

small to mid-scale LNG solutions

LNG-TO-POWER



two companies with a powerful link

LNG-TO-POWER



Combining small to mid-scale LNG Floating Storage and Regasification Units (FSRU) with floating power barges provides flexible and easy access to emerging energy markets.

Significant quantities of liquid natural gas (LNG) supplies are emerging from production facilities under construction. The increased volume is leading to saturated off-taker markets. As a result, many molecule owners in the LNG sector will have a surplus. Due to these market conditions, LNG suppliers are exploring new market opportunities. One of these opportunities is the small to mid-scale LNG supply chain based on marine transportation. This supply chain segment provides access to remote or underdeveloped markets with limited access to gas supplies.

The power barge concept is a proven technology: it satisfies the energy needs of emerging countries and regions quickly and safely. Despite the need for electricity in these regions,

feasible ways to implement gas grid or LNG infrastructure has been lacking. As a result, leading energy providers have tended to select oil as their fuel of choice.

As gas has become more readily available, however, power projects using gas-based solutions on floating infrastructure have become commercially viable – when supported by the right technical solutions.

TGE Marine Gas Engineering GmbH (TGE Marine) is a market-leading engineering contractor for the design and supply of gas handling systems for gas carriers and offshore units. TGE Marine has been working on FSRU designs since the turn of the millennium and can deliver the complete FSRU design.



Burmeister & Wain Scandinavian Contractor A/S (BWSC) has 30+ years of experience in the design and supply of small to medium-sized power stations, and has successfully delivered more than 180 turnkey projects, including a number of power barges.

The basis for the technical development of the LNG-to-power solution are the existing designs for FSRUs and power barges as well as the current advances in both technologies. The power barge design can be adapted to particular project requirements and constraints. Design features include the integration of the power barge's waste heat for regasification.

The power barge is equipped with multiple, large bore reciprocating engines operating in either pure gas mode or

dual fuel systems using oil as a back-up fuel. This ensures high availability and efficiency from low loads to maximum capacity. In addition, the efficiency of reciprocating engines does not derate until an ambient temperature of 39°C or more is reached, which in tropical areas provides an advantage over other generation technologies. With a very low draught of less than four metres, a power barge does not require valuable quay space. Emission levels comply with World Bank Guidelines, and equipped with abatement systems, the power barge can meet even stricter emission limits.

A FSRU with an integrated 60-150 MW power barge is a highly flexible and mobile solution for clean power supply.

POWER BARGE



Turnkey projects based on reciprocating engine technology

BWSC markets a proven power barge design based on our vast experience in reciprocating engine-based power plants. The power barge is designed to utilise four to eight large bore engines operating natural gas or dual fuel (natural gas together with heavy or light fuel oil), delivering thermal efficiency rates of up to 50 percent at all loads, even at partial loads. Standard power plant spacing between engines has been maintained for optimal operation ability and maintenance.

Power barges are designed and constructed as industrial installations on a marine-classed deck barge and delivered to their selected site by ocean tow or heavy lift ship. They are designed for mooring in sheltered coastal areas and on rivers. Their low draught and hull painting allows for underwater inspections, making dry docking unnecessary.

Power barges have the same guaranteed performance and operation and maintenance costs as land-based plants, and BWSC can offer operation and maintenance plans on a long-term contract.

Operations are self-contained, with the necessary tanks located on board and able to hold 2.5 days' worth of fuel. The hull is designed to accommodate utility rooms and storage areas. The electrical equipment is located on board, including control, low and medium voltage switchboards and step-up transformers with an option for on-board HV breakers to protect the barge against any land-based incidents. The barge is capable of a so-called 'black start', restoring power without an external power source.



The power barge will supply the FSRU with electricity and hot water for regasification.

Minimising environmental impact

- Designed to comply with World Bank Emission Guidelines
- Use of radiator coolers to avoid heat up of seawater
- Oily water treatment on board

Reciprocating engine technology

- From standby to full load in less than seven minutes
- No derating of output up to 39°C ambient temperature
- Full interchangeability of dual fuel engines between gas and liquid fuels (15-100%)
- Designed for MAN Energy Solutions large-bore engines 18.5 - 21 MW each

Dimensions

| | |
|--------------------------------|-----------------|
| Operating draught | from app. 3.5 m |
| Length | 65-90 m |
| Width | 39 m |
| Height (stack tops) | 40 m |
| Standard design for wind loads | up to 200 km/h |

A well-designed power barge that uses proven technology is a low-risk mobile asset, financed with little or no stranded costs. Once a Power Purchase Agreement (PPA) has terminated, the barge can be removed and relocated to another site, ensuring an extremely high asset value to the owner and a minimal impact on the local environment.

