



**Yokogawa  
LNG Supply Chain**

Ichthys LNG Production Facilities  
Photo courtesy of INPEX CORPORATION



# A Trusted Partner With Proven Experience

Yokogawa's commitment to innovation in LNG projects worldwide dates back to the 1970s.  
Yokogawa keeps encompassing leading edge technology for the LNG industry to maximize productivity.

## Providing the latest technology to the world's largest LNG terminals since 1973

The Tokyo Gas Sodegaura LNG terminal started operations in 1973 and is one of the world's largest LNG terminals, with a total amount of 4,509 million tons received per year (as of 2018), a storage capacity of 1.35million kℓ and a vaporization capacity 1,455t/h. Yokogawa has since gone on to migrate the DDC to a Distributed Control System (DCS), changing panel operations to a centralized operation.

## Never disturbing plant operations

The challenge of control system migration is to update systems without interrupting production. At LNG terminals, the temperature inside the tank has to be maintained at a constant -162°C to avoid generating boil-off gas (BOG). Yokogawa has more than 40 years experience providing customers with hot cutover.

## Supporting Plant Integrity

The Sodegaura Terminal is currently divided into two areas (East and West), each with its own receiving berth, electrical, and supply system. This double-plant setup enables the two areas to back each other up, assuring a high degree of reliability. Yokogawa supplies integrated control and safety systems to the two independent areas, and achieve the centralized operation of both areas, improving operation efficiency and integrity of the plant.

Sodegaura LNG receiving terminal  
Photo courtesy of TOKYO GAS Co., Ltd.

