

TGE MARINE

Company presentation

TGE Marine Gas Engineering
2023 | Bonn, Germany

THE GAS EXPERTS

Innovations for Greener Shipping

1. Introduction

2. Product Range

- Fuel Gas System (FGS)
- Ammonia (NH₃) Carrier & FGS
- Gas Carrier
- Bunker Vessel
- Floating Unit
- CO₂ Carrier

3. Expertise & Service

THE GAS EXPERTS – Innovations for Greener Shipping

TGE Marine Gas Engineering is the leading liquefied gas systems' provider, specialising in the design and engineering of cargo handling systems and tanks for any type of liquefied gas carriers, bunker ships and FSRUs.

Furthermore TGE Marine works under EPCS agreements on liquefied fuel gas systems for LNG, Ammonia (NH₃) and future fuels.

Over 40 years of experience with more than 250 gas carrier and around 100 fuel gas systems contracted.

Shareholder: Mitsui E&S Holdings Co., Ltd. Japan

Address: **TGE Marine Gas Engineering GmbH** Bonn • Germany

TGE Marine Gas Engineering Technology (Shanghai) Co. Ltd., Shanghai • China

Web/LinkedIn:  www.tge-marine.com /  <https://www.linkedin.com/company/tge-marine>

We are the leading provider of clean and efficient gas handling and fuel gas systems for the marine industry. Our motivated and skilled team creates value together with our customers by developing plants of the highest standards, paving the way for a sustainable future.

Keeping the Promise.

We are a reliable partner and show high integrity. We take responsibility for all our actions. Honesty, openness and transparency are the key to our strong working relationships.

Passion for Innovation.

We develop innovative solutions for our customers and deliver sustainable products of the highest quality. Our passion and experience enables us to discover new ways into the future.



For Greener Shipping.

We are committed to use nature's resources responsibly. It is our goal to enhance vessels with clean and efficient systems to reduce our ecological footprint.

All Aboard.

The greatest asset are the people who work in our crew. Our collaboration is based on trust, fairness and respect. Diversity is our strength and basis for innovation.

Our Product Range



Fuel gas systems	Cargo handling system and tanks		CO ₂ Carrier	Ammonia Carrier & FGS
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- Type C LNG tanks or vacuum insulated type
- Gas processing system
- LNG, LPG, Ammonia and alternative Fuels

- LPG carrier
- Ethylene carrier
- LNG shuttle tanker
- Other Gas carrier

- Bunker vessel

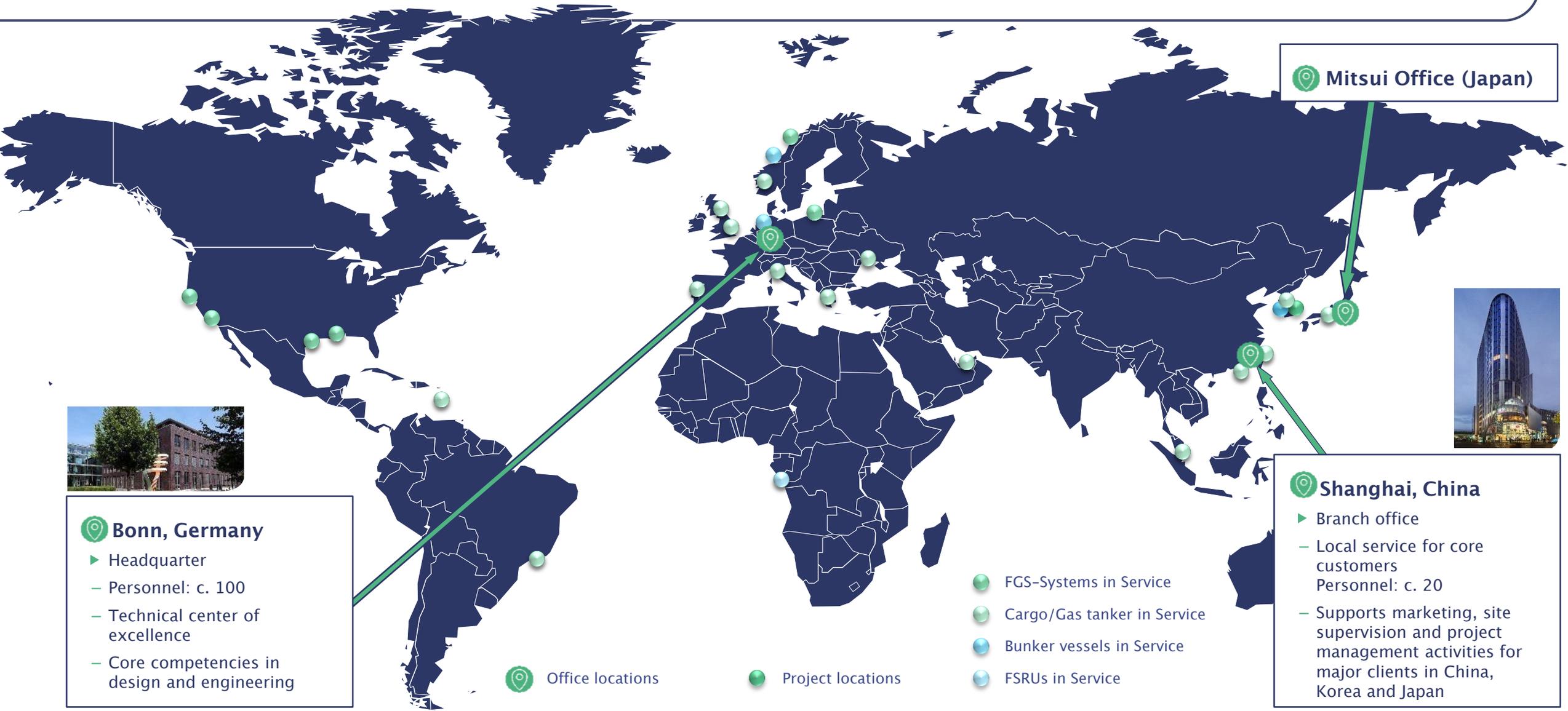
- FS(R)U and F(P)SO

- Shipping of and floating solutions for CCS

- Ammonia shuttle tanker
- Ammonia fuel gas systems

<ul style="list-style-type: none"> • Class Approvals • Type C Tanks • Naval Architecture 	<ul style="list-style-type: none"> • Engineering • Procurement • Construction Supervision 	<ul style="list-style-type: none"> • Project Management • FEED Studies • Training 	<ul style="list-style-type: none"> • After Sales • Service & Support • Operation Support
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Global footprint