THE LNG FSRU



Flexible storage capacity, reliable energy delivery

TGE Marine's LNG FSRUs for the small and mid-scale markets are perfectly suited as fuel supply units for power barges.

TGE Marine provides the unit's complete design, including delivery of the entire gas-handling system with storage and re-gasification plant. The hull and mooring arrangements are based on experience from various FSRU projects. TGE Marine supports clients from the project's start, throughout the feasibility phase, the development of the complete design as well as with preparation of the documentation required for local operation and environmental permits. Due to the implementation of type C tank technology, the project can be executed by any experienced shipyard. The barge is designed to marine standards and meets all classification requirements. Offshore standards may be implemented where necessary.

TGE Marine's FSRU design ranges from 5,000-80,000 m³ of storage capacity. The ressure vessel type C tanks are delivered to the fabrication yard fully tested and calibrated. The re-gasification technology is based on ambient air vaporisers or on intermediate cycle vaporiser technology with seawater (open loop) or gas (closed loop) used as a heating source.

To further optimise efficiency, the re-gasification plant uses waste heat from the power barge for the re-gasification process. As the re-gasification system on an FSRU is directly connected with a power barge, it is effectively a gas fuel system, so TGE Marine can draw on its vast experience with LNG fuel gas system supplies. The requirements of the load changes induced by the power production are integrated into the control design of the FSRU.



In addition to the storage system and re-gasification plant, TGE Marine takes care of the complete hull design, the design of the gas-handling system and all gas and safety-related utilities as well as electrical and control systems. With TGE Marine's supervision and support, the construction of the FSRU barge can be carried out by any experienced shipyard.

During the lifetime of the project, TGE Marine will perform all after-sales services as well as the required training of operators.

Particulars of FSRU (as shown above)

- Peak/nominal send-out: 200 t/h / 150 t/h
- Maximum send-out pressure: up to 100 barg
- Design seawater temperature: min. 11°C
- Additional boilers allows send-out at low seawater temperatures
- Electricity generated with natural gas-fuelled gensets
- Tank design (pressure vessels) increases operational flexibility – 2 x 10,000 m³
- High flexibility
- Length: 83 m
- Width: 37 m
- Draught: 6.5 m
- Liquid send-out to shore (truck-loading)
- Liquid send-out to ship (bunkering)
- Operation with or without additional storage unit (FSU)

Access to reliable, low-cost energy is essential in order to achieve sustainable economic growth and develop the private business sector and society. Utilities, independent power producers (IPPs) and power-generating industrial companies are increasingly dependent on their ability to maximise the efficiency of their assets, and they need business partners who understand the core of their business.

Burmeister & Wain Scandinavian Contractor A/S (BWSC) is a world-leading turnkey contractor and operator for medium and large diesel and gas engine-based power systems. BWSC also has extensive experience in biomass technologies. Our expertise ranges from all aspects of plant design to rehabilitation, operation, maintenance, service and financing.

