HELGA II, a part of LNG in Baltic Sea Ports II

DESIGN OF A MULTIFUNCTIONAL BUNKER SHIP

FINAL REPORT HELGA II, 2016

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</tbody>
</table>
0. Conclusions

General

- From the work conducted under the project HELGA I, we know that approximately 80% of the sales volume from an LNG storage of 15,000 m$^3$ will be to the maritime sector. In order to reach the maritime volumes an LNG bunker ship is required that can easily provide ship to ship bunkering.

- The work conducted since 2011 has clarified our awareness that all predictions regarding market, sourcing and competing fuels have been challenged by political and economic realities. To rely on just one fuel would most likely jeopardize a ship owners business. In an unpredictable future one needs to be flexible. A multifunctional bunker ship that can easily adapt to market and fuel price fluctuations is in our belief the best solution to enable this.

- Another important lesson learned is that a new infrastructure for bunker fuels needs a co-operation between multiple stakeholders. Competition and “all benefits to me attitude” within the “LNG family” will kill investments. The competition from other fuels is already tough enough to handle.

- A dialog with the customers (ship owners) and possible bunker operators is crucial in finding a multi-functional bunker concept that can be in operation on different market areas for a long period. In that process one will also need a skillful and innovative design company (like OMT).

- The “truth” that the ship owners will not retrofit their ship to LNG is not valid for tanker vessels in the market area of Helsingborg. Nine tanker vessels will be retrofitted with dual fuel engines. These ships will need a small amount of MGO for the auxiliary machinery and for ignition, the main engines can run on LNG or MGO. Should the bunker operator think LNG or think full service (LNG, MGO, ship supply)? We believe that Helsingborg should enter the service track.

- Ship owners find Helsingborg to be an attractive location for bunkering. They want to bunker ship to ship close to the terminal site. A very suitable place is the Helsingborg road located outside the port of Kemira, south of the terminal site.

- Ship owners prefer to bunker both LNG and MGO at the same operation. It would be a strong benefit if they also can get ship supplies simultaneously thus further improving marketability of fuel sales from the LNG storage facility in Helsingborg.
Bunker ship

The ship is a highly flexible platform that enables the operator to:

- Start with a small number of LNG storage tanks and increase the number of LNG storage tanks as the market develops.
- Transport a large amount of diesel bunker on-board enabling a diesel bunker trade in the beginning (more tanks than what is shown on the lay-outs can be installed if this is requested).
- The open deck installation allows a high degree of independent design of the top side.

Main Dimensions and Data

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length OA max.</td>
<td>95,30 m</td>
</tr>
<tr>
<td>Rule length</td>
<td>92,44 m</td>
</tr>
<tr>
<td>Breadth (MLD)</td>
<td>18,00 m</td>
</tr>
<tr>
<td>Depth to upper deck (MLD)</td>
<td>6,00 m</td>
</tr>
<tr>
<td>Design draught</td>
<td>3,5 m</td>
</tr>
<tr>
<td>Gross tonnage</td>
<td>3700 tons</td>
</tr>
<tr>
<td>Deadweight at design draft, Abt</td>
<td>2,082 tons</td>
</tr>
<tr>
<td>Service speed</td>
<td>8-10 knots</td>
</tr>
<tr>
<td>Fuel</td>
<td>LNG or diesel</td>
</tr>
</tbody>
</table>

The ship equipped with two (2) steerable thrusters serving as rudders

One bow thruster
1.0 Back Ground

HELGA, Helsingborg Liquid Gas Association, are four companies and two associations in a joint effort to establish a LNG/ LBG infrastructure in the area of Helsingborg southern Sweden. The work started in 2011

Companies

- Öresundskraft – energy company
- KEMIRA – large industry and site owner
- Port of Helsingborg
- NSR – producer of biogas

Associations

- Sveriges hamnar
- Energias Sverige

Projects in Helsingborg

HELGA I, studies, the project was finished in 2014, and a report is available. HELGA I was an activity in the project LNG in Baltic Sea Ports I (*). (Co-financed by EU).

