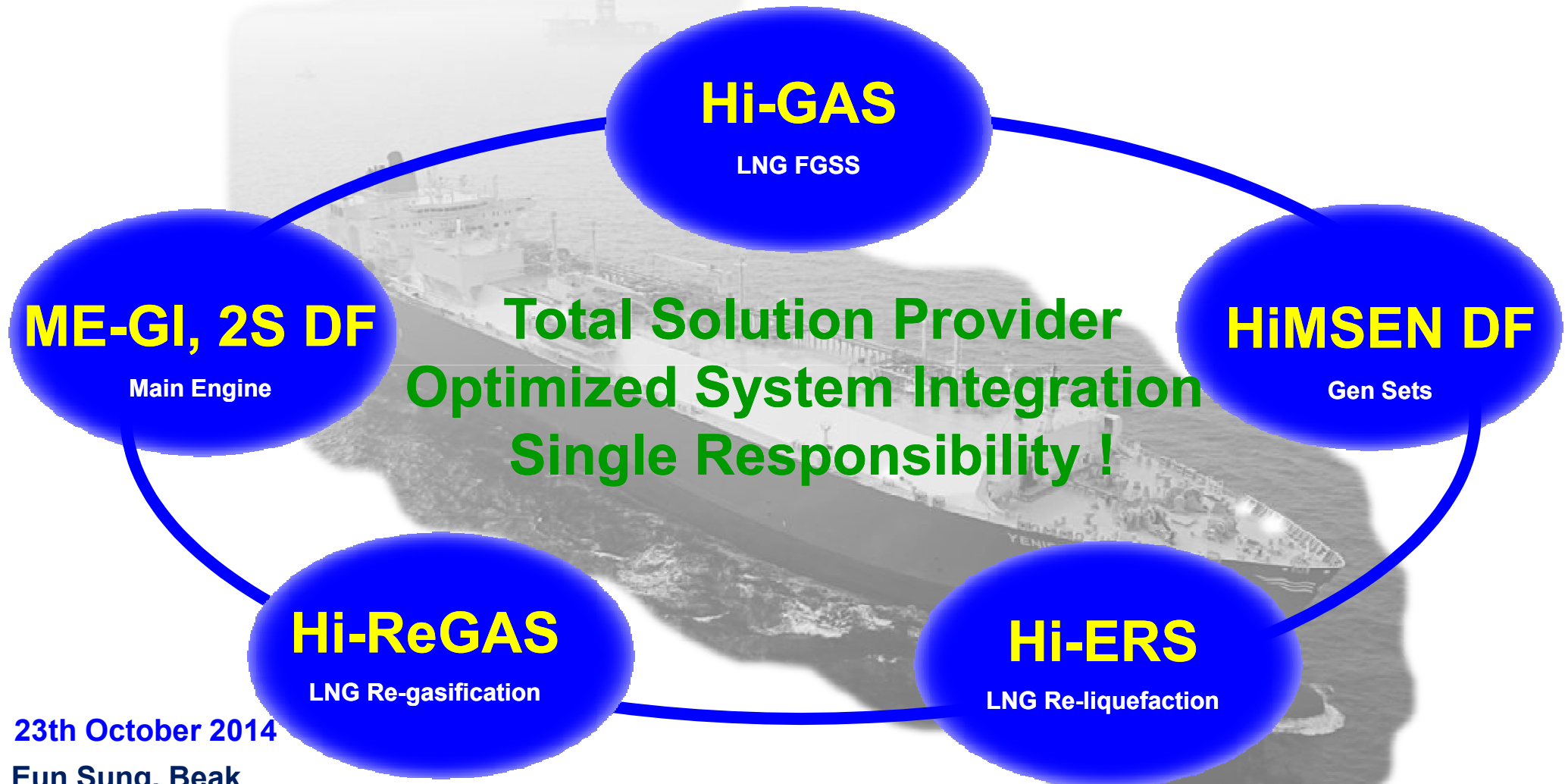


HHI's Gas Package Solution

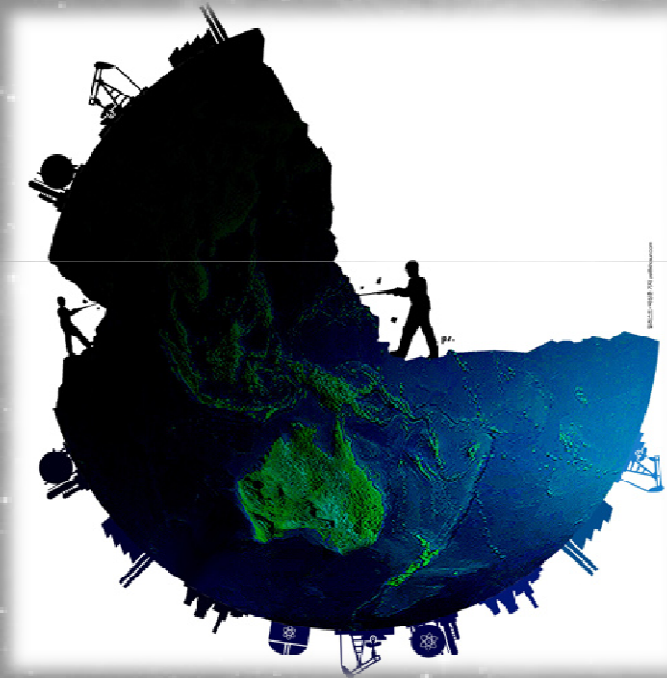
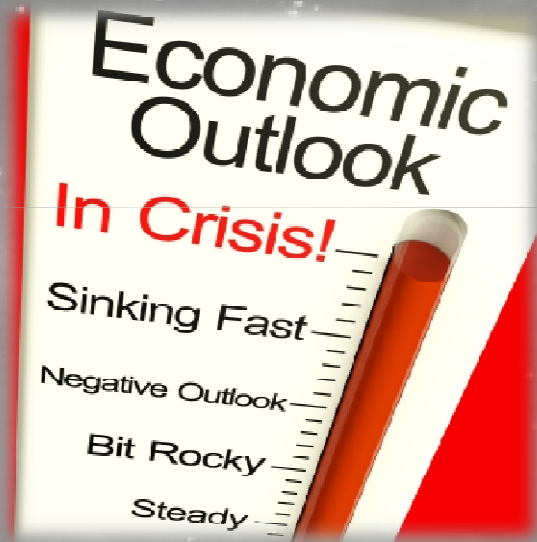


