• Introduction
• LNG Carriers
• LNG Barges
Company 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: Caledonia Investment plc and GASFIN Group

- Address: Mildred-Scheel-Str. 1, 53175 Bonn, Germany

- Web: [www.tge-marine.com](http://www.tge-marine.com)
Key facts

- 30 years of experience
- More than 160 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 in service built at Jiangnan Shipyard and one (+3 options) 35,000 m³ ethylene carriers largest ships under construction
  - Topsides for 95,000 m³ LPG-FSO built at Samsung
  - World’s first combined 7,500 m³ LNG/ethylene carrier built at Remontova for the Anthony Veder Group
  - World’s first 16,000 m³ LNG-FLSRU under construction at Wison Offshore & Marine Ltd. for Exmar Group
  - World’s first high pressure LNG fuel supply system for Nakilat Qmax vessel (conversion to ME-GI)
  - World’s largest LNG-carriers based on type C cargo tanks: 3 x 30,000 m³ (under construction in China)
- Well established in East Asia with Shanghai branch office since 1994
- Delivery or fabrication of more than 250 cargo tanks
- More than 50%* market share for ethylene carrier gas plants (*historically by total, >60% market share from 2002 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 supply chain

- Global LNG supply chain
- Large scale LNG liquefaction plants
  - Onshore/Offshore
- Small scale LNG production
  - Pipeline gas
  - Stranded Gas
  - Onshore/Offshore
- Re-export from Import/Re-gas terminals
  - Two of the main players in China (CNPC and CNOOC) are working on mid scale LNG chains based on re-export

19-May-2010 „Coral Methane“ loading at Zeebrugge, first loading of a small carrier at a large import terminal.
7,500 m³ LNG/LEG carrier:
- Owner: Anthony Veder, Holland
- Yard: Remontowa, 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
- Bilobe tanks
- Duel fuel, direct drive
**30,000 m³ LNG-carrier:**

- **Owner:** CNOOC, China
- **Yard:** Jiangnan Shipyard, China
- **Classification:** CCS, ABS
- **Completion:** 2015 (under construction)
- **Scope:** Complete gas handling system, cargo tank design and material package

- **Loading Terminals**
  - **Fujian**
    - 4 x 160,000 cbm tanks
  - **Jiangpu, Hainan**
    - 2 x 160,000 cbm tanks

- **Receiving Terminal**
  - **Guanxi**
    - 2 x 30,000 cbm tanks
    - No gas send out
    - Truck loading station
    - Start of operation in 2014
28,000 m³ LNG-carrier:

- Owner: Dalian INTEH Group, China
- Yard: COSCO Dalian
- Classification: CCS
- Completion: 2015 (under construction)
- Scope: Complete gas handling system, cargo tank design and material package

- Loading Terminals
  - e.g. Dalian LNG

- Receiving Terminals
  - JOVO LNG Donguan
    - 2 x 80,000 cbm tanks
    - No gas send out (future extension to pipeline from Xinjiang
    - Truck loading station
    - Reliquefaclon
    - Jetty for 3 – 50,000 cbm vessels
  - Shennan LNG, Hainan
    - 2 x 20,000 cbm tanks
    - No gas send out
    - Truck loading station
    - Start of operation in 2013
Gas Plant Design

- **Objective:** minimize the CAPEX
- **Utilize the know-how from design of Ethylene carriers**
- **Main questions:**
  - Terminal Compatibility
  - Client Vessel Compatibility – bunker interface
  - Cargo tank design
  - Boil-off gas handling / propulsion system
    - Fuel Gas Systems
  - Multi cargo vessel
  - 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 30,000 m³
      - 4 tank design up to 45,000 m³
Type C tanks for LNG carriers and floaters

- 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 up to 450 mm: k-value up to 0.065
  - Improvement of insulation with combined polystyrene/polyurethane slabs (300 mm): k-value 0.095
  - Modification of design details of the insulation due to:
    - shrinkage
    - stress