Bonn, Germany

- ▶ Headquarter
- Personnel: c. 100
- Technical center of excellence
- Core competencies in design and engineering

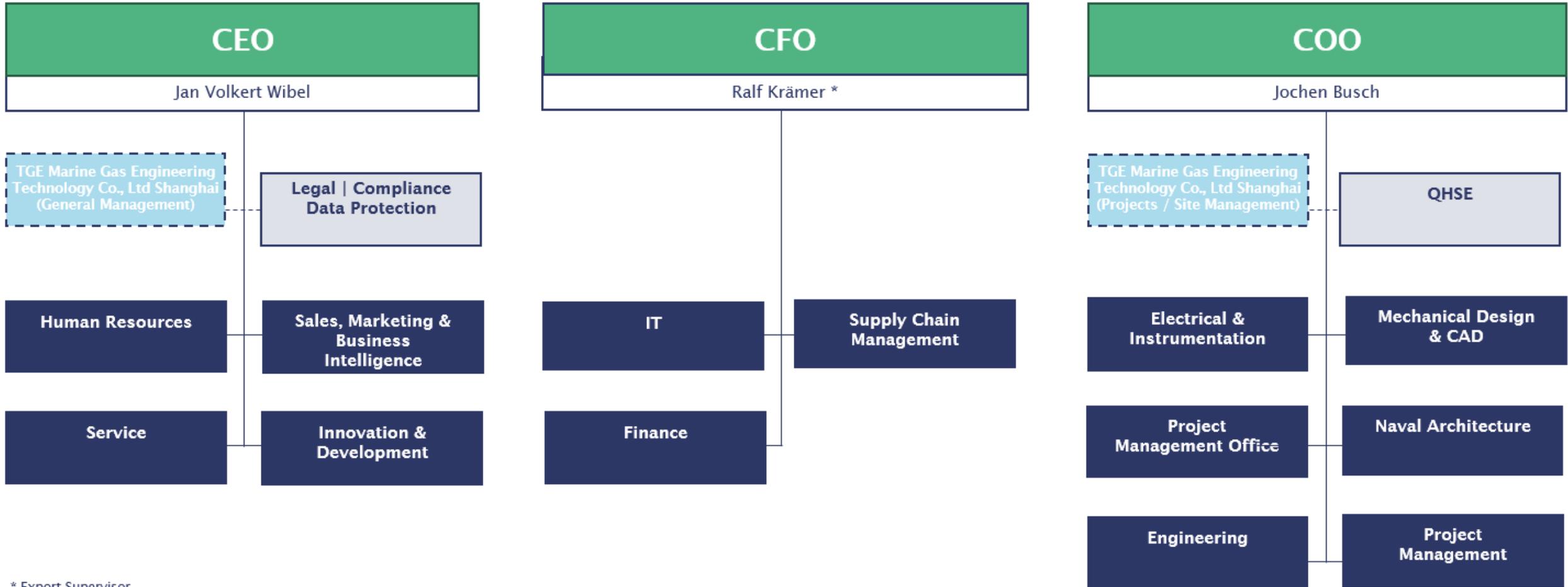


Shanghai, China

- ▶ Branch office
- Local service for core customers
Personnel: c. 20
- Supports marketing, site supervision and project management activities for major clients in China, Korea and Japan

- FGS-Systems in Service
- Cargo/Gas tanker in Service
- Bunker vessels in Service
- FSRUs in Service

