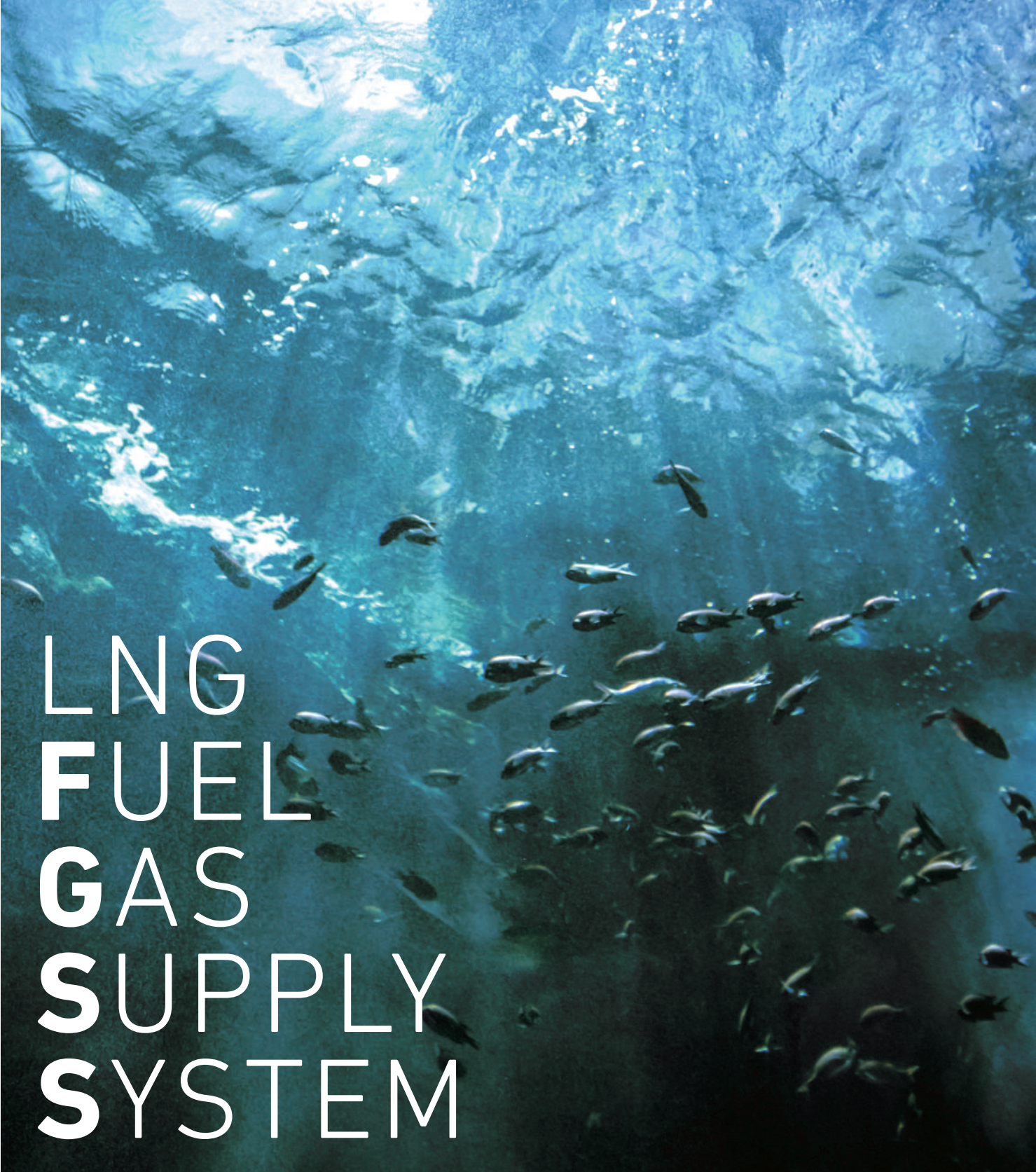


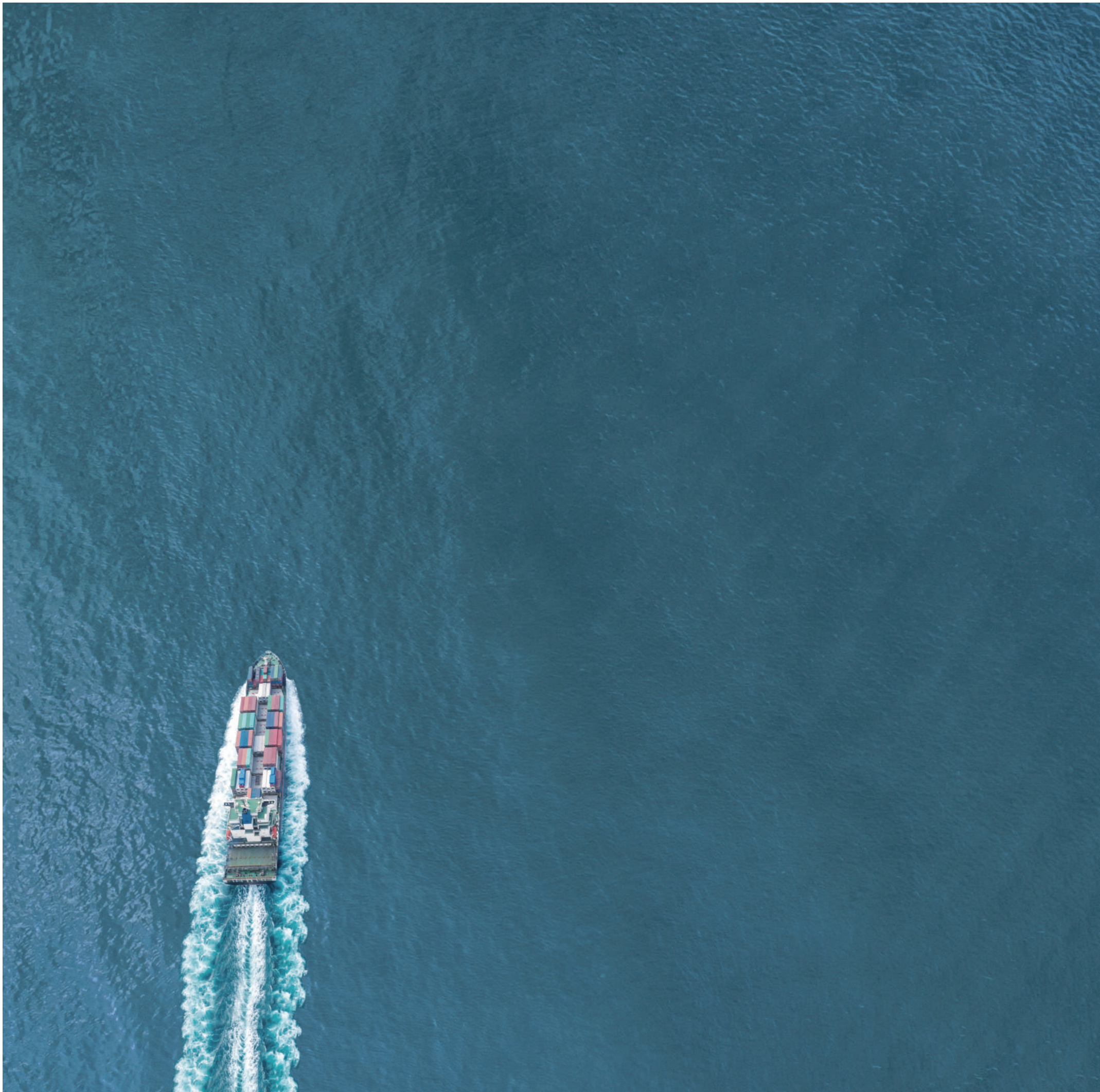
MOVE THE WORLD FORWARD  MITSUBISHI
HEAVY
INDUSTRIES
GROUP



LNG
FUEL
GAS
SUPPLY
SYSTEM

Mitsubishi Shipbuilding Co., Ltd.

 **MITSUBISHI**
HEAVY INDUSTRIES



Contributing to protect global environment with cutting-edge technologies.

Throughout our long history in shipbuilding as a member of the Mitsubishi Heavy Industries (MHI) Group, Mitsubishi Shipbuilding has been manufacturing a broad range of vessels and maritime products. We offer a variety of environmental solutions that address the demand for reducing the environmental impacts related to shipping and the maritime field, based on our deep technological expertise in shipbuilding as the culmination of experience and know-how we have acquired over our history, and by leveraging the wide range of technologies across MHI Group.

The shipping industry has been advancing studies related to alternative fuels to meet the goal of reducing GHGs. Among these various GHG reduction measures, LNG fuel has already been shown to hold the potential for application in large-scale propulsion plants and the industry is expanding LNG supply chain and port infrastructure. As of today, LNG is therefore considered to be the most practical solution. In order to address this demand, Mitsubishi Shipbuilding developed the LNG Fuel Gas Supply System (FGSS) as an essential component for LNG-fueled vessels.