20XX

CENTUM VP

as subsystems

2006

CENTUM CS 3000 R3

Hot Cutover

1988

CENTUM V

Upgrade

1973

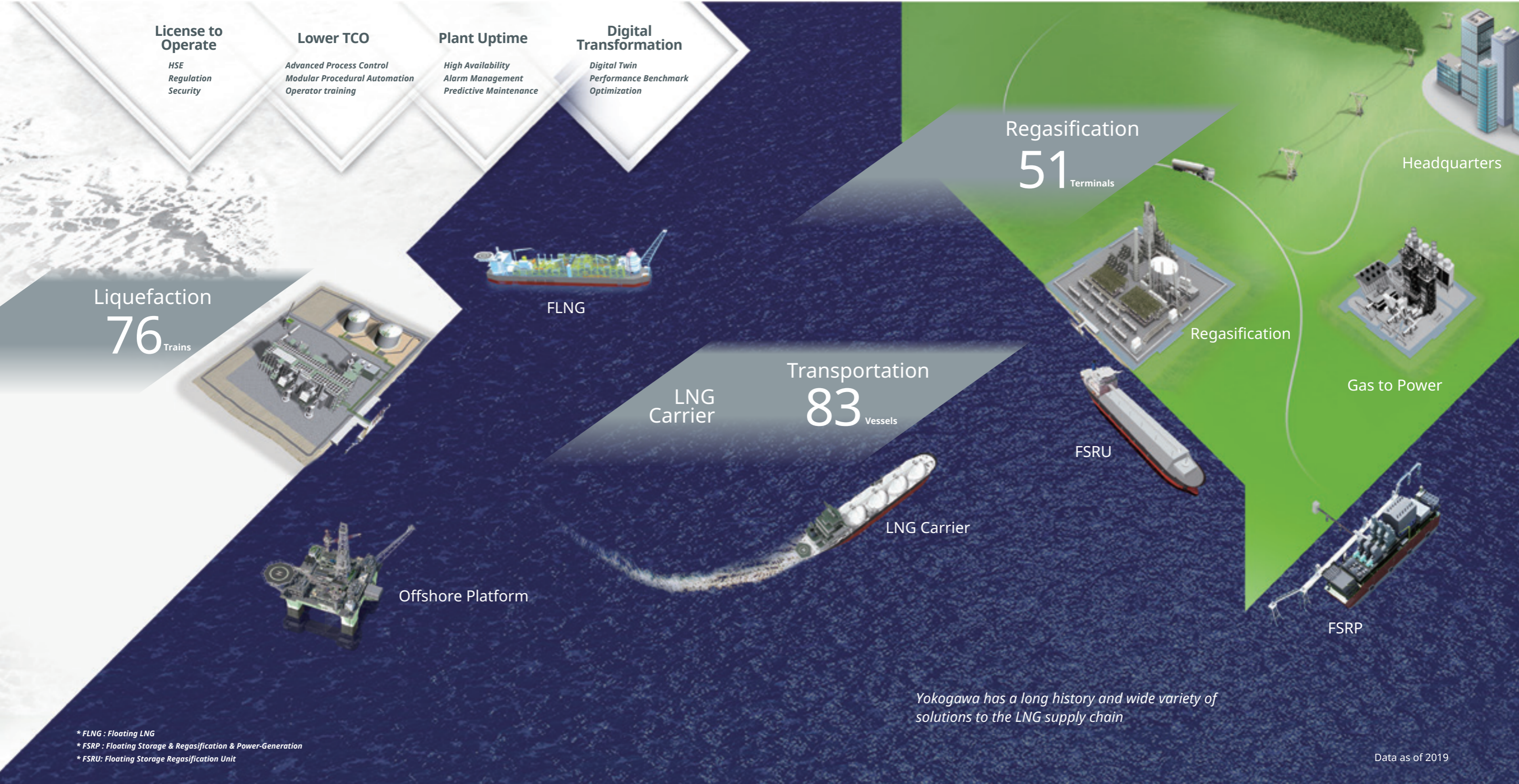
LNG terminal  
Sodegaura started

Over 40year's LNG experience



# Explore the Yokogawa capability in LNG industry

Yokogawa has long standing expertise providing solutions to the LNG industry



\* FLNG : Floating LNG  
\* FSRP : Floating Storage & Regasification & Power-Generation  
\* FSRU: Floating Storage Regasification Unit



# Liquefaction Experience

Yokogawa has installed 76 trains globally with a wide capability of products and solutions from sensors to modelling

## Dehydration and mercury removal

- Drier sequence control
- Regeneration gas compressor control

## Liquefaction

- Feed Gas Pressure/flow Control
- MR balance control
- Pre-cool refrigerant compressor and flow/temp control
- MR refrigerant flow/temp controls
- End Flash and pressure control
- LNG Rundown and Production control
- Anti-Surge Control

## Acid Gas removal

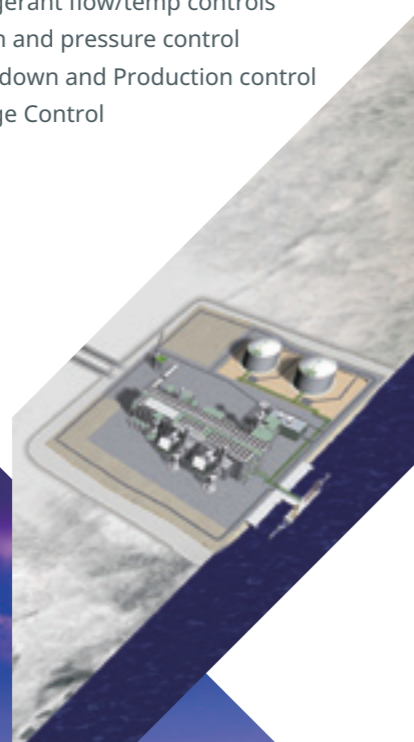
- Feed gas KO Drum pressure control
- Absorber Bottom Level/Flow control
- Absorber inlet lean amine flow control
- Pressure monitoring
- Temperature monitoring
- Treated gas quality monitoring
- Amine regeneration control
- Sulphur recovery unit control

## NGL Recovery/Fractionations

- Feed Gas Pressure Control
- Bottom level and Disch. Flow control
- Reflux Flow control
- Reboiler temp control