● Office locations ● Project locations



* Export Supervisor

World's firsts



World's first high pressure LNG fuel supply system



World's largest LNG carrier based on type C tanks



World's first combined 7,500 m³ LNG/LEG/LPG carrier



37,000 m³ ethylene/ethane carrier, the largest ethylene ship in the world



World's first 16,100 m³ FLNG



World's first LNG bunker new building



World's first conversion of a container vessel



World's biggest fuel gas system for a crane vessel



World's first FRU Barge



World's first fuel gas system for an IceClass vessel



World's first vacuum insulated LNG fuel tanks



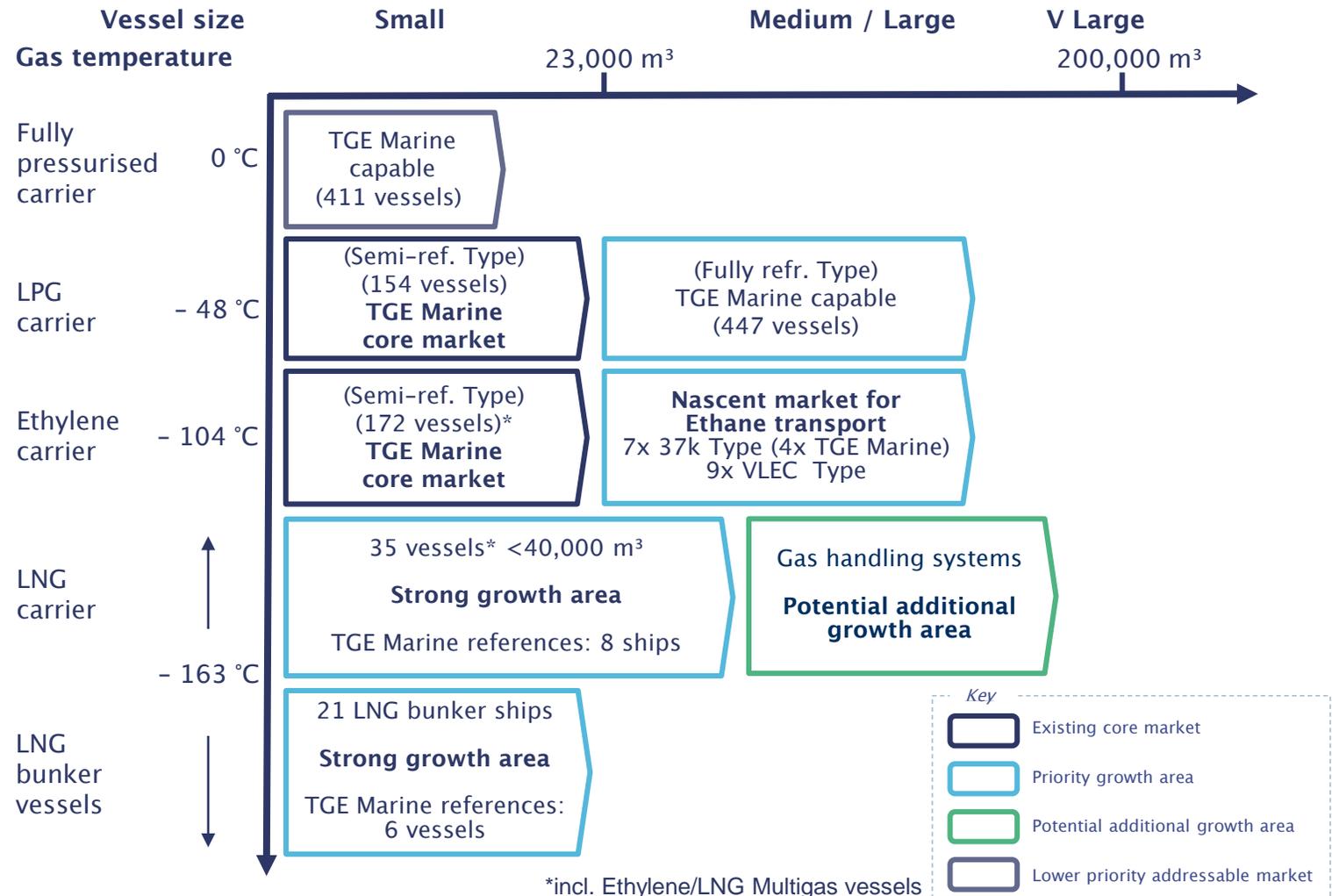
World's biggest PCTC entering in service in 2024

Summary

TGE holds a leading position in the small and medium sized segments of the gas carrier market:

- >60% share of the semi-ref Ethylene/LPG carrier market
- c.25% share of the small scale LNG carrier market
- c.30% market share of the global LNG bunker vessel market

Market positioning



status February 2021

Loyal customer base – track record of repeat business



Shipyards

China Merchant JinLing	Mitsubishi HI
CSSC	Nantong
DSME	Neptun Werft
DSIC	Remontowa
Fincanteri	Rolls-Royce
German Drydocks	Royal Bodewes
Guangzhou Wenchong	Samsung
Hanjin HI	Sanoyas
Hudong	Sasaki
Hyundai	Sempcorp Marine
Jiangnan Shipyard	Sinopacific Shipbuilding
Jiangsu Merchant	Taizhou Wuzhou
Jurong Shipyard	VT Halter Marine
Keppel AmFels	Wison
Keppel Nantong	Yangzhou Dayang
MAN Diesel & Turbo	Zhejiang
Meyer Werft	

Ship owners

Adnatco-NGSCO	Exmar	PASHA
AIDA	Formosa	Pertamina
Anthony Veder	Furetank	Petreded
Benelux Overseas	Geogas	Phillips Petroleum
Bergen Tankers	Harpain	Qatar Shipping
BWEK	Hartmann	Rimorchiatori
CNOOC	Heerema	Riuniti Panfido
Containerships	Höegh Carliner	Schulte Group
Crowley	Hyproc Shipping	Shell
Daelim	K-Line	Slovan Neptun
Elbdeich Reederei	Miyawa	Solvang
Elcano	Naftomar	Total Energies
Eletson	Nakilat	UECC
Engie	Navigator Gas	Uyeno
Equinor	NYK	Wideshire
Eships	Odfjel	

1. Introduction

2. Product Range

- Fuel Gas System (FGS)
- Ammonia (NH₃) Carrier & FGS
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- Floating Unit
- CO₂ Carrier

3. Expertise & Service



Clean fuel for future

We support the industry in reaching their sustainability targets and transforming to a greener future.

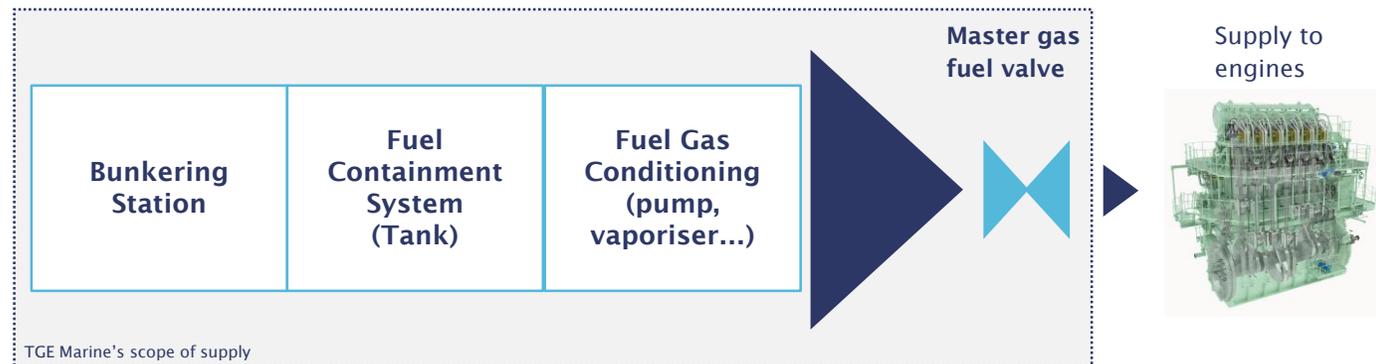
We engineer safe and reliable systems for storage and conditioning of various gases used as marine fuel.



