MarTech LNG

Activities & Projects
Dipl.-Ing. Michael Kraack

LNG as a future chance for the maritime industry
Warnemünde, January 09, 2014
Marine Service GmbH

- Marine Service GmbH at a glance:
  - Hamburg-based marine consultancy firm, founded in 1958, involved in LPG & LNG since the mid 1960’s
  - Core business is commercial and technical consultancy services for:
    - LNG & LPG/ethylene/NH$_3$ shipbuilding / shipping
    - NG terminals / LNG FSRUs / LNG FPSOs
    - Small scale LNG / LNG as marine fuel projects
    - Offshore wind farm AC/DC converter platforms
  - 30 office staff in Hamburg, 12 – 25 project managers, supervisors & engineers in site offices worldwide

ISO 9001:2010 certified
The World of LNG

Atlantic Basin

Pacific Basin

- LNG importer
- LNG exporter
- New LNG export capacity under construction/development
- Substantial gas reserves for LNG export capacity development

09. Jan 2014

LNG Activities & Projects
Older LNG Tonnage

LNGC “LNG Aries” (1977)
Source: Andreas Spörri

LNGC “Tenaga Satu” (1979) now serving as LNG FSU at Lekas LNG, Malaysia
Source: Daniel Ferro
Emissions regulations driven shift to cleaner fuels:

- **IMO:**
  - $SO_x$ MEPC 58 Regulation 14
  - $NO_x$ MEPC 58 Regulation 13

- **EU:**
  - $SO_x$ Directive 2005/33/EC (aligned with IMO Sulphur Tiers)
  - $NO_x$ Directive 97/68/EC and Directive 2004/26/EC:
    - Tier I for newbuildings from 2000
    - Tier II for newbuildings from 2011
    - Tier III to be applied in ECA’s from 2016, Tier II will be applicable outside these areas
ECA Zones Worldwide

- Existing
- Possible future ECA

Source: DNV, Hamburg
2,200 vessels are operating in the North Sea and the Baltic ECA area on any given day.

Source: DNV, Hamburg
LNG in Europe
LNG Import in NW-Europe

Fluxys LNG terminal in Zeebrugge (BEL)
GATE LNG terminal in Rotterdam (NED)
Grain LNG terminal at Isle of Grain (UK)
South Hook LNG terminal in Milford Haven (UK)
Mid Scale LNG Plant

Risavika LNG plant in Stavanger

(source: Skangass)
Small scale LNG storage:
- Quickly implementable
- Flexible location-wise
- Scalable
- LNG supply by truck or ship
- NIMBY / BANANA

LNG storage 2 x 500 m³ at Halhjem ferry terminal

(source: Marintek/Sintef)
LNG Logistics Solution

LNG ship-to-ship transfer from LNGC "Höegh Galleon" to MT "Pioneer Knutsen"

Source: grady
Traditional LNG Bunkering

MF "Glutra" bunkering LNG at night

Source: Langsten Slip & Båtbyggeri AS
LNG Terminal Bunkering

- Infrastructure is available, but the ship might not fit
- Many berthing slots reserved for LNG loading

MT "Bit Viking" bunkering LNG at Risavika LNG terminal

Source: Tarbit Shipping
Source: Skangass
LNG bunkering today

- LNG bunkering with trucks:
  - High flexibility location-wise
  - Limited fuel quantity

MT “Argonon” in Antwerp

Eidesvik OSV in Norway

MS “Viking Grace” in Finland

Source: Deen Shipping

Source: Gasnor

Source: Åbo Underrättelser
LNG Bunker Vessel

- LNG bunkering by dedicated LNG bunker vessel:
  - Flexible in terms of location
  - Larger quantities
  - Quite similar to current marine fuels bunkering practices
  - Regulations for LNG bunkering still unclear

Source: Karl Gabor
Source: Jochen Schmidt-Lüssmann
Well, It’s Not All Good News

- LNG requires additional storage space onboard:
  - Cylindrical LNG storage tank shape (although solution might be available)
  - Tank insulation
  - Additional bulkheads, void spaces, access trunks, vents, etc.

- LNG could require up to 3 - 4 times as much space as MDO for the same amount of energy

### Comparison LNG to MDO

<table>
<thead>
<tr>
<th>Fuel</th>
<th>LHV [MJ/kg]</th>
<th>Density [kg/m³]</th>
<th>Energy density [MJ/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDO</td>
<td>42.7</td>
<td>900</td>
<td>38,430</td>
</tr>
<tr>
<td>LNG</td>
<td>49.5</td>
<td>445</td>
<td>22,028</td>
</tr>
</tbody>
</table>

MDO/LNG energy density ratio: 1.75
LNG requires higher CAPEX for storage and distribution than traditional residual and distillate fuels

LNG has BOG issues that require attention

Most of LNG related accidents happened during LNG handling

Release of un-combusted Methane contributes to Green House Effect 23 – 72 times more strongly than CO$_2$
Approximate LNG fuel cost (21 May 2013):

- Europe (TTF): USD 10.09 / MMBTU
- 30% mark-up for seller: USD 3.03 / MMBTU
- Logistics & bunkering: USD 6.00 / MMBTU
- Total LNG fuel cost: USD 19.12 / MMBTU

Bunker fuel prices Rotterdam:

- IFO-380: USD 586 / ton
  USD 15.38 / MMBTU
- MGO: USD 855 / ton
  USD 21.13 / MMBTU
# LNG Fuel End-user Prices

## Fuel pricing 2013/05/21

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Total price in ship bunker [$/MMBTU]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotterdam IFO-380 RMG ($586/ton) / MGO DMX ($855/ton)</td>
<td>$15.38 / $21.13</td>
</tr>
<tr>
<td>LNG TTF ($10.09/MMBTU), 30% mark-up, $6/MMBTU logistics</td>
<td>$19.12</td>
</tr>
<tr>
<td>LNG TTF ($10.09/MMBTU), 20% mark-up, $3/MMBTU logistics</td>
<td>$15.11</td>
</tr>
<tr>
<td>Tokyo IFO-380 ($651/ton) / MDO DMB ($912/ton)</td>
<td>$17.09 / $23.94</td>
</tr>
<tr>
<td>LNG CIF Japan ($14.53/MMBTU), 50% mark-up, $8/MMBTU logistics</td>
<td>$29.80</td>
</tr>
<tr>
<td>LNG CIF Japan ($14.53/MMBTU), 20% mark-up, $3/MMBTU logistics</td>
<td>$20.44</td>
</tr>
<tr>
<td>Houston IFO-380 ($590/ton) / MGO ($967/ton)</td>
<td>$15.48 / $24.37</td>
</tr>
<tr>
<td>Gas Henry Hub ($4.10/MMBTU), 20% mark-up, $2.50 liquefaction,</td>
<td></td>
</tr>
<tr>
<td>$3/MMBTU logistics</td>
<td>$10.42</td>
</tr>
</tbody>
</table>
Why LNG in Shipping

1000
Liter per Year

What about Shipping?

09. Jan 2014
Why LNG in Shipping

1.000.000
Liter per Year

- Container vessel
- Cruiseliners
- Bulker
- River Barge
- Offshore Supply Vessel
- Car Ferry
- Tug

Million instead of Thousand Liter!
Bunkering v/s Containers

- **Bunkering:**
  - LNG transfer with spill risk; most LNG incidents have occurred during LNG cargo handling
  - LNG bunkering permission in port

- **Containerized LNG:**
  - No transfer of LNG
  - Handling of IMDG containers is standard practice in container ports
  - Uses existing multi-modal infrastructure
ISO LNG tank container:

- IMDG container to use existing container infrastructure
- IGC compliant Type C tank to allow use onboard as shipboard fuel bunker
- Vacuum insulated to ensure long holding time
- ESD Valves for vapor and LNG
- LNG, vapor and safety valves with quick couplings
Vacuum Insulation

Vacuum space with radiation foil

+ Low heat conductivity
+ Free movement of pipes in vacuum space
+ Small vacuum space
- Higher heat conductivity in case of lost vacuum
- Accurate installation necessary

Source: Ziemann International
To achieve holding times of 80 days or more for the fuel gas tank, a vacuum pressure of $10^{-4}$ mbar is necessary.
LNG Fuel Tank Container

- Up to 6 LNG fuel tank containers in one stack
- LNG container hose connections in cell guides
Flexible cryogenic hose assembly with dry quick connectors, break-away coupling and vacuum monitoring

Male connector

Female connector with break-away coupling

Double-walled vacuum insulated flexible hose
Coupling Test Video
Container Vessels
Mobile Container Tank Solution

Mobil 40’ LNG ISO Bunker tank
Certified to BV

LNG Container Solution for loading at the Container Terminal
Shipping Applications

Cruiselinier

Possible Capacities  3-14 MW

AIDA Hyperion Class with Dual Fuel Engines
Shipping Applications

New building & Conversion with fix installed LNG Tanks inside

New building Harbor Tug

Conversion Car ferry
Shipping Applications

Bulker & Tanker
with fix installed LNG Tanks outside

LNG Tank Location vertical on Afterdeck

LNG Tank Location horizontal on Free deck
LNG Power Barge

LNG Tank Container

Stromerzeuger
LNG-Processing System

Gas Handling Container
Gas Aufbereitung

Gas Valve Room
Gasventilraum

Engine Room
Maschinenraum

LNG Tank Container

Switchboard Room
Schaltanlagenraum

Pump
Pumpe

Vaporizer
Verdampfer

Control Valve
Gasregelventil

Gas Motor

Transformer
Trafo


09. Jan 2014
LNG Activities & Projects
Conversion of 138,830m$^3$ LNGC “Golar Frost” (2004) to LNG FSRU “FSRU Toscana” (2008 - 2013) for Offshore LNG Toscana (E.On Ruhrgas)

Dubai Drydocks (UAE)

MS work scope:

- Design concept review
- Plan approval
- On-site conversion supervision
Subsea gas pipeline to shore

Offshore Livorno, Italy
5.0 BCMA, open loop regas, 2011
Mooring Arrangements

- Turret mooring:
  - Offshore, exposed to winds, waves, currents and tides
  - Requires special hull adaptations and stiffening
  - Requires underwater gas pipeline
  - Requires elaborate offshore underwater constructions
Turret Mooring System

LNG FSRU “FSRU Toscana”
Source: Marine Service
Turret Mooring System

LNG FSRU “FSRU Toscana”
Source: Marine Service
Is LNG Safe?

Source: Hardstaff Group / Steve Storrar
Thank you very much for your kind attention

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