23th October 2014

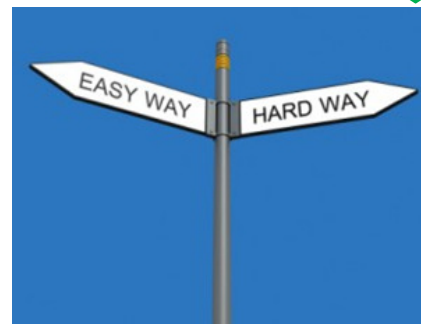
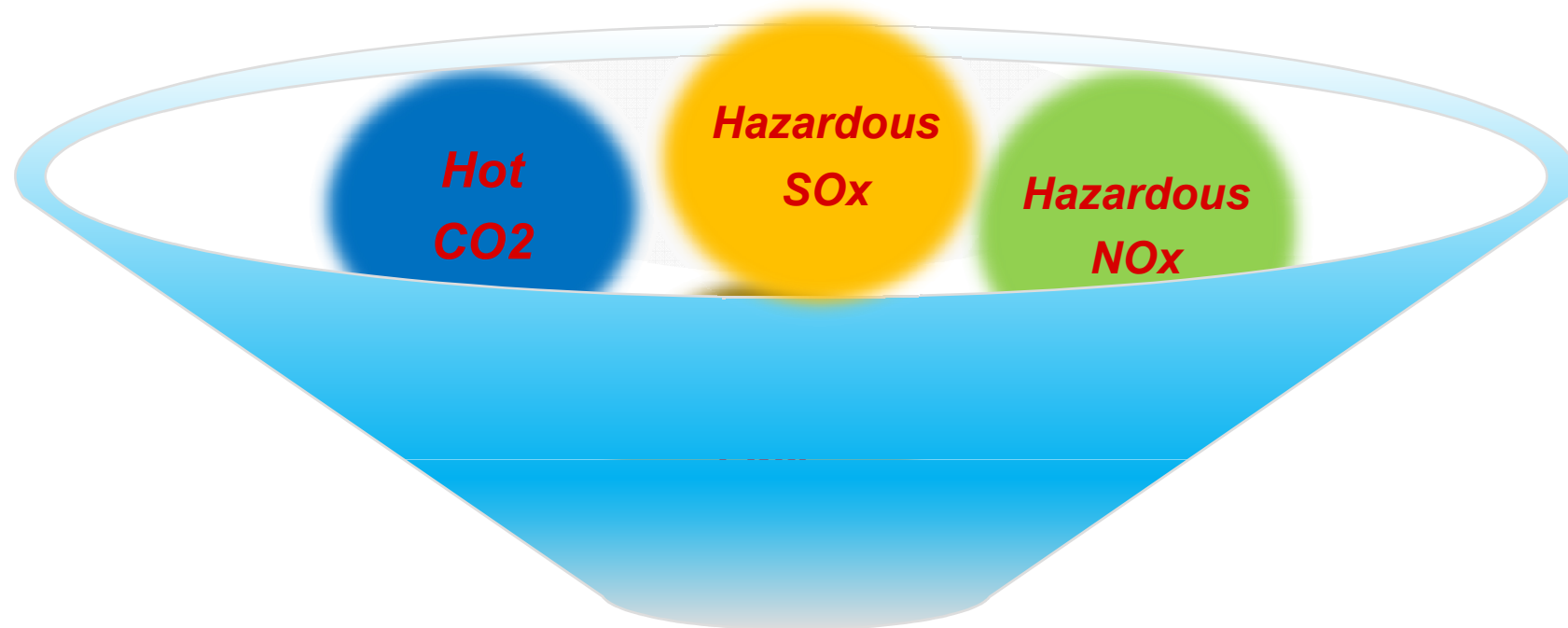
Eun Sung, Beak

Engine & Machinery Division, Hyundai Heavy Industries. Co., Ltd.

Chaos . . .



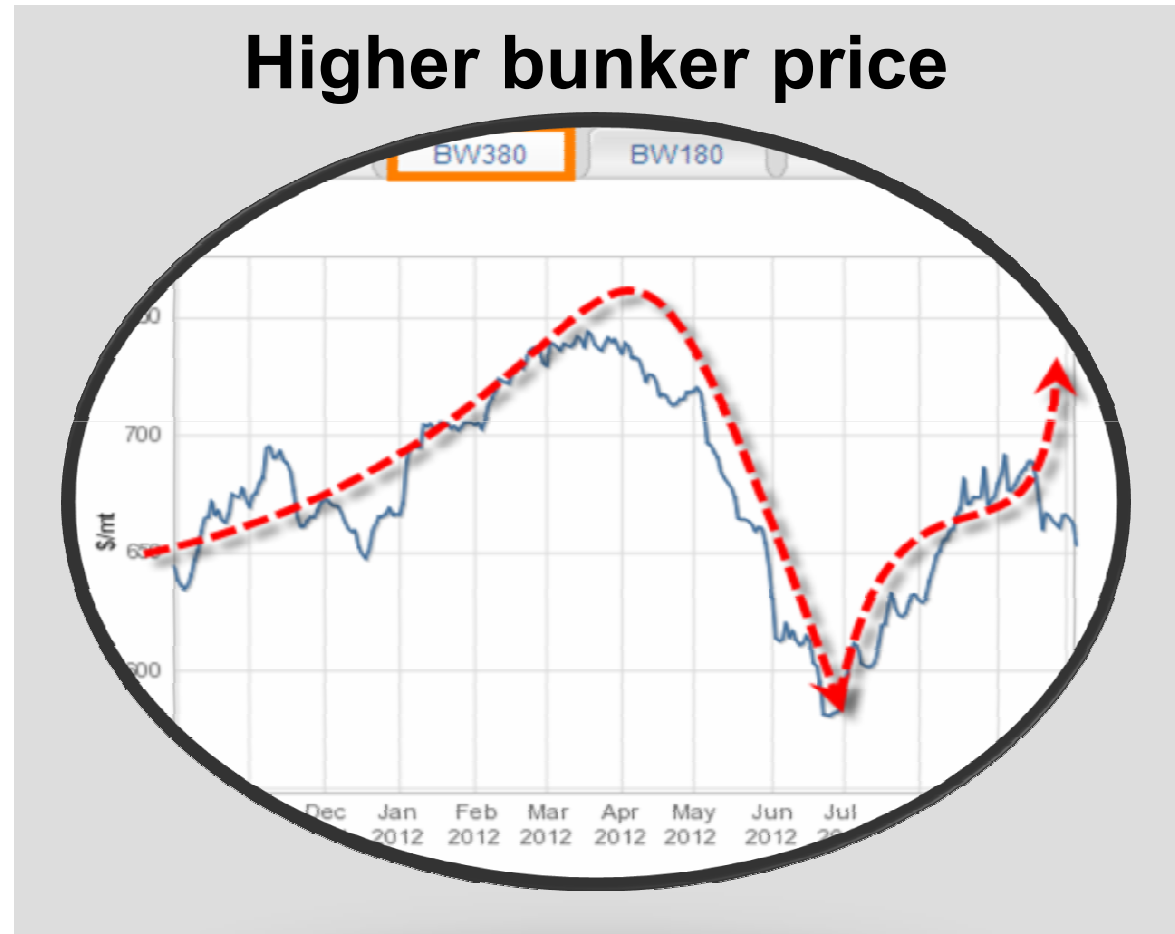
Difficulties . . .



Difficulties . . .

