Assessment of Innovative Small Scale LNG Carrier Concepts

Carlos Guerrero
Global Market Leader Tankers and Gas Carriers
Bureau Veritas Marine and Offshore
The small scale LNG carrier world

- Break bulk of LNG / specific locations
- Cargo volume below 40,000 m³
- Type C tanks lead the market
- Dual fuel engines in modern designs
- IMO IGC Code / Class Rules apply

**Fleet / Cargo Containment Systems**

- Type C
- Mark III
- Moss

**SS LNGc (<40k) Fleet / Class Societies**

- BV
- NKK
- DNV GL
- CCS
- LR

<table>
<thead>
<tr>
<th>Class Societies</th>
<th>BV</th>
<th>World</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS LNGc (&lt;40k)</td>
<td>15</td>
<td>41</td>
<td>~36.6%</td>
</tr>
</tbody>
</table>

Data from Clarsons Research + Bureau Veritas stats (1st March 2019)
Drivers for designs of novel small scale LNG carriers

- Environmental regulations for ships (IMO, EU, etc) and for other segments
- Gas fueled ships of all types in service or on order. Numbers growing
- Small scale LNG ships under development to bunker the fleet
- New small scale LNG concepts to respond to clean fuel demand
Specificities of LNG bunkering vessels (LBV)

- Different operation profile
  - Speed and maneuverability
  - Boil off gas consumption
  - In port (not only terminal)
- A segment that requires specific solutions
  - Containment of LNG
  - Ship to Ship (STS) LNG
  - Related to other technologies
- Guidelines and regulations recently developed or under development
- Classification societies, IACS and other associations and NGO’ support is key
  - Example: Bureau Veritas rule NR.620 (October 2015)
Preferred Features of LBV

- Maneuverability and reduced dimensions
- Suitable boil off gas (BOG) handling
- Safe / efficient LNG transfer system
- Able to load cargo from LNG terminal
- Silent designs and able to deliver multiple bunker fuels of interest as well
LBV – Cargo containment system (CCS)

- Decision linked to BOG management and cargo volume
  - Pressurized type C – pressure build up (flexibility)
  - Prismatic type – optimum cargo volume (ship’s dimensions)
  - Atmospheric systems in combination with BOG handling systems. Pressure/temperature kept low
- System used in LNG bunker and LNG fuelled ship
LBV - BOG management

- Cargo kept at the lowest temperature and pressure may be preferred
  - DF engines & Boilers (energy production)
  - GCU (just burn BOG)
  - Sub-cooling and reliquefaction systems
LBV - Propulsion system

- Flexibility for port and BOG handling (main & aux. engines)
- Maneuverability. Diesel electric (DE) + azimuth propellers
- Engine maintenance (engine speed, cylinders)
- Cost (mechanical vs. DE)
LBV - LNG transfer system

- STS implemented since 2005 (FSRUs)
- For LNG bunker systems specific assessment
  - Flexible hoses handled by cranes
  - Specific transfer arms
- Assessment Bureau Veritas rule NR.620 (section 4)
  - Risk analysis
- Recent ISO standards
- Keep always in mind the risks of LNG
  - Risk of brittle fracture in case of leak
  - Gas is low flash point gas (5 and 15% in air)
  - Global warming (methane is a GHG)

Courtesy of Houlder / Klaw

Reach 4 LNG bunker mast
LBV - Case studies

- New buildings / sea going and inland
  - Type C + DF engines widely used
  - If volume matters – prismatic CCS is an option
  - Conversions (scope may vary)

<table>
<thead>
<tr>
<th>BV class ships &amp; Barges</th>
<th>Shipowner</th>
<th>CCS</th>
<th>Cap. (m3)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORAL METHANE</td>
<td>Anthony Veder</td>
<td>Type C</td>
<td>7.500</td>
<td>Converted/In service</td>
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<tr>
<td>ENGIE ZEEBRUGGE</td>
<td>Gas4Sea</td>
<td>Type C</td>
<td>5.100</td>
<td>Delivered/In service</td>
</tr>
<tr>
<td>CORALIUS</td>
<td>Sirius Veder AB</td>
<td>Type C</td>
<td>5.800</td>
<td>Delivered/In service</td>
</tr>
<tr>
<td>OIZMENDI</td>
<td>Itsas Gas Bunker</td>
<td>Type C</td>
<td>660</td>
<td>Converted/In service</td>
</tr>
<tr>
<td>BUNKER BREEZE (*)</td>
<td>Guardiax</td>
<td>Type C</td>
<td>1.200</td>
<td>Delivered/In service</td>
</tr>
<tr>
<td>FLEXFUELLER</td>
<td>Titan LNG</td>
<td>Type C</td>
<td>1.480</td>
<td>On order / 2019</td>
</tr>
<tr>
<td>FLEXFUELLER II</td>
<td>Titan LNG</td>
<td>Type C</td>
<td>1.480</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>LNG London</td>
<td>CFT &amp; Victrol</td>
<td>Type C</td>
<td>3.000</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>Hudong-Z.</td>
<td>MOL</td>
<td>GTT – Marl III Flex</td>
<td>18.600</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>Damen Yichang</td>
<td>Eesti Gaas</td>
<td>Type C</td>
<td>6.000</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>Keppel Nanhtong</td>
<td>Shturman Koshelev</td>
<td>Type C</td>
<td>5.800</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>Western Marine Shipyard</td>
<td>Jahre Marine AS</td>
<td>Type C</td>
<td>1.200</td>
<td>On order / 2020</td>
</tr>
<tr>
<td>Sembacorp</td>
<td>MOL</td>
<td>GTT – Mark III Flex</td>
<td>12.000</td>
<td>On order / 2021</td>
</tr>
</tbody>
</table>

As of 1st of March 2019 / (*) The ship is assessed for LNG bunkering but the tanks have not yet been installed
MOL 18,600 m3 LNG Bunkering vessel

- Ship chartered by TOTAL (on order at Hudong Z. delivery date Q1-20)
- Cargo capacity as per client request (DF ULCS for CMA-CGM)
- 2 x Mark III Flex membrane cargo tanks / No filling restrictions / Sloshing assessment is key
- DF engines / DE propulsion
- Reliquefaction system
- High manoeuvrability
- High bunkering rate
LBV - Multibunker Fuels

- Bunker of oil products and LNG
- Compliance with IGC and Marpol Annex I
- Classification rules including dual service notations
- Main challenges: stability and freeboard
- Main hurdle: limited LNG capacity
- Newbuildings and conversions
Not an LNGc but a Virtual LNG pipe

- Where infrastructure does not exist
- LNG ISO Containers from mainland to islands
- Multimodal transportation from main LNG terminal (trucks + Ships) to satellite LNG terminals or final consumers
- Projects already in operation in several locations:
  - Portugal, Spain, USA, etc
- Assessment & Regulations. IGC not applicable
  - Container ship / IMO IMDG Code
  - LNG transfer to the containers is not considered

Source: Grupo Sousa
Conclusions

• Small scale LNG carriers of novel design
  • Driven by the environmental regulations
  • Highly innovative & tailor made projects
  • Newbuildings, conversions and upgrades
• Technical solutions
  • Covering specific issues of such designs
  • Available or being currently implemented
• Virtual LNG pipe opening new markets
• Guidelines and rules implemented or under development
  • IMO, Class societies, ISO, NGO’s, etc