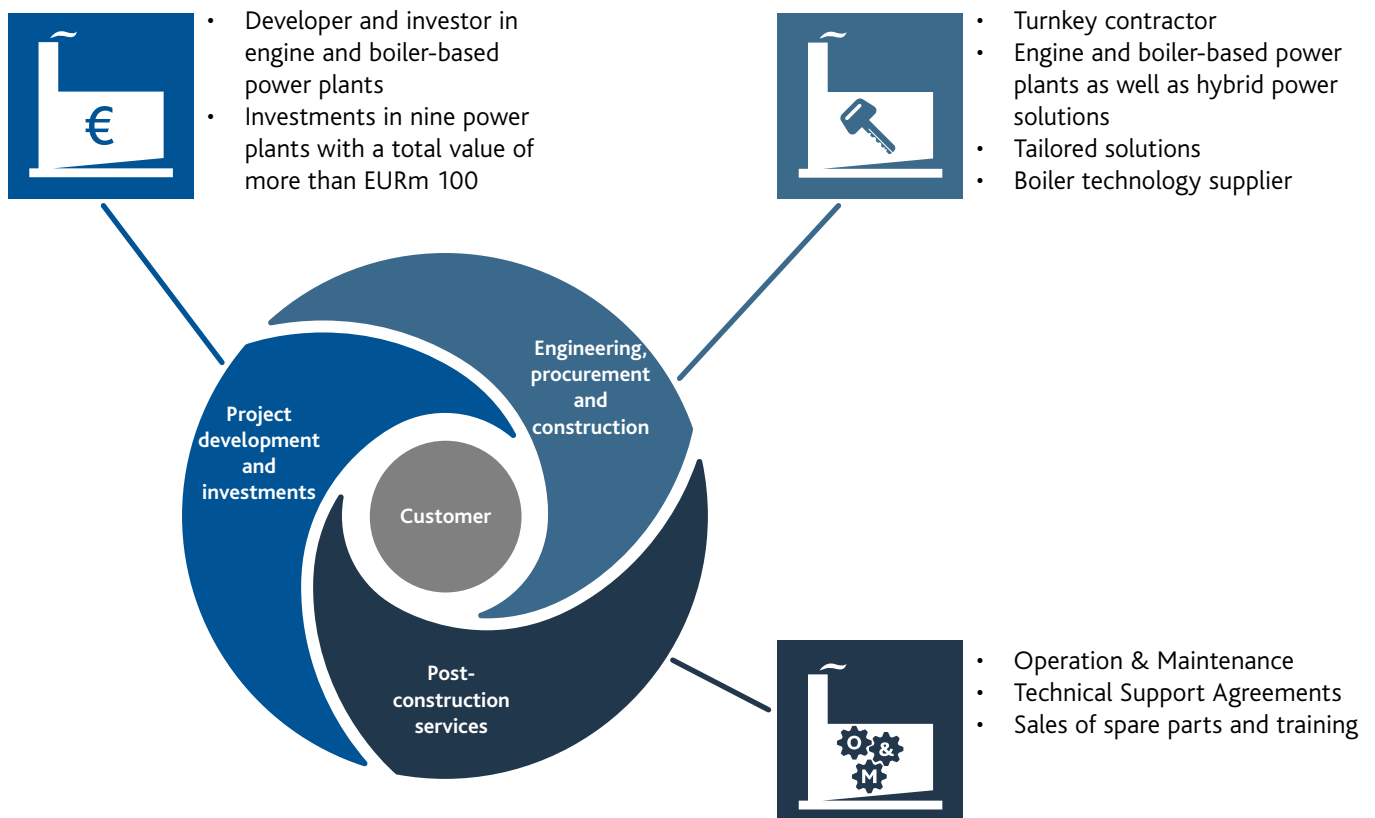
BWSC takes a leading role in the development of IPP companies. This includes the establishment of all commercial and legal agreements, including power and fuel purchase contracts, financing, insurance and land lease arrangements. In addition to assuming the initial role of developer, BWSC undertakes the supply and construction of the complete plant on a turnkey basis and provides operation and maintenance (O&M) services for the lifecycle of the plant.

BWSC has supplied more than 180 power plants to 54 countries, with a total generating capacity in excess of 3,800 MW. In addition to turnkey power plants, BWSC's product range includes transmission lines, distribution systems, generation services, training, spare parts and power plant rehabilitation.

BWSC has its origins in the stationary engine division of Burmeister & Wain (B&W), which built and installed diesel engines from 1904. BWSC was established in 1980 as a separate specialist company with the aim of developing their technologies into high-efficiency power plants. Since then, the company has evolved into a full turnkey contractor and developer of power plant projects all over the world. In 1990, BWSC was acquired by Mitsui E&S Holdings Co., Ltd., Japan.

Main activities

BWSC offers services throughout a power plant's life cycle





60 MW power barge:

Customer: Mitsui E&S Holdings Co., Ltd.
 Country: Sri Lanka
 Award: 1999
 Completion: 2000

Scope: Electrical engineering, supply and erection of electrical equipment, barge-mounted diesel power plant. Four MAN B&W 12K50MC-S engines.
 Operation and maintenance for 15 years.



2 x 102.5 MW power barges:

Customer: National Power Corporation
 Country: Philippines
 Award: 1992
 Completion: 1994

Scope: Two turnkey power barge projects. Each barge is powered by two Mitsui MAN B&W 12K90MC-S engines.
 Operation and maintenance for 20 years.



13 MWe + 12.2 MWh CHP station at Revithoussa Island:

Customer: Hellenic Gas Transmission System Operator
 Country: Greece
 Award: 2007
 Completion: 2009

Scope: Turnkey project. Two Caterpillar G16CM34 gas engines.