*Expensive
Fuel*

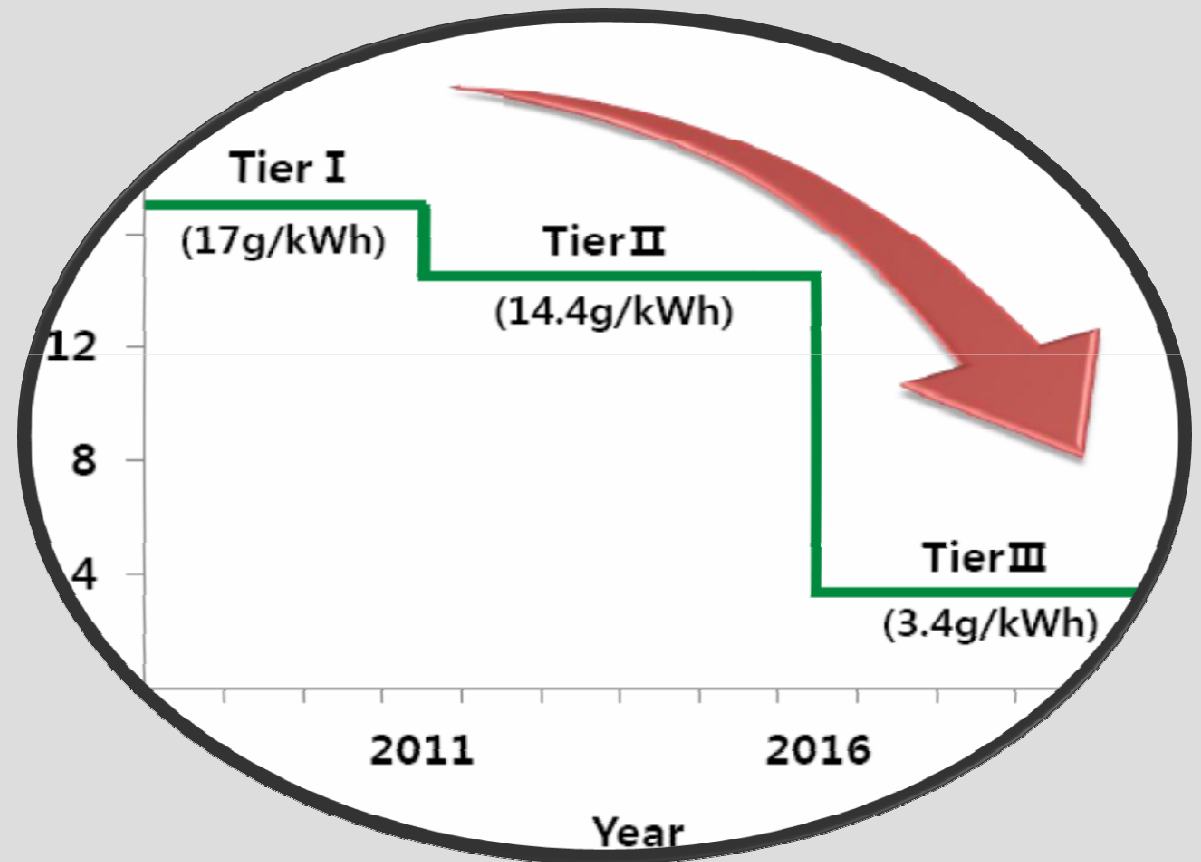
Higher bunker price



Difficulties . . .

**Hazardous
NOx**

NOx Emission Regulation



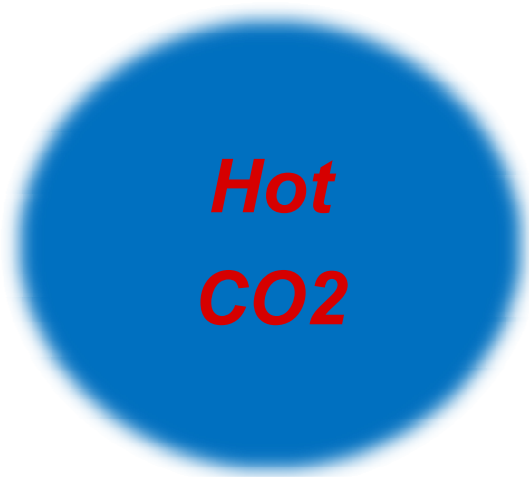
Difficulties . . .

EEDI (Energy Efficiency Design Index)



$$EEDI = \frac{\sum C_F \cdot SFC \cdot P}{Capacity \cdot V_{ref}}$$

→ Transport efficiency indicator



EEDI =

Air pollutant (CO₂)



Transport work

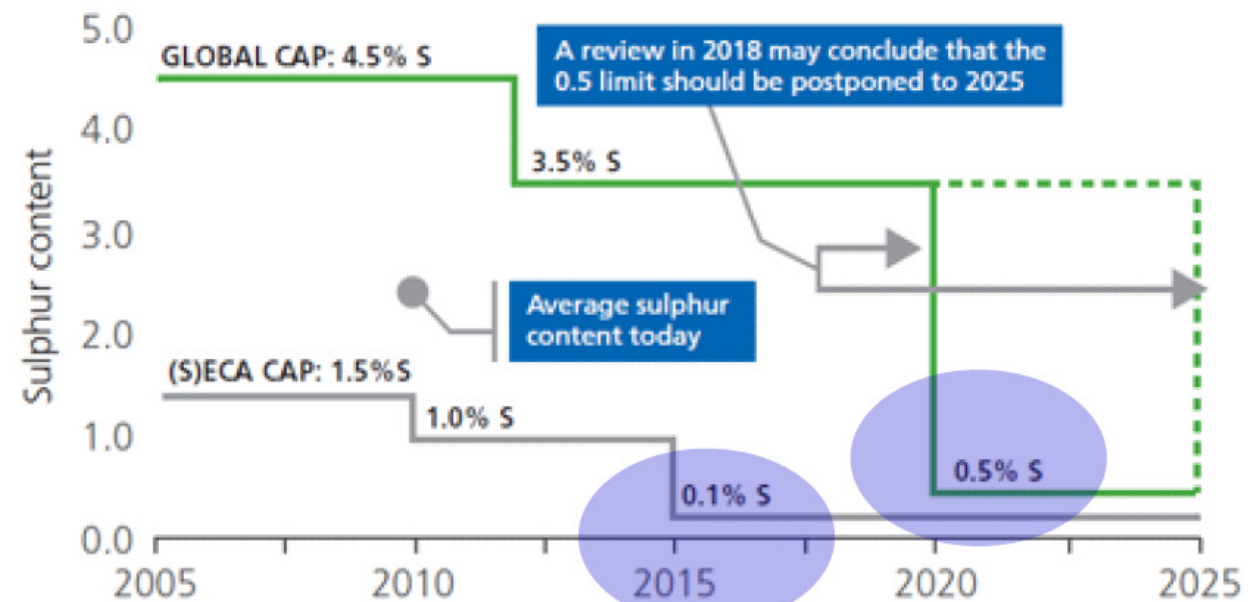
1. Vessel size to be bigger
2. Engine power to be less
3. Fuel consumption to be lower
4. Ship speed to be higher

**Mandatory for new ships > 400 GT
after 1 Jan. 2013 (MEPC 62, July 2011)**

Difficulties . . .

*Hazardous
SO_x*

RESTRICTIONS FOR SULPHUR CONTENT IN MARINE FUELS:



Difficulties . . .