## LNG Storage Loading

- Tank monitoring
- Loading sequence
- Circulation control for loading lines
- BOG compressor



## Key technology for your benefit

### Faster Start-up Contributes to Quick Production Delivery

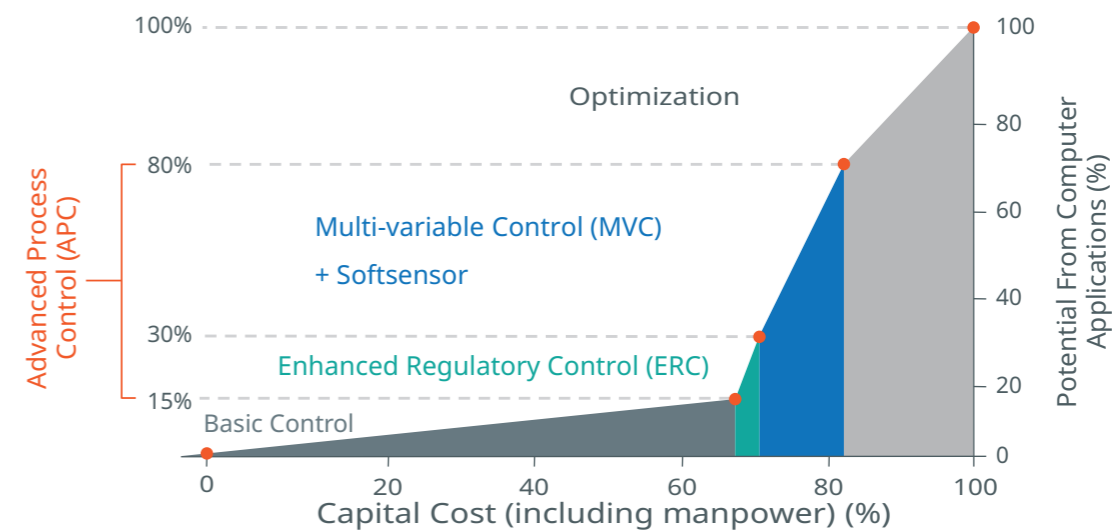
#### Automated cool down of the Main Cryogenic Heat Exchanger (MCHE) using Modular Procedural Automation (MPA) shortens start-up time and avoids equipment damage

The MCHE is the key component of an LNG plant. It consists of large bundles of tubes in an aluminum shell. At start-up, the MCHE has to be cooled down from ambient temperature to around minus 160°C where the natural gas is liquefied. Controlling the temperature of the MCHE according to the ideal temperature curve is challenging for the operator. Several valves need to be controlled at the same time while the process response changes as the cool-down progresses. Poor operation may result in exceeding the maximum allowable temperature change over time, which can damage the MCHE due to thermal expansion and contraction. However, slow cooling will delay the start of production. To avoid these risks, highly reliable and efficient automated operation is required. Yokogawa's Modular Procedural Automation (MPA) employs the best operators experience, process expertise, analyses of the existing procedure and historical data. Automated cool down is enabled as if an experienced operator were controlling the plant. The start-up time is shortened without damaging MCHE.

### Next-generation Advanced Process Control maximizes throughput

#### Platform for advanced control and estimation optimizes production while ensuring stable control

The liquefaction process is complex because it is affected by factors, such as gas composition, ambient temperature, separator level and compressor performance. To achieve steady process control, those variables need to be controlled by Advanced Process Control (APC). Yokogawa has been providing APC licenses and consulting for more than 20 years. Based on our expertise in process automation, Yokogawa's next-generation of APC, called Platform for Advanced Control and Estimation, provides process optimization to maximize throughput while ensuring steady process control.