HELGA II, design of a multi-functional bunker ship suitable for the market area in Helsingborg. The work that was co-financed by EU was finished December 2015. The dialog with ship owners and other stakeholders is still ongoing. HELGA II was an activity in the project LNG in Baltic Sea Ports II (*). (Co-financed by EU).

HELGA III, design and construction of step I in the building of a LNG terminal in Helsingborg, starting with a liquefaction plant with a filling station. The work has started. The project is a part of project HEKLA that is a co-operation between HELGA, Klaipedos Nafta and Actia Forum. (Co-financed by EU).

LBG/ LNG Filling station for heavy trucks installed 2014.

*) More info can be found at http://www.lnginbalticseaports.com

Fillingstation for LBG/ LNG
2.0 Main goal – HELGA II

Description in Commission Decision, ‘LNG in Baltic Sea Ports II’ - 2013-EU-21007-S - in the field of the trans-European transport network (TEN-T), annex II:

The objective of this activity is to design a multifunctional bunker ship solution in south of Sweden.

The main purpose is to identify technical and functional solution for a bunker ship that can operate in the area. The design documentation will be a part of the “Invitation for Tender” for a bunker vessel. The documentation shall support a turn-key agreement (design and built) with a shipyard. This option is financially more advantageous than procurement of design and construction separately. Next phase will be a design and built bunker ship, through a turn-key contract.

The bunker ship will be a multi-function ship that can provide: (i) LNG bunkering (ii) MGO bunkering (iii) Other services (ship supply services).

The following shall be stated for the LNG bunker ship: (i) size (ii) number fuel tanks (iii) type of bunker fuel that the ship shall carry (the ship shall be running on LNG) (iv) type of other services that should be performed by the ship and its crew (v) bunkering devices and type of bunkering procedures (vi) functional demand regarding bunkering (weather condition, wave height, safety devices, flow demands, ice class etc.

The outcome of this activity will be the technical design of a multi-functional bunker ship that will satisfy all important stakeholders in the area. It will require that the conditions in the local ports must be analysed.

Work method

The process started with establishing basic design parameters (based on the local market conditions) and ending with in depth design solution that could be attractive for a bunker operator in the area of Helsingborg.
3.0 Work process

The work process is illustrated below:

The process to find a final bunker ship design was iterative. Ideas have been challenged, experience and demands from ship-owners and bunker operators have played an important role together with the technical knowledge at the design company OMT *).

*) More information about OMT can be found at: http://www.odensemaritime.com
3.1 Identify market demands and possibilities

The knowledge from the market work in HELGA I was the foundation for the work. Following was available from HELGA I:

- Market report - LNG demand from shipping, report made for HELGA I by Ramböll.
- Demand Study regarding maritime volumes in the market area of Helsingborg based on interviews with ship owners, made by Helle Bjerre.
- Stakeholders analysis made by HELGA and external consultants.
- Minutes of meeting with bunker operators, ship owners, neighbouring ports, pilots, maritime authorities, etc.
- LNG report from CMP made by SSPA, made available by the partners ship within LNG in Baltic Sea Ports I.
- The DMA report from 2012 has also been considered.

The project started with in depth discussions with bunker operators. More than five bunker operators have been approached. There have been in-depth discussions with 3 bunker operators. There has also been in depth discussions with several ship owners.

Result:

In narrow time three tank ship operators will retrofit their tank fleet into dual fuel machinery for the main engines. The auxiliary machinery will still be running on MGO. The retrofitted tankers can choose to go on LNG or MGO, depending on the fuel price. This is something that the project believe will be a common approach for many ship owners.

Many new build ships will also have this possibility to choose fuel depending on the fuel price. There are many reasons for this, one is of cause the residual value for the ship when it will be sold.
The market area for a bunker vessel in Helsingborg was changed after in depth discussions with bunker operators and ship owners.

The ship owners prefer to bunker ship to ship on Helsingborg road located outside the port of Kemira where the LNG bunker terminal will be built.
Conclusion:

✓ Ship owners find Helsingborg to be an attractive location for bunkering.

✓ Ship owners do not want to bunker in the port. They want to bunker ship to ship close to the Kemira site (Råå’s Redd).

✓ Ship owners prefer to bunker both LNG and MGO at the same operation. It would be a benefit if they also can get ship supply simultaneously.

