Planung eines „small scale LNG Terminals im Hamburger Hafen“
Rostock, Januar 09th, 2014
Bomin Linde LNG is a joint venture between Marquard & Bahls / Bomin and Linde AG to supply marine LNG

- 50-50 joint venture (JV) was founded in October 2012
- M&B / Bomin:
  - Leading independent bunker supplier
  - Other relevant competencies covered via Oiltanking
- Linde: leading supplier of industrial gases
- Objective: become a leading supplier of LNG as a marine fuel LNG in ECA waters
ECAs in Amerika und Europa

source: Rolls-Royce 2011
By 2015 new emission limits for sulphuroxides to be introduced, ship owners/operators need to act

Emission limits: $\text{SO}_x$ and $\text{NO}_x$

**Comments**

- Stricter emission limits in Emission Control Areas (ECA)
  - North Sea
  - Baltic Sea
  - English channel
  - US and Canadian coastline
- Reduction in sulphuroxides:
  - ECA: by 2015 from 1% to 0.1%
  - Global (aim): by 2020 from 3.5% to 0.5%
- Timing for reduction in nitrogenoxides under discussion

Ship owners/operators need to act: new emission limits cannot be met by present use of Heavy Fuel Oil as bunker fuel
There are three ways to comply with future emission limits: MGO, LNG and HFO + Scrubber

**Marine Gas Oil (MGO)**
- Distillate fuel with reduced sulphur content (<0.1%)
- MGO today already 50% more expensive than HFO
- Price increase due to rising demand by 2015 highly likely

**Liquid Natural Gas (LNG)**
- Natural gas, cooled down to around -160° C, at which point it contracts to form a liquid
- Cheaper than MGO
- Sustainable: LNG meets all current and planned emission limits

**Heavy Fuel Oil (HFO) + Scrubber**
- Scrubber: permanently installed desulphurization system
- Operating challenges (e.g. increasing fuel consumption, handling of resulting hazardous waste)
- Sustainability questionable

10/01/2014 Source: Bomin Linde LNG
**LNG emissions versus HFO and MGO**

Indicated emissions to air from LNG and liquid petroleum fuels for ships.


<table>
<thead>
<tr>
<th>Fuel type</th>
<th>SOx (g/kWh)</th>
<th>NOx (g/kWh)</th>
<th>PM (g/kWh)</th>
<th>CO2 (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual oil 3,5% sulphur</td>
<td>13</td>
<td>9-12</td>
<td>1,5</td>
<td>580-630</td>
</tr>
<tr>
<td>Marine diesel oil, 0,5% sulphur</td>
<td>2</td>
<td>8-11</td>
<td>0,25-0,5</td>
<td>580-630</td>
</tr>
<tr>
<td>Gasoil, 0,1% sulphur</td>
<td>0,4</td>
<td>8-11</td>
<td>0,15-0,25</td>
<td>580-630</td>
</tr>
<tr>
<td>LNG (natural gas)</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>430-480</td>
</tr>
</tbody>
</table>

Source: Marintek

10.000 ton LNG HVC comply: 152.000.000 kWh

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>SOx (kg)*</th>
<th>NOx (kg)*</th>
<th>PM (kg)*</th>
<th>CO2 (kg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual oil 3,5% sulphur</td>
<td>1.976.000</td>
<td>1.596.000</td>
<td>228.000</td>
<td>91.960.000</td>
</tr>
<tr>
<td>Marine diesel oil, 0,5% sulphur</td>
<td>304.000</td>
<td>1.482.000</td>
<td>57.000</td>
<td>91.960.000</td>
</tr>
<tr>
<td>Gasoil, 0,1% sulphur</td>
<td>60.800</td>
<td>1.482.000</td>
<td>30.400</td>
<td>91.960.000</td>
</tr>
<tr>
<td>LNG (natural gas)</td>
<td>0</td>
<td>304.000</td>
<td>0</td>
<td>69.160.000</td>
</tr>
</tbody>
</table>