*Expensive
Fuel*

*Hazardous
SO_x*

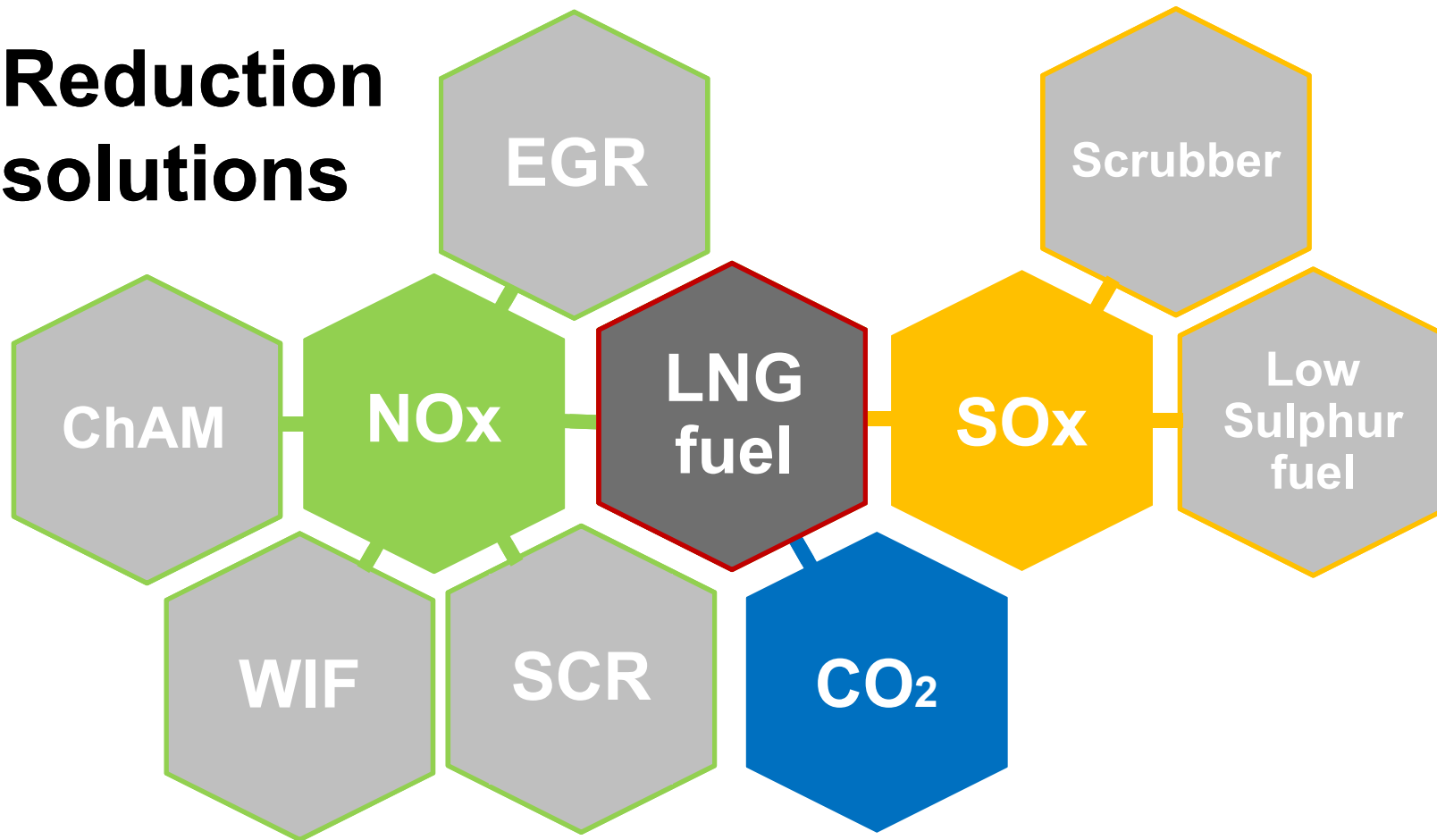


*Hot
CO₂*

*Hazardous
NO_x*

Various Solutions Available

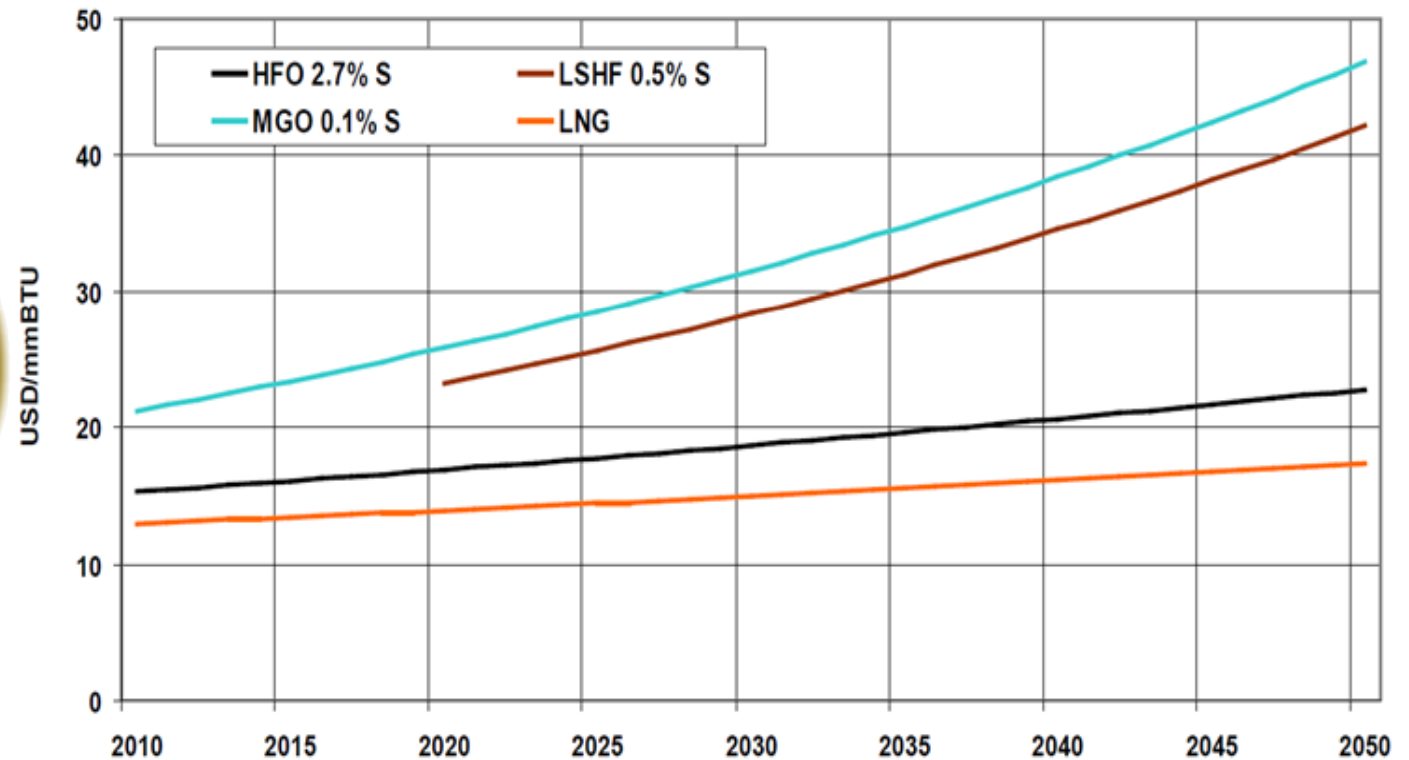
Reduction solutions



Economic Solutions Available

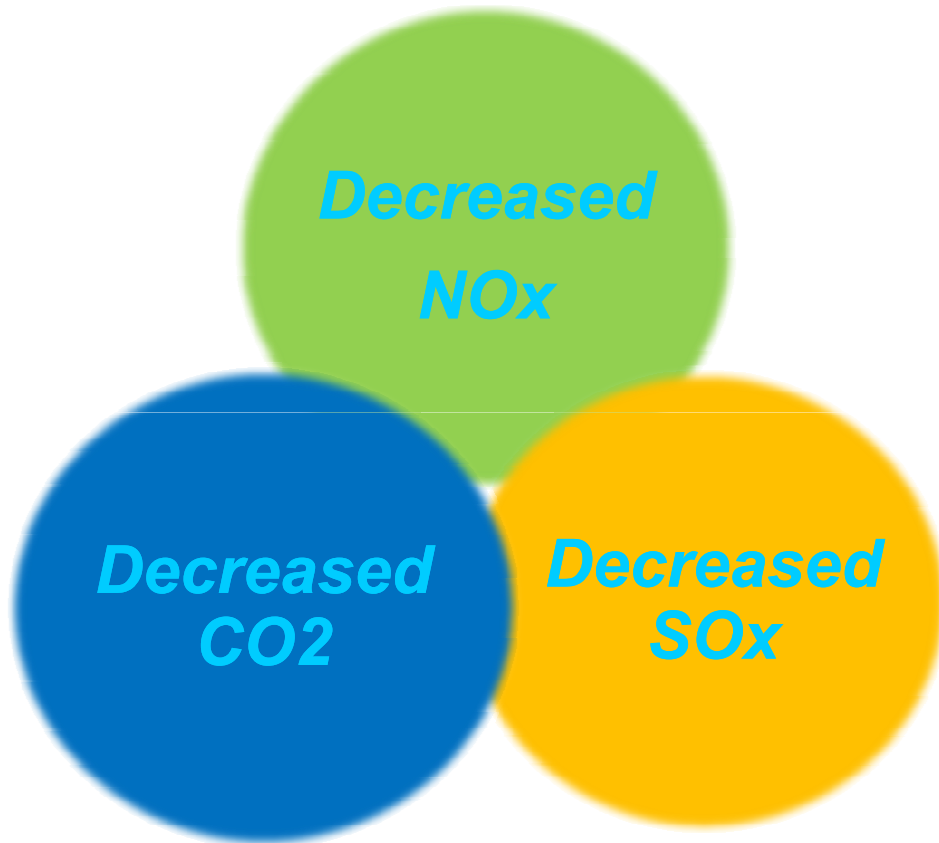
*Economical
Fuel*

Fuel price scenario

