

small to mid-scale LNG solutions

# LNG-TO-POWER



strong partnership between sister companies

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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 new LNG supplies are emerging from new liquefaction plants under construction. The increased volume is leading to saturation of the existing off-taker markets and even to a situation of oversupply. In other words, many molecule owners in the LNG sector will have excess LNG and are looking for new outlets. Due to these market conditions, LNG providers are looking into new market opportunities. One of these market openings is the small to mid-scale LNG supply chain based on marine transportation. This segment of supply chain provides access to remote or underdeveloped markets with limited access to gas.

The power barge concept is a proven technology in terms of satisfying the energy demand of emerging countries and regions in a prompt and safe manner. Within these regions,

there has rarely been concurrence between the need for electricity and an easily accessible way to implement gas grid or LNG infrastructure, causing oil to be the fuel of choice.

However, as fuel availability has now significantly shifted towards easily accessible gas, gas-based power projects using floating infrastructure have become commercially viable, if 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.



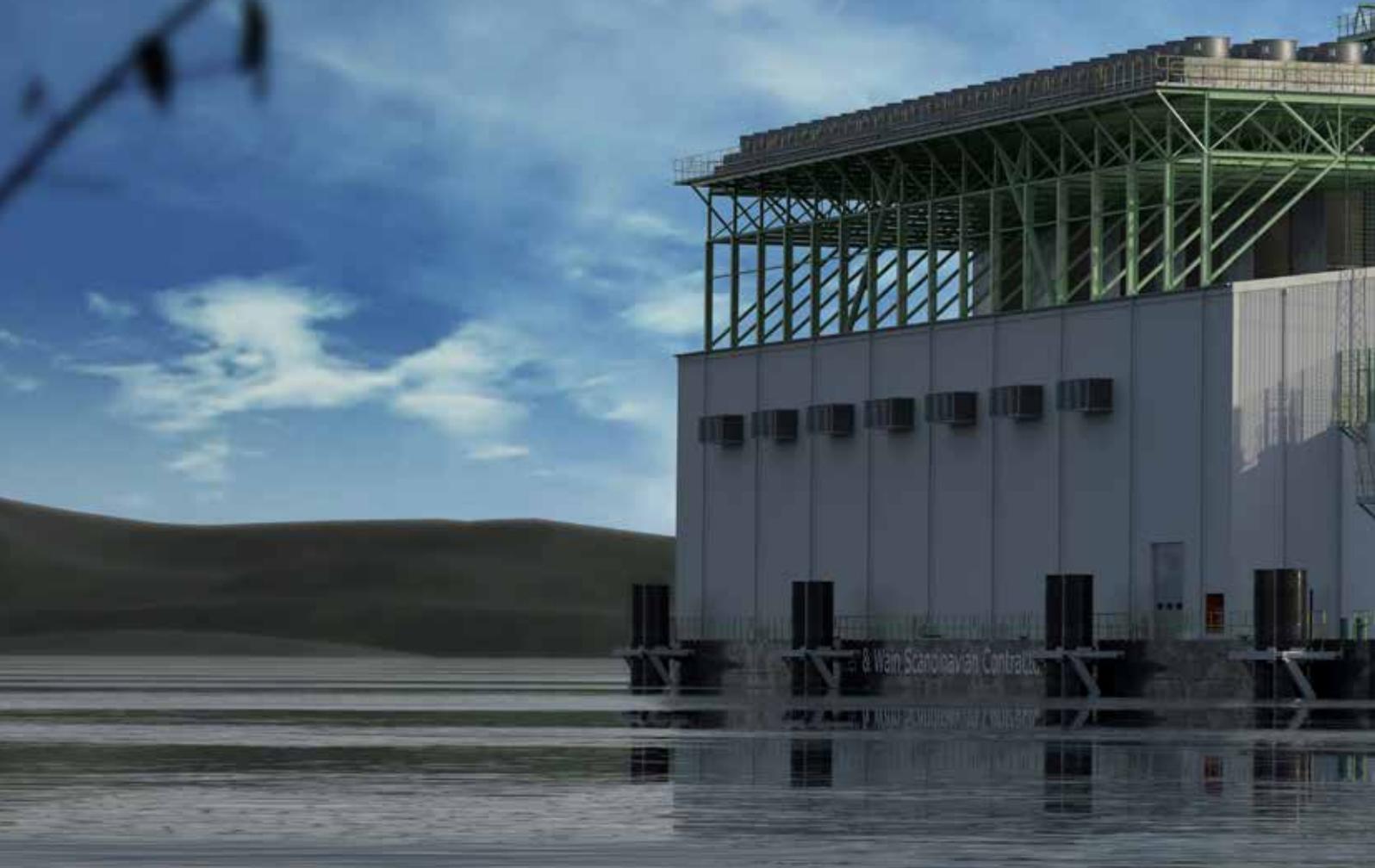
Burmeister & Wain Scandinavian Contractor A/S (BWSC) has +30 years of experience in the design and supply of small-scale to medium-sized power stations, including power barges, and has successfully delivered more than 180 turnkey projects.