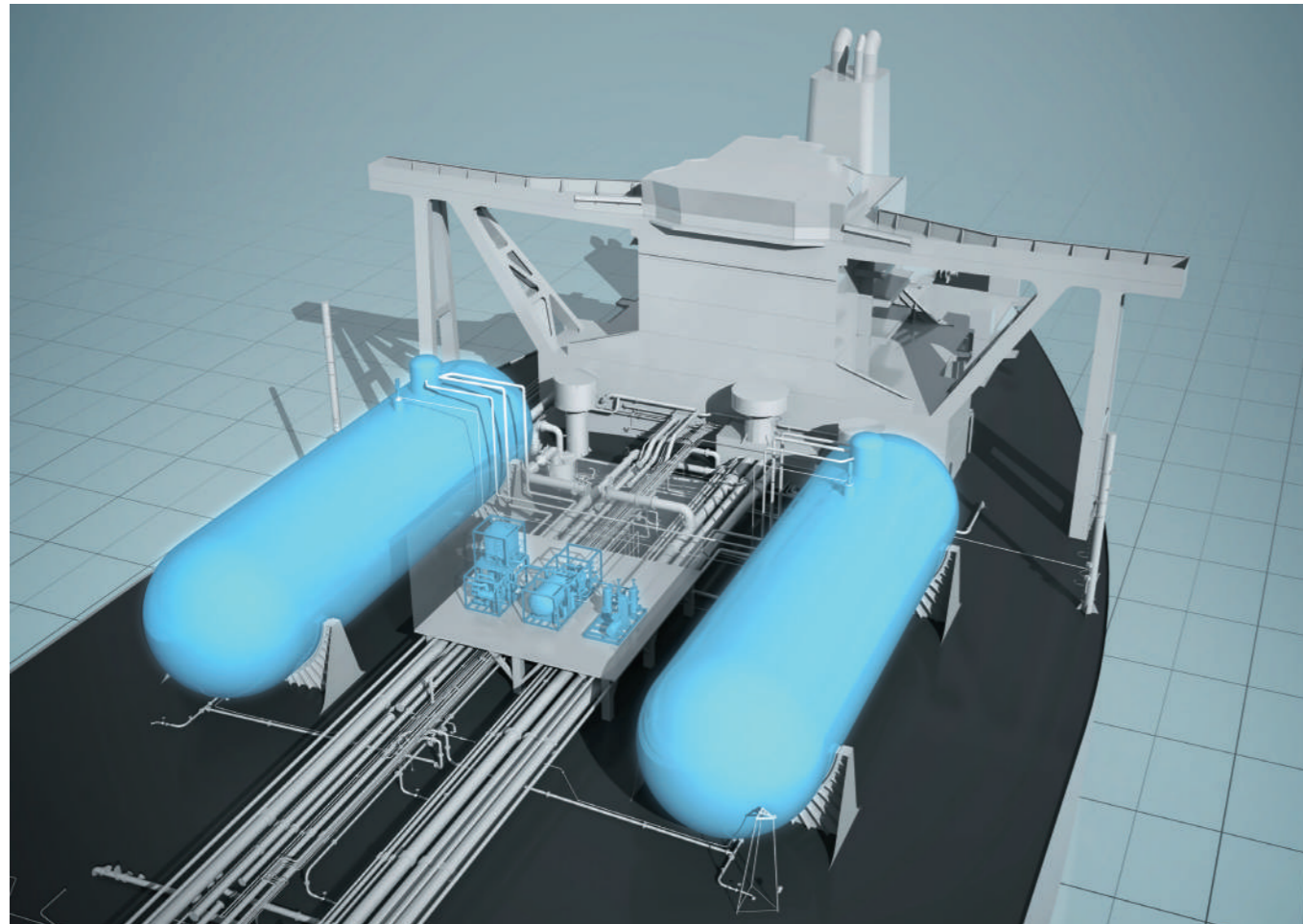


Major Products of Mitsubishi Shipbuilding

Highly reliable FGSS based on Experience and Know-how in Building LNG Carriers

Mitsubishi Shipbuilding has long experience in the designing and building LNG carriers with both MOSS and Membrane type tank. Moreover, we also have a history of developing our own fuel gas supply systems for the dual fuel engines used on these types of vessels.

Based on a great deal of experience and know-how of designing, building, commissioning and operating (gas trial) for LNG carriers, we developed the LNG Fuel Gas Supply System (FGSS) for marine engines.



Mitsubishi Shipbuilding's FGSS

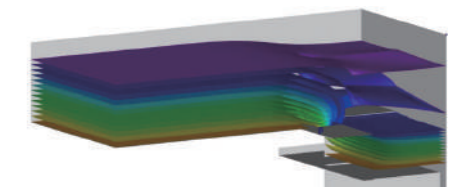
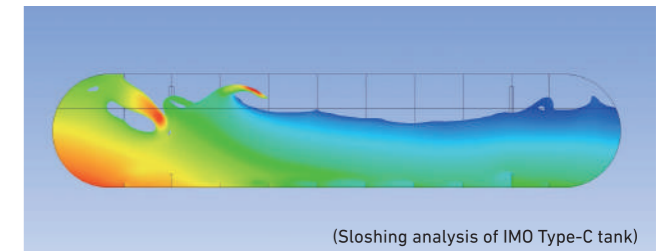
FGSS Module

Mitsubishi Shipbuilding provides the main components (LNG vaporizer, gas heater, gas compressor, etc.) for FGSS, and delivers as modularized units which has sophisticated design in consideration of maintainability and space-saving based on the long experience and know-how as a shipbuilder.