# Transportation Experience

Yokogawa has installed 83 vessels with a wide capability of products and solutions from sensors to modelling

## Power Management System

- Control of circuit breakers and monitoring
- Load Dependent Start/Stop
- Load Sharing
- Frequency Control
- Blocking of Heavy Consumers
- Load Reduction to Propulsion Drives
- Load Shedding (preferential trip)
- Automatic restarting after blackout
- Generator Control & Monitoring
- Propulsion Drive Interface
- Emergency Switchboard Interface

## Machinery System

- Fuel Oil & Fuel Gas System
- Personnel Alarm System
- Extension Alarm System
- Reduction Gear System
- Fresh, Cooling, Feed Water System
- Bilge Level Monitoring System
- Air Ventilation and Fans
- Compressed Air System
- Lube Oil System
- Machinery Miscellaneous

## Gas Management System & Fuel Gas Supply System

- Tank Pressure Control
- Fuel Mode Control
- GCU Control
- Fuel Gas Pressure Control
- Forcing Vaporizer Control
- N2 Purge Sequence
- Vent Control
- Master Gas Valve Control

## Ballast System

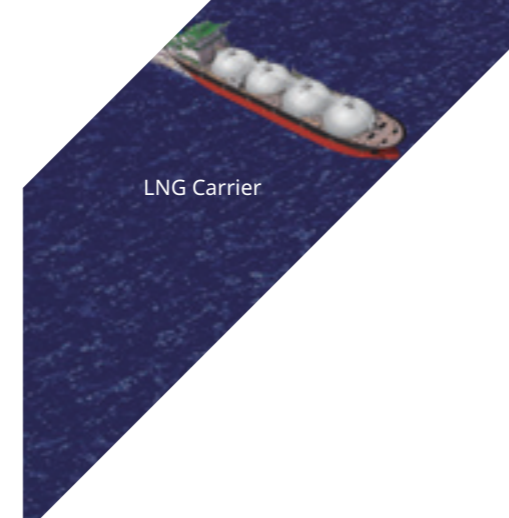
- Ballast Pumps & Valves
- Automatic Ballast/Deballast Control
- Automatic Ballast Water Exchange

## Regulation

- Sox monitoring for new IMO agreement

## Vapor Handling System

- Fuel Gas Compressor
- Vapor Return Compressor
- Forcing Vaporizer
- LNG Vaporizer
- Gas heater



## Cargo Containment System

- Temperature Monitoring
- Pressure Monitoring
- Level Monitoring

## Cargo Control System

- Cargo Pumps Control
- Stripping/Spray Pumps Control
- Emergency Cargo Pumps
- Cargo Operation (Loading/Unloading)

## Cargo ESDS

- ESD for Cargo Containment System
- Cargo Tank Protection System
- Fuel Gas Master Valve
- Ship/Shore Communication System

## Re-liquefaction System

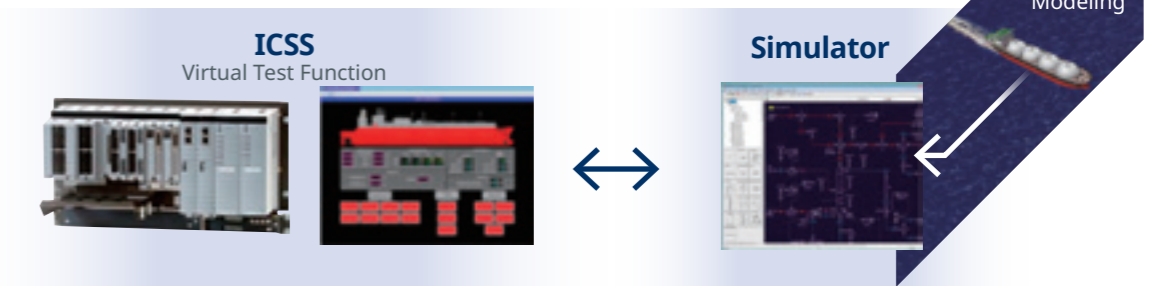
- Re-liquefaction Componder Control System
- Heat Exchange Control

# Key technology for your benefit

## Prepare for unexpected conditions

*Dynamic simulator trains the operator to prepare for the unsteady operations*

Yokogawa is driving the advanced usage of the dynamic simulator which can be used for multiple purpose throughout the lifetime of the LNG carrier. The dynamic simulator is ideal for operator training, and it can be a useful tool to validate the system design by allowing rigorous system testing under all operating condition. By combining the ICSS test function with the process dynamic simulator, process reaction can be predicted.



