Activity 3-LNG in Helsingborg

Study – Possibilities for establishment of a marine LNG terminal in Helsingborg

Final report 2014

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1 Executive summary

The goal of this project was to investigate the possibility for establishment of an LNG terminal and associated infrastructure in the Helsingborg area. The project in Helsingborg is called HELGA (Helsingborg Liquefied Gas Association) and is a cooperation venture between the Port of Helsingborg, Öresundskraft, Kemira and NSR.

The terminals projected market area includes the Swedish coastal area of Halmstad in the north to the port of Ystad in the south and the Danish port of Fredericia in the west. Detailed analysis of potential locations in the region show that the most favourable result is establishment of an LNG terminal in the port of Helsingborg, within the Kemira Kemi AB industrial area.

Market studies show that heavy truck operation using LNG as a fuel will start to develop during 2015, increasing during 2016 and then accelerate to 2020. The development of the maritime sector is expected to be moderate to 2020 and thereafter accelerate.

As a result of the slowly growing maritime market the LNG infrastructure in Helsingborg will be most cost efficient if it is built in several steps. Already today it is possible to supply LNG or LBG (liquefied biogas) from other terminals in Sweden or Norway. However, it is an expensive solution and not sustainable for larger volumes. Therefore, the first step calls for development of a liquefaction plant with a small, 430 m$^3$ tank storage capacity. This initial investment is expected to increase interest for a long term LNG solution for ship owners in the area thereby driving local investment in LNG carriers.

Once there are LNG ships operating in the market area, step two will see expansion of the terminal with development of a further 3-5 steel tanks of 1000 m$^3$ each. In order to reach the ships operating in the region, it also requires a bunker boat for ship to ship bunkering and for supplying LNG to the neighbouring ports. When the market is large enough, step three will develop of a full-scale terminal of 15 000 m$^3$ including a jetty in order to receive LNG from feeder vessels up to 40 000 m$^3$.

The project has applied for EU-funding from the MOS-program (Motorways of the Sea) for step one.
2 Background, purpose and scope of work

2.1 Introduction

In 2015 stricter sulphur emission requirements for shipping will be introduced in Emission Control Areas. The areas include the North Sea, Baltic Sea and the English Channel. LNG meets the new regulation and therefore has great potential to become an attractive alternative to shipping in the region. The potential is large but there is today no infrastructure for bunkering of ships. Helsingborg has a good strategic position to place a LNG intermediary terminal. In addition to the shipping segment a terminal could also be used to distribute LNG to other market segments; for example heavy trucks and local industry, found in the region.

![Figure 1. The market area for a LNG-terminal in Helsingborg](image)

The Port of Helsingborg has a strategic location and the city of Helsingborg, owner of the port, has ambitious environmental plans for the region.

An LNG terminal in the port could provide alternative fuel for ships resulting in a lower environmental impact that will benefit both locally and globally.

An LNG terminal in Helsingborg area will help to build a well-functioning infrastructure around the Baltic and the North Sea, whilst increasing the port of Helsingborg’s long-term competitiveness.
2.2 Background

This report is part of the project “LNG in Baltic Sea Ports”, partly financed by the European Union’s Trans European Transport Network (TEN-T) and coordinated by the Baltic Port Organization (BPO). In the project there are seven ports around the Baltic Sea: Helsingborg, Aarhus, Copenhagen-Malmö, Stockholm, Tallinn, Helsinki and Turku.

The aim of the global project is to develop a harmonized approach regarding LNG bunker filling infrastructure in the Baltic Sea region. A more standardized process of how to plan and construct the relevant infrastructure will be achieved through knowledge sharing between the ports and their associated stakeholders.

The project in Helsingborg is called HELGA (Helsingborg Liquefied Gas Association) and is a co-operative venture between the Port of Helsingborg, Öresundskraft, Kemira and NSR.

Öresundskraft – energy company owned by the city of HELSINGBORG

KEMIRA – large industry and site owner

Port of Helsingborg owned by the city of HELSINGBORG

NSR – producer of biogas partly owned by the city of HELSINGBORG

The project also has the support of:

Ports of Sweden

Energigas Sverige
2.3 Purpose

The purpose of project HELGA, referred to as activity 3 in the global project, is to investigate the possibility for establishment of a marine LNG terminal and associated infrastructure in Helsingborg. This report has two purposes; firstly to be a final report for the feasibility study and secondly to serve as a basis for an EU funding application for investment.
3 Methodology and scope of work

Project HELGA has since 2012 investigated the possibilities for establishment of a maritime LNG terminal in the area of Helsingborg. EU has supported the work covering 50% of the costs.

The overall goal for the work is to produce information/documentation that could provide the basis for a final investment decision regarding a maritime LNG terminal in the port area of Helsingborg.

The first task in the project was performance of a risk analysis in order to highlight possible show stoppers and to determine if these could be eliminated. The following possible show stoppers were identified.

- Location
- Market
- Sourcing

3.1 Scope of work

According to the commission decision 2012 Helsingborg should perform following work:

**Market, sourcing, location and stakeholder’s analysis**
This activity includes (i) a market analysis; (ii) a stakeholder analysis; (iii) an analysis of possible locations for LNG terminal: in depth studies of the proposed location within the Kemira Kemi area, including land surveys. A review will also be done for alternative locations; (iv) a review of potential suppliers of LNG / LBG

**Basic design of the terminal and quay and investment calculation**
This activity includes: (i) basic design of the terminal and quay; (ii) analysis of needed volume for tanks; (iii) Basic design for at least the following installations: Tank; quay and sailing fairway; loading and unloading equipment of LNG from quay; systems for bunkering of ferries in the port of Helsingborg; loading equipment for trucks and railways; filling station for LNG vehicles; Possibility for delivery of LBG to the facility; evaporation plant for gas and connection to the gas network; filling stations for gas to vehicle; supply media (nitrogen, pressurized air, firewater, possibly steam, flare, water and sewage, electricity, district heating etc.); piping systems for all media; (iv) investment and profitability calculation

**Risk assessment project and check of process for permits**
This activity includes (i) an analysis of the permit process impact on the project: a review of the various permits required for installation. Control of processing times; (ii) an overall risk assessment for the future project both in terms of technical risks (health and environmental) and sensitivity analysis of the investment.
**Design of terminal and quay including ship simulations**

The activity foresees (i) the elaboration of more detailed design of the terminal (Sufficiently detailed for tender documents) covering at least the installations for which a basic design was performed under 3.2; (ii) Ship simulation to quay and fairway.

**Preparation of permits and tender documents**

The sub)activity covers (i) investigations for and preparation of documents for the various permitting processes; (ii) Preparation of tender documents for all necessary facilities

### 3.2 Location as a possible showstopper

One of the first actions was to see if there is any reason to believe that there could be any objections to maritime LNG terminal in Helsingborg from local authorities, laws and permit requirements

- One problem would be if there were better locations than Helsingborg for a regional maritime LNG terminal in south of Sweden?

- The project set up fundamental demands and important demands. These were communicated to the Swedish consulting company Sweco who developed the localization study.

