Small scale LNG carriers
Demand for Specific Carries Segments – Will there be a push for small scale LNG carriers?

Björn Munko
• **Introduction**

• Small Scale LNG

• The small scale LNG fleet

• Small LNG vessels
Introduction

- TGE Marine Gas Engineering is one of the world’s leading engineering contractors specialising in gas carrier and offshore units.
- The Group was founded in 1980 as “Liquid Gas International” (LGI) and in 1993, was acquired by Tractebel/Suez operating as “Tractebel Gas Engineering”. Since an MBO in 2006, the Group has been called “TGE Marine AG” (“TGE Marine Gas Engineering GmbH”).
- Major shareholders: 49.9% Caledonia Investment plc and GASFIN Group approx. 47.4%, Management, employees, individual shareholders approx. 2.7%
- Address: Mildred-Scheel-Str. 1, 53175 Bonn, Germany
- Web: www.tge-marine.com
Key facts

• 30 years of experience
• More than 140 gas carrier contracts
• Delivery of several novel and innovative gas plant solutions:
  • Five 22,000 m³ ethylene carriers, largest purpose-built ethylene ship in the world built at Jiangnan Shipyard
  • Topsides for 95,000 m³ LPG-FSO built at Samsung
  • World’s first combined 7,500 m³ LNG/ethylene carrier built at Remontova for Anthony Veder Group
  • Lloyd’s List Ship of the Year Award in 2008 for 8,000 m³ ethylene carrier “Isabella Kosan” built at Sekwang HI for Lauritzen Kosan Group
• Well established in East Asia with Shanghai branch office since 1994
• Fabrication and delivery of more than 200 cargo tanks
• More than 50%* market share of ethylene carrier gas plants
  (*historically by total, >70% market share from 1992 to present)
• Own patented LNG tank support design for shuttle tankers and floating units
• In-house ship design packages available for a wide range of gas carriers
Business activities and expertise

**Cargo handling systems and tanks for gas carriers**
- LPG carriers, CO₂ carriers
- Ethylene carriers
- LNG carriers

**Cargo handling systems for offshore units**
- FSO/FPSO for LPG
- FSRU and FPSO for LNG
- CO₂ liquefaction, storage and offloading units

**Fuel gas systems**
- LNG fuel supply for merchant vessels
- Type C LNG tanks
- Gas processing system
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LNG as fuel for small power plants on islands and remote locations

- Potential locations: Caribbean islands, Indonesian islands, Mediterranean islands, Philippines etc.
- Environmental pressure to implement “clean fuel” instead of HFO/MDO or even coal
- Potential de-coupling of LNG from oil price link and consequently reduced fuel cost compared to MDO
- Tailor-made small-scale LNG supply chain will reduce CAPEX compared to traditional on-shore solutions

FLNG (“Floating LNG”)

- Improved process technology for LNG-FPSO (“Floating production storage & offloading”) have strongly improved the CAPEX requirements for capacities of 0,5 to 1,5 mtpa with project budgets of 600 – 1,000 USD/t of annual liquefaction capacity
- LNG-FPSOs and FSRUs (“Floating storage & regasification units”) can be fabricated in modern shipyards within 18 to 36 months depending on complexity and consequently, be faster implemented than on-shore solutions

LNG as fuel for merchant vessels

- In 2015 MARPOL Annex VI revision will force owners operating in environmental control areas (ECA,SECA: North Sea/Baltic Sea) to use either expensive MGO, switch to LNG as fuel or implement scrubber technology
- “Chicken and egg” situation as the necessary infrastructure is not yet in place
LNG supply chain

- Global LNG supply chain
- Large scale LNG liquefaction plants
- Small scale LNG production
  - Mostly pipeline gas, e.g. Norway
- Re-export from Import/Re-gas terminals
  - More and more import terminal apply for re-export licences

19-May-2010 „Coral Methane“ loading at Zeebrugge, first loading of a small carrier at a large import terminal.

![Diagram of LNG supply chain]
• Singapore LNG Corp. (SLNG) has awarded ECP contract for secondary berth project at their terminal on Jurong Island including a dedicated jetty for small LNG ships
  • “... to facilitate future LNG bunkering opportunities” (SLNG press release)
• Zeebrugge and Gate have also taken FID’s for small jetties

Artist impression from SLNG press release Aug. 2011
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• Small LNG vessels
The small scale LNG fleet

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Capacity</th>
<th>Delivery</th>
<th>Owner/Operator</th>
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**7,500 m³ LNG/LEG carrier:**
- Owner: Anthony Veder, Holland
- Yard: Remontova, Poland
- Classification: BV
- Completion: 2009
- Cylindrical type C tanks
- Dual fuel, diesel/gas electric drive