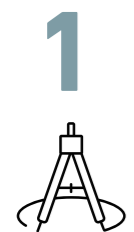
LNG Fuel Tank

Mitsubishi Shipbuilding provides IMO Type-C LNG fuel tanks. We can also offer engineering services for Membrane type tank. Since the designing and fabricating LNG fuel tanks with heat insulation systems used to handle cryogenic liquids requires high-reliability, we apply our advanced design, analysis technologies and strict quality control, to deliver high-quality products.



FGSS Control System

Mitsubishi Shipbuilding has developed its own Integrated Automation System (IAS: cargo handling and propulsion plant control system) for LNG carriers, which has many successful records. We also incorporated this experience and know-how into the FGSS control system. Further, with extensive knowledge about gas handling, our engineers are also able to customize the system to customer's needs.



Space-saving and excellent maintainability modular design



Customizable control system with excellent operability and safety



Planning and design engineering services for LNG-fueled vessels

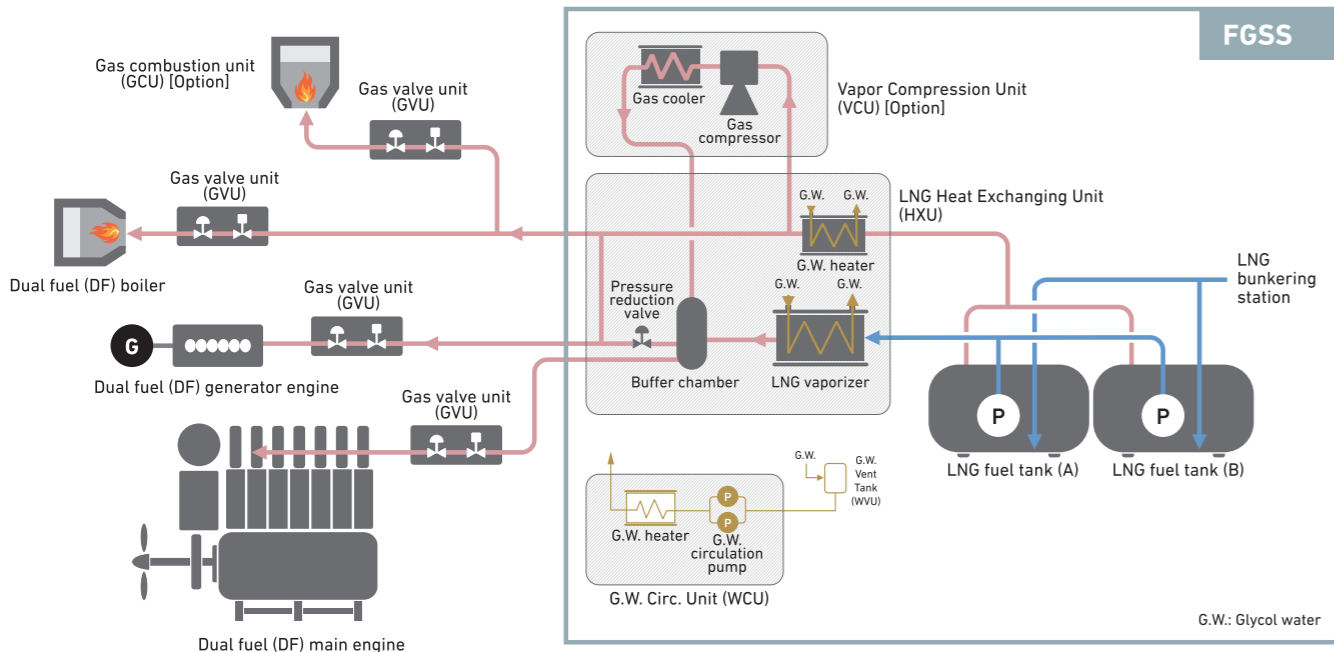


Commissioning and gas trial support for LNG-fueled vessels

Low-pressure (LP) FGSS

Our FGSS mainly consists of an FGSS module incorporated with the main components, LNG fuel tanks for onboard LNG storage, and an LNG bunkering station to receive LNG from shore facilities or LNG bunkering vessels. We offer a standard line-up that suits a wide range of engine models and a variety of demands.