The study shows, that within the market area, only Helsingborg and Malmö have a location that fulfils both fundamental demands and important demands. *(See Appendix 1, Lokaliseringsutredning).*

**Fundamental demands are fulfilled:**

- Existing port depth 10 metres or more
- Close to major waterway/ fairway
- Close to natural gas grid
- Close to railroad and roads suitable for LNG distribution vehicles
- Location on area planned for industrial use (at least 10 000 m²)

**Important demands are fulfilled:**

- Adequate distance to third party (min. 600 metres, desirable 1000 meter)
- National interest
- Natural environment (conservation areas etc.)
- Cultural interest (historical remains/ building)
- Recreation areas
- Landscape
- Air quality (emissions, particles, etc.)
3.3 Slow development of market as a possible showstopper

Initially Ramböll AS and ÅF Industry AB made market studies. The studies made it possible to make assumptions of the LNG volumes that could be handled by a LNG terminal in Helsingborg.

To confirm the results of the market studies contact was made with ship owners and other stakeholders. The resulting information did not fully support the result regarding the maritime volumes and when they could be expected to grow to significant levels. (See Appendix 2, LNG Demand for Shipping and Appendix 3, Marknad – Industri och Transport).

![Figure 2, First volume prognosis made in 2012](image)

3.4 Cost efficient sourcing as a possible showstopper

The project had initially contact with suppliers and other LNG projects. Today it is possible getting LNG to Helsingborg by feeder vessel if the volumes are significant (2000 m3 and more). The redundancy in the value chain is limited if a disturbance will occur due to a limited amount of feeder vessels.

The long-time competitiveness of a maritime terminal is heavily dependent on the sourcing price of LNG compared to MGO. Collection of large volumes leads to favourable prices. This could be achieved through development of other LNG projects.

The project had limited cost frame to investigate sourcing possibilities. A parallel project was established that looked into the sourcing question. This project was not supported by the EU.

3.5 Strategic approach

It became clear that in order to answer the question, if it is possible to establish a maritime LNG terminal in Helsingborg, constant analysis of business opportunities are required after initial development of the project. The maritime market demand is hard to predict. In order to handle this uncertainty we have used a business orientated design. A terminal in Helsingborg will serve 3 segments, shipping, industry and heavy vehicles. There is a fast growing demand for liquefied biogas and LNG to be used by heavy vehicles. It is most likely that the LNG volumes for the shipping segment will grow slowly, significant volumes could be foreseen 2018 -2020.
As such, Helsingborg, as an initiating first step, will need to invest in a Liquefaction plant for production of LBG and LNG for the transport sector (heavy vehicles and smaller ships).

When the maritime market is ready there will be a sustainable bunker solution in the market area of Helsingborg. The business possibilities in the area is in the long run excellent due to the fact that Helsingborg is a major logistic hub in south of Sweden through which 45 000 ships and 3 million trucks are passing every year.

- The city officials have been informed about the plans and stands behind the efforts to establish a maritime LNG terminal in Helsingborg.
- The regional authority “Länsstyrelsen” has been informed and have, as yet, not put up any "red flags".
- The Swedish Civil Contingencies Agency (MSB) has been informed by the project and no obstacle is foreseen by the project.
4 Strategy for the infrastructure development

A LNG infrastructure in Helsingborg will provide liquefied gas for three different market segments; maritime, industrial and heavy trucks. When the infrastructure in Helsingborg is completed (step 1 to step 4 is finished), 85% of the volume will go to the maritime segment. Therefore, the full project entirely depends on demand for LNG from the shipping segment in the market area.

The results from the market analysis shows that ship owners believe that LNG is an interesting fuel for the future, but they have not yet taken any decision to invest in LNG ships. Ship owners are also concerned that there should not be a reliable supply of fuel. (See Appendix 2).

In order to meet a gradually growing market and thereby minimize the risks, the infrastructure will be built in four steps:

**STEP 1 –**

Development of a liquefaction plant with a small tank (430 m³), that will liquefy gas from the natural gas grid. The plant will produce 110 GWh LNG per year. Tank trucks will distribute LNG/ LBG to ships in the port of Helsingborg and nearby ports, as well to LNG refuelling stations for heavy trucks in the region.

The advantage is to start on a smaller scale and thereby show the ship owners a functioning infrastructure with locally produced LNG. This is an important factor for them and we expect that it will increase the probability that they will invest in LNG fuelled ships.

The first step is planned to be operational by 2017.

**STEP 2 –**

The plant will be expanded with 1000 m³ steel tanks, (with a total volume of 3 000-5 000 m³), when demand from the maritime sector increases. A nearby quay will be extended so that it is possible to receive feeder vessels and bunker boats. The plant will also have fixed infrastructure for bunkering via pipeline.

The market analysis shows that the ship owners want to bunker while loading/unloading so that they can avoid time loss, and/or the need to travel to another port for bunkering. Therefore, in order to better provide bunkering in the market area, there is a need for a multi-fuel bunker vessel. The bunker vessel will have several tanks, one of which will initially be dedicated to LNG. To lower operating costs, the bunker vessel might also distribute low sulphur HFO, MGO and methanol. The bunker vessel will be fuelled by LNG.

The second step is planned to be in operation in 2020.
STEP 3 -

The full-scale terminal will be built when demand from the maritime segment exceeds 200,000 m³ per year. It will be a 15,000 m³ steel-concrete full containment tank.

The third step is planned to be operational in 2027.

STEP 4 –

Extensive loading and unloading of LNG affects other activities in the existing port. Therefore, a jetty will be built to be able to receive larger LNG tankers (up to 40,000 m³). Larger tanker tonnages will also give favourable sourcing.

Figure 3, Lay-out showing the four steps (step 1 - green colour, step 2 – orange colour, step 3 – lilac colour, step 4 – yellow colour)
5 Market and stakeholder analysis

5.1 Market analysis

The market area that can be serviced by an LNG terminal in Helsingborg, stretches along the Swedish coast from Halmstad to Ystad. The market area also includes ports on the Danish coast.

Figure 4. The HELGA market area

Three market studies have been conducted within the project:

✓ A study of the market potential for heavy truck traffic and industry. (See Appendix 3, Marknad, Industri och Transport).
✓ An analysis of the market potential in the maritime segment. (See Appendix 2, LNG Demand for Shipping).
✓ An in-depth analysis of how the ship owners in the market area will handle the new sulphur directive and their attitude to LNG.

The results of the studies show the following volumes potentials for the terminal in Helsingborg:

<table>
<thead>
<tr>
<th>Market segment</th>
<th>Total volume (GWh per year)</th>
<th>LNG potential for the terminal in Helsingborg (GWh per år)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy trucks</td>
<td>700</td>
<td>200</td>
</tr>
<tr>
<td>Industry</td>
<td>1 500</td>
<td>250</td>
</tr>
<tr>
<td>Maritime</td>
<td>66 500</td>
<td>3 000</td>
</tr>
</tbody>
</table>

In addition to ships calling ports within the market area, there might be additional volumes obtained from the transit traffic, which is deemed to have a fuel consumption of approximately 320 000 GWh per year.
5.1.1 Heavy trucks

LNG is an interesting alternative primarily as fuel for long distance trucks.

Figure 5, Main routes for heavy trucks

24 LNG filling stations are planned or under construction in Sweden. The following cities could be supplied from Helsingborg:

- Malmö
- Jönköping
- Kalmar
- Helsingborg
- Kristianstad
- Växjö

In Denmark three stations are planned. The one in the south of Copenhagen could be supplied from Helsingborg.

The table below is a summary of diesel volumes long distance trucks refuelled in each city during 2012. The total potential fuel consumption of the region is over 700 GWh per year.