The basis for the technical development of a power barge is the existing designs for FSRUs and power barges as well as the current advances in both technologies. The goal of the development is to establish a design fit for purpose and adapted to particular project requirements and constraints. Design options include the various methods available for re-gasification of LNG, such as ambient air vaporisers, open and closed cycle seawater heated vaporisers and, in particular the possibility of integrating waste heat available from the power barge.

The power barge is equipped with multiple large bore reciprocating engines operating in either pure gas mode or dual fuel systems with oil as a back-up fuel. This ensures very high availability and high efficiency from low loads up until the maximum capacity. Furthermore, reciprocating engine technology will not derate until the ambient temperature reaches 39°C or more, which is advantageous to other generation technologies in tropical areas. With a very low draught of less than 4 metres, the power barge will not demand valuable quay space. Emission levels comply with World Bank Guidelines, and the power barge may be equipped with abatement systems to meet even stricter emission limits.

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

# POWER BARGE



## 60-150 MW power barges as turnkey EPC, including onshore EPC, based on high-efficiency reciprocating engine technology

BWSC markets a proven power barge design with arrangements based on BWSC's vast experience in reciprocating engine-based power plants. The power barge is designed to utilise 4-8 large-bore engines operating natural gas or dual fuel (HFO or LFO) with thermal efficiency up to 50% at all loads, also part load. Standard power plant spacing between engines has been maintained for optimal operation ability and maintenance.

The power barge is designed and constructed as an industrial installation on a marine-classed deck barge and delivered to the selected site by ocean tow or heavy lift ship. It is designed for mooring in sheltered coastal areas and on rivers with a low draught and hull painting allowing for underwater inspection instead of dry docking.

The power barge has the same guaranteed performance and operation and maintenance costs as land-based plants, and BWSC can offer Operation and Maintenance on a long-term contract.

Operation is self-contained, with all necessary tanks on board. Liquid fuel tanks on board hold, as a standard, up to 2½ days of operation. The hull holds spacious utility rooms and storage. All electrical equipment is on board, including control, low and medium voltage switchboards and step-up transformers, and with an option for on-board HV breakers to protect the barge against any incidents on the land site. The barge is capable of black start.



The power barge will supply the FSRU with electricity and hot water for re-gasification.

#### 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 7 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 Diesel & Turbo large-bore engines 18.5-21 MW each

#### Dimensions

Low operating draught	app. 3.5 m
Length	65-90 m
Width	39 m
Height (to top of stacks)	40 m
Standard design for wind loads	up to 200 km/h

A well-designed power barge, applying established 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 minimum impact on local environments.

# THE LNG FSRU



LNG FSRUs with 5,000-60,000 m<sup>3</sup> storage with a high range of send-out pressures and send-out capacities

TGE Marine's LNG FSRUs for the small and mid-scale markets are perfectly suited as fuel supply units for power barges. TGE Marine is able to provide the complete design of the unit including delivery of the entire gas-handling system with storage and re-gasification plant. The hull and mooring arrangements are based on TGE Marine's experience from various FSRU projects. TGE Marine supports the client right from the start of the project, throughout the feasibility phase and the development of the complete design and with preparation of the documentation required for local operation and issue of 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 5,000-60,000 m<sup>3</sup> storage capacity based on type C tank technology. The tanks will be delivered fully tested and calibrated to the fabrication yard. The re-gasification technology is based on ambient air vaporisers or on intermediate cycle vaporiser technology with seawater as heating source (open loop) or gas as heating source (closed loop). In combination with the power barge, the re-gasification plant will use waste heat from the power barge for the re-gasification process to further optimise the efficiency. As the re-gasification system on an FSRU in direct connection with a power barge is effectively used directly as a fuel gas system, TGE Marine can draw on its vast experience with supply of LNG fuel gas systems which utilise send-out pressure of 4-300 bar. 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. The construction of the FRSU barge can be carried out by any experienced shipyard, with TGE Marine's supervision and support. During the lifetime of the project, TGE Marine will perform all after-sales services as well as necessary training of the 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
- Send-out at low seawater temperatures with additional boilers
- Electricity generated with natural gas-fuelled gensets
- Tank design (pressure vessels) increases operational flexibility – 2 x 10,000 m<sup>3</sup>
- 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 to achieve sustainable economic growth and the opportunity to develop business 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 engine-based and gas-based power systems. Further, BWSC has vast experience in biomass technologies, and our expertise ranges from all aspects of plant design to rehabilitation, operation, maintenance, service and financing.