We provide modularised LNG fuel gas systems for high volume markets such as bulkers and tankers as well as tailor made solutions for special applications designed in close cooperation with our customers.

- 2- and 4-stroke main and auxiliary engines and boilers with precise process control
- bunkering
- boil off gas handling
- dynamic load control
- combined LNG / NH3 tanks are possible

We are confident that ammonia fuel gas systems and other alternative fuels will play a strong role in decarbonisation of shipping.



Key references: LNG Fuel Gas System

1,000 m³ TEU Container Vessel 'Seaboard Blue':

- Owner: Elbdeich Reederei, Germany (ex. Wessels)
- Yard: German Drydocks, Germany
- Classification: BV
- Completion: 2017
- Scope: Low pressure fuel gas system for 4-stroke dual fuel main engines, 1 x 480 m³ fuel gas tank (type C)
- Highlight: World's first conversion on a containership to dual fuel



Semi Submersible Crane Vessel 'Sleipnir':

- Owner: Heerema, The Netherlands
- Yard: Sempcorp Marine, Singapore
- Classification: LR
- Completion: 2019
- Scope: Low pressure fuel gas systems for 4-stroke dual fuel engines, 8 x 1,151 m³ fuel gas tanks (type C)
- Highlight: Four independent fuel gas systems and eight vertically installed foam insulated fuel gas tanks, feeding engines with a power of 100 MW in total. Biggest fuel gas system in the world



Key references: LNG Fuel Gas System

28,000 m³ FSRU 'Torman':

- Owner: Gasfin Development S.A., Luxembourg
- Yard: CSSC Jiangnan Shipyard (Group) Co. Ltd., China
- Classification: BV
- Completion: 2020
- Scope: Cargo handling system with cargo tanks, LNG regasification units, BOG handling including TGE re-condenser, Low pressure fuel gas system for 4-stroke auxiliary engines, MV & LV Switchboard
- Highlight: Biggest cylindrical type C cargo tanks in the world with a volume of 14,000 m³ each

8x 9,100 PCTC:

- Owner: Höegh Autoliners AS, Norway
- Yard: China Merchants Heavy Industry (Jiangsu) Co., China
- Classification: DNV
- Completion: 2024-2026
- Scope: High pressure fuel gas system for a 2-stroke main engine and low pressure fuel gas system for 4-stroke auxiliary engines. 1 x 3,400 m³ bilobe fuel gas tank (type C) and TGE recondenser for sustainable BOG Management.
- Highlight: Ammonia and methanol fuel ready class notation. The new AURORA Class is the world's biggest PCTC entering in service in 2024



Key references: LNG Fuel Gas System

Conversion of 3,750 DWT Product Tanker 'Bergen Viking':

- Owner: Bergen Tankers, Norway
- Yard: Noryards, Norway
- Classification: BV
- Completion: 2015 (for conversion to gas propulsion)
- Scope: Low pressure fuel gas system, 2 x 150 m³ vacuum insulated fuel gas tanks (type C)
- Highlights: Two fully redundant fuel gas systems due to pure gas engines



Key references: LNG Fuel Gas System

2x 3,800 Pure Car Carrier:

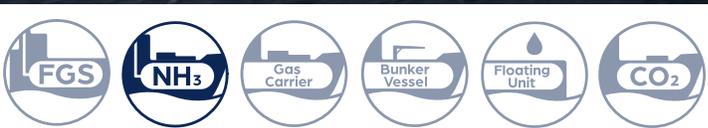
- Owner: UECC (Wallenius/NYK), Norway
- Yard: NACKS, China
- Classification: LR
- Completion: 2016
- Scope: High pressure fuel gas system for a 2-stroke main engine and low pressure fuel gas system for 4-stroke auxiliary engines, 1 x 760 m³ fuel gas tank (type C)
- Highlight: World's first dual fuel PCTC



**Clean fuel for future
Ammonia (NH₃)**

**We support the industry
in reaching their
sustainability targets
and transforming to a
greener future.**

**We engineer safe and
reliable systems for
storage and
conditioning of various
gases used as marine
fuel.**

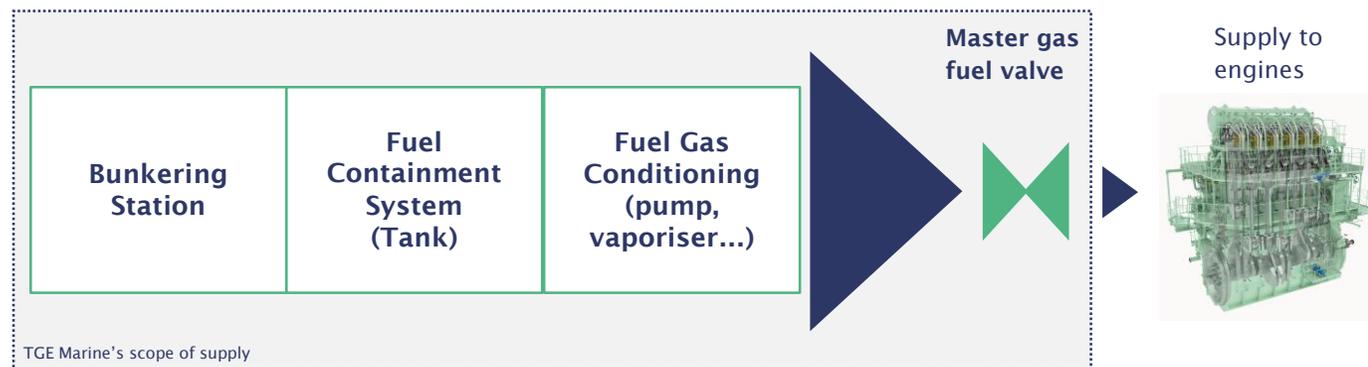


Ammonia (NH₃) Fuel Gas System

We provide modularised NH₃ fuel gas systems for high volume markets such as Ammonia carriers and PCTCs as well as tailor made solutions for special applications designed in close cooperation with our customers.