3.2 Establish basic design criteria’s

We decided to work in business orientated process, initially considering following topics:

- Market demands
- Authority demands
- OPEX
- Risk

- Operational demands
- Possibilities locally
- CAPEX

All information gathered from HELGA I, in depth discussions was analysed and discussed with design companies, this combined with the main goal for HELGA formed the basic design criteria’s.
3.3 Identify different bunker ship concepts

Initially the HELGA project decided to look into following concepts:

A) Retrofitting existing bunker ship, so it can carry MGO, ECO fuel, and LNG. Total tank volume 2000 -3000 m3.

B) Retrofitting existing bunker ship, so it can carry MGO, ECO fuel, and LNG. The machinery shall be converted/ replaced to LNG propulsion Total tank volume 2000 -3000 m3.

C) A new bunker ship carrying LNG, MGO and HFO with high flexibility to adjust to new markets conditions. Total tank volume 2000 -3000m3.

D) A new self-propelled bunker barge for LNG and MGO (classed for inland waterways).

E) Retrofitting an existing bunker barge to carry MGO and LNG. An existing tug boat will transport the barge. LNG tank appr 500 m3, MGO tank appr 500 m3

The Danish company OMT was selected for making the investment- and operation costs calculations for the concepts above. During the initial discussions, OMT suggested that an additional concept should be considered, and this was accepted by the project.

The concept was:

F) A 2nd hand transport barge is acquired and equipped with 40” ISO insulated LNG containers in the deck.
3.4 Calculations of different bunker ship concepts

Limitations for the price calculations:

- It was assumed that there are no requirements from port related to manoeuvring capability, speed and engine reliability.
- Due to the location in open weather vacuum insulated tanks are preferred. (They consist of a stainless “wetted” inner tank, a layer of perlite insulation and an outer tank in mild steel capable of resisting the negative pressure.)
- +/-20% accuracy in the calculations

Result of the investment cost calculations

Investment cost:

- Concept A: Price appr. 50 - 70 Million SEK
- Concept B: Price appr. 70 – 90 Million SEK
- Concept C: Price appr. 210- 220 Million SEK
- Concept D: Price appr. 130 – 140 Million SEK
- Concept E: Price appr. 72 - 75 Million SEK
- Concept F: Price appr. 63 - 65 Million SEK

Comments

Concept A and B will have a limited residual value the operational cost will be high.
Concept C was judged to be too expensive, the capex will most probably be too high for the available bunker volumes.
Concept D, Inland waterways is not applicable for the market/ bunker area.
Concept E, suitable local tugs are not operating in the area of port of Helsingborg.
Concept F is not flexible enough and the residual value will be low.

Conclusions

The evaluation showed that a new concept was required.
3.5 Selected bunker ship concept

After evaluating the cost calculation report and the following discussions with tug operators, bunker operators and OMT, the project decided to **develop following bunker ship concept**:

A self-propelled barge/vessel with one or two LNG tank(s) with a total volume of 500 m³ on the deck or in hull depending on design (assumed to be type-C) and a number of ISO 40” LNG containers as space allows.

MGO tank(s) shall be included in the hull on say preferably 300 m³ in order to allow supply of MGO and ignition oil to dual-fuel engines.

Speed = 7-9 knots

Hull shape = Barge like shape suitable for local operational area.

The accommodation shall be made for 6 persons as regular crew but also be able to hold a number of trainees on-board.

The vessel shall be easy to modify after changed market conditions.

Dual fuel machinery (LNG and MGO).
3.6 Establish final design criteria’s

During the design phase the final design criteria’s was constant under revisions all to find a market and business orientated final design.

- The bunker ship shall perform full service to the ship owners (LNG, MGO, Supplies.)
- The design shall allow for full competition between European ship builders, no in-house LNG competence shall be required.
- Standard barge concept allows for low investment cost.
- Flexibility allows for low operational cost.
- High residual value allows for low Capex.
- ETC

The final design is based on making a versatile ship allowing to:

- Carry a large amount of diesel, also larger than the normal volume considered for a LNG bunker tanker.
  - Allows for diesel trade in the beginning until the LNG market develops
  - Allow scaling of the LNG volume as market develops by adding more tanks on the deck

The ship shall be flexible and adaptable to market changes. The residual value after 20 years shall be high.
Port Restrictions in the market area (data collected by OMT).