<table>
<thead>
<tr>
<th>City</th>
<th>Long distance trucks (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsingborg</td>
<td>156</td>
</tr>
<tr>
<td>Malmö</td>
<td>119</td>
</tr>
<tr>
<td>Jönköping</td>
<td>145</td>
</tr>
<tr>
<td>Kristianstad</td>
<td>80</td>
</tr>
<tr>
<td>Växjö</td>
<td>31</td>
</tr>
<tr>
<td>Kalmar</td>
<td>48</td>
</tr>
<tr>
<td>Köpenhamn</td>
<td>160</td>
</tr>
</tbody>
</table>

Table 1, The market potential for long distance trucks (2012)
The alternative fuel for the segment “heavy trucks” is diesel and the diesel price used in this analysis is 1 200 SEK/MWh (the price is including CO2 tax (219 SEK/MWh) energy tax (157 SEK/MWh)).

To be an attractive fuel for the trucking companies the LNG price need to be 10-15 percent below the price of diesel. The introduction of the sulphur regulation 2015 is expected to result in an increased demand for Marine Gas Oil, which in turn is expected to lead to a higher diesel price.

A filling station for LNG trucks was opened in Helsingborg November 2014, and is expected to have an LNG demand of 100 GWh in 2020.

5.1.2 The Industrial Segment

It is mainly the industries that today use gas oil, fuel oil or propane in their processes that could be a potential market for LNG. Industries with a consumption of less than 10 GWh are not considered as an interesting market due to the cost of converting existing equipment to LNG.

```
<table>
<thead>
<tr>
<th>Province</th>
<th>Propane Total &gt; 10 GWh</th>
<th>Gas oil and fuel oil Total &gt; 10 GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blekinge län</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Hallands län</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Jönköpings län</td>
<td>65</td>
<td>8</td>
</tr>
<tr>
<td>Kalmar län</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Konobergs län</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Skåne län</td>
<td>71</td>
<td>5</td>
</tr>
<tr>
<td>Västra Götalands län</td>
<td>100</td>
<td>11</td>
</tr>
<tr>
<td>Östergötlands län</td>
<td>27</td>
<td>5</td>
</tr>
</tbody>
</table>
```

Table 2, Number of industries in southern Sweden that use propane, gas oil or fuel oil in their process.

The tax varies depending on whether the industry is within or outside the EU-ETS (Emissions trading system). The alternative price 2014 (excluding tax) for the industrial segment are:

- Propane (560 SEK/MWh)
- Gas Oil (670 SEK/MWh)
- Fuel Oil (490 SEK/MWh)

If LNG can be supplied from the Helsingborg area at a price that is 20 percent lower than alternative price we expect around 1 000 GWh to be commercially attractive.
5.1.3 The Maritime Segment

The total fuel consumption for the maritime sector in the Helsingborg region is estimated to about 400 TWh. In the volume mentioned all vessels are included that serve Helsingborg port, nearby ports and the transit traffic regardless of where they bunker today. Nearby ports include ports on both the Danish and Swedish coast from Ystad in the south to Varberg in the north and Fredericia in the west.

<table>
<thead>
<tr>
<th>Fuel consumption</th>
<th>GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsingborg</td>
<td>1500</td>
</tr>
<tr>
<td>Nearby ports</td>
<td>65000</td>
</tr>
<tr>
<td>Transit traffic</td>
<td>320000</td>
</tr>
<tr>
<td>Sum</td>
<td>386500</td>
</tr>
</tbody>
</table>

Table 3, Total fuel consumption for shipping in the region.

The potential for LNG within the shipping segment in the region is based on the fact that LNG is only an alternative for new vessels, and that 4% of the fleet is replaced each year. Of the new vessels we expect that 10% will operate on LNG and based on available statistics we estimate that 50% of the vessels will bunker in the region.

From discussions with the ship owners, our conclusion is that they will not sail to the port of Helsingborg only to bunker their ships. Therefore, besides a terminal, there must be a bunkering vessel operating in the area to meet the demands of other ports and ship to ship bunkering possibility for the transit traffic.

The port of Helsingborg has regular calls from 13 vessels (container / tanker and RoRo ships). There is also a regular ferry link between Helsingborg and Helsingör that is daily served by four ships. These vessels have a total fuel consumption of 1500 GWh.

There is a political interest from both the cities of Helsingborg and Helsingör to influence shipping industries in the region to switch to a fuel with improved environmental qualities. The ferries have already been converted to marine gas oil (MGO). When existing ferries are replaced, LNG will be an interesting alternative as ship fuel. Another possibility is to retrofit the ships with battery driven main engines.

5.2 Stakeholder analysis

Initially a stakeholder’s analysis was made by the project. The analysis was necessary for planning the work to investigate the prerequisites for a marine LNG terminal in Helsingborg. The project has been in contact with more than 75 stakeholders. The project has also gone through a lot of reports, articles and other type documentations. On the next pages there is a summary of the results from contacts with key stakeholders.
5.2.1 Politicians and officials view

During the project, politicians and officials working in different administrations in the city of Helsingborg, have continuously been informed. Most are in favour of an LNG infrastructure in Helsingborg, especially since it will contribute to improved air quality and improved competitiveness for the port of Helsingborg. An important factor is also that LNG is seen as a bridge to a future biogas community. There have also been contacts with Region Skåne, the County Board, Ministry of Industry, Ministry of transport, Danish Maritime Authority (DMA) and Swedish Civil Contingencies Agency.

5.2.2 Suppliers of LNG

There are several suppliers of LNG that could be of interest for future sourcing. Because the volumes initially will be relatively small, it will be a success factor to co-operate with other LNG terminals around the Baltic Sea to share the cost of LNG transport.

5.2.3 Other ports in the region

If every port in the area were to build a LNG terminal it would lead to sub-optimization and to a high cost for the LNG-infrastructure. Therefore there have been discussions with nearby ports to have a joint LNG infrastructure, with distribution from the LNG terminal in Helsingborg via tanker trucks or bunker boats. Other ports can thereby offer their customers LNG without investing in LNG tanks. We have had contact with the ports in the following cities: Carlshamn, Åhus, Ystad, Halmstad, Trelleborg, Fredericia, Aarhus and Copenhagen/Malmoe.

5.2.4 Ship owners

Ship owners are mainly looking for a long-term competitive price for LNG linked to MGO. For them to invest in LNG there must also be a reliable and efficient infrastructure.

5.2.5 Transport buyers

Several customers that utilise transport services have already decided to use environmental friendly transport solutions and therefore require their transport distributors to use LNG/LBG as fuel.

In November 2014 Öresundskraft opened their first filling station in Helsingborg that currently provides 100 percent LBG. The filling station is primarily for heavy trucks in the region, but there have already been demand from long-distance trucks. The filling station is an important part of creating a functioning infrastructure for LNG, especially because the refuelling station is located along EU's LNG “Blue Corridors”. Öresundskraft is now looking for new locations that may be suitable for future LNG filling stations.
5.2.6 Industry

Industries in the region that are not connected to the existing natural gas grid are interested in an alternative to fuel oil and LPG. They see LNG as an interesting alternative if the fuel can be delivered reliably and at an attractive price. They also see an advantage with the fuel in their environmental profiling and especially if we can provide a product that consist of some amount of LBG.

(A list of contacted stakeholders can be found in Appendix 4.)

5.3 Conclusion - market and stakeholders analysis

The conclusion of the market studies performed by the HELGA project group is, that the heavy truck operation using LNG as a fuel will start to develop during 2015 and it will increase during 2016 and then accelerate to 2020. For the marine sector it is expected that the demand of LNG will increase gradually after 2020.

The reasons for the delay in demand from the marine sector are as follows:

- The required technology for clean fuels or treatment of flue gases is still not fully developed or available on the market. Each different shipping company or operators have found themselves uncomfortable in this situation, finding that it is not so simple to identify and choose the right option for the future: LNG, methanol or scrubber.