- NH₃ main engines, auxiliary engines and boilers
- bunkering
- reliquefaction

We are confident that ammonia fuel gas systems and other alternative fuels such as hydrogen will play a strong role in decarbonisation of shipping.



Key references: NH₃ Fuel Gas System

8x 9,100 PCTC NH₃ and Methanol ready:

- Owner: Höegh Autoliners AS, Norway
- Yard: China Merchants Heavy Industry (Jiangsu) Co., China
- Classification: DNV
- Completion: 2024-2026
- Scope: High pressure fuel gas system for a 2-stroke main engine and low pressure fuel gas system for 4-stroke auxiliary engines. 1 x 3,400 m³ bilobe fuel gas tank (type C) and TGE recondenser for sustainable BOG Management.
- Highlight: Ammonia and methanol fuel ready class notation.

NH₃ can be loaded into the fuel tanks without any modification.





Cargo handling systems and cargo tanks for gas carriers under the IGC code.

**Ethylene Carriers
Ethane Carriers
LPG Carriers
small- and midscale
LNG carriers
other Gas Carriers**

**Semi-refrigerated
Fully-refrigerated**



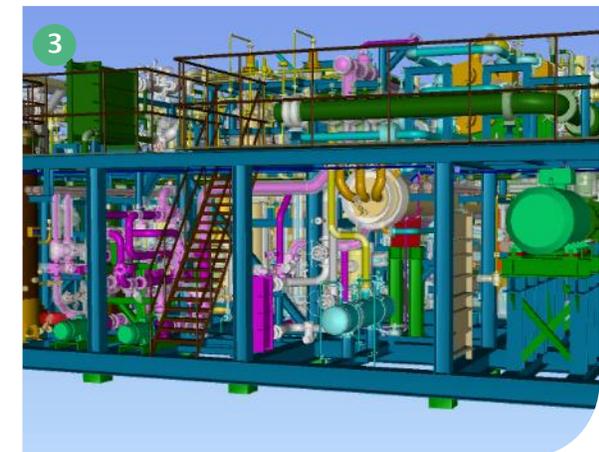
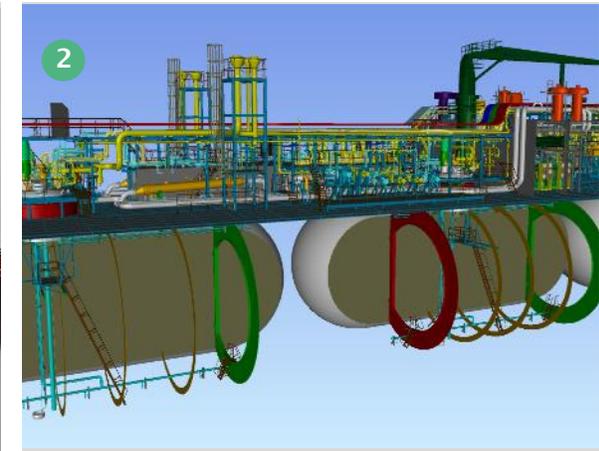
Cargo handling systems and cargo tanks for all kind of cryogenic liquefied gases

More than 250 gas carriers equipped:

- Ethylene
- Ethane
- LPG
- Petrochemicals
- CO₂

More than 450 cylindrical or bilobe type C tanks

In house ship design packages for complete project development.



1. 13,000 cbm LPG carrier
2. 3D Model of cargo tanks, piping, arrangement, and reliquefaction plant
3. Reliquefaction plant on a gas carrier

4x 37,000 m³ LEG/LPG Carrier:

- Owner: Navigator Gas, United Kingdom
- Yard: CSSC Jiangnan Shipyard, China
- Classification: ABS
- Completion: 2016–2017
- Key fact: EPCS–contract, gas handling system incl. cargo tanks and LNG fuel gas system for ME–GI engine and LNG fuel tanks

5x 21,000 m³ LEG Carrier:

- Owner: Navigator Gas, United Kingdom
- Yard: CSSC Jiangnan Shipyard, China
- Classification: DNV–GL
- Completion: 2014–2015
- Key fact: EPCS–contract, gas handling system and cargo tanks



Small to medium size LNG carrier

Capacities: 5,000 m³ up to 70,000 m³

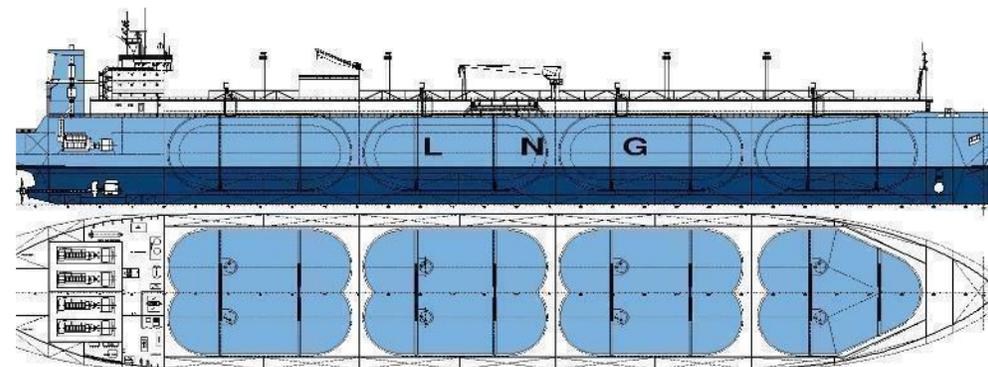
- 6 vessels delivered
- current market: 5,000 m³, 10,000 m³, 12-15,000 m³, 20,000 m³ and 30,000 m³

Ship design packages available

Cargo tanks: type C pressure vessels
cylindrical or bilobe

More operational flexibility due to pressure built-up technology.