## Keep vessels safe anywhere they are located

*Real-Time Fleet Monitoring System contributes to integrated monitoring of your fleet*

Yokogawa provides a real-time base fleet monitoring system with secure data transmission. Real-time data contributes to monitor fleet conditions without delay and fully customizable KPI dashboard assists swift decision-making in fleet management.





# Regasification Experience

Yokogawa has installed 51 terminals globally with a wide capability of products and solutions from sensors to modelling

## LNG Unloading

- Recirculation Flow Control
- Return Gas Temperature and Pressure Control
- LNG Drain Drum Level Control
- Uploading lineup control
- Berth Monitoring System
- Unloading Arms Packaged System Function

## HP Send-out Pump

- Pump Start/Stop Control
- Discharge Control
- Kickback Flow Control

## Send Out Control

- Send out Header Pressure Control
- Send Out Gas Calorie Control
- Gas Odorization Flow Control

## BOG Compressor/Recondenser

- Compressor Start/Stop Control
- Suction Drum Temperature Control
- Kickback Flow Control
- Recondenser Control
- Packaged PLC Functions
- Capacity Control

## Open Rack Vaporizer (ORV)

- LNG Flow Control
- Seawater Flow Control
- Seawater Pump Control
- Start/Shutdown Sequence Control

## Submerged Combustion Vaporizer

- LNG Flow Control
- Packaged System Functions

## Fuel Gas and Service Gas

- Fuel Gas Pressure Control
- Fuel Gas Heater Control

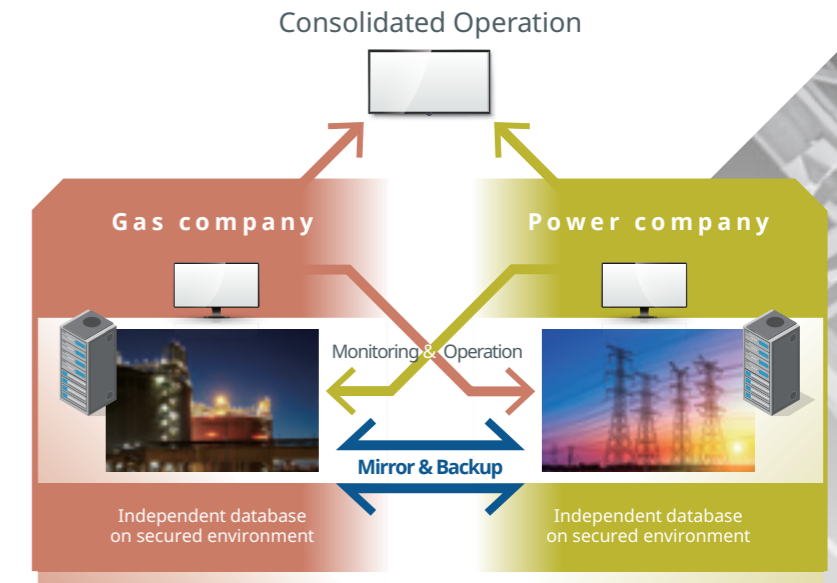
## LNG Tank

- Tank Inlet Mixing Line Valve Control
- Tank Pressure Control
- Level, Temperature, and Density Monitoring
- In-tank Pump (LP Pump)
- Pump Start/Stop Control
- Kickback Flow Control
- Supply Chain Scheduler

