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
Legal structure

Board of Directors:
Dr. Manfred Küver, CEO
Dr. Klaus Dieter Gerdsmeyer
Steffen Schober
Ulrich Menninghaus

Management:
Dr. Manfred Küver, CEO
Dr. Klaus Dieter Gerdsmeyer
Steffen Schober
Ulrich Menninghaus

Management:
Dr. Klaus Dieter Gerdsmeyer
Daniel Louys

TGE Marine AG
(Holding Company)

100%

TGE Marine Gas Engineering GmbH
(Operating Company)

100%

TGE Marine Shanghai Office
(Branch Office)
Key facts

• More than 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 200 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
Overview

- **Headquarter**
  Bonn, Germany

- **Branch Office**
  Shanghai, China

- **Agencies**
  Korea, Japan

- **Personnel**
  Approx. 90 engineers and specialists including temporary staff

- **Turnover**
  Financial year 2013: ca. 100 M€
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**
- Type C LNG tanks or vacuum insulated type
- Gas processing system

**Ship design packages**
- Basic Ship Classification drawings or complete design package incl. steel drawings
Services

EPCS contractor (engineering, procurement, construction supervision)

- Technical/commercial feasibility studies
- Conceptual design studies
- Front end engineering design
- Project management
- Basic engineering
- Detailed engineering
- Procurement
- Construction or construction supervision
- Commissioning and start-up
- Training of operators
Engineering & Managements tools

**EPCS contracting software tools:**

- Process design: Unisim Design (Honeywell); Steady-State and Dynamic
- Shell & Tube Heat exchanger design: HTFS design package
- Document control: PIMS, Omega(Norway)
- Project management: Microsoft Project Server
- ERP-System: Microsoft Navision
- 3D-Design: AVEVA Marine latest version
- Ship design: AVEVA Marine, Hydrostatic, Hull
- CAD Software: Microstation; AutoCAD
- Pipe stress calculation: CAESAR II; Rohr 2
- After Sales Service: in-house Microsoft sharepoint based software
Ship design – a global scope

- Sophisticated design packages for all kinds of gas carriers
- Close co-operation with customers and classification societies
- Delivery of high quality documents based on solid technical competence and state-of-the-art software tools (AVEVA Marine)
- Consultancy during design and construction phase
- Substantial number of reference vessels for all ship sizes in the TGE Marine core market with all kinds of different tank configurations
Market presence

Worldwide projects supported by main German headquarter and branch office in Shanghai

- Contracts executed with more than 20 shipyards in Europe, Asia and Latin America
- Since 1994 the Shanghai office has supported marketing and site supervision activities for our major clients in China, Korea and Japan
- Agencies in Korea and Japan
- Quality control for tank fabrication and procurement in China

Project locations
Office locations
Gas carrier market

**TGE market share:**
- LPG-carrier: 29%
- Ethylene-carrier: 54%

**Small**
- 23,000 m³
- Fully pressurised carrier
- 0 °C
- TGE Marine capable (648 vessels)

**Medium/large**
- 200,000 m³
- No demand
- (Semi-refr. type)
- (165 vessels)
- TGE Marine capable (approx. 261 vessels)

**V Large**
- (Semi/full refr. type)
- New potential market for Ethane transport:
  - 1 (+3) x 35k-under construction

**Growth area**
- 22 vessels <30,000 m³
- TGE Marine references: 3 ships + 3 x 30,000 m³ under construction

**Temperature Ranges**
- LPG carrier: -48 °C
- Ethylene carrier: -104 °C
- LNG carrier: -163 °C
Major clients

Shipyards

- Samsung, DSME, STX, Sekwang HI, HMD
- Jiangnan, Hudong-Zhonghua, Sinopacific HI, Shanghai Edwards, Dingheng, Taizhou Wuzhou, Wison Offshore & Marine
- Sanoyas, Sasaki, De Poli, Remontova, Metalnave
- Meyer-Werft, Thyssen, Lindenau, Pattje

Shipowners

- Hartmann, Schulte Group, Anthony Veder, Lauritzen Kosan, Solvang, Sloman Neptun, Naftomar, Navigator, Harpian, Benelux Overseas, Pedredec, BLT, Ugland, E-Ships, Pertamina, NGC (Skaugen), Eitzen, Exmar, Ultragas Group, Qatar Shipping, Geogas, ADNOC, CNOOC, Eletson Group
TGE Marine order distribution