10.000 ton LNG LVC comply: 137.000.000 kWh

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>SOx (kg)*</th>
<th>NOx (kg)*</th>
<th>PM (kg)*</th>
<th>CO2 (kg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual oil 3,5% sulphur</td>
<td>1.781.000</td>
<td>1.438.500</td>
<td>205.500</td>
<td>82.885.000</td>
</tr>
<tr>
<td>Marine diesel oil, 0,5% sulphur</td>
<td>274.000</td>
<td>1.335.750</td>
<td>51.375</td>
<td>82.885.000</td>
</tr>
<tr>
<td>Gasoil, 0,1% sulphur</td>
<td>54.800</td>
<td>1.335.750</td>
<td>27.400</td>
<td>82.885.000</td>
</tr>
<tr>
<td>LNG (natural gas)</td>
<td>0</td>
<td>274.000</td>
<td>0</td>
<td>62.335.000</td>
</tr>
</tbody>
</table>

* average value
According to DNV the outlook for LNG-fuelled vessels is positive – 400 vessels in Europe by 2020

LNG fuelled vessels world-wide & per region per shiptype

Comments

- Especially tanker and Offshore segments expected to grow strongly after 2015
- Slower developments in the segments: passenger ships, RoRo’s and container vessels
- DNV expects 1,000 vessels to be running on LNG by 2020 of which 400 will operate in Europe
The North-West European marine LNG market expected to account for close to 300,000 t per year by 2015

<table>
<thead>
<tr>
<th>North-West European marine LNG market [t/ year]¹)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph showing LNG market growth" /></td>
<td>- Baltic sea and ARA region expected to grow significantly after 2015</td>
</tr>
<tr>
<td></td>
<td>- North sea region with high progressive growth starting in 2009</td>
</tr>
<tr>
<td></td>
<td>- Norwegian coast area expected to remain in steady-state after 2014</td>
</tr>
<tr>
<td></td>
<td>- Development of an LNG market in the English Channel expected to begin by 2015</td>
</tr>
</tbody>
</table>

¹) Excluding large LNG carriers, includes firm and speculative vessels
Definition of LNG bunker sizes

Large Scale
large
> 50,000 m³

Medium Scale
middle
10,000 – 50,000 m³

Small Scale
small
< 10,000 m³

Source: GUS & BominLinde
LNG operation in Germany – A long history!

- 2 x middle sized LNG plants since >40 years in operation
- Several small scalled satellites plants exists
- LNG as fuel for trucks
- Mobile vapour units
- Usage of LNG in the industry
- Know-How for engineering / cryogenic equipment exists

Source: GUS & BominLinde LNG
Bomin Linde LNG builds LNG infrastructure in the North- and Baltic sea

LNG supply chain

BLLNG core activities

- **Comments**
  - Bomin Linde LNG is able to cover the entire LNG value chain
  - This is enabled through competence as well as financial commitment internally as well as from the shareholder side
  - “Tailor made solutions” such as small terminals and individual bunkering locations can be realized depending on volume demand
  - Economies of scale key for intermediate storage and transportation
Bomin Linde LNG is ready to deliver in Sweden, three more terminals in permitting / approval process

Bomin Linde LNG locations in Europe

Stockholm (Linde)
- Operational
- 20,000 cbm capacity
- LNG Bunker Barge AGA Seagas

Hamburg (Bomin Linde LNG)
- Planned
- Capacity up to 6,000 cbm (Phase 1)
- Option to expand significantly

Bremerhaven (Bomin Linde LNG)
- Planned
- Initial capacity up to 4,500 cbm

Rotterdam (Bomin Linde LNG)
- Planned
- Capacity up to 1,500 cbm
- Focus on inland market

1/10/2014 Source: Bomin Linde LNG
Operational experience: BLLNG has access to Nynäshamn LNG terminal and Seagas bunker barge

Nynäshamn LNG terminal

- 20,000 m³ terminal in operation since 2011 with several 250 m³ LNG tanks
- Terminal located next to the Nynas refinery
- BLLNG has full access to both terminal and bunker vessel (exclusivity for marine LNG)

Comments
Operational experience: BLL has access to Nynäshamn LNG terminal and Seagas bunker barge