- All involved parties are subject to the same consequences, they need a little more time for consideration and investigations and therefore prefer to wait. In the meantime the new and expensive MGO (marine gas oil) with max 0.1% sulphur is in use.

- It is a long lead process to order and construct new ships and to phase-out existing fleets. Upgrading or conversion of ships in current use is an expensive alternative and therefore normally not a preferred option.

- Pricing of LNG is still unclear, which is a draw-back for the whole sector.

- Still unclear regulations for bunkering of LNG ships. The ship owners would prefer a standardized procedure for LNG bunkering of ships and possibility for ship-to-ship bunkering is advantageous.
6 Sourcing and pricing

Ramböll has analysed the sourcing possibilities for a terminal in Helsingborg and a prognosis of the LNG price development. (See Appendix 2, LNG Demand for Shipping)

**PRICE SCENARIOS IMPLY THAT LNG IS HIGHLY COMPETITIVE IN ALL SCENARIOS IN LONG TERM**

However, not a purely economic decision.

Issues such as scrubbers, considerable investments and waste management are not clear yet.

Issues of fuel availability and infrastructure will also be important.

The results shows that LNG price will be competitive compared oil gas / diesel in all kinds of scenarios. In the worst case, fuel oil and LNG end up at the same price by 2030.
VALUE CHAIN OPTIONS AFFECT THE PRICE OF THE LNG

- Truck costs assume a 440 km round trip with 23 and 70 m³ capacities for truck and trailer respectively (loading Gothenburg).
- Rail costs from Norway would appear competitive but calculations are indicative, reality could be more complex and no history of rail LNG transport in Europe.
- The cost of the bunkering and freight may differ dependent on the terminal delivery point.
- Size of terminals is not clear so terminal costs have not been added.
- LNG cannot be transported from European mainland.

The Ramböll report shows the global market for LNG is developing, which is largely driven by the shale gas development in the USA and Canada and major new gas discoveries in Australia and Africa. There is speculation that the future LNG trade will have up to 20% of the total volumes that are based on long-term fixed contracts. Gas prices on the US stock exchange, Henry Hub, are significantly lower than the European stock markets. But today it is unclear to what extent the US will allow the export of gas, and if there will be a more harmonized prices between the markets.

The aggregate of volumes in the Ramböll and ÅF reports, shows a volume potential for the Helsingborg region of 2-5 TWh. One conclusion which can be drawn from the result in this project is that shipping is significant, or even critical to a project in the Helsingborg area (about 90% of the total volume). Furthermore, one can conclude that ships calling other ports than Helsingborg represents about 80% of the total shipping volumes. Therefore it is critical that the project cooperates with other ports in the region regarding the supply of LNG.

To establish the needed volumes it is important that the project continues to work with the shipping industry. But the results from the market analysis also shows that both the industrial and transport segment provide opportunities to gradually secure market volume and therefore are seen as important components.

In summary, to establish stable sourcing it is important to secure volume in the Helsingborg market area. At the same time it is important to establish a large-scale cooperation within the Baltic Sea, with regard to both procurement and infrastructure, such as bunker/feeder vessels.
7 Profitability analysis

The project has studied several alternative solutions for a LNG terminal and associated infrastructure in Helsingborg.

- LNG or LBG (liquefied biogas) distributed by tanker truck from other terminals in Sweden or Norway
- Liquefaction plant with different sized tanks for storage of LNG
- Plant with several steel tanks (each 1000 m$^3$), to a total volume of 3000 m$^3$, 5000 m$^3$ and 10000 m$^3$
- Full-scale LNG terminal with a 15000 m$^3$ steel-concrete tank
- The above alternative solutions with and without a bunker boat, and also with and without a jetty

Analysis shows that the LNG infrastructure should be built in four steps. Already today it is possible to supply LNG or LBG (liquefied biogas) from other terminals in Sweden or Norway. However, it is an expensive solution and not sustainable for larger volumes. Therefore, the first step is to build a liquefaction plant with limited storage capacity. The investment is expected to result in a positive interest for LNG from the ship owners in the area and that they invest in LNG driven vessels. None of the other alternatives are profitable before there are LNG ships operating in the market area.

Once there are LNG ships operating in the market area, there will be an expansion of the terminal.

To reach the ships operating in the region, it also requires a bunker vessel supplying LNG to the neighbouring ports and for ship to ship bunkering.

When the market is large enough a full-scale terminal of 15 000 m$^3$ including a jetty will be built, in order to receive LNG from feeder vessels up to 40 000 m$^3$. 

8 Technical description

8.1 Background

The studies of different sites for suitability performed by the HELGA project group, show that the most favourable conditions to establish an LNG terminal is in the port of Helsingborg, within the Kemira Kemi AB industrial area and close to a quay. The region studied includes the coastal area of Halmstad in the north and to the port of Ystad in the south.

The conclusion of the market studies performed by the HELGA project group is that heavy truck operation using LNG as a fuel will start to develop during 2015, increase during 2016 and then accelerate to 2020. For the marine sector it is expected that the demand of LNG will increase gradually after 2020.

8.2 Step-by-step development of the LNG terminal

The LNG terminal will be developed closely in line with the expected growth of the market and for that reason the build-up and extensions are foreseen to take place in three or four implementation steps:

Step 1
Step one is a liquefaction plant for local production of LNG to provide the market with vehicle fuel for heavy trucks. Also bunkering of ships and supply of bunker fuels to other ports in the region are foreseen. Öresundskraft has already built and is currently operating a LNG filling station for trucks in Helsingborg (November 2014) and is planning to build more stations in the market area. The liquefaction plant is planned to be in operation 2017.

Step 2
Step two is an expansion of the storage tank volumes to cope with the increasing demand of LNG from the marine sector. It includes also an extension in the existing quay in Kemira harbour with unloading/loading equipment for ships.

Figure 6, Step 1, the liquefaction plant with storage tank, 430 m3, and loading/unloading of trucks
At this time also a bunker ship must be available. This ship will make it possible to offer ship-to-ship bunkering at sea and in port. The ship can also distribute LNG to other ports in the region. Step two is expected to be in operation 2020-2022.

Figure 7, Step 2, expansion of the plant with new storage tanks, expanded new quay and a bunker vessel.

Step 3
A full containment tank, 15,000 m³, is implemented and a new jetty is planned to facilitate unloading of bigger LNG supply ships. Step three is expected to be in operation 2025-2027.

Figure 8, Step 3, a full containment storage tank, concrete and steel, 15 000 m³, is installed close to the existing terminal.
Step 4
A new jetty able to receive larger LNG tankers (up to 40 000 m³) is built.

Figure 9, Step 4, a new jetty located directly to the sea side and close to the new storage tank.

8.3 Feasibility Studies

A Geological investigation Study has been performed and it shows that the stability of ground in the harbour area is sufficient for all of the planned installations. Some reinforcement work will be necessary for the large tank. (See Appendix 4).

A Basic design Study has been performed in an early stage. The purpose was to analyse if there would be any major obstacles and to define and analyse the investment cost. The findings was used in the profitability analysis. (See Appendix 5, Basic Design Study).