Example of FGSS Configuration



Equipped on the first LNG-fueled Pure Car Carrier built in Japan



"SAKURA LEADER," the first LNG-fueled pure car carrier built in Japan

Line-up of LP FGSS Module

HXU (LNG Heat Exchanging Unit)

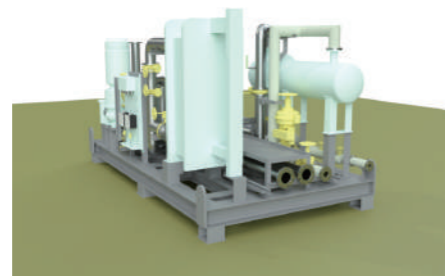
Model No.	Main engine model
HXU-1	X40DF
HXU-2	X52DF flex50DF X62DF
HXU-3	X72DF
HXU-4	X82DF
HXU-5	X92DF
HXU-6	X92DF



HXU-2

WCU (Water Circulation Unit)

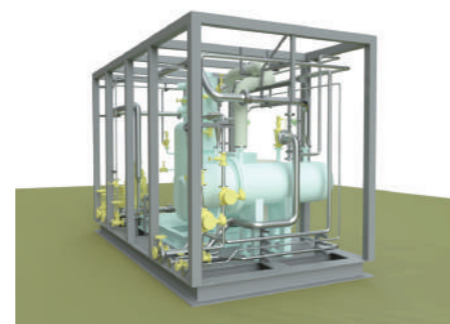
Model No.	HXU combination
WCU-1	HXU-1
WCU-2	HXU-2
WCU-3	HXU-3
WCU-4	HXU-4
WCU-5	HXU-5
WCU-6	HXU-6



WCU-2

VCU (Vapor Compression Unit)

Model No.	Application
VCU-L	Fuel gas supply to generator engines
VCU-M	Fuel gas supply to main engines (low-pressure type)