# Consolidated Gas-to-Power System Increases Operation Efficiency

Operation windows with different databases can be cross monitored in each plant

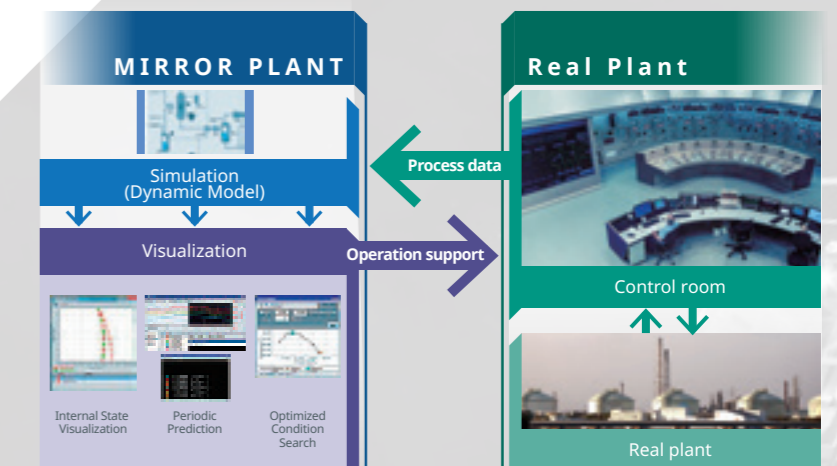
The two main uses of LNG are power generation and town gas supply. The number of Gas-to-Power projects, in which a gas power plant is constructed in conjunction with an LNG terminal, is increasing in countries with growing power demand. Consolidated operation between the LNG terminal and the power plant is required more since each plant operation affects the other. For example, an unexpected incident at an LNG terminal may cause a significant decrease in the pressure of gas delivery, which can result in a gas turbine trip or parallel-off of generators at a power plant. An unexpected problem with a gas turbine at a power plant may cause excessive gas supply, which forces the LNG terminal to suppress the gas supply. Consolidated operation enables agile operations, such as first cut-out, and efficient balancing of the gas supply and demand at each plant. Yokogawa provides a consolidated operation environment while securing each company's data independently, based on long expertise in power generation and LNG terminal automation.



# Operators Take Quick Action to Prevent Alarms

Yokogawa's online simulator MirroPlant predicts LNG regasification plant behavior

Yokogawa's MirrorPlant dynamically simulates the behavior of a plant by updating the model's parameters using feedback from the real plant. By applying DDR (Dynamic Data Reconciliation) algorithms, a more precise representation of the current state of the process is achieved. MirrorPlant calculates LNG calorific value by using factors such as Boil-Off Gas (BOG) and calculates delivering gas quality (calorific value and odor concentration), and visualizes the results in graphical and trend form. MirrorPlant forecasts possible alarms by predicting the process behavior of the LNG terminal. Then agile action can be taken according to these predicted behavior changes to ensure stable operations.



# Highly Automated and Highly Reliable Systems Ensure a Stable Gas Supply

Yokogawa provides field-proven software and redundant configurations

Advanced terminal unit control (ATUC) is a group of software modules on FCS\* developed through Yokogawa's extensive experience working with gas companies. ATUC is specialized for LNG terminal control, optimizing load sharing according to demand changes and achieves immediate control during unexpected conditions. ATUC also enables automated supply volume without the operator's intervention, lowering the load on operators. By implementing ATUC in redundant configuration, continuous supply is ensured in case of unexpected incidents and during maintenance.

\*FCS: Field Control Station (control unit of Yokogawa DCS)