**15,600 m³ LNG carrier:**
- Owner: Anthony Veder, Holland
- Yard: Meyer-Werft, Germany
- Classification: BV
- Completion: 2012 (under construction)
- Bilobe tanks
- Duel fuel, direct drive
6,500 m³ LNG/LEG carrier:
- Owner: Anthony Veder, Holland
- Yard: Dingheng, China
- Classification: BV
- Completion: 2012 (under construction)
- 1 cylindrical, 1 bilobe
- Direct drive, diesel

20,000 m³ LNG carrier / 25,000 LNG FSRU:
- Owner: Gasfin / EDF
- Yard: tbn
- Classification: BV
- FID: early 2012
- Completion: 2014
- 1 cylindrical
- 2 x 25K LNG FSRU
- 1 x 20K LNGC
- 1 x 20K LNG/LPG (back up vessel)
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TGE’s design approach to small LNG carriers

- Objective: minimize the CAPEX
- Utilize the know-how from design of Ethylene carriers
- Main questions:
  - Cargo tank design
  - Boil-off gas handling / propulsion system
  - Multi cargo vessel
  - Compatibility with terminals
  - Equipment sizing
Tank Design

- (internal insulation tanks)
- (Integral tanks)
- (Semi-membrane tanks)
- Membrane Tanks
- Independent tanks
  - (Type A)
  - Type B
  - Type C

Type C tanks

- Self supporting pressure vessel
- Cylindrical or bilobe with outside insulation
- No secondary barrier required
- No restriction concerning partial filling
- Tank design temperature: -163°C
- Tank material:
  - (Aluminium)
  - 9% Ni-steel
  - SS AISI 304L

Tank Sizing

- Ship capacity < 20,000 m³
  - Cylindrical tank design
    - 2 tank design up to abt. 12,000 m³
    - 3 tank design up to abt. 20,000 m³
- Ship capacity > 20,000 m³
  - Bilobe tank design
    - 3 tank design up to 25,000 m³
    - 4 tank design up to 35,000 m³
Type C tanks for LNG

• Design constraints for LNG compared to Ethylene:
  • Higher material shrinkage due to:
    • Larger delta T during cooling down
    • Higher material shrinkage factor for AISI 304L
  • Problem especially for bi-lobe tanks:
    for 15 m diameter tanks the shrinkage is 35 mm (304L)
  • Detailed design review and complete re-design of supports necessary (displacement and stress analysis, temperature profiles)!
• Design appraisal by a classification society
• FEM analysis of tank shell, supports and shipside steel structure for different loading cases
→ Patented design for type LNG tank supports

• Tank insulation
  • Same insulation type applied as for LPG or ethylene carriers
    • LPG/LEG carriers: polystyrene slabs up to 240 mm: k-value 0.186 W/m²K
    • Increase of insulation thickness to 360 mm: k-value 0.121
    • Improvement of insulation with combined polystyrene/polyurethane slabs (300 mm): k-value 0.121
  • Modification of design details of the insulation due to:
    • shrinkage
    • stress
**BOG Handling**

- Pressure increase
  - Ease of operation
  - Limited sailing time
- BOG consumption as fuel
  - Diesel/Gas electric
  - Direct drive
- BOG reliquefaction
  - High capex
  - Sophisticated operation
  - High maintenance cost
  - Loss of cargo
- Gas combustion unit (GCU)
  - Ease of operation
  - Loss of cargo

**Multi cargo / Compatibility / Equipment**

- Multi cargo vessels have been designed and are available
- Compatibility
  - Vessel are equipped with additional or single elevated manifold
  - ESD ship shore link (pneumatic, electric or fiber optic)
  - Qualification of new vendors and technologies for LNG, e.g.
    - Deepwell pumps
    - Valves
    - Standard ‘Ethylene’ compressors as LNG fuel gas compressors
- Optimization of Capex with a market specific approach to upgrade the technology of Ethylene carriers to LNG instead of downsizing full size LNG carriers to small scale LNG
Mid Scale LNG carrier Designs

- 20,000 cbm LNG carrier
- 3 cylindrical tanks
- LNG version designed for the Trinidad-Guadelupe/Martiniuque trade
- LNG/LPG Version as back up vessel
**Mid Scale LNG carrier Designs:** 30,000 cbm LNG carrier with bilobe tanks

- **Principal particulars:**
  - Length o. a. 184.60 m
  - Length b. p. 175.20 m
  - Breadth moulded 27.60 m
  - Depth moulded 18.50 m