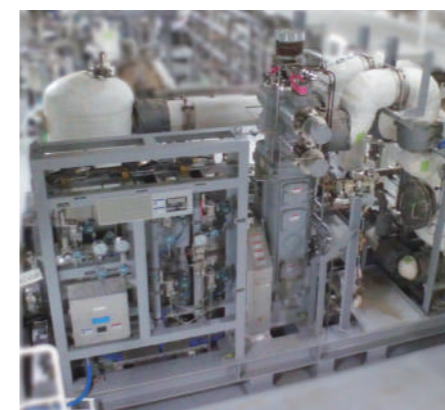
VCU-L



Delivery ceremony of LNG fuel tank



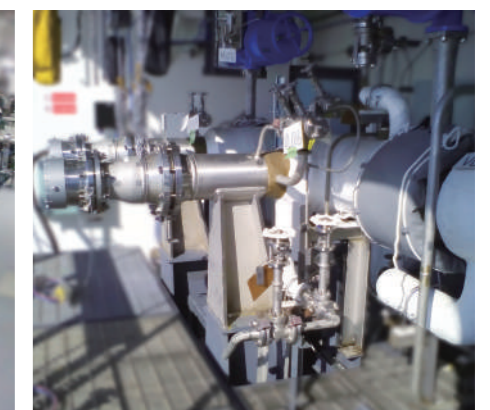
FGSS Module



FGSS Module



FGSS Module



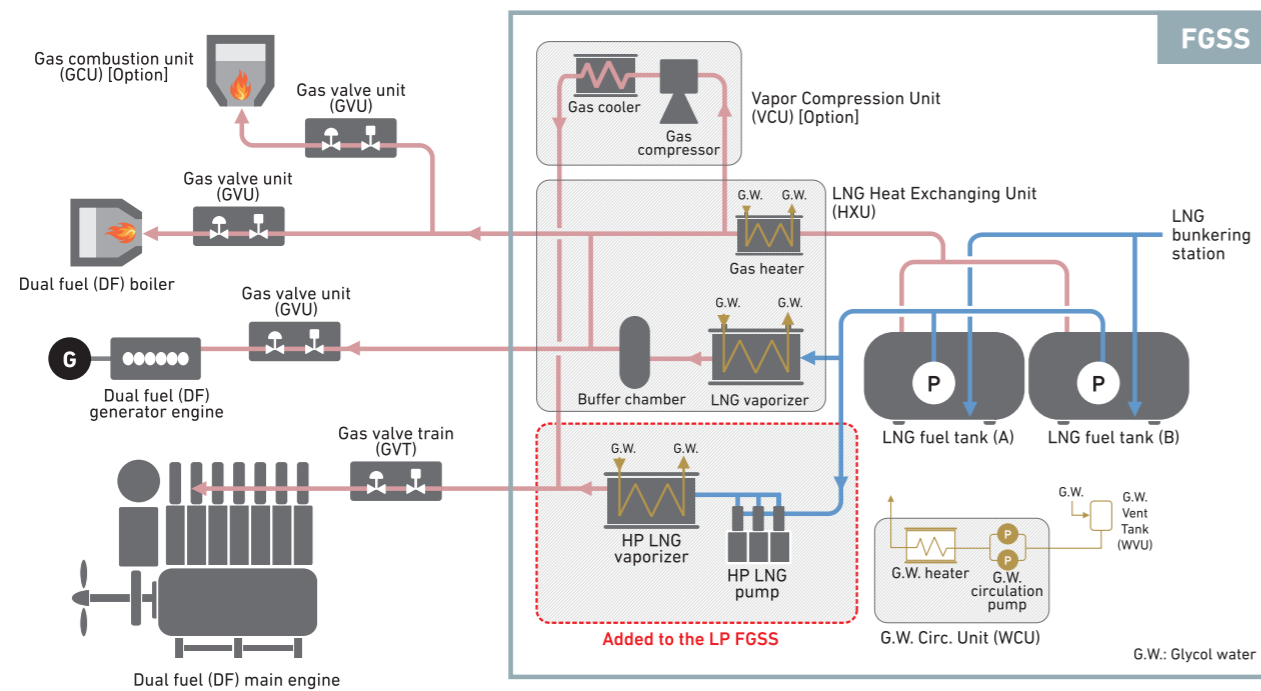
LNG bunkering station



FGSS GALLERY

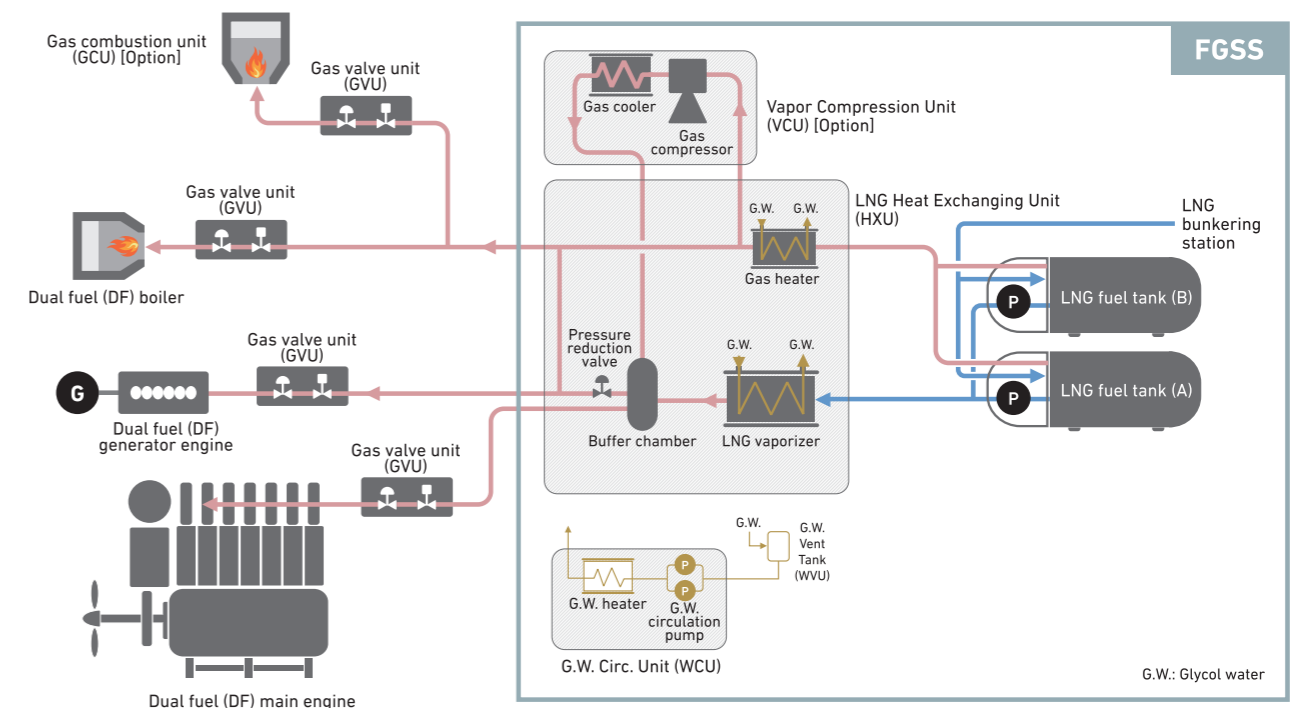
High-pressure (HP) FGSS

Our HP FGSS supplies high-pressure gas of around 30 MPaG to the main engines, so is equipped with a HP LNG pump and a HP LNG vaporizer located down-stream from the LNG pump on the LNG fuel tank. Mitsubishi Shipbuilding's HP FGSS has already been adopted as a marine engine shop test facility at Mitsui Engineering & Shipbuilding Co., Ltd. (currently, Mitsui E&S Machinery Co., Ltd.) and Hitachi Zosen Corporation.