Tank material: 9% Ni steel or stainless steel



Key references: Ethylene Carrier

4x 12,000 m³ LEG/LPG Carrier:

- Owner: Eletson, Greece
- Yard: Hyundai Mipo Dockyard, Korea
- Classification: LRS
- Completion: 2015
- Key fact: EPCS-contract, gas handling system and

2x 4,700 m³ LEG/LPG Carrier:

- Owner: Anthony Veder, The Netherlands
- Yard: Dingheng Shipyard, China
- Classification: BV
- Completion: 2014
- Key fact: EPCS-contract, gas handling system



Key references: LPG Carrier

2x 23,000 m³ LPG carrier:

- Owner: Qatar Shipping, Qatar
- Yard: STX, Korea
- Classification: DNV-GL
- Completion: 2003-2004
- Key fact: EPCS-contract, complete gas handling system, cargo tanks & ship design development



2x 13,000 m³ LPG carrier:

- Owner: Hyproc Shipping, Algeria
- Yard: CSSC Jiangnan Shipyard, China
- Classification: BV
- Completion: 2018
- Key fact: EPCS-contract, complete gas handling system and cargo tanks



18,000 m³ LNG carrier 'Coral EnergICE':

- Owner: Anthony Veder, The Netherlands
- Yard: Neptun Werft, Germany
- Classification: BV
- Completion: 2018
- Key facts: complete gas handling and fuel supply systems

28,000 m³ LNG carrier 'Qi Yuan':

- Owner: Dalian Inteh Group, China
- Yard: COSCO Dalian, China
- Classification: CCS
- Completion: 2016
- Key facts: complete gas handling system and fuel gas system, cargo tank design and material package





LNG Bunkering

Bunker vessels are the new workhorse to provide clean fuel to the clients.



Small to medium size LNG carrier

Capacities: 5,000 m³ up to 70,000 m³

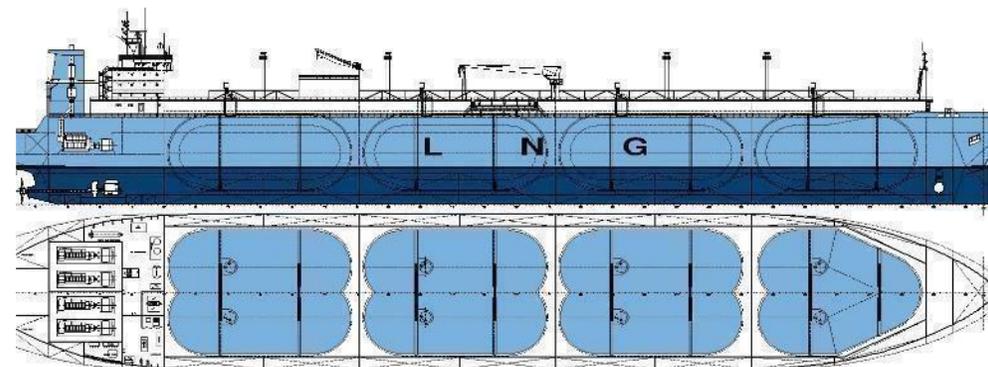
- 6 vessels delivered
- current market: 5,000 m³, 10,000 m³, 12–15,000 m³, 20,000 m³ and 30,000 m³

Ship design packages available

Cargo tanks: type C pressure vessels
Cylindrical or bilobe

More operational flexibility due to pressure built-up technology.

Tank material: 9% Ni steel or stainless steel



Key references: LNG bunker vessel

7,500 m³ LNG carrier & bunker vessel 'Coral Methane':

- Owner: Anthony Veder, The Netherlands
- Yard: Remontowa, Poland
- Classification: BV
- Completion: 2009/Conversion 2018*
- Key facts: EPCS-contract, cargo handling system, fuel supply system, complete cargo tanks, ship design development

*Conversion to LNG bunker vessel

5,800 m³ LNG bunker vessel 'Coralius':

- Owner: Sirius Veder, Sweden/The Netherlands
- Yard: Royal Bodewes, The Netherlands
- Classification: BV
- Completion: 2017
- Key facts: cargo handling system with cargo tanks, LNG fuel gas system





Floating LNG/LPG solutions will bring plenty of benefits for our customers.

We offer:
Regasification plants & gas handling Equipment, LNG/LPG storage tanks for small- and midscale applications
Design studies, FEED & shipbuilding basic engineering packages



FSRU

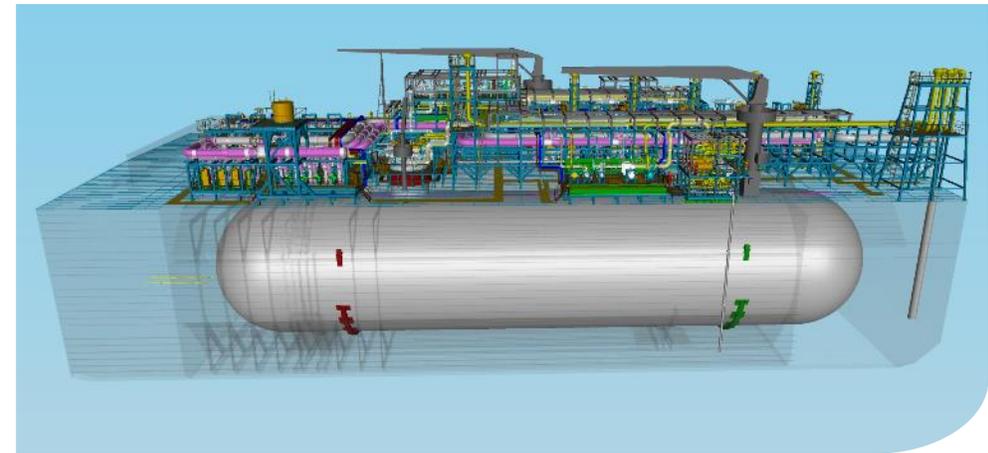
LNG terminals can be built either on land or as a floating unit. A floating terminal – known as a Floating Storage and Regasification Unit (FSRU) can be realised most economically and quickly.