- **Tanks**
  - Tank 1: conical bilobe
  - Tank 2-4: bilobe

- **Draught/Deadweight:**
  - Design Draught 8.80 m
  - Corresponding deadweight 17,600 T

- **Speed/Endurance:**
  - Service speed at design draft 16.00 kn
  - Endurance 12,000 nm

- **Machinery**
  - Dual fuel engine 9000 kWe
LNG bunker vessel

3 000 cbm LNG BUNKER SUPPLY VESSEL
FOR INLAND WATER AND COASTAL AREAS

Principal particulars

- Length overall: 96.60 m
- Length between perpendiculars: 93.00 m
- Breadth molded: 14.20 m
- Depth to main deck: 7.60 m
- Cargo tank capacity (%): 3 000 cbm
- Design keel: draught: 4.00 m
- Gross cargo: deadweight at field: 1 900 t
- Service speed at design draught: 12.00 kn

Small scale LNG carriers, Seoul 2011
LNG bunkering options:

Bunkering from LNG trucks
• Only possible for small quantities
• performed in Norway

Bunkering at the LNG bunkering terminal
• Technically safest solution, but not applicable for most shipping areas due to timing issues

Bunkering from LNG bunker vessel/barge
• TGE has designed a 3,000 m³ LNG bunkering ship to serve RoRo and container feeders at the corresponding terminals
• First test bunkering will be executed between the 'Knutsen Pioneer' and the 'Bit Viking'

Gasnor set to undertake first bunkering transfer of LNG

Norwegian gas distributor Gasnor will undertake something of a first next month when it performs its first test of what looks set to be the world's first LNG bunkering vessel.

Brage Gulliksen, who heads Gasnor's commercial department, says the company will supply 1,000 cubic m of LNG from its shore-based 3,000 cubic m LNG carrier 'Knutsen Pioneer' (built 2004) to the first limit on board Turkish ship Egea.

The test has been carried out in co-operation with TGE Marine Gas Engineering.
### Customers– where does the bunker LNG go to?

#### Ro-Ro - Vesssel
- volume: 1,000 m³
- bunker time: max. 4 h
- bunker rate: 300 m³/h
- bunker manifold height: max. 4 m above waterline
- bunker station location: approx. 50 m from steven

#### Passenger Vessel
- LNG volume: 2,000 – 3,000 m³
- bunker time: 4 h
- bunker rate: 700 m³/h
- bunker connection: 8"
- bunker manifold height: 3 – 4 m above waterline
- bunker station location: midships

#### Container Vessel
- LNG volume: approx. 5,000 m³
- bunker time: approx. 4 - 8 h
- bunker rate: up to 1,000 m³/h
- bunker connection: estimated min. 8"
- bunker manifold height: 6 – 8 m above W.L.
- bunker station location: ¼ of ship length
Requirements for bunkering operations

- High loading rates due to tight time schedule
- Large total amount of LNG for larger vessels
- Safe but easy handling of heavy equipment
- Dry-break emergency couplings
- Bunkering during cargo operations
- Parallel bunkering of LNG and MDO

Numbers

- LNG - volume: up to 3,000 m³ (5,000 m³)
- bunker time: 4 - 6 h
- bunker rate: 100 – 1,000 m³/h
- bunker connection liquid: 3” – 8”
- bunker connection vapour: 2” – 6”
- bunker manifold height: 3 – 10 m above waterline
- bunker station: all possible locations

- Regulations and standards for the bunker interface and related operations are under preparation by several international working groups
  - Hoses
  - Bunker arms
  - ESD link
  - Procedures
Design Considerations

- Tank size: 2 x 1,500 cbm cylindrical
- Multi cargoes (LNG and MGO, MDO)
- LNG deepwell pumps with frequency controlled drive for different bunkering rates
- Loading manifold cannot be suitable for full size LNG terminal due size of vessel
- Mechanical/hydraulical system to handle bunker hoses or arms with coupling
- Dry-break emergency release coupling
- Vapour return connection
- Optional transfer compressor
- Signal interface, including ESD with loading terminal and customer vessel
- Possible additional services:
  - Inerting with Nitrogen
  - Tank purging and cooling with NG/LNG, tank
  - Emptying and warming-up
Conclusions

• Small scale LNG is established mainly in Japan and Norway
• abt. 20 LNG carriers (1,000 – 20,000 cbm) exist, but mostly dedicated to specific trades
• The demand for clean energy is growing
• More LNG is available today
• Several small scale LNG projects planned and close to FID’s
• LNG as fuel will demand bunker vessels and LNG feeder vessels
• Carrier design have been adapted for small scale LNG
• There will be more small scale LNG carriers in the near future
For further information please email:

sales@tge-marine.com

Thank you for your attention

www.tge-marine.com