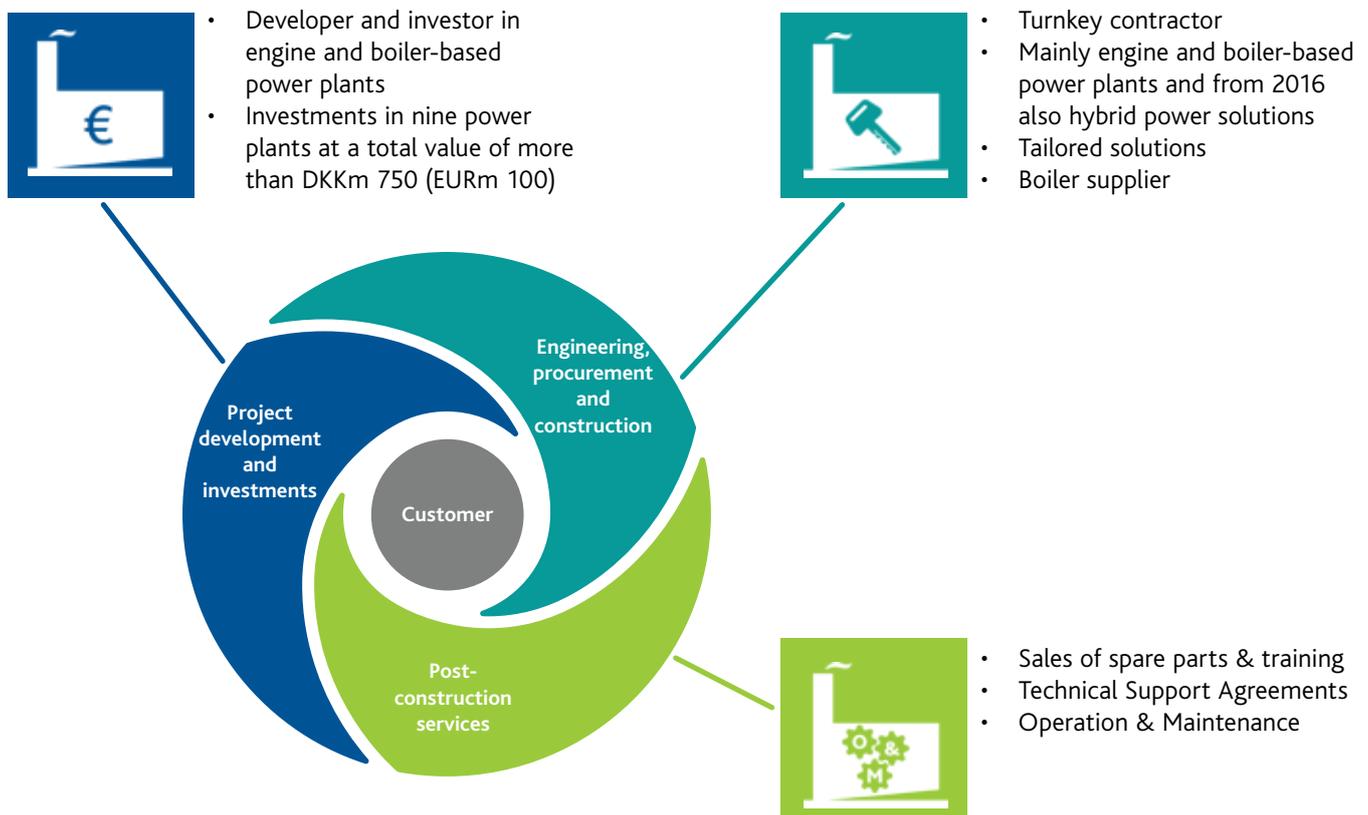
BWSC takes a leading role in the development of IPP companies. This comprises the establishment of all commercial and legal agreements, including power and fuel purchase contracts, and the financing, insurance and land lease arrangements, etc. In addition to the initial role of developer, BWSC undertakes 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 53 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 origin in the stationary engine division of Burmeister & Wain (B&W), which has built and installed diesel engines since 1904. BWSC was established in 1980 as a separate specialist company with the aim to develop their known technologies into high-efficient power plants. Since, 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 Engineering & Shipbuilding Co. Ltd. (MES), Japan.

## Main activities

BWSC assist customers worldwide throughout the entire or specific phases of a power plant's life cycle.