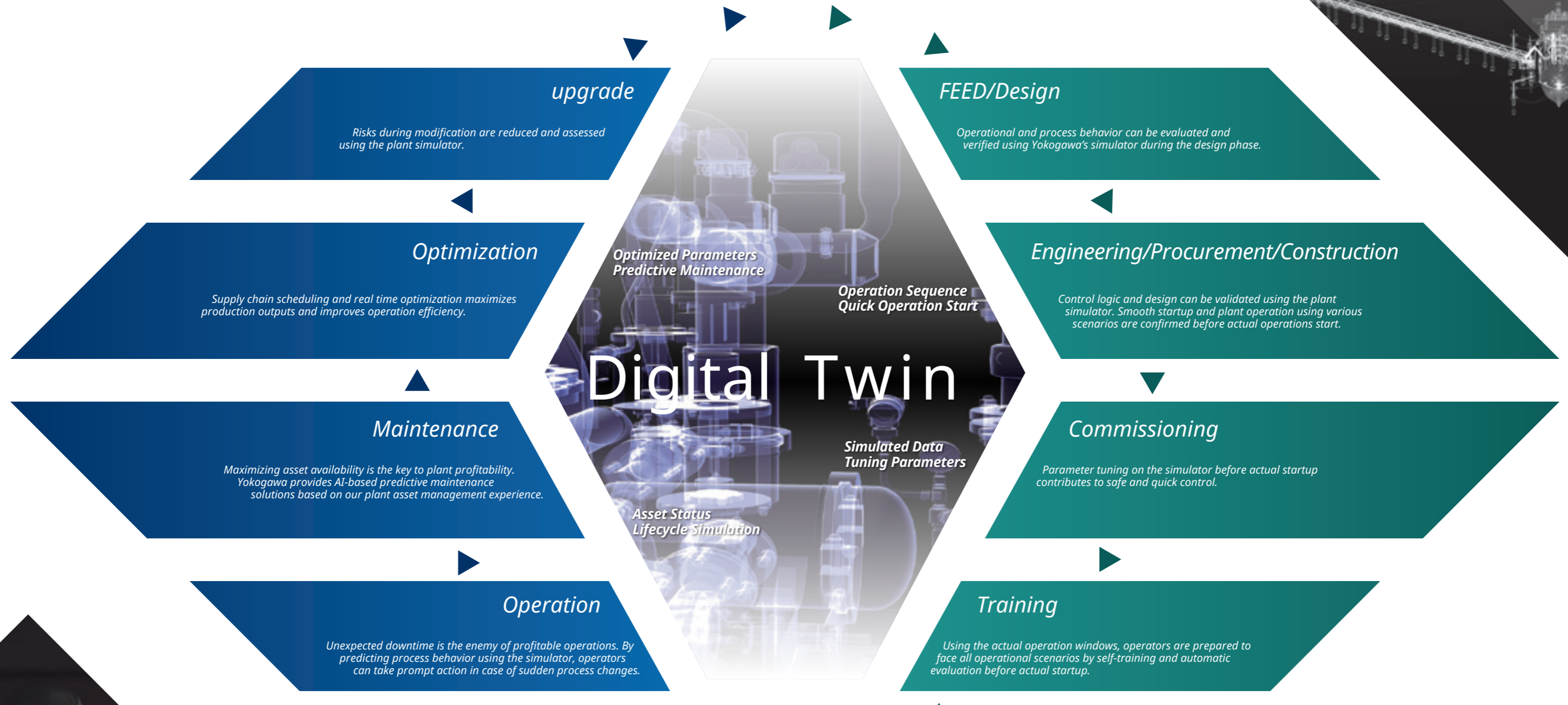
# Future Path Embracing Digital Technology

As a genuine MAC (Main Automation Contractor), Yokogawa brings digital transformation to LNG plants at each stage of the plant lifecycle

## Operational Readiness

### Agile Project Execution

Plant startup time is reduced and plant integrity is improved by validating the control logic and setting the tuning parameters using Yokogawa's digital twin technology.