**Case study: Seagas bunker barge**

- World’s first LNG bunker barge
- Ferry Viking Grace as lead customer (55,000 dwt)
- Bunkering of Viking Grace 5-6 times a week in less than 1 hour
- No methane slip due to use of dry cryogenic couplings
- Official christening in March 2013 in Stockholm
For LNG installation several rules & standards have to be considered:

- **LNG relevant rules & standards are e.g.:**
  - DIN EN 1473 LNG plants (materials)
  - DIN EN 1160 characteristic of LNG
  - DIN EN 13645 LNG plants < 200t
  - DIN EN ISO 28460 Ship to shore interface and port operations
  - SIGGTO regulations (Society of International Gas Tankers and Terminal Operators)
  - GIIGNL regulations (International Group of Liquified Natural Gas Importers)

- **Other rules & standards:**
  - DIN EN 13458 Kryo – stationary vessel vacuum insulated
  - Operation Safety regulation (Betriebssicherheitsverordnung) with
    - Techn. Regelwerk für Betriebssicherheit (operational safety for liquid gas! *)
    - Approval for filling station
    - Explosion preventing documents
LNG is a boiling liquid
Every heat impact results in a small vaporization of liquid = Boil-off-Gas
Boil-off-Gas is (depending on its composition) at approx. -100 °C lighter than air
Boil-off-Gas can not be prevented
Methods to handle Boil-off-Gas are:

- Storage is designed as pressurized vessel
- Pressure reduction by cooling down / liquefying gas phase in storage with LIN
- E&I facilities to alarm unforeseen high pressure in storage
- E&I safety protection systems to shut down systems, close valves, stop pumps
- Controlled venting of LNG with control valves venting facilities
- Redundant safety valves on each storage
Bomin Linde LNG Terminal in Hamburg
Design of Bunker Station

Trucks/Container

30 trucks/week
60 container/week
36 m³/h
~ 2 barg
~ -160 °C

LNG storage
cylindric, vacuum insulated,
horizontal pressurized vessels

Min. 474 m³ (Ø 5.4m x 29 m)
Max 1700 m³ (Ø 8 m x 46 m)
Design: 8 barg/-196 °C

Total capacity: 6000 m³
Total storage: approx. 2690 t
(@ density 448 kg/m³)

40 ships/week
102/250 m³/h
~ 5.5 barg
~ -135 °C

Source: GUS & BML LNG
Bomin Linde LNG Terminal in Hamburg
Basis of Design

System groups

- Loading/unloading of trucks and containers
- LNG-Storage tanks
- Loading/unloading of ships
- LIN supply system
- Safety & Protection facilities
- Auxiliary systems

Operation Modes

- Filling of storage via truck
- Filling of storage via LNG bunker barge
- Filling of LNG container
- Filling of LNG truck
- Filling of LNG Bunker Barge
- Bunkering of LNG driven ship
- “Hold modus” (keeping LNG at condition if no loading/unloading occur)
- Emptying of LNG driven ships (for maintenance)
- **LNG filling station for trucks (LNG driven)**

Source: GUS & BLLNG
Bomin Linde LNG Terminal in Hamburg
Location: Hamburg at Oitanking in Kattwykhafen

1/10/2014  Source: Bomin Linde LNG
Bomin Linde LNG Terminal in Hamburg
PFD (Process Flow Diagram)
Bomin Linde LNG Terminal in Hamburg
Layout
Bomin Linde LNG Terminal in Hamburg
Layout 3D

Source: BMLLNGL
Basis of Design finalised
Basic Engineering closed to be finalised (PFD; P&ID, technical data sheets)
HAZOP executed and finalised
Civil engineering including piling started
Preparation for Authority approval ongoing
Examination of incidents (Störfallauswirkungsbetrachtungen nach KAS-18) finalised including incident blasting investigations
Bomin Linde LNG Terminal in Hamburg
Project Schedule

16.12.2013
Opening conference with all relevant authorities

02/2014
Submission of all authority engineering documents (BlmSchG)

05/2014
Public Commitment

09/2014
Approval by authorities

2014/2015
Erection of plant

Q2/ 2015
Initial Start-Up

Source: BMLNG
Thank you for your attention.