### 60 MW power barge:

Customer: Mitsui Engineering & Shipbuilding 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 power barge with 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

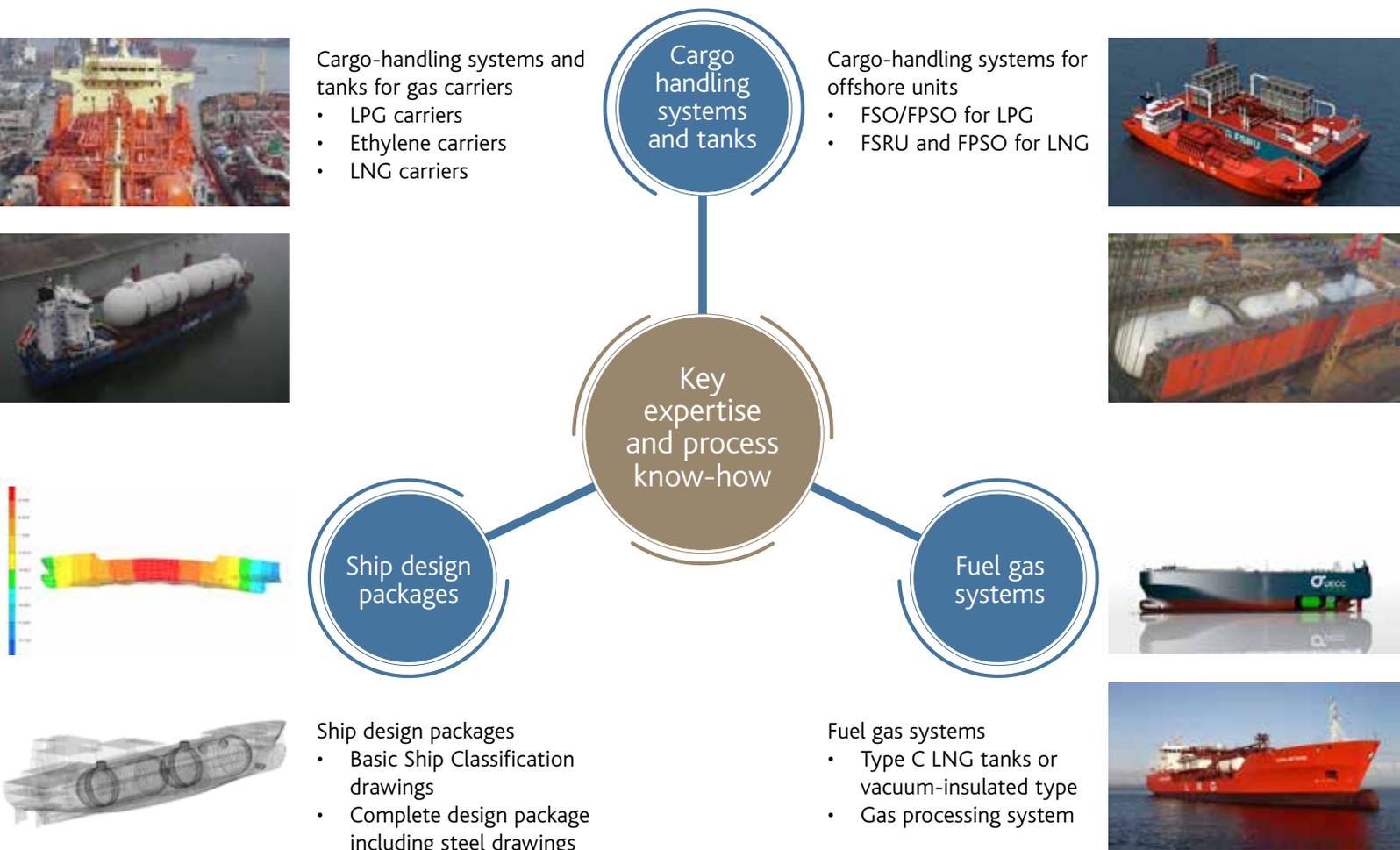
TGE Marine Gas Engineering GmbH (TGE Marine) is a market-leading engineering contractor for the design and supply of gas-handling systems for gas-carriers and offshore units.

TGE Marine delivers turnkey solutions (engineering, procurement and construction supervision (EPCS)) for the storage and handling of cryogenic gases (LNG, ethylene, LPG, ammonia) onboard of gas carriers, floating units and merchant ships operating with LNG as fuel. TGE Marine specialises in the containment system 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.

- More than 30 years of experience
- Approximately 70% 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 m<sup>3</sup>
- 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 Engineering & Shipbuilding Co. Ltd. (MES), Japan.





### 16,100 m<sup>3</sup> 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 m<sup>3</sup> 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 m<sup>3</sup> 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

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