LNG-to-Power

Combing small to midscale LNG FSRU with gas consuming power plants provides flexible and easy access to emerging energy markets.

Offshore

Since the early 1990 we are active the Offshore gas market. As industries partner we developed tailor made solutions for new buildings and conversions.



LNG-to-Power 5,000–80,000 cbm:

- Flexible solutions for diverse technical- and environmental requirements
- Nominal send-out from 5–250 MMSCFD (4–200 t/h)
- Send-out pressure: 8–300 bar
- Tank type: type C cargo tanks with high operational flexibility
- Closed loop vaporisation with waste heat from power barge
- Electrical supply from power barge
- BOG handling

28,000 m³ FSRU 'Torman':

- Owner: Gasfin Development S.A., Luxembourg
- Yard: Jiangnan Shipyard, China
- Classification: BV
- Completion: 2021
- Scope: FEED, Hull Design, EPC(S) for tanks, cargo handling and re-gas system



16,000 m³ Tango FLNG:

- Owner: Exmar, Belgium
- Yard: Wison Offshore & Marine, China
- Classification: BV
- Completion: 2016
- Scope: complete gas handling for loading and unloading, cargo tanks
- Process liquefaction package: contracted to Black & Veatch by Wison

95,000 m³ LPG FSO 'Liberdade':

- Owner: Conoco Philips, Australia
- Yard: Samsung HI, Korea
- Classification: LR
- Completion: 2003
- Scope: complete gas handling system



Shipping of and floating solutions for Carbon Capture & Storage (CCS)

TGE offers low pressure (8 barg, -55°C) to medium pressure (19 barg, -35°C) solutions, depending on your value chain

We offer: Tank design, FEED studies, engineering and procurement for the whole cargo handling system and much more





LNG Carrier



- Membrane type
- Moss type
- Prismatic SPB type
- Type C Tanks



Design pressure too low
(<5 barg)



Fully-press. LPG Carriers



- Type C Tanks



Design temperature too high
(-10°C)



LPG Carrier



- Type A Tanks



Design pressure too low
($<0,7$ barg)

LPG Carrier, Semi-ref



- Type C Tanks
- Reliquefaction
 - Refrigerant loop to be added
 - Higher OPEX
- Suitable if $P_{design} > 6.5\text{barg}$
- Severe filling limit restrictions
 - Design density (610–680kg/m³)
 - Scantling draught

Ethylene Carriers



- Type C Tanks
- Reliquefaction
 - Higher OPEX
- Severe filling limit restrictions
 - Design density (690kg/m³)
 - Scantling draught

Pressurised CO₂ Carrier



- Type C Tanks
- Uncooled
- $P_{design} >$ Pressure build-up during voyage
- Operation analysis
- Higher CAPEX; lower OPEX

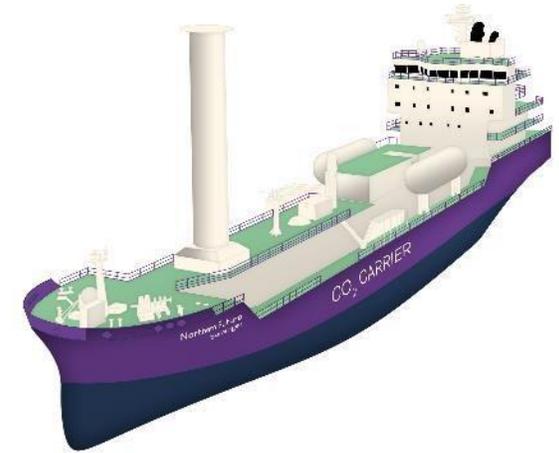


Very limited number of existing carriers suitable for CO₂ shipping

-  On-shore CO₂ Liquefaction, Storage and Shipping **exists and is proven**
-  CO₂ **Shipping** is a viable option for CO₂ logistics
-  CO₂ Transport with **existing fleet very limited**
-  Technical **solutions** for all steps of offshore CO₂ transport chain **available**
-  **Combination** of CO₂ with cargoes like **LPG, Ethylene**, **reduces** the **risk** for early-movers
-  On-board **carbon reliquefaction and storage** solutions are available
-  **CCS** important role on the CO₂ way to **net-zero and beyond**

7,500 m³ CO₂ Gas Carrier:

- Owner: Northern Lights (JV between Shell/Total/Equinor)
- Yard: DSIC Dalian Shipbuilding Industry, China
- Classification: DNV
- Completion: under construction (End of 2024)
- Scope: Cargo Handling system (excl. Tanks) incl. engineering & procurement of the system



LCO₂ Carrier study (DanUnity)

GreenSand Project in DK

- Carbon capture and storage
 - Conceptual development of LP (~8 barg; -55°C) LCO₂ Carriers
 - 12,500 cbm
 - 22,000 cbm
 - 50,000 cbm



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- Floating Unit
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3. Expertise & Service

Tank fabrication expertise

TGE Marine is a world leading contractor for fabrication and delivery of cargo tanks.