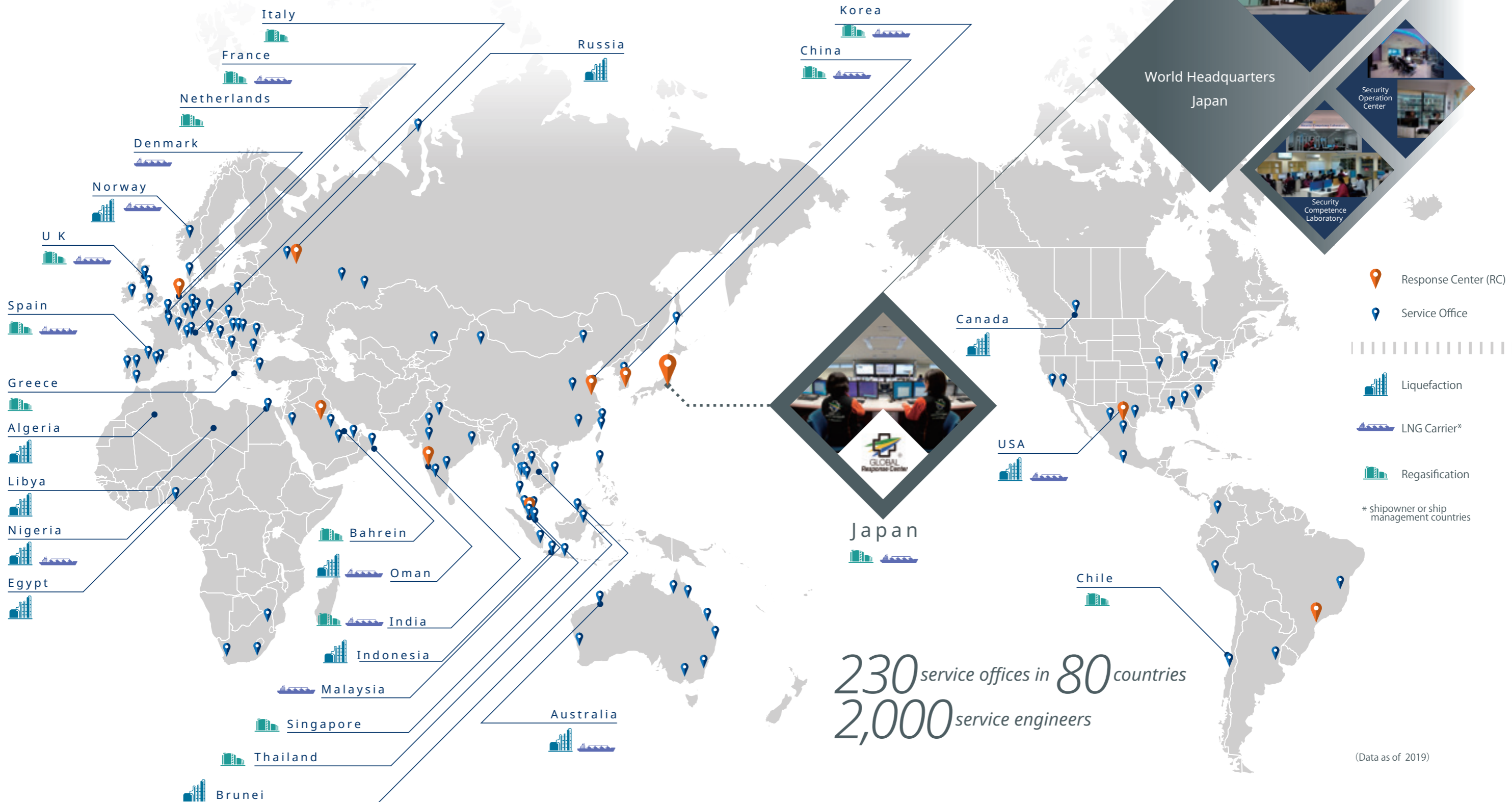
## Business Readiness

### Profitable Operation and Maintenance

Highly reliable control systems are the basis of plant integrity, however optimization of assets and resources are required to increase business profitability. Yokogawa's digital twin contributes to plant optimization.

# LNG Experiences and Global Network

Regional response center



(Data as of 2019)



**OpreX™** Yokogawa achieves operational excellence by providing products, services, and solutions based on the OpreX comprehensive brand that cover everything from business management to operations.

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