TGE order distribution 1993 to 2016 by contract value

Order distribution by shipyards

World Ethylene Fleet in 2016
Major pool players controlling c. 77% of world fleet

Order distribution by shipowners
Key references: LNG/Ethylene carriers

**7,500 m³ LNG/LEG carrier:**
- Owner: Anthony Veder, Holland
- Yard: Remontova, Poland
- Classification: BV
- Completion: 2009
- Scope: Complete gas handling system, cargo tanks and ship design

**15,600 m³ LNG carrier:**
- Owner: Anthony Veder, Holland
- Yard: Meyer-Werft, Germany
- Classification: BV
- Completion: 2012
- Scope: Complete gas handling system
Key references: LNG carriers (under construction)

30,000 m³ LNG carrier:
- Owner: CNOOC, China
- Yard: Jiangnan Shipyards, China
- Classification: CCS(ABS)
- Completion: 2015 (under construction)
- Scope: Complete gas handling system, cargo tanks

28,000 m³ LNG carrier:
- Owner: Dalian Inteh Group, China
- Yard: COSCO Dalian, China
- Classification: CCS
- Completion: 2015 (under construction)
- Scope: Complete gas handling system, cargo tanks
**16,000 m³ LNG-FLSRU:**

- **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
Key references: LNG fuel gas systems

7,500 m³ LNG/LEG carrier:
- Owner: Anthony Veder, Holland
- Yard: Remontova, Poland
- Classification: BV
- Completion: 2009
- Scope: fuel gas system for RR gas engines

15,600 m³ LNG carrier:
- Owner: Anthony Veder, Holland
- Yard: Meyer-Werft, Germany
- Classification: BV
- Completion: 2012
- Scope: fuel gas system for 4-stroke dual fuel main engine
Key references: LNG fuel gas systems (under construction)

**260,000 m³ LNG-carrier (conversion):**
- Owner: Nakilat (Qatargas)
- Contract: MAN Diesel & Turbo (MDT)
- Yard: Nakilat Keppel Offshore & Marine, Qatar
- Classification: ABS
- Completion: 2015 (under construction)
- Scope: pre-fabricated high pressure LNG fuel gas system for 2-stroke dual fuel MAN ME-GI main engine

**35,000 m³ Ethane-carrier:**
- Owner: Navigator Gas Ltd.
- Yard: Jiangnan Shipyards, China
- Classification: Germanischer Lloyd
- Completion: 2016 (under construction)
- Scope: LNG fuel gas tanks and high pressure fuel gas system for MAN-ME-GI dual fuel main engine
Key references: Ethylene carriers

4 x 17,000 m³ LEG carrier:
- Owner: Harpain Shipping (GASCHEM)
- Yard: Meyer-Werft, Germany
- Classification: DNV
- Completion: 2009
- Scope: Complete gas handling system

5 x 22,000 m³ LEG carrier:
- Owner: Navigator Gas
- Yard: CSS Shanghai Jiangnan Changxing Heavy Industry, China
- Classification: GL
- Completion: 1999-2000
- Scope: Complete gas handling system and cargo tanks
**8 x 8,000 m³ LEG carrier:**
- Owner: Lauritzen Kosan
- Yard: Sekwang HI, Korea
- Classification: BV
- Completion: 2005 - 2009
- Scope: Complete gas handling system, cargo tanks and ship design

**3 x 5,600 m³ LEG carrier:**
- Owner: Anthony Veder
- Yard: De Poli, Italy
- Classification: RINA/BV
- Completion: 2007
- Scope: Complete gas handling system and cargo tanks
Key references: LPG carriers

**2 x 23,000 m³ LPG carrier:**
- Owner: Qatar Shipping, Qatar
- Yard: STX, Korea
- Classification: DNV
- Completion: 2003 - 2004
- Scope: Complete gas handling system and cargo tanks

**8,600 m³ LPG carrier:**
- Owner: Geogas, Switzerland
- Yard: Sasaki/Sanoyas, Japan
- Classification: BV
- Completion: 2007
- Scope: Complete gas handling system and cargo tanks
Key references: LPG FSOs

**78,000 m³ LPG FSO “N’Kossa II”:**
- Owner: A.P. Moller Group
- Yard: Odense Lindo, Denmark
- Classification: BV
- Completion: 1996
- Scope: Chilling units, booster pumps, cargo heater and deck piping
- Vessel: Conversion of LPG carrier