More than 400 cylindrical, bi-lobe or prismatic cargo tanks contracted to date

Tank materials: 9% Ni steel, 5% Ni steel, 0,5% Ni steel, LT-carbon steel, high strength steel, stainless steel (304L, 316L)

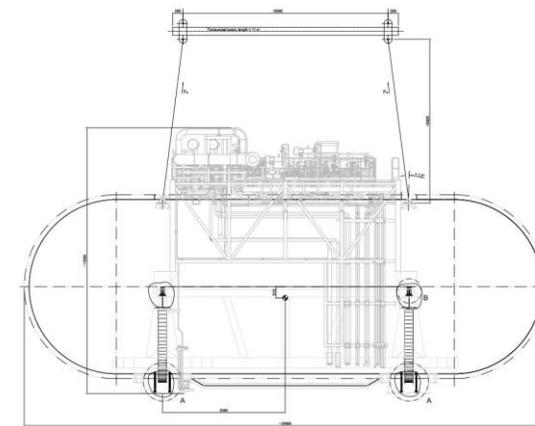
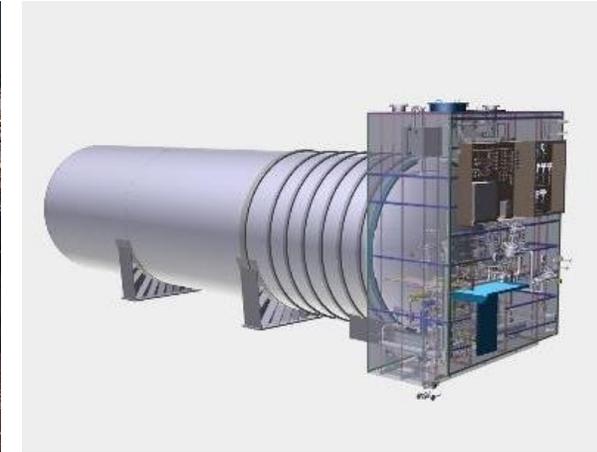
Total net steel weight more than 120,000 tons

In close co-operation with its fabrication partner - CSSC Jiangnan Shipyard (Group) Co., Ltd. - TGE Marine has delivered tanks from China to Korea, Japan and Europe

TGE Marine co-operates for vacuum insulated tanks with experienced tank suppliers

TGE Marine's scope of services for type C tanks:

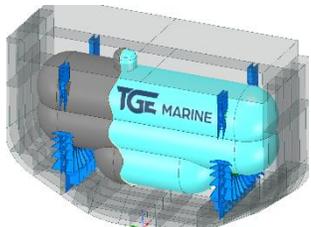
- Tank design with classification approval
- Supply of all materials
- Supervision of fabrication
- Delivery of tanks with classification certificate to the shipyard



TGE Marine has gained significant experience in the last 40 years. In combination with the World First experience, we generate innovative solutions while keeping high safety & quality standards, maximum reliability and optimum system functionality.

The innovations have the target to achieve for the benefit of our clients in cooperation with our partners

- the best possible system efficiency
- a sustainable reduction of GHG emissions
- environmentally friendly solutions based on LCA
- first class tools for operational support
- high flexibility to support Owner's trade/requirements



We provide innovative solutions for the marine & offshore industry in cooperation with and for the benefit of our customers.

Our focus is to increase system efficiency, decrease GHG emissions, optimizing operation while ensuring operational safety, high quality and system functionality.

The project management system (PMS) at TGE Marine is based on proven project management standards, methods and tools. To ensure deliveries on time, budget and quality, our focus is on:

- Robust project planning from the beginning
- Regular reporting of project status and progress
- Continuous risk monitoring and mitigation
- Experienced and well-developed project teams
- Efficient communication and collaboration
- Engagement of project stakeholders at all times

Supported and accompanied by our internal project steering committee (PSC) and project management office (PMO).



Professional project management is the key to project success & essential to satisfy our customers.



Service & Support



Customers often have questions about the correct handling of liquefied gases by the ships' crews. We are continuously working on advanced process automation and improved support, combined with the development of modern training standards.

Our Services department offers support with in the following areas:



Aftersales



Warranty



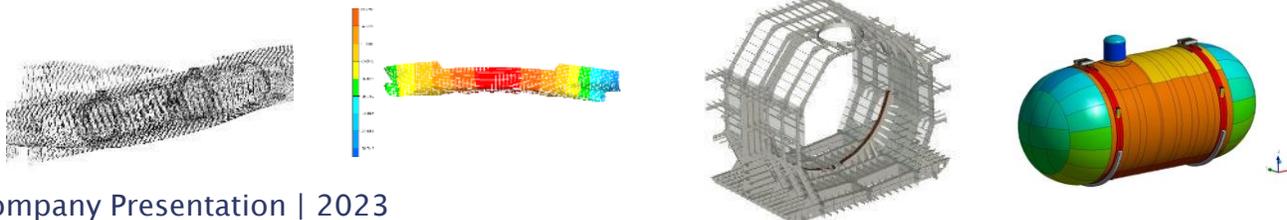
Technical Field Service



As the market leader in the ethylene and small-scale LNG tanker segment, we are well aware of the safety requirements that liquefied gases entail, as they can be toxic and flammable. This requires sophisticated engineering with a focus on safety.

We provide our clients with solid technical expertise and state-of-the-art software tools throughout the entire construction phase.

- Ship theoretical evaluations in respect to hydrostatics such as longitudinal strength, intact and damage stability.
- Optimisation of principal particulars and ship lines for highly efficient hydrodynamic speed/power performance and low fuel consumption
- Steel structure classification documents based on finite element calculations
- Propulsion machinery and auxiliary systems
- Outfitting and safety systems
- As a new development, the tanks can now also be installed in a more space-saving manner by turning the horizontal tank 90 degrees while retaining the same design.



Our naval architects and marine engineers offer sophisticated design packages ranging from feasibility studies to complete sets of class-approved design documents for all types of modern gas tankers.



TGE MARINE

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