A port study is performed and this shows that LNG vessels sized to 10 000-15 000 m³ of LNG are able to berth at this port. The port requirements for use of pilots and tugboats depend on the actual size and control equipment installed of the vessel. The fairway into the port berth is well known and in use by cargo vessels today but an extension of the quay will be necessary for berthing of LNG vessels. The new planning of the port has been discussed and verbally agreed with the Local Nautical Council (Nautiska rådet) as well as with the pilots of Helsingborg. The safety routines in the ports will be extended to include the safe handling, loading and unloading of LNG vessels. (See Appendix 6, Port Study)
Figure 10, Plan of the south port area, Bulkhamnen, where the LNG terminal site will be installed on the outer end of the west quay.

Sea bed investigations have been performed for three sites where the extension of the port by a new jetty/berth may be constructed during the development of the LNG terminal. These investigations show that molluscs and other endangered fauna exist, especially in the southern marine area. (Appendix 7, Seabed Investigations)

Figure 11, Areas studied for a new jetty site.
Risk and safety assessment analysis have been performed for all of the planned implementation phases of the LNG terminal and no show stoppers have been identified for the site in the Port of Helsingborg. Exploratory negotiations have been held with the relevant national authorities, MSB (Swedish Civil Contingencies Agency) in November 2014. The extended handling of dangerous goods in the port area due to the new transports by LNG trucks have been checked together with the current traffic planners in Kemira Kemi and it is found that the new LNG transports will fit very well into the existing transport system. *(See also chapter 9)*

Feed systems are planned and cost estimations have been done, regarding natural gas from the gas grid, electrical supply, heat, fresh water, fire water, sewage water, boil off gas and tail gas to the existing gas distribution net.

### 8.4 Basic Technical Data, step 1

LNG Liquefaction Plant with loading/unloading of trucks

- About 25 tonnes LNG/LBG per day
- Yearly production about 110 GWh, 1800 tpa
- About 430 m³ pressurized double walled, super-insulated LNG storage tank
- 30 bar supply pressure for the gas to liquefy
- Gas treatment plant for returning the tail gas into the gas grid
- A special area for loading and unloading of LNG trucks and semi-trailers
- The whole LNG area will be fenced
- Blow off of gas to atmosphere will be used only in emergency cases
- The plant will be prepared for extension to the double capacity in future phases

![Figure 12, Step 1, General P&ID for the LNG liquefaction plant](image-url)
8.5 Basic Technical Data, step 2

Four self-contained 1000 m³ LNG storage tanks, loading and unloading of LNG vessels at berth.

- 4 self-contained, double walled, horizontal, vacuum insulated, steel storage LNG tanks each of 1000 m³.
- Extension of existing quay for mooring of vessels carrying up to 15,000 m³ LNG. New LNG pump for loading of LNG bunkering vessels.
- Marine loading arms and bunkering equipment on the quay for loading and unloading of LNG tankers and bunkering vessels.
- Export/import piping between storage tanks and the quay.
- A Fire water tank of 500 m³ and fire-fighting equipment for foaming and shielding located in the tank area and on the quay.
- A new control room, equipped for remote control and supervision.
- Extension of the truck loading area for simultaneous loading/unloading of two LNG trucks.
- Gas analysis and volume metering equipment.

Figure 13, Step 2, Extension of the plant
8.6 Basic Technical Data, step 3
Full containment LNG storage tank 15,000 m³.

- Storage tank
- Submerged storage tank pump
- New piping between the new tank and the existing tank farm
- Heating plant for temperature control in the storage tank foundation
- Protective systems (lighting, electrical earthing, supervision, remote control)

![Diagram of full containment tank]

Figure 14, Step 3, Split view of full containment LNG storage tank

8.7 Basic Technical Data, step 4
A new Jetty

- Construction of a new jetty for vessels carrying up to 40,000 m³ LNG
- Marine loading arms and bunkering equipment for loading and unloading of LNG vessels and bunkering ships
- New piping for loading and unloading of vessels
- New access road for the jetty
- Gas analysis instrumentation and volume metering equipment
- Protective systems (lighting, electrical earthing, supervision, remote control)
Figure 15, Step 4, A new jetty, to the west
9 The permit process

9.1 Work procedure for permit and agreement of site for the terminal

A feasibility study has been performed according to the Swedish Environmental Act with the purpose to identify sites, suitable for establishing a new LNG terminal with a storage capacity up to 15 000 m$^3$ of LNG. The outcome of the study is presented in a report in Swedish language, see Appendix 1. The works for the study has been developed in several steps. In step 1 the limitation of the area for the survey is done and out of this limitation the sites to be further assessed in the study are selected. A number of criteria and target values are used and assessed in the study of the sites. For each step a selection of sites is done for the further assessments in the next step.

The study of sites has been performed in steps where each selected site has been assessed according to a number of criteria covering both technical and environmental aspects.

The harbours in Halmstad, Helsingborg, Landskrona and Malmö were found to fulfill the basic criteria for a site selection and were studied in close detail. Finally the sites in Helsingborg and Malmö were found to fulfil all of the criteria for an establishment of an LNG terminal. For these two sites an overall risk assessment was made to obtain full clarification of current status.
In the final site selection several aspects have to be considered. Important factors used in the study are to identify any alternative planning for the land areas, current availability and costs for purchase or to lease the land areas. These aspects have been summarized in the study as it is found that they have a considerable impact on the final choice of the site.

In the area of Helsingborg a site has been identified that now fulfils the required criteria. For the proposed site in Malmö a deeper investigation is necessary regarding extension or reconstruction of existing quays in the harbour before a site selection can be granted.

9.2 Works procedure during QRA

The selected sites for the construction of an LNG terminal are studied also for suitability due to safety aspects in a qualitative risk assessment study, QRA. The purpose of the QRA is to find the initial, general, risk level from the public perspective and based on the LNG conceptual design also check that the achieved risk level is kept within tolerable limits. The QRA for the Helga project is available in Appendix 8.

The methodology for the QRA is specified in Appendix 9. The risk levels are calculated based on design conditions and the safety aspects are assessed in order to verify that an acceptable risk level is achieved.

The flow is generally applied in QRA and is obtained from the standard, EN ISO 31000 (Risk Management, 2009). The following description of the methodology is an interpretation of the standard as applied in the study. In figure 17, the flow is shown.

![Diagram of risk assessment methodology](image)

Figure 17, Method of risk assessment applied in the study
The applied method is described as an interpretation of the route in the above mentioned standard. The resulting risk for individuals is shown in Figure 2. Based on the risk profile regarding individuals, it is evident that no scenario is of a particular risk for the public and this is therefore not shown in the report.

From the public risk perspective the construction of the LNG terminal on the Kemira site in Helsingborg harbour area is thereby justified.

Based on the presented risk assessment the following recommendations are made:

- The LNG terminal shall be designed in accordance with the standard EN 1473:2007 Installation and equipment for liquefied natural gas – Design of onshore installations. The design assessment of the integrity of the tanks is given special attention and the full containment tank type in EN 1473:2007 is found of preference for the terminal.

- The relief of gas to atmosphere shall be made only in case of emergencies. The relieved gas is to be blown-off from an elevated point without influence to EX hazardous areas in the plant or in the harbour.

- Emergency shut-down valves shall be available both by remote and by locally operated panels and push buttons. The ESD valves stop the flow and interrupt the LNG process and the gas handling in the plant.

- Leak detectors will be installed in certain areas where a high risk for leakage is found. The detectors will trigger alarms and/or shutdown processes in the event of both low and high temperature scenarios.

- The ESD and leak detectors shall be included in the main supervision and communication system which is shared between local operators and the chief supervisor in the main control room.

- The overall planning of dangerous goods transport by trucks inside the harbour area shall be updated for inclusion of the LNG trucks.