**95,000 m³ LPG FSO “Liberdade”:**
- Owner: Conoco Philips
- Yard: Samsung HI, Korea
- Classification: Lloyd’s Register
- Completion: 2003
- Scope: Complete gas handling system
TGE Marine is a world leading contractor for fabrication and delivery of cargo tanks

- More than 200 cylindrical, bi-lobed or prismatic cargo tanks delivered to date
- Tank materials: 9% Ni steel, 5% Ni steel, 0.5% Ni steel, LT-carbon steel, high strength steel, stainless steel (304L, 316L)
- Total net steel weight more than 75,000 tons
- In close co-operation with its fabrication partner – CSSC Shanghai Jiangnan Changxing Heavy Industry - TGE Marine has delivered tanks from China to Korea, Japan and Europe
- TGE Marine’s scope of services:
  - Tank design with classification approval
  - Supply of all materials
  - Supervision of fabrication
  - Delivery of tanks with classification certificate to the shipyard
TGE Marine has significantly invested in R&D activities to support small scale LNG technologies and identified a new potential market in addition to its core business:

- Small to medium-sized LNG carriers with IMO type C tanks*
- FLNG solutions from 5,000 to 80,000 m³ with type C tanks* for FSRU and FPSO projects (utilising “stranded” gas reserves; target market: isolated energy centres)
- LNG fuel gas systems and bunkering technology*
- Efficient LNG BOG reliquefaction based on cascade technology for MAN ME-GI dual fuel engine
- CO₂ shipping and offshore liquefaction/storage*

Remark: * several patent applications pending or granted
Small to medium size LNG-carriers

- Capacities: 5,000 m$^3$ up to 70,000 m$^3$
  - 3 x 30,000 m$^3$ under construction
  - Current tenders: 5,000 m$^3$, 10,000 m$^3$, 12-15,000 m$^3$, 20,000 m$^3$ and 30,000 m$^3$
- Ship design packages available
- Cargo tanks: Cylindrical or bilobe type C pressure vessels
- More operational flexibility due to pressure built-up technology
- Tank material: 9% Ni steel or stainless steel
Small scale LNG-FPSO

- Capacity: 0.5 mtpa liquefaction
- Conceptual design, pre-FEED and cost estimates for undisclosed client
- Process: SMR

- IMO type C tanks
- 40,000 m³ storage capacity
- 4 cylindrical storage tanks
- LxBxD: 145 m x 43 m x 24 m
Small scale LNG-FSRU

- Required storage capacities for isolated energy centres much smaller than existing LNG carriers (→ conversions not economical)
- Floating solutions faster to implement
- Barge concepts with same reliable tank technology (IMO type C pressure vessels)
- Designs available for varying processes and heating sources, based on in-depth knowledge from large LNG import terminals
- Conceptual design and FEED package for 25,000 m³ LNG-FSRU for GASFIN Group destined to provide gas supply for the islands of Guadeloupe and Martinique
**LNG fuel gas systems and bunkering technology**

- MARPOL VI revision will force vessels operating in Environmental Control Areas (ECAs) to
  - use expensive MGO as fuel
  - implement LNG fuel supply systems
  - implement scrubber technology

- TGE Marine has developed fuel gas systems for merchant vessels:
  - RoRo, RoPax, Container Feeder
  - VLOC’s, Cruising ships

- LNG bunkering technology standards to be developed to support LNG fuel supply logistics
  - TGE Marine has developed a bunker supply vessel
  - Special hard loading arms have been designed in close co-operation with specialised vendors
**Efficient LNG-BOG re-liquefaction**

For the MAN ME-GI dual fuel engine (2-stroke, high pressure injection)

- Ship capacity up to 210,000 m³ LNG
- Design based on TGE Marine’s vast experience of cascade systems
- Superior efficiency compared to nitrogen cycles
- 2 x 75% BOG/ethylene compressor (Laby®-GI)
- 2 x 75% refrigerant compressors
- 1 cold box (plate fin heat exchanger)
- 1 refrigerant condenser

TGE Marine Company Presentation 2014
**CO₂ liquefaction, storage and shipping solutions**

- Conceptual design for a 40,000 m³ CO₂ FLSO (“Floating liquefaction storage & offloading”) with 1,0 Mio. tons p.a. throughput

- CO₂ carrier from 10,000 m³ to 60,000 m³ with turret mooring and dynamic position system as well as cargo heating and high pressure gas injection system for special North Sea applications

- IMO type C pressure vessel application with special high strength steel
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