 30,000 m³ which covers both LNG demand for shipping and for inland purposes.

To be competitive with the large-scale liquefaction plants there exists around Europe there needs also to be made large investments in a relatively large plant. However, the Danish gas-grid provides an advantage that not many other countries possess and will hence be able to produce LNG where it is needed.

Another advantage for Denmark as an LNG production country is that a relatively large percentage of the gas in the gas-grid consists of biogas from agriculture, sewage etc. On average in the entire Denmark app. 10 % of the gas is biogas and, in some regions, – especially areas with large agricultural activities, such as Northern Jutland - the amount of biogas in the grid is on average more than 20 %.

This means that LNG made from the Danish gas-grid will contain varying amounts of biogas and may hence be considered as LBG. The LBG content needs to be used as an advantage in order to compete with the prices and concepts from other existing LNG producers and providers.

Costs: Liquefaction plants comes in many different sizes. Kosan Crisplant will be able to deliver a 150 tonnes plant with 1,000 m³ storage for app. 35 million Euro. At a much smaller scale, Galileo will be able to deliver a 650 kg/h Cryobox production unit for app. 4 million Euro.

Demand from Port of Skagen: Secure area for a plant depending on the liquefaction solution from 1,000 m² to 100,000 m².

Potential providers: Kosan Crisplant, Nærenergi/Galileo (Cryobox), HMN naturgas

Solution 4: LNG ship-ship concept

Concept: To be able to service the busy strait at the B and T-route and the mooring ships at the Skaw Road it is necessary to service them by STS operations. This means that a smaller LNG-bunkering vessel needs to be contracted or owned by the LNG-operator. Depending on the demand, additional tank-capacity may be needed.

There are several solutions that could be applied to enable STS operations – one opportunity could be to charter a company like Cryo-shipping to bring the LNG from the tanks in the port to the ships at the Skaw Road. Cryo-shipping and similar operators can be chartered on a daily basis and serve the Skaw Road.

Costs: Ships like cryo-shipping will be chartered for a specific period of time or tasks and a dialogue with the company is necessary to make a relevant price estimation.

Demand from Port of Skagen: An investment in preparing the quays for receiving LNG carriers and LNG bunkering vessels.

Potential providers: Cryo-shipping, Scangas, KLAU LNG



3. Bunkering logistics – relevant solutions

In solution 3 and 4, the following points in regards to the bunkering logistics need to be considered before choosing which solution to analysis further in a feasibility study. The following bunkering logistics are based on a Cryobox liquefaction unit, but is still applicable to other small-or nano-scale liquefaction units.

The LNG supply chain is depending on the gas infrastructure and existing storage options. The well-developed gas grid in Denmark and other countries creates the opportunity to base the LNG production on gas-grid gas and hence avoid large logistic costs that may be charged on traditional STS and PTS operations. It would be necessary for an operator to investigate whether the local gas grid can supply the amount of gas (m^3/hour) that is needed for the production. In the case of the Port of Skagen, supply from the existing grid is enough. There may be a need for installing a branching pipeline from the main pipeline to supply the production at site.

In relation to storage, there exist a wide range of options from LNG ISOcontainer with a max storage of 42 m^3 to large scale storage tanks with a capacity of 50.000 m^3 . With a nano-scale LNG perspective, investment in tanks over 600 m^3 is not economically sound due to relatively small LNG demand at the moment.

Smaller, and if possible, flexible storage options should be considered, and LNG ISOcontainers where one container is exchanged with another when refuelling could be a relevant solution. The LNG ISOcontainer storage systems also allows for supply inland demands for natural gas given that the container is dimensioned for truck transportation. A further issue for logistics is to issue that the production follows the port security and that the distribution of LNG adheres to the Danish guidelines for vessel bunkering in Danish ports as well as guidelines laid out by the Cryobox producer.

Two general supply chains may be established based on a Cryobox with ISO container storage solution and will in the following section be presented in the context of the Port of Skagen. The two supply chains are:

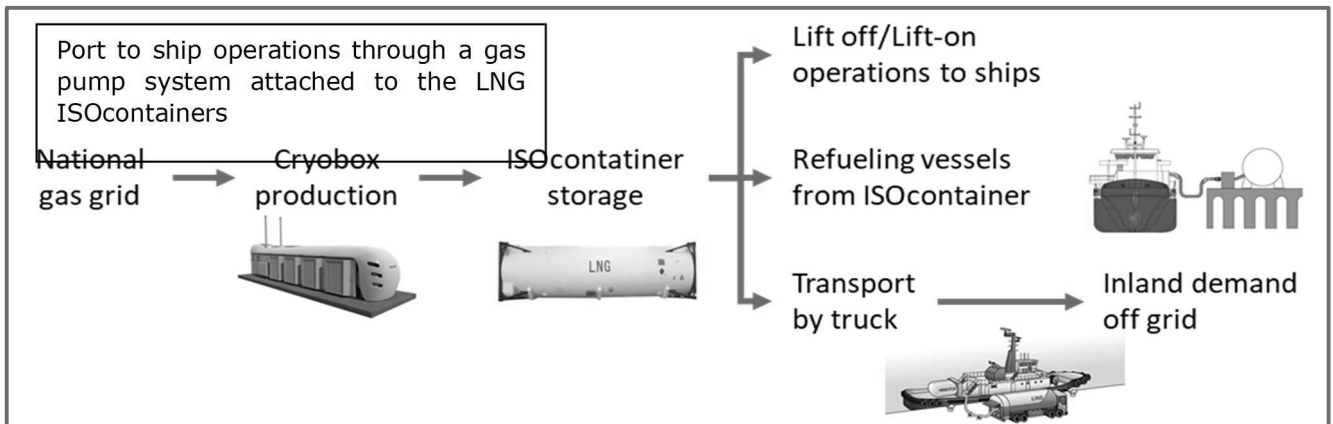
1. Shore side or port-to-ship operations
2. In addition to shore side; seaside or ship-to-ship operations

The Cryobox production will draw on the local gas grid for the LNG production. The LNG is stored in LNG ISOcontainer which will be a part of a closed loop system where boil-off gas is returned to the box and cooled down again.

The LNG may be distributed in three general methods:

1. Lift off/lift on operations to vessels with that possibility
2. Truck transport of LNG ISOcontainer to ships that is located outside of the Port of Skagen or to inland demand.

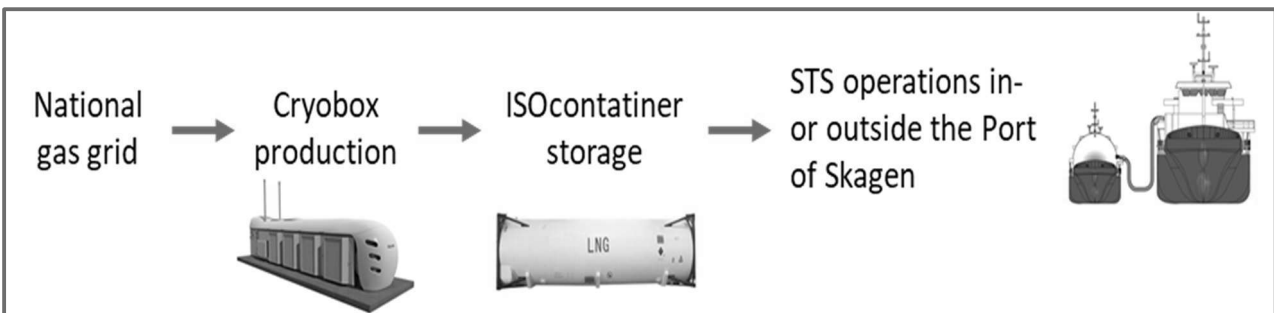
Like the shore side solution, the Cryobox production is based on the local gas grid. LNG



is stored in LNG ISOcontainer and depending on demand and orders the LNG ISOcontainers are loaded on a barge with a gas pump system.

The barge can service customers both inside the port and on the Skaw Road. The need for a gas pump on the shore is removed.


This STS solution would provide an LNG operator with an extra service for vessel owners that prefer STS. The solution increases the CAPEX of LNG production operation by 7-13 million € depending on the selected barge. In addition, OPEX would increase with approx. 10 €/MWh LNG.



This price increase would make an LNG operation less competitive and it is recommended that a nano-scale LNG production unit at the Port of Skagen focuses on shore side and inland supply. This may in future be supplemented with a bunker barge.

4. Profiles on LNG operators

The following is an overview of the LNG providers with relevance for the port of Skagen. the providers have been selected based on the criteria's set in the four scenarios.




BG (Shell)

Shell is one of the world's largest LNG shipping operators, managing and operating more than 40 carriers and has 50 on time-charter. Combined, these approximately 90 LNG carriers is around 20% of the global LNG shipping fleet.

Our trading operation buys and sells LNG to and from Shell, its partners and third parties, helping to meet customers' long-term energy needs and respond flexibly to short-term changes in demand.