- The traffic planning also includes bulk handling which shall be re-routed to increase safety for the LNG handling inside the harbour.

- It shall be verified during the design phase that the storage and handling of dangerous media in the harbour area will not create unsafe conditions for LNG handling or vice versa.

9.3 Exploratory discussions before the application for permits (valid for step 2-4)

The Helga project group has studied the conditions for handling of natural gas and LNG in the harbour of Helsingborg. Upon board approval for finance and construction of the plant, several permit applications are required by Swedish legislation to have been prepared and submitted to the relevant authorities for
review. The application which needs to be submitted according to the Swedish Environmental Act will require exploratory discussions with relevant authorities and the public. The discussions, supplied public information and subsequent local opinion must be arranged and presented well before the formal application can be submitted.

The handling of flammable media in the planned LNG terminal is subject to the requirements as described in Section No 39.60 in Chapter No 20, §1, of the Swedish Environmental Act (2013:251). Therefore the planned activities shall be subject to review by the Environmental Committee of the regional County Administrative Board of Skåne (Scania) Matters referring to the handling of bio gas, natural gas and LNG are subject for review by the Helsingborg rescue organization (local fire brigade) in co-operation with the national Board for these matters, MSB (Swedish Council for Contingency).

Upon completion (step 2-4) of the planned terminal, the storage volume of LNG will exceed upper limits according to the Seveso II legislation in EU. Therefore the plant shall also be subject to review by the referred Authorities according to the Swedish Act No 1998:899, Enclosure to Section No 4 concerning environmental protection and protection of health. This is required for installations with activities subject to requirements found in Section 39.60 of the Environmental Act 1998:905, which states that, when preparation of a study regarding environmental consequences is necessary, it shall generally be performed exploratory discussions in advance as they are causing a environmental impact.

The exploratory discussions shall be performed with the regional and the local authorities along with the public, external organizations and national regulatory boards issuing regulations applicable for the installation and operation of the plant including the requirements of the study regarding environmental consequences.

A preparatory meeting was held between the County Administrative Board, CAB, and the HELGA project group in Malmö on 29 May 2013. Another preparatory meeting was held together with the CAB and the environmental committee of the Town of Helsingborg. The official exploratory discussion according to the Environmental Act, Chapter 9, was held when the first issue of the study of sites was presented on 17 January 2014.

Exploratory discussions were also held with the group of people (named the “dialogue group”) living in the vicinity of the Kemira industrial park. This group of public has presented its opinion about increase in traffic, noise levels and risk levels. As part of the preparatory works the HELGA project group has regularly held discussions with the dialogue group, the latest being on the 14th of October 2014.
Exploratory discussions have also been performed with organizations, such as Friends of Earth, on the 4th of December 2013. The Friends of Earth has presented a report to HELGA in which renewable fuels are preferred in front of fossil fuels.

The local board of rescue organizations (fire brigade) in Helsingborg that is both an authority for review of permit application as well as the authority for periodic inspection during operation has been continuously informed, by the project, of the studies and QRA.

9.4 General presentation of documents for the permit applications

The project appointed WSP Environmental AB, to prepare a general presentation document for permit application that not only includes the site study but also the risk assessments and the QRA for the basic scenario of the plant. This presentation will be the basis for a future study which will encompass the environmental consequences and handling of a water construction permit that are due to be initiated as soon as a decision is taken by the board regarding financing and construction of the plant.

9.4.1 Permit application for site construction works

When the described site studies are agreed with the involved parties a building permit to construct will be applied to the municipal city development board. The development board has the possibility to influence the appearance of the plant as well as to point out that certain building requirements shall be followed by the applicant. The review also includes the applicant’s proposal for inspections and competence of the staff that are responsible for construction inspections during site works. A construction permit is therefore required before the on-site works can commence. Final project completion is to be supported by project documentation from site inspections which shall be reviewed before the final construction report is presented to the local authorities of the city.

9.4.2 Permit application for handling and storage of flammable gases

As described above all matters referring to handling of flammable gas such as bio gas, natural gas and LNG are subject to review by the local rescue organization (fire brigade) primary according to Swedish legislation and current ordinance MSBFS 2013:3. The review will be performed mainly to verify that:

- The applicant is competent and reliable as manager and operator for the described installations and has engaged skilled people for inspections, operation and maintenance.
- There is an organization with a competent manager to handle the plant correctly also in case of mishaps.
The plant is constructed and maintained in accordance with valid regulations, EU directives, standards and the applicable codes for flammable gases as well as the electrical high tension and EX regulations.

Risk assessments are performed by the applicant, that the results are followed and that the plant is upgraded accordingly.

The permit for handling and storage of flammable gas, LNG, will be subject to periodic inspections by the local rescue organization.

The review by the local rescue organization will be done in close cooperation with the national Board for these matters, MSB (Swedish Council for Contingency) who is also involved in the review of the Seveso II application as described above.

9.4.3 Studies for preparations of other permit applications

As a part in the risk assessment scenario the risk levels of the different implementation steps of the project has been prepared. The risk assessment includes all phases of the HELGA project with the assessment of LNG being presented separately for each step. Storage and handling of LNG, loading and unloading of ships and trucks are included in the risk scenarios.
10 Risk analysis

10.1 Introduction

The project performed the first qualitative risk analysis in 2012. The risk analysis was revised in December 2014. The project has constantly worked to reduce the risks.

The risk analysis of the market and sourcing shows major difficulties to predict the LNG volumes to shipping and the price difference between LNG and MGO. The prevailing opinion (2014) in the Baltic Sea area is that a terminal based solely on sales to shipping will result in economic risks that exceed current risk thresholds.

As such, a LNG terminal cannot solely depend on shipping it must also serve land transportation and industries.

Demand for LNG/ LBG to heavy vehicles is growing daily. The industry is awaiting the development of the price for propane and oil. Market research in 2014 indicates that the volumes for shipping will start to grow significantly around 2020.

Profitability calculations show that following scenarios provides for an acceptable risk level:

**Step 1**

Building of a liquefaction plant, a storage tank and preparation of groundwork's for extension of the storage. The plant shall serve LNG to Heavy trucks and smaller vessels.

**Step 2**

Purchase of a LNG bunker vessel (according to a developed specification suitable for the market area).

Expansion of storage capacity with 3000 – 5000 m$^3$ (steel tanks).

Extension of the existing dock, allowing bunker vessel and feeder vessel to load and unload LNG from/to storage.

**Step 3**

Building of a full scale LNG facility with a 15 000 m$^3$ storage tank (full containment).

Dismantling and relocation of steel tanks to other sites.

**Step 4**

Building of a new jetty for feeder vessels up to 40 000m$^3$. 
10.2 Basic information

The risk analysis is performed for a terminal built on IPOS (Kemira) industrial estate in Helsingborg.

Only risks that fulfills following criteria's are considered:

✓ The risk consequence (cost) is one million Euros or more (based on current exchange rate at date of publishing)
✓ That could be regarded as “show stoppers”
✓ That could lead to delays of more than 6 months

10.3 Revised project risk analysis

Below are the events that reached risk level 6 or more in 2012. Now updated with performed actions, new information, recommended decision and new risk level.

<table>
<thead>
<tr>
<th>Item</th>
<th>Event / Consequence</th>
<th>Action</th>
<th>R-level today</th>
</tr>
</thead>
</table>
| 1,6  | Event
Modification/ extension of existing berth or New Jetty

Consequence
Authority approval regarding dock/jetty is denied.

Proposed actions from the authority are too costly.