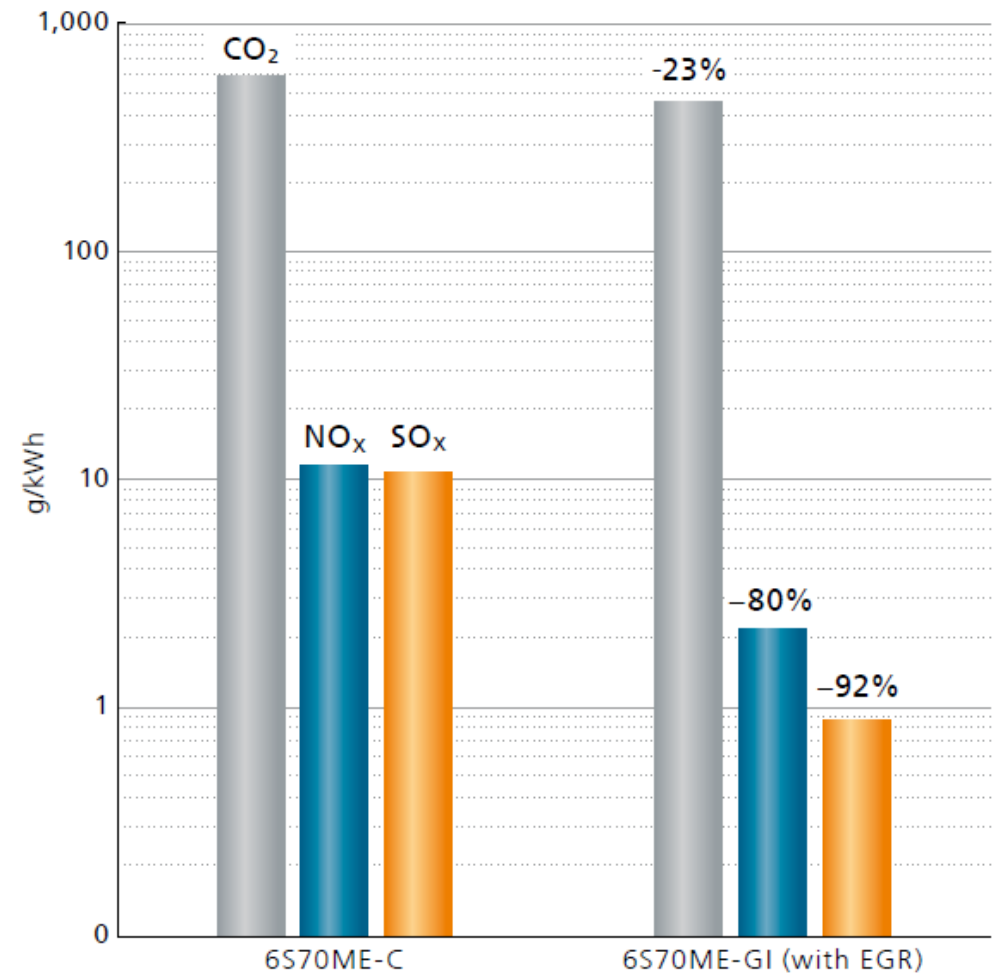


Source: GL-MAN container vessel advanced propulsion roadmap

Environmental Solutions Available



Emissions components (100% load)



SOURCE : Costs and benefits of LNG as ship fuel for container vessels(GL)

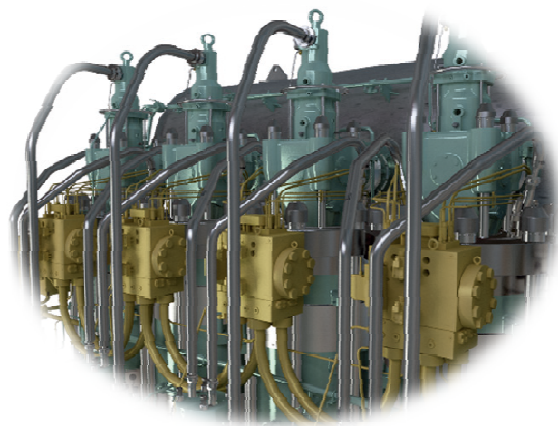
Where we go ?



What is ME-GI ?