LNG is either provider through truck or STS to customers in the maritime industry.

Today Shell has LNG supply projects around the world. We also have a major interest in two regasification plants – Hazira, India and Dragon, UK –, and long-term access to capacity in several others in Europe, the Middle East and North America.




Cheniere

Cheniere Energy, Inc. is an international energy company headquartered in Houston, Texas, and is the leading producer of liquefied natural gas in the United States.

Cheniere provide clean, secure, and affordable energy to the world, while responsibly delivering a reliable, competitive, and integrated source of LNG, in a safe and rewarding work environment. Cheniere's operations, construction and development also support energy and economic development across the United States. By 2020, Cheniere is expected to be a top-5 global provider of LNG.

Cheniere is a full-service LNG and offer their customers the option to load the LNG onto their vessels at Cheniere terminals.

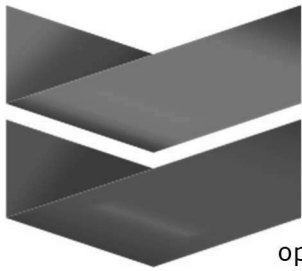
CHENIERE ENERGY'S EXPORTS FROM SABINE PASS TERMINAL



Destination	Cargoes
MEXICO	77
CHILE	27
ARGENTINA	75
BRAZIL	13
COLOMBIA	1
DOMINICAN REPUBLIC	5
UNITED KINGDOM	2
NETHERLANDS	12
SPAIN	10
PORTUGAL	8
MALTA	1
ITALY	3
LITHUANIA	2
POLAND	1
TURKEY	12
JORDAN	19
ISRAEL	1
EGYPT	5
UAE	5
PAKISTAN	3
KUWAIT	9
INDIA	18
CHINA	51
SOUTH KOREA	66
TAIWAN	9
JAPAN	23
THAILAND	1

Note: Total exports delivered to date: 385
Cargoes loaded and currently en route to destinations: 12
Source: S&P Global Platts Analytics

Chevron



Chevron

American company with worldwide operations.

Chevron is one of the largest LNG providers worldwide. While most of Chevron's focus is on supplying the Asian LNG market, there is also an established export of LNG to the Europe market.

Chevron's main focus is however on providing LNG for regasification. There is also little evidence for Chevron doing STS operation with the maritime industry, making Chevron more of a supplier than an LNG operator if the STS operations.

LNG shipments	LNG liquefaction	Storage facilities
118 worldwide import terminals	28 export terminals	100+ LNG is kept until needed



equinor

Equinor

Norwegian company with worldwide operations

Equinor is the Norwegian state-owned energy company that is responsible for the gas production in Norway. The company is a co-owner of Snøhvit facility in the Barents Sea which is one of the major production sites in the Europe of LNG.

Equinor primarily provides the LNG to operators through special LNG carrier ships. There are some indications that Equinor also sells LNG directly to the end-user, but this doesn't seem like a primary business focus for the company.



Nordic marine oil

Nordic marine oil is a Danish oil supply company that is present in most fishery ports and other larger ports in Denmark. The company does not supply LNG today but states on their webpage that they are following the development tightly and might hence be an LNG provider in Denmark. Nordic Marine oil is also present in the Port of Skagen.

Today, Nordic Marine Oil operates the oil bunker barge M/S Gaia Nordic with which they serve ships at the Skaw Road. Nordic Marine Oil hence has knowledge about the local market and traditional fueling operations

MONJASA

Monjasa

several offices around the world.

Monjasa is a Danish oil trader and oil supplier company. Monjasa operates internationally and has

In Denmark, Monjasa has an oil terminal at the Port of Skagen and are providing similar services than Nordic Marine Oil.

SWEDEGAS

> VISIONSKARTA

GAS FÖRNING / REGIONALT NÄT

— Befintlig — Vision

LNG-TERMINAL

● Befintlig ○ Vision

BIOGASANSLUTNING

● Befintlig ○ Vision

LOKALT BIOGASNÄT

● Befintlig



Swedegas

Swedish company with international operations.

Swedegas is the national gas provider Sweden and a relative new LNG provider.

Swedegas currently operates an LNG import Terminal at the Port of Gothenburg, which serves as a strategic access point for the company's ability to provide natural gas for companies in the Swedish hinterland and the maritime industry.

According to Swedegas access to natural gas could be a matter of survival for Swedish companies. LNG could solve the problem and to facilitate this, terminals are required at strategic locations.