The approval process is delayed more than 6 months. |
| Recommendation 2012: |
Start discussions with the authorities early. Investigate if existing berth of Kemira could be used. |
| Performed actions 2012-2014: |
There has been early contact with the authorities. Feasibility studies and surveys regarding existing berth and new locations have been performed. Ongoing discussions with pilots regarding suitable berth and vessels. |
| Recommended decision: |
| 1 for step 1 |
3 for step 2 |
1 for step 1 |
3 for step 2 |
2 for step 1 |
4-6 for step 2 |
| 1.7 | Event
It will not be allowed to bunker ship to ship in Öresund/ Bälten. |
| Consequence
The maritime market volumes will be lower. The cost for maritime LNG infrastructure will be higher. |
| Recommendation 2012: |
Start discussions with relevant Swedish and Danish maritime authorities. |
| New info during 2013-2014:
Viking Grace has been ship to ship bunkered more than 500 times. Nothing indicates that there will be a problem. |
| Performed actions 2013-2014:
The project has initiated a new project regarding a bunker vessel in Helsingborg “LNG in Baltic Sea II”. This project will investigate the matter. |
<p>| 4 for step 2 |</p>
<table>
<thead>
<tr>
<th>Event</th>
<th>Recommendation 2012:</th>
<th>Performed actions 2013-2014:</th>
<th>Step(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem getting approval for handling flammable liquids by the Swedish Civil Contingencies Agency (MSB).</td>
<td>Start discussions with the authorities early.</td>
<td>QRA, basic design drawings, P&amp;I-diagram and lay-out have been presented to MSB. No major obstacles are foreseen by MSB.</td>
<td>1-2 for step 1 2-3 for step 3 2-3 for step 3</td>
</tr>
<tr>
<td><strong>Consequence</strong></td>
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<tr>
<td>The terminal cannot be built.</td>
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<tr>
<td>The cost for building the terminal could be too high.</td>
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<tr>
<td><strong>2.1</strong> Event</td>
<td>Recommendation 2012:</td>
<td>Performed actions 2013-2014:</td>
<td></td>
</tr>
<tr>
<td>The price for LNG will be too high for the ship owners.</td>
<td>Follow the development through &quot;Swedish Gas Association&quot;.</td>
<td>Discussions with the ship owners show that the LNG price must be 20% less than the price for MGO. Ship owners want a price that is linked to the MGO price. The project has a limited budget for sourcing questions. Therefore a parallel project (not funded by EU) was set up to investigate the sourcing possibilities. Information from this project was made available.</td>
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<tr>
<td><strong>Consequence</strong></td>
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<tr>
<td>The maritime volumes will not grow.</td>
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<tr>
<td>The terminal could be too big and the investment and/or operation costs too high.</td>
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<tr>
<td><strong>2.2</strong> Event</td>
<td>Recommendation 2012:</td>
<td>Performed actions 2013-2014:</td>
<td></td>
</tr>
<tr>
<td>The maritime market will be smaller than expected.</td>
<td>Start discussions with the ship owners. Secure contracted volumes before building the terminal. Use the coordinator role to promote LNG for maritime use.</td>
<td>Market study and discussions with the major ship owners/ traffic buyers in the market area of Helsingborg.</td>
<td></td>
</tr>
<tr>
<td><strong>Consequence</strong></td>
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</tr>
<tr>
<td>The terminal could be too big and the investment - and operation costs too high.</td>
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<tr>
<td><strong>Recommended decision:</strong></td>
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<td></td>
</tr>
<tr>
<td>Start with a liquefaction plant using natural gas/bio gas from the gas grid.</td>
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<tr>
<td>Work with the sourcing question.</td>
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</tbody>
</table>
### 2.2.1 Event
“The volume growth will not correspond to the size of the terminal."
Terminal too big too early.
Wrong sizing of the terminal.

**Consequence**
Increase in investment – and/or operation costs too high.
Or
The full advantage of the business opportunities will not be used.

**Recommendation 2012:**
Start discussions with the ship owners, on shore transport buyer and industries. Investigate the smallest volumes that could be delivered by feeder vessel. Analyse margins and contract forms (sourcing/ sales price).
Consider to build the terminal in step.

**Performed actions 2013-2014:**
Discussions with the major ship owners/ traffic buyers in the market area of Helsingborg. Investigation of suitable technical design that could allow a cost effective stepwise building of a maritime LNG terminal. Profitability calculations for different scenarios.

**Recommended decision:**
Build up the terminal in 4 steps.
Start with a liquefaction plant using natural gas/ bio gas from the gas grid.

### 2.2.3 Event
Not being the first terminal in the market area

**Consequence**
A maritime LNG terminal in Helsingborg will be less profitable and it could lead to that the investment in step 2-4 will cancelled.

**Recommendation 2012:**
Start discussions with the ship owners, on shore transport buyer and industries. Try to collect LNG volumes with others all to find the best sourcing.
Be active and work with important stakeholders.
Find a bunker vessel solution. Consider building up the terminal in steps.

**Performed actions 2013-2014:**
Discussions with the major ship owners/ traffic buyers in the market area of Helsingborg.
Discussions with others to find common sourcing solution.
Active regarding bunker vessel solution.

**Recommended decision:**
Start with a liquefaction plant as soon as possible, using natural gas/ bio gas from the gas grid.

### 2.2.5 Event
The LNG terminal in Göteborg will get many customers and could start an initial price dump.

**Consequence**
The profit will be too low due to too low margins.
Investment in a terminal in Helsingborg will be delayed.

**Recommendation 2012:**
Follow the development.

**New info during 2013-2014**
There has not been any decision yet to invest in a terminal in Göteborg.

**Performed actions 2013-2014:**
Meetings with Swedegas.

**Recommended decision:**
Start with a liquefaction plant as soon as possible, using natural gas/ bio gas from the gas grid.
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>2.2.7 Bunker operators will operate from other ports than Helsingborg.</td>
<td>Start discussions with the ship owners. Secure contracted volumes before building the terminal.</td>
<td>Discussions with several bunker companies and ship owners. Started a bunker ship project within the MOS programme.</td>
<td>4-6 step 2</td>
</tr>
<tr>
<td>The ship owner will decide to bunker outside the market area of Helsingborg.</td>
<td></td>
<td></td>
<td>6-9 step 3</td>
</tr>
<tr>
<td>Consequence</td>
<td></td>
<td></td>
<td>6-9 step 4</td>
</tr>
<tr>
<td>The maritime volumes will not grow, the terminal could be too big and the investment – and operation costs too high.</td>
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<tr>
<td>Recommendation 2012:</td>
<td></td>
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<tr>
<td>2.3.1 The market for heavy vehicles will not develop as predicted.</td>
<td>Start discussions with the transport buyers and transportations companies.</td>
<td>Discussions with the transport buyers resulted in a filling station for LNG/ LBG at Filborna in Helsingborg. There is a growing need for LNG to heavy vehicles.</td>
<td>1-2 all steps</td>
</tr>
<tr>
<td>Consequence</td>
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<tr>
<td>The initial volumes will be too low for supporting a first step.</td>
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<tr>
<td>Recommendation 2012:</td>
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<tr>
<td>2.3.2 The market for industry will not develop as predicted.</td>
<td>Start discussions with the industries in the market area.</td>
<td>Industries have been contacted. The project cannot offer LNG, this has to be done by someone else.</td>
<td>1-2 all steps</td>
</tr>
<tr>
<td>Consequence</td>
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<tr>
<td>The initial volumes could be too low for supporting a first step.</td>
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<tr>
<td>Comments</td>
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<tr>
<td>Initially the volumes to vehicles and smaller ships will sufficient enough.</td>
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<td></td>
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<tr>
<td>Recommendation 2012:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5 Too few small feeder vessels available in the market.</td>
<td>Start discussions with feeder operators.</td>
<td>Market studies shows that the maritime market will grow slower than expected.</td>
<td>2-3</td>
</tr>
<tr>
<td>Consequence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The sourcing could face problems and then LNG price would be higher than expected, this could lead to small margins.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Recommendation 2012:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Event</td>
<td>Consequence</td>
<td>Recommendation 2012:</td>
<td>Performed actions 2013-2014:</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>Start with a liquefaction plant as soon as possible, using natural gas/ bio gas from the gas grid.</td>
<td>No market if LNG would be costly.</td>
<td>Secure good contacts with the government and authorities.</td>
<td>Ongoing contacts with government and authorities. No indication that LNG could face obstacles in the near future.</td>
</tr>
<tr>
<td>2.6 Event Swedish government starts to oppose against LNG to heavy trucks and ships.</td>
<td></td>
<td>Recommendation 2012:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The regional parliament (Region Skåne) starts to oppose against LNG to heavy vehicles and ships.</td>
<td>Inform politicians that the local air quality in Helsingborg will improve a lot. LNG can secure local jobs and create new.</td>
<td>Communication through different channels and events.</td>
</tr>
<tr>
<td>4.1.4 Event</td>
<td>Harder to get authority approvals? Slowdown in the market growth.</td>
<td>Recommendation 2012:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The market analysis is wrong.</td>
<td>Inform the organizations about the connection between LNG and LBG and that LNG will improve the local and global environment.</td>
<td>Discussions have been performed with the most important stakeholder's organisations.</td>
</tr>
<tr>
<td>7.1 Event</td>
<td></td>
<td>Recommendation 2012:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Get a second opinion from external expert.</td>
<td>A new market analysis has been performed by a Danish maritime expert in 2014, this show that the market growth in the maritime sector will be slower than earlier expected.</td>
</tr>
</tbody>
</table>
The full advantage of the business opportunities will not be used.

**Recommended decision:**
Start with a liquefaction plant as soon as possible, using natural gas/ bio gas from the gas grid. Work initially with the market for heavy vehicles and smaller ships.

<table>
<thead>
<tr>
<th>7.2</th>
<th><strong>Event</strong></th>
<th>The profitability calculation is not correct.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Consequence</strong></td>
<td>The terminal could be too big or too small and the investment and operation costs too high. Or The full advantage of the business opportunities will not be used.</td>
</tr>
<tr>
<td></td>
<td><strong>Recommendation 2012:</strong></td>
<td>Get a second opinion from external expert.</td>
</tr>
<tr>
<td></td>
<td><strong>Performed actions 2013-2014:</strong></td>
<td>An external consultant made a second opinion in august 2014.</td>
</tr>
<tr>
<td></td>
<td><strong>Recommended decision:</strong></td>
<td>Start with a liquefaction plant as soon as possible, using natural gas/ bio gas from the gas grid. Work initially with the market for heavy vehicles and smaller ships</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7.5</th>
<th><strong>Event</strong></th>
<th>Few real stakeholder contacts.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Consequence</strong></td>
<td>The understanding of the market, sourcing and the possibilities for entering a partnership with a bunker company will be lost. This could lead to a total misjudgement of the opportunities for the LNG business.</td>
</tr>
<tr>
<td></td>
<td><strong>Recommendation 2012:</strong></td>
<td>Start the sales work early, work with other to set up a reliable infrastructure. Start communication with the major customers and stake holders.</td>
</tr>
<tr>
<td></td>
<td><strong>Performed actions 2013-2014:</strong></td>
<td>An external consultant made a second opinion in august 2014.</td>
</tr>
<tr>
<td></td>
<td><strong>Recommended decision:</strong></td>
<td>Start with a liquefaction plant ASAP, using natural gas/ bio gas from the gas grid. Work initially with the market for heavy vehicles and smaller ships</td>
</tr>
</tbody>
</table>
11 Key success factors

11.1 Suitable location for a LNG-terminal

The port of Helsingborg has access to a suitable site, which has a strategic location with close proximity to both sea routes and European highways (E4 and E6). It is also an advantage that the potential market consists of three different segments (heavy trucks, industry and shipping):

- Approximately 45 000 ships per year
- Approximately 3 million heavy trucks per year

11.2 Access to a renewable alternative

NSR today produces biogas that can be liquefied to LBG (liquefied bio gas). That would give access to a locally produced renewable product that can be used to increase interest for liquefied gas. Several customers are looking to increase their environmental profile and therefore require that their products will be transported with low environmental impact. This may lead to requirements for ship and truck owners to switch to LNG fuel.

11.3 Efficient and reliable infrastructure

LNG is a new fuel for the maritime sector that currently leads to high investment costs compared to existing alternatives for the customers who want to switch fuels. The small scale infrastructure to handle the liquefied gas is not completely developed in every part of the value chain, leading to costly investments for the first movers.
11.4 Exchanging best practice
Helsingborg is the coordinator of the EU project LNG in the Baltic Sea Ports. It provides the opportunity for the exchange of best practice with other ports and other LNG projects around the Baltic Sea.

11.5 Cooperation with nearby ports
Another port in the region could build a terminal that would result in competition on the geographic market. To avoid this, there are discussions about creating a common infrastructure with nearby ports in the region.

11.6 Price difference between LNG and MGO
A high price of LNG compared with MGO and other options may make it impossible to create a profitable business.

11.7 The impact of the SECA-directive
If the introduction of the new sulphur regulations in 2015 are not connected to sanctions it could lead to a delay to development or no change in fuels used within the shipping segment.
12 Appendix

Appendix 1, Lokaliseringsutredning (2014), SWECO

Appendix 2, LNG Demand for Shipping (2012), Ramböll

Appendix 3, Marknad – Industri och Transport (2013), ÅF

Appendix 4, Geological Investigation Study

Appendix 5, Basic Design Study
  - Technical description (2014), Norconsult
  - Kostnader för LNG terminal (2014), Norconsult
  - Kostnadssestimat og plassbehov (2014), Norconsult
  - Terminal – plan (2014), Norconsult
  - Terminal – schema (2014), Norconsult

Appendix 6, Port Study
  - Fördjupad utredning LNG kaj vid Bulkhamnen i Helsingborg (2014), SSPA

Appendix 7, Seabed Investigations
  7.1 Marinbiologisk undersökning kring västra bulkhamnen 2014 i Helsingborg (2014), Clinton & SSPA
  7.2 Miljöeffekter av muddring nära Knåhakens marina reservat (2014), Clinton & SSPA

Appendix 8, LNG terminal, Quantitative risk analysis overview, QRA
  - Projekt HELGA – LNG-terminal, Övergripande kvantitativ riskanalys, QRA, Tove Prag.

Appendix 9, Requirements for development of a quantitative risk analysis for a LNG terminal in Helsingborg
  - Arbetssteg för genomförande av kvantitativ riskanalys för LNG-terminal i Helsingborg upprättat av COWI (Davidsson & Karlsson).

Appendix 10, Risk analysis supporting documents.
  - Underlag riskanalys, HELGA projektet, Helsingborg, Etapp 1 – 3, Strateco.

Appendix 11, Calculations based on project material.
  - QRA- beräkningar utifrån projektmaterial av WSP Risk, Björn Yndemark.