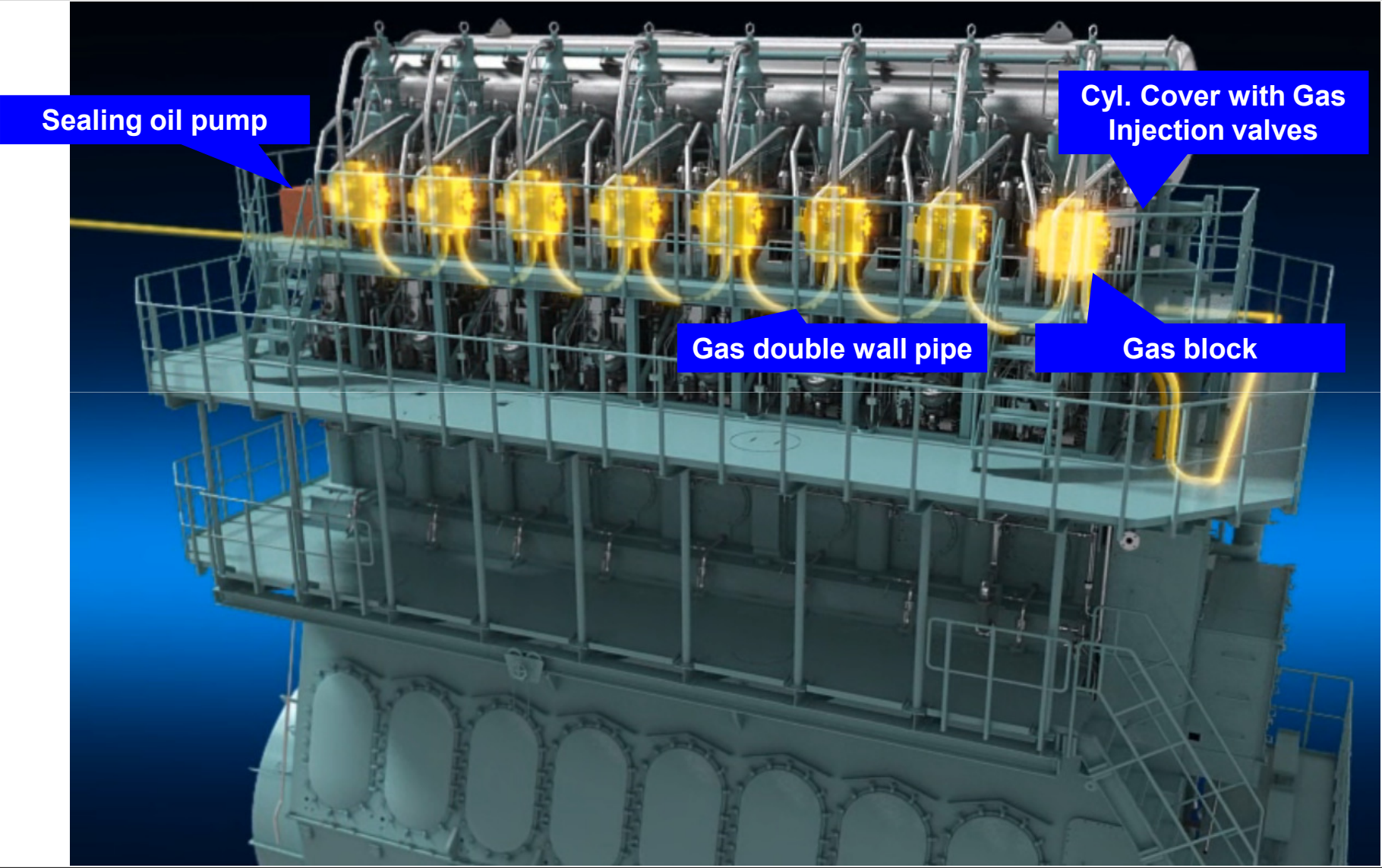


***ME-GI : M Electrically controlled
GI = High Pressure Gas Injection***



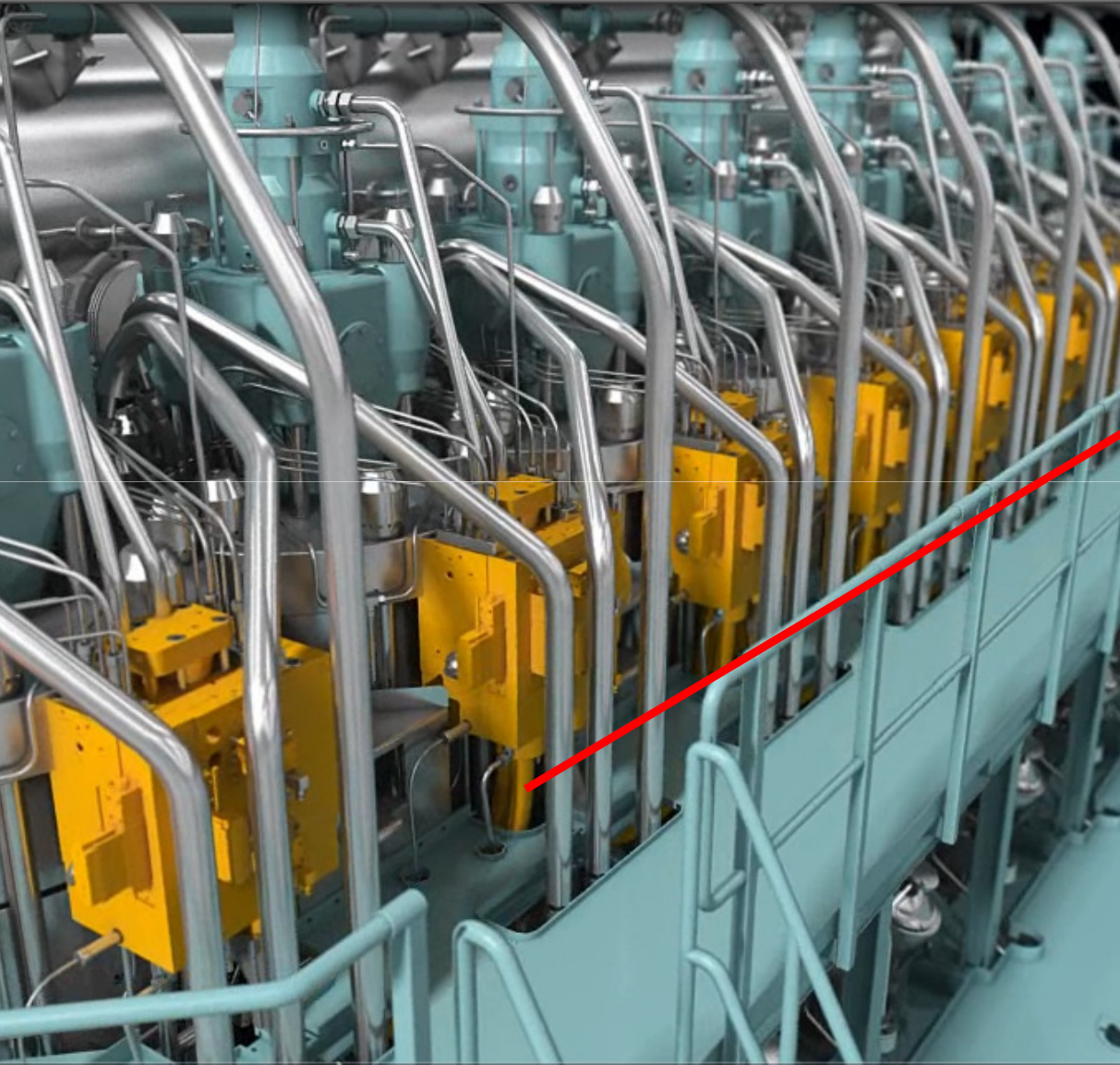
Proven System

ME-GI Configuration