Stavanger, 2014
Terminal Compatibility

- Manifold position → Elevated Manifold
- Manifold sizing
- Loads on manifold flanges/piping
- Mooring arrangement
- Fenders – parallel body length
- ESD ship shore connection
- CTS – custody transfer

Artist impression from SLNG press release Aug. 2011

Coral Methane loading in Zeebrugge
Cargo Handling System 15,600 cbm LNG carrier
**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
  - High trading flexibility
- Gas combustion unit (GCU)
  - Ease of operation
  - Loss of cargo

**Multi cargo / Equipment**

- Multi cargo vessels have been designed and are available
- 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
Fuel Gas Systems

- Diesel electric ↔ Direct Drive
- Two stroke ↔ Four Stroke
  - Supply pressure
  - BOG handling
- Dual Fuel ↔ Single fuel
- Burning of BOG, Forced vaporization
- Separation of fuel Tanks
- BOG Compressors, Fuel gas compressors, Transfer Compressors
- LNG Compositions
- Dynamic behaviour of fuel gas system
- Buffer capacities
**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
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LNG Barges in China

LNG demand and bunker barges in China

- End of 2014 abt. 20 LNG fuelled vessels will be in operation in China
- September 2013, CCS released the classification rules for LNG fueled ships, new edition.
- March 2014, CCS released the classification rules for LNG bunkering barges.
- May 2014, Chinese government released policy to encourage the LNG fueled ships. This includes incentives for Chinese owner for DF retrofits and new buildings.
- LNG barges and floating installations are currently driven by the change to LNG as fuel
- One main region is the Yangzi River
- Two bunker barges are in operation
- Further bunker stations are planned
- Nanjing, Shanghai, Wuhan
- Yangzi is not yet open for LNG bulk transport
Mid scale LNG barges and FSRU's

- Design based on a case study for the Caribbean
- Purpose built FSRU of 25,000 m³ storage (2 – 50,000 cbm)
- FSRUs moored in vicinity of power plants with short subsea pipeline to shore (jetty moored or spread moored)
- LNG supply from regional terminals by a purpose built LNG carrier
- Send out to pipeline, power plant in combination with truck loading and bunkering
- Size of shuttle tanker: Min. 20,000 m³ (and backup option)

- TGE Marine performed the FEED for the shuttle tankers and the FSRUs (hull, marine and cargo systems); mooring studies, subsea systems, etc. subcontracted to others
Technical concept – FSRU

- Send out to subsea pipeline via flexible risers
- Regasification using air vaporizers (no environmental impact)
- Electricity generated with natural gas fuelled gensets
- 20+ year docking interval, designed to remain on site during severe weather conditions
- Tank design (pressure vessels) increases operational flexibility
- High redundancy with minimal maintenance
- Length: 106m; width: 39m; depth: 20m; draft 7m
- Send out: max. 50t/h, normal 25t/h @ 14 bar (battery limit)
16,000 m³ LNG-FLSU:
(under construction)

- Owner: Exmar Group, Belgium
- Yard: Wison Offshore & Marine Ltd, China
- Classification: BV
- Completion: 2015 (under construction)
- Scope: Complete gas handling system for loading and unloading, cargo tanks
- Process liquefaction package: Contracted to Black & Veatch by Wison
Conclusion

• The market in China for floating small to mid-scale LNG solutions is fast growing.
• Three LNG carriers are under construction for the domestic market and more are under development.
• LNG bunker barges have started operation to serve the emerging fuel gas market
• LNG as fuel will be a further driver for this market
• The main players CNOOC, CNPC are committed to mid-scale LNG distribution and LNG as fuel
• LNG is supported by initiatives launched by the government
• Small and mid scale LNG is a future market and which has already started and is steadily increasing.
For further information please email:

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Thank you for your attention

www.tge-marine.com