FGSS for Small and Medium-sized Vessels

Based on the technology and know-how we have acquired through the development of FGSS products for large-sized vessels, we developed this system for installation primarily on coastal ferries and small- and medium-sized cargo vessels. It therefore uses small vacuum insulated type LNG fuel tanks. This system has received an Approval in Principle (AIP) from Bureau Veritas (BV), thereby proving the high reliability of the design.



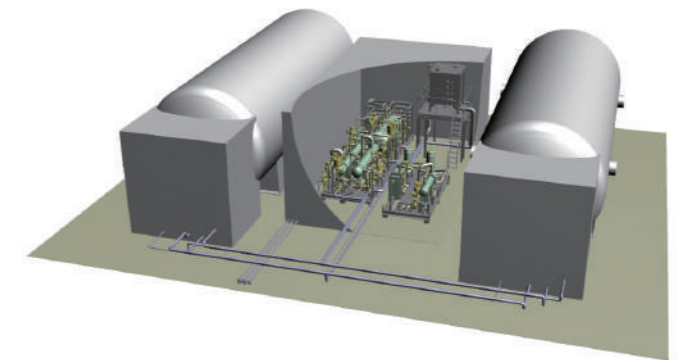
HP FGSS unit



HP LNG pump



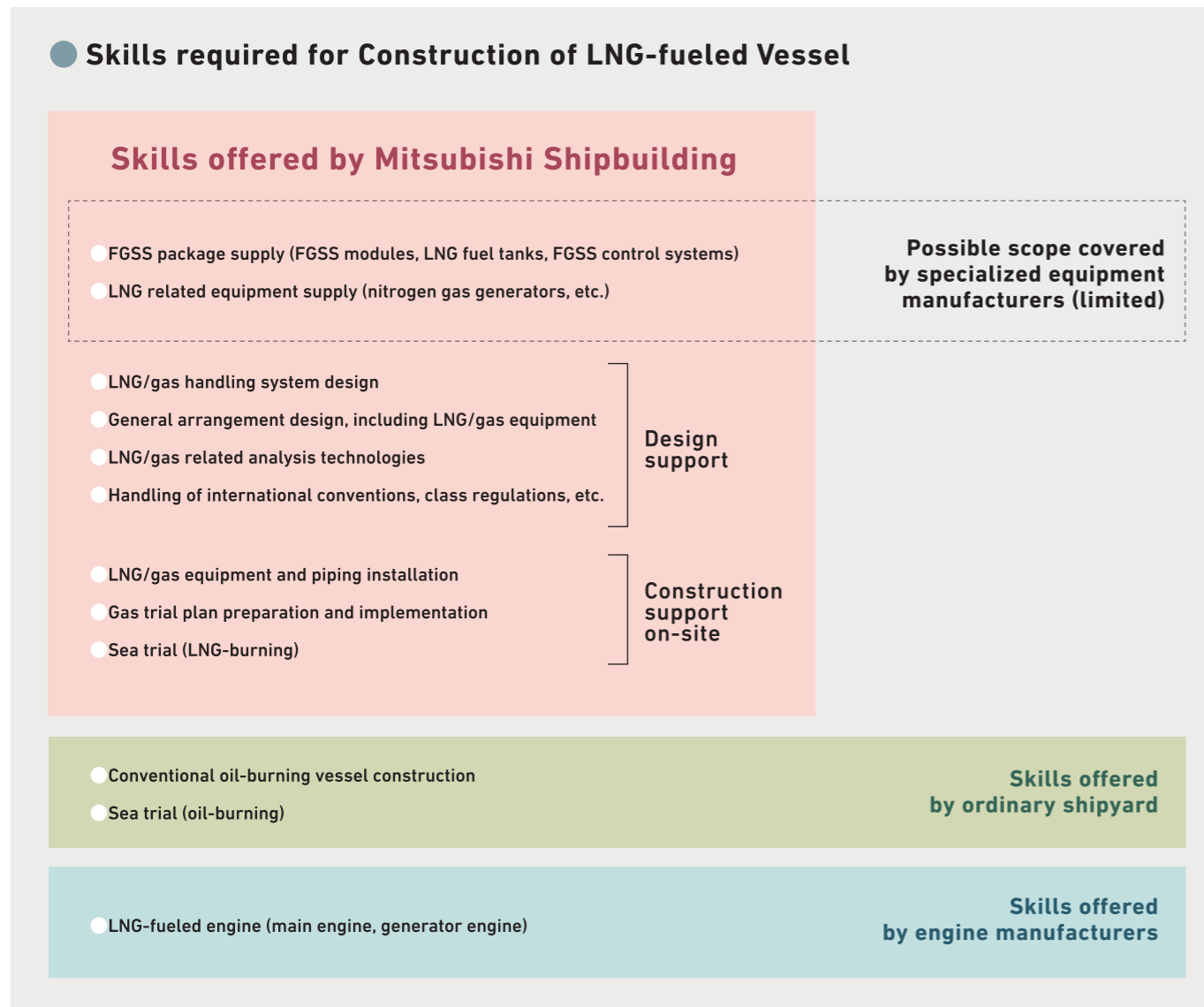
AIP Certificate



FGSS with vacuum insulated tanks

Engineering Services

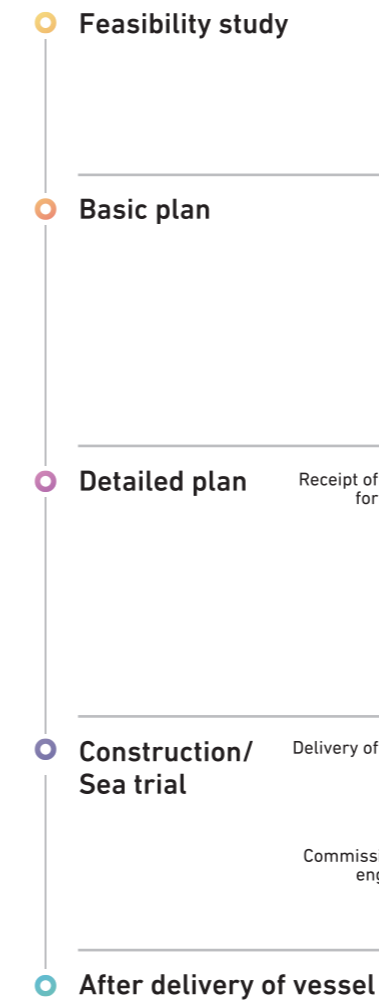
Mitsubishi Shipbuilding offers a broad range of engineering services relating to LNG-fueled vessel that is best suited to the various needs of our customers.



Utilizing the experience and know-how accumulated over many years of building LNG carriers and other types of vessels, we not only sell FGSS packages but also provide engineering services related to the design and construction of LNG-fueled vessels. After the vessel goes into service, in addition to after-sales services such as parts supply and dispatch of engineer, we can also offer support services for operations of LNG-fueled vessel if customers need it, including gas handling training for crew members of LNG-fueled vessel and technical support for special operations (gas free before docking, cooling down after docking, etc.).



Master Schedule for LNG-fueled Vessel



Engineering Services (option)

Details of engineering services (example)	
Design support	<ul style="list-style-type: none"> ● Principle particular (Preliminary) (LNG/gas equipment) ● Rough arrangement (LNG/gas equipment) ● BOG management study (tank pressure management)