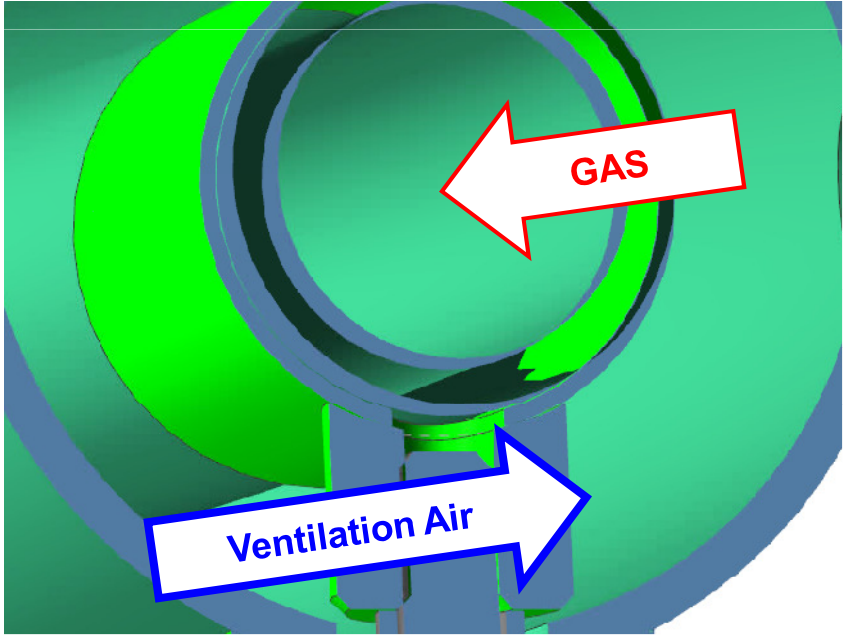
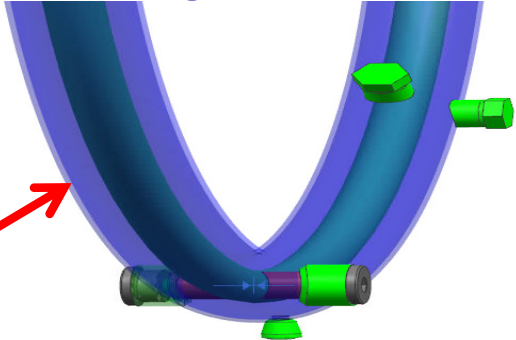


Proven System

Chain Pipe-Double Wall Gas Pipe

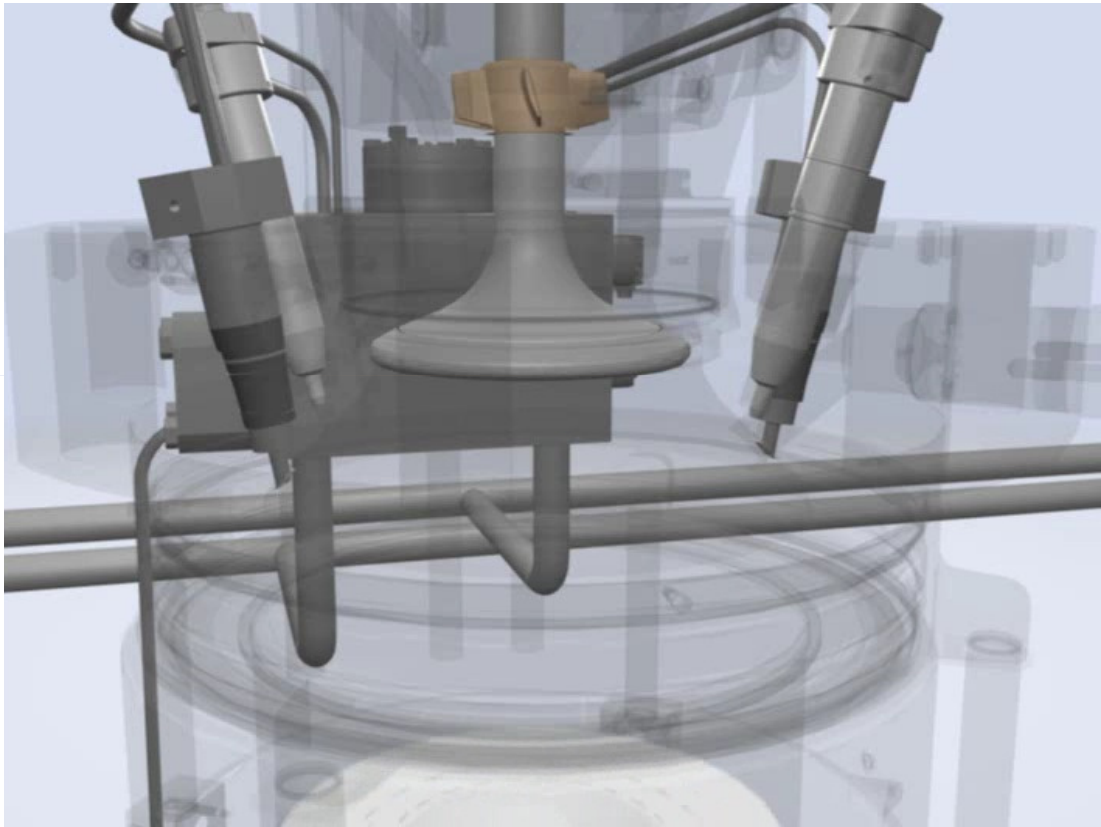
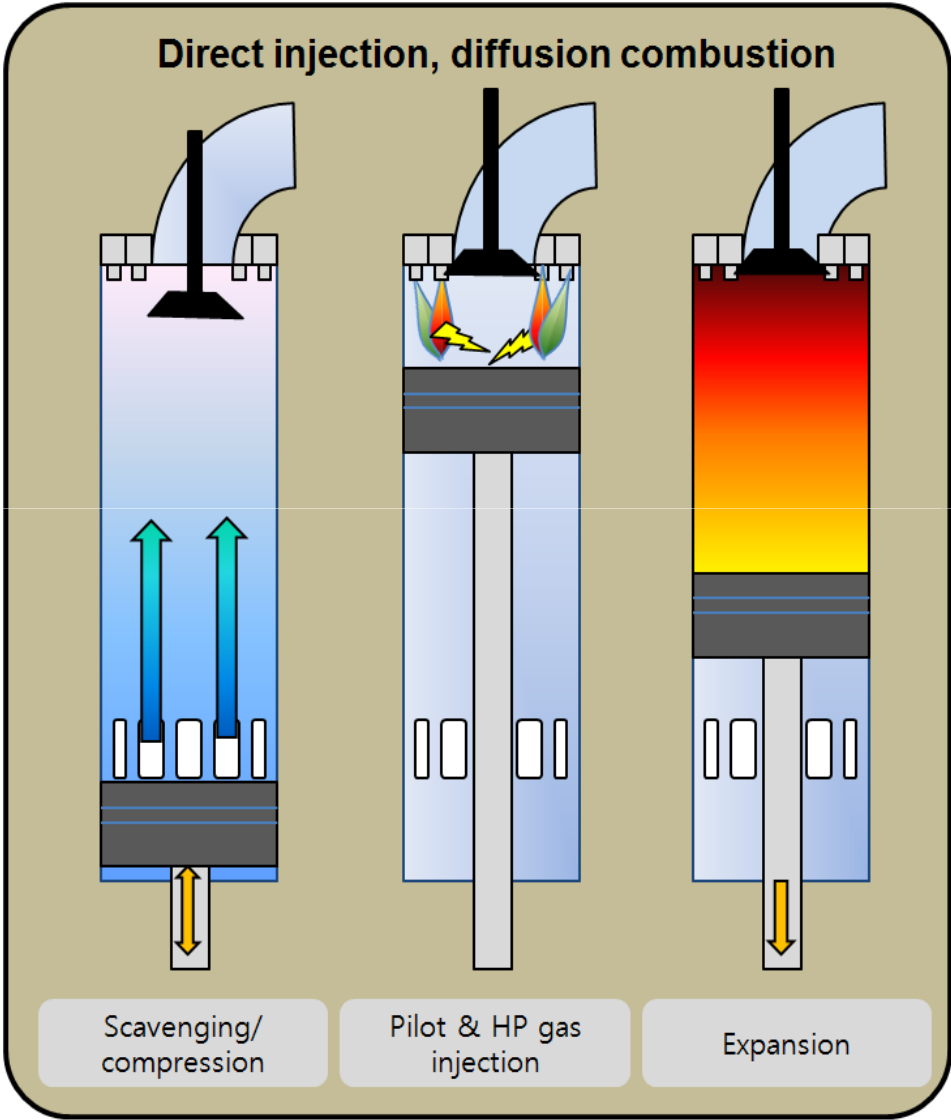