TGE MARINE

TGE Marine Gas Engineering GmbH (TGE Marine) is a market-leading engineering contractor specialising in the design and supply of gas-handling systems for gas-carriers, offshore units and LNG fuel gas systems

TGE Marine delivers turnkey solutions (engineering, procurement and construction supervision - EPCS) for the storage and handling of cryogenic gases (LNG, ethylene, LPG, ammonia) onboard gas carriers, floating units and merchant ships operating with LNG as fuel. TGE Marine specialises in containment systems and processing of liquefied gases (these are often both highly toxic and flammable) and is market leader in the ethylene and small LNG carrier segment.

Most of our customers are commercial shipyards which build gas carrier ships. To date, TGE Marine has supplied gas-handling and storage systems to more than 200 gas carriers constructed at more than 20 shipyards across Europe, Asia and South America. Since 1989, TGE Marine has been operating in China and has supplied gas plants for most gas carriers built for international shipowners.

- Almost 40 years of experience
- Approximately 70 percent market share of highly sophisticated ethylene carrier segment
- Market leader for small LNG carriers based on type C tank technology
- More than 200 gas tankers supplied with cargo-handling systems and cargo tanks
- Patented tank concept for LNG carriers of up to 35,000 m³
- Experience in FSOs, FPSOs and FSRUs (LPG, LNG)
- Competence in innovative LPG and LNG offshore projects
- Design packages for all types of modern gas tankers
- Customised LNG fuel gas systems for merchant and passenger vessels

In 2015, TGE Marine was acquired by Mitsui E&S Holdings Co., Ltd., Japan.



Cargo-handling systems and tanks for gas carriers

- LPG carriers
- Ethylene carriers
- LNG carriers
- LNG bunker vessels



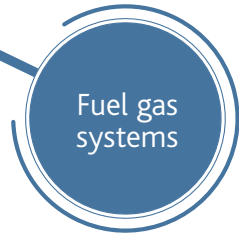
Cargo-handling systems for offshore units

- FSO/FPSO for LPG
- FSRU and FPSO for LNG



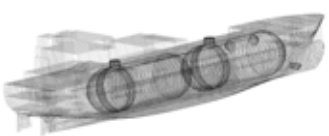
Ship design packages

- Basic Ship Classification drawings
- Complete design package including steel drawings



Fuel gas systems

- Type C LNG tanks or vacuum-insulated type
- Gas processing system





16,100 m³ Caribbean FLNG:

Owner: Exmar, Belgium
 Yard: Wison Offshore & Marine, China
 Classification: BV
 Completion: 2016

Scope: Complete gas handling system for loading and unloading, cargo tanks
 Process liquefaction package: Contracted to Black & Veatch by Wison



30,000 m³ LNG carrier:

Owner: CNOOC, China
 Yard: CSSC Jiangnan Shipyard, China
 Classification: CCS (ABS)
 Completion: 2015

Scope: Complete gas handling and fuel supply system, cargo tank design and material package



7,500 m³ LNG/LEG/LPG carrier:

Owner: Anthony Veder, The Netherlands
 Yard: Remontova, Poland
 Classification: BV
 Completion: 2009

Scope: EPCS contract, gas handling system, fuel gas system & cargo tanks, ship design development

Burmeister & Wain Scandinavian Contractor A/S
Gydevang 35
DK-3450 Allerød
Denmark

Phone: +45 4814 0022
Fax: +45 4814 0150

bwsc@bwsc.dk
bwsc.com

TGE Marine Gas Engineering GmbH
Mildred-Scheel-Straße 1
53175 Bonn
Germany

Phone: +49 228 50218 0
Fax: +49 228 50218 880

sales@tge-marine.com
tge-marine.com

FACTS ABOUT BWSC

- World-leading turnkey EPC contractor and service provider for diesel, natural gas and renewable baseload power plants for electricity generation and thermal energy production
- More than 180 power plants designed and supplied in 54 countries
- Two decades of experience in operation and maintenance of power plants
- A comprehensive range of power plant support services, from spare parts to complete rehabilitation
- Training programmes for all aspects of power plant operation and maintenance
- Extensive experience in financing and development of power plant projects
- Headquartered in Denmark and supplemented by an international sales and support network
- 700 employees based at our main office and power plants around the world
- 100% subsidiary of Mitsui E&S Holdings Co. Ltd., Japan
- Certified according to ISO 9001, ISO 14001 and OHSAS 18001
- Long-standing AAA rating, 2017 revenues: EURm 387