<table>
<thead>
<tr>
<th>Port</th>
<th>Draught m</th>
<th>Length m</th>
<th>Beam m</th>
<th>Air m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ystad</td>
<td>6.7</td>
<td>170</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Trelleborg</td>
<td>7.4</td>
<td>200</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Malmø</td>
<td>11.4</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>11.4</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Halmstad</td>
<td>6.5</td>
<td>200</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Århus</td>
<td>No detailed information but no relevant limitations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helsingborg, West port - Container</td>
<td>9</td>
<td>Quay from 80m and up</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Helsingborg, South port - Tankers, RORO</td>
<td>5-6</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Design</td>
<td>3.5</td>
<td>95</td>
<td>18</td>
<td>21.6</td>
</tr>
</tbody>
</table>

3.7 Selected design company

The design company Odense Maritime Technology A/S (OMT) was selected for making the final design of the bunker ship. For more information of OMT see:

http://www.odensemaritime.com
4. Bunker ship designed for the market area of Helsingborg.

4.1 GENERAL

The ship is a highly flexible platform that enables the operator to:

- Start with a small number of LNG storage tanks and increase the number of LNG storage tanks as the market develops.
- Transport a large amount of diesel bunker on-board enabling a diesel bunker trade in the beginning (more tanks than what is shown on the lay-outs can be installed if this is requested).
- Carry a number of 40" ISO gas containers on the upper deck enables the operator to provide LNG to ports very fast e.g. between a ferry departure and arrival. The containers are designated as “swift containers”.
- The open deck installation allows a high degree of independent design of the top side.

The ship shall be designed and constructed as an environmentally friendly, all welded steel ship with gas/diesel electrical thruster propulsion.

The engine room is located below the superstructure aft. The forward mooring platform is located on the forecastle deck.

Diesel is carried in the hull, LNG carried on deck. Hence compared to most others tankers it is capable of operating as a standard bunker tanker.

Vacuum insulated double-shell type-C tanks (due to the fact that the tanks are exposed to weather).
4.2 LAY – OUT

Lay-out of the bunker ship developed for the market area of Helsingborg (Drawing available in appendix 1).
Lay-out of the bunker ship developed for the market area of Helsingborg (Drawing available in appendix 1).
4.3 Main Data

**LNG BUNKER VESSEL**

**MAIN DIMENSIONS (ALL APPROX):**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH OA MAX.</td>
<td>95.30 m</td>
</tr>
<tr>
<td>LENGTH PP APPROX.</td>
<td>93.10 m</td>
</tr>
<tr>
<td>RULE LENGTH</td>
<td>92.44 m</td>
</tr>
<tr>
<td>BREADTH (MLD)</td>
<td>18.00 m</td>
</tr>
<tr>
<td>DEPTH TO UPPER DECK (MLD)</td>
<td>6.00 m</td>
</tr>
<tr>
<td>DESIGN DRAUGHT</td>
<td>3.50 m</td>
</tr>
<tr>
<td>DWT (DESIGN DRAUGHT), GROSS GAS</td>
<td>2000.0 m³</td>
</tr>
<tr>
<td>DWT (DESIGN DRAUGHT), DIESEL</td>
<td>2028.0 t</td>
</tr>
<tr>
<td>SERVICE SPEED (SCANTLINGS DRAUGHT) ABT.</td>
<td>8.0-10.0 kn</td>
</tr>
<tr>
<td>CREW, SINGLE CABINS</td>
<td>8-9</td>
</tr>
<tr>
<td>GROSS TONNAGE</td>
<td>3,700</td>
</tr>
</tbody>
</table>

**CLASS NOTATION:**

ABS * A1 LIQUEFIED NATURAL GAS CARRIER
WITH INDEPENDENT TANKS, ACCU, ICE-CLASS 1C

FOR DIESEL BUNKER VERSION OIL CARRIER
(FLASHPOINT >60°C)

**DEADWEIGHT**

Deadweight at design draft Abt. 2.082 t

**SPEED**

The speed is subject to final power predictions but is expected to provide a service speed of 8-10 knots, with 15% sea margin, draught 3.5, calm weather and clean hull.