Gas distribution in ventilated,
No gas to engine room



Proven System

Combustion Process of ME-GI



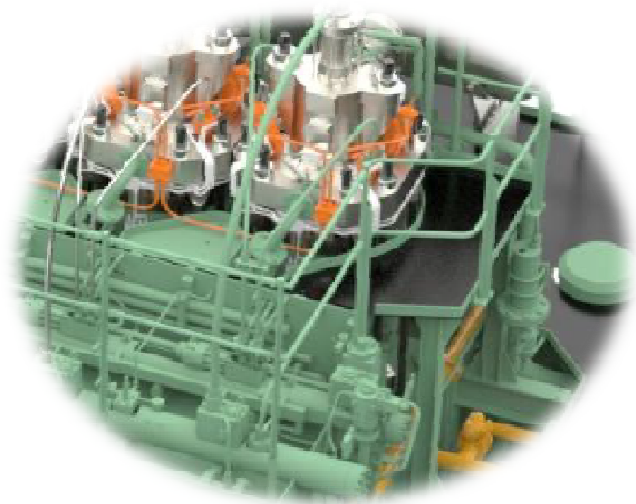
Proven System **ME-GI Engine**



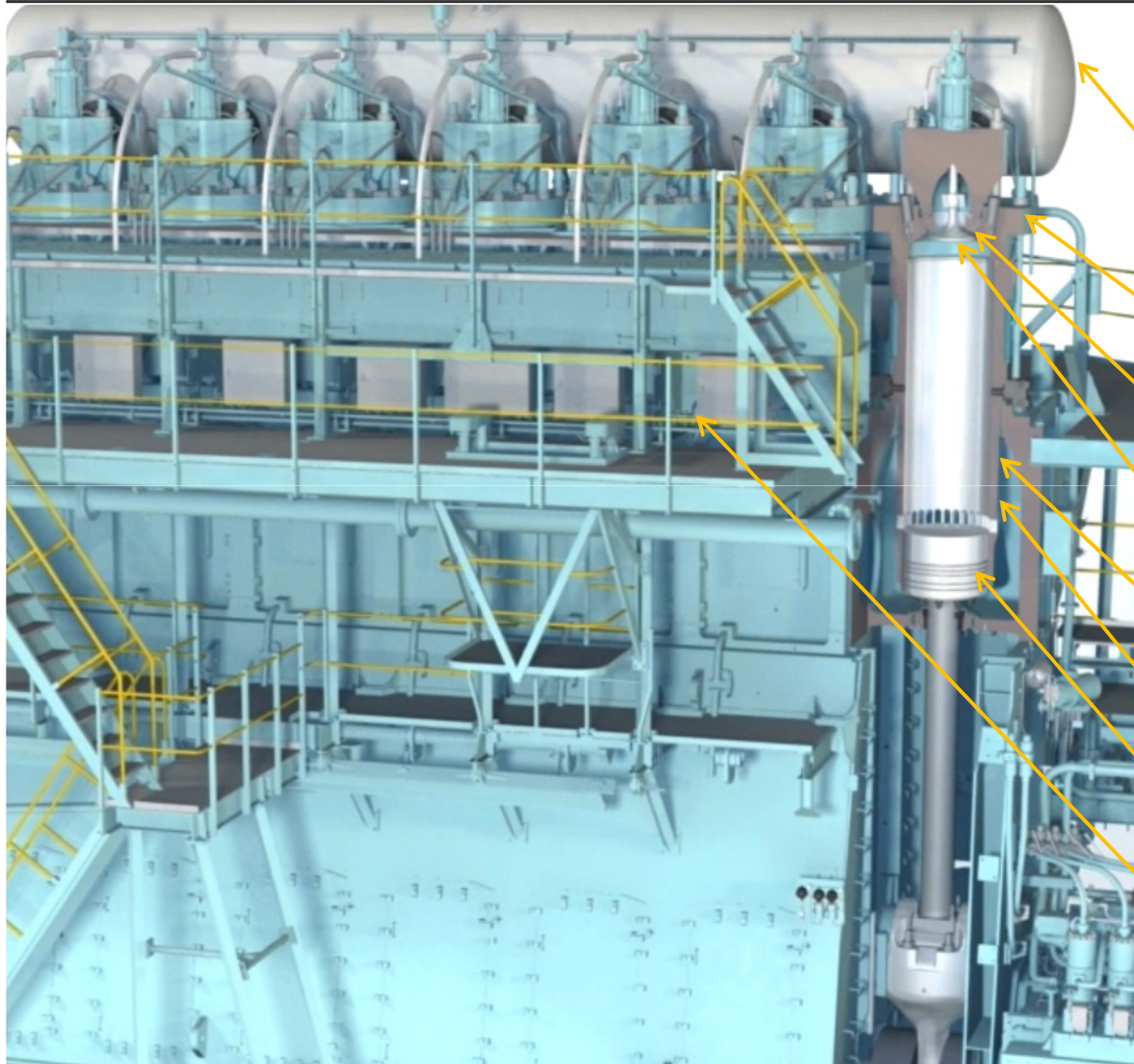
What is 2S DF ?



2S DF : generation X-Dual Fuel



2S DF Engine



Turbocharger / Exhaust waste gate / SAC

Cyl. Covers

Micro-pilot + Common Rail

Pre-chamber technology