The LNG terminal in Gothenburg is the first of 8 planned LNG import terminals in Sweden.

The vision of Sweden gas is to be able to supply more of Sweden with LNG through terminals since Swedish gas grid is underdeveloped in certain areas of Sweden.



THE LINDE GROUP

The Linde Group

The Linde Group is a world-leading gases and engineering company with more than 130 years of experience. It is headquartered in Munich, Germany, and has circa 62,000 employees in more than 100 countries worldwide.

In the field of industrial, process and specialty gases, Linde offers a complete portfolio of high-quality products and innovative processes. Besides being a leading technology partner for the engineering and construction of turnkey industrial plants, Linde also operates and maintains over 1,000 plants around the world.

Linde operates 30 LNG production plants worldwide with capacities ranging from 18 to 13,000 metric tons per day.

nauticor

Clean shipping powered by Linde

Nauticor

Nauticor is a German company that is part of the Linde Group. Nauticor GmbH & Co. KG is a leading provider of liquefied natural gas (LNG) as marine fuel. Nauticor and the group companies of its shareholder

The Linde Group have access to a broad range of expertise in cryogenic engineering, logistics and fuel supply.

Nauticor's strategy is to cover the complete LNG value chain – from sourcing and transport through storage and distribution to refueling ships (STS) with LNG in strategically important ports.

AGA

AGA

AGA is a Swedish company that is part of Linde Group focus on the Nordic and Baltic market (import)

AGA is a diversified gas provider in the Nordic and Baltic market where LNG is a relative new leg in their business model.

The primary LNG service is focused on the supply of Swedish inland industry, with some services focused on supplying the ferries and cruise ships around Stockholm from their terminal in Nynäshamn.

Cyro-shipping

CRYO SHIPPING

Cyro-shipping is a newly started Norwegian company with ambitions of conducting national operations in Norway.

CRYO Shipping AS is a shipping company delivering that specializes in environmentally friendly and cost-effective small-scale LNG ship transport and bunkering services.

CRYO Shipping main focus is to provide LNG vessel solutions that are designed for cost-efficient transport and flexible ship-to-ship bunkering. The services are provided to service off-grid markets such as LNG-fuelled ships and natural gas-fuelled industries, terminals and power plants.

TitanLNG

TitanLNG

TitanLNG is a Dutch Company with national and some international operations

Titan LNG is an experienced supplier of LNG to shipping companies and operators of LNG bunkerstations via truck-to-ship.

Titan LNG offers everything for full-service solutions, including the project planning of bunker solutions.

In 2018 Titan LNG will launch the first bunkering pontoon in Europe: the LNG FlexFueller1. The FlexFueller1 will serve as a stationary delivery location to inland water barges and small seagoing vessels. TitanLNG is therefore primarily a land-based operator and most of their assets seems to design for the Dutch LNG market primarily.



Skangas

Skangas is a Norwegian company focused on LNG production and distribution. The company is part for the Gasum Group.

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 re-gasified to natural gas or delivered as fuel to the end-user.

Skangas supplies LNG in:

- Nordic industry markets
- North European ECA for marine

Skangas currently imports and exports LNG from

- Øra
- Lysekil
- Risavika, also serves as liquidation plant.

Skangas have since 2017 been present in the Gothenburg area with the LNG bunker vessel Coralius, which has a bunker capacity of 5,400 m³.



Q8

Scandinavian LNG provider with a Scandinavian focus.

Q8 is the current provider of LNG to the Samsø ferry. This is a relative new business leg for the company and the scale of the LNG activity is unknown.

Q8 primarily provides the LNG to customers through a truck solution.



Unioil supply

Unioil supply is a Danish company with international customers. Danish Unioil Supply is a part of Bunker Holding Group, which owns and operates trading and physical supply operations in 27 countries. The global group's strength combined with Unioil Supply's expertise make us the preferred business partner of a vast range of customers, who all rely on our excellent service.

Unioil Supply's core business is based in Europe, Scandinavia and Nordic waters. Unioil Supply offers LNG as bunkers for delivery in all ports in Europe in truck lots of approximately 20 metric tons. As a first mover in LNG bunkering by truck, the company is already quite experienced in coordinating and supplying LNG as bunkers.

For larger supplies multiple trucks are available for one supply operation. Additionally, Unioil Supply offer setup of smaller LNG installations up to 50 metric tons in European ports upon request. Unioil Supply handles the safety procedures as well as taking care of the necessary and often very complex permits required by the authorities.