**FUEL**

Natural gas or diesel. The engines are capable of running at sulphur DO with a viscosity of minimum 1.8 cSt at engine inlet.
4.4 RULES AND REGULATIONS

The vessel shall be detailed designed, constructed and outfitted in accordance with the rules and regulations of American Bureau of Shipping (ABS) with the following base lines class notation (additional notations may be added in final design).

ABS Unrestricted Navigation +A1 Liquefied natural gas carrier with independent tanks, GFS, ACCU, ICE CLASS 1 C.

OTHERS:

- Class Rules according to Class Notation
- Maritime Regulations of the Flag State
- International Load Line Convention
- International Convention for the Safety of Life at Sea, SOLAS
- International Convention for the Prevention of Pollution from Ships, MARPOL
- International Convention on the Control of Harmful Anti-Fouling Systems on Ships
- International Convention on Tonnage Measurement of Ships,
- International Telecommunication Union (ITU) Radio Regulations, including GMDSS rules
- International Labour Organisations Maritime Labour Convention
- MSC Requirements for Emergency Towing
- CSS CODEIMO Res. MSC337(91) Code on Noise Level on board Ships
- ISO 6954:2000, guidelines for the overall evaluation of vibrations in ships
- IMO NOX Tier II compliance for engines (engine fulfills TIER III in gas operation)
- INMARSAT Regulation
- IEC requirements for electrical installations in ships
- IMO Res. A 574 (XIV), Recommendation on General Requirements for Electronic Navigation Aids
- BNWAS – Bridge Navigational Watch Alarm System
- IGC-code

4.5 HULL

- Designed with a vertical stem with a small flare to minimize wave resistance.
- The slim design of forward ship allows for installation of a tunnel thruster
- Large skeg aft to improve course stability
- Relatively large block coefficient to provide large carrying capacity for combined diesel and LNG
- Small amount of curved plates to ease production; hence lowering the production cost
4.4 Manoeuvring and Propulsion

Manoeuvring

Rudder:
The ship is equipped with two (2) steerable thrusters serving as rudders

Thruster:
One (1) bow thruster
- Electrical motor (690 kW) with frequency drive
- Fixed pitch propeller, diameter appr. 1.2 m

Propulsion

Diesel Engines for propulsion:

Two (2) 4-stroke generator set are installed for supplying power to the electrical propulsion system and auxiliary systems. The engines are of dual-fuel type with integrated double wall piping designed for running on natural gas with pilot diesel fuel or running on diesel.

When running on natural gas the engines fulfills TIER III. The engines also serves as BOG removing devices.

Air suction for the engines will be taken from the engine room.
Engine
Specified maximum continuous rating (SMCR)
Turbochargers
Number of cylinders
Fuel

Wärtsilä 6L20DF
1,100 KWe, each engine
1 pcs
6 (six) each engine
Natural gas or diesel.
The engines are capable to run on low sulphur DO with a viscosity of minimum 1.8 cST at engine inlet.
In accordance with ISO3046-1-2002, i.e barometric pressure 100 kpa, air temperature 25 °C, relative humidity 30%.

Ambient conditions for output

Propellers

Two (2) steerable thrusters are installed each with a 4-bladed propeller with a diameter on approx. 1500 mm.
The blades are manufactured in accordance ISO to ISO484-1981, class 1 and the surface according to ISO484-1981 class 2.
4.8 Accommodation

**Upper deck**

The upper deck area consists of the service function and 2 slots that can be used for cabins or for other purposes.

This allows e.g. students to be accommodated on board in single cabins.

**A-deck**

On A-deck the majority of the crew cabins are located.

All cabins are equipped with own bath and toilet.

The cabins for captain and chief officer are designed to officer standard.
Void deck

HVAC and bridge electronic are located right below the bridge.
APPENDIXES

APPENDIX 1:

APPENDIX 2:
General Arrangement, doc 101-100-005, rev A