Design support	<ul style="list-style-type: none"> ● LNG fuel tank arrangement study ● Fuel preparation room arrangement study ● LNG bunkering station arrangement study ● LNG/gas operations flow study ● Risk assessment support (HAZID, FMEA, etc.)
Construction support on-site	<ul style="list-style-type: none"> ● LNG/gas piping route study (including piping stress calculations) ● Operations manuals <ul style="list-style-type: none"> - Standard operations - LNG bunkering operation - Operations for before/after docking
Construction support on-site	<ul style="list-style-type: none"> ● Construction schedule/process study support ● Gas trial plan preparation and implementation support ● LNG/gas equipment and piping installation support ● Sea trial (LNG-burning) support
Operations support	<ul style="list-style-type: none"> ● Instruction for crew prior to delivery ● Instruction/operations support by onboard engineers ● Operations data analysis/operations planning support ● Maintenance support

Mitsubishi Shipbuilding not only supplies FGSS package but also provides comprehensive support for construction and operations of LNG-fueled vessel through design, on-site support (including dispatch of engineer) and operations support.

Our well experienced engineers fully support design and construction of LNG-fueled vessel. If you have any questions and/or concerns about LNG-fueled vessels, please feel free to contact us at any time.



LNG FUEL GAS SUPPLY SYSTEM WEBSITE

JAPANESE <https://www.mhi.com/jp/products/ship/fgss.html>

ENGLISH <https://www.mhi.com/products/ship/fgss.html>

MAIL to

marine-solution@msb.mhi.co.jp



Mitsubishi Shipbuilding Co., Ltd.

3-3-1 Minatomirai, Nishi-ku, Yokohama 220-8401
Tel.: 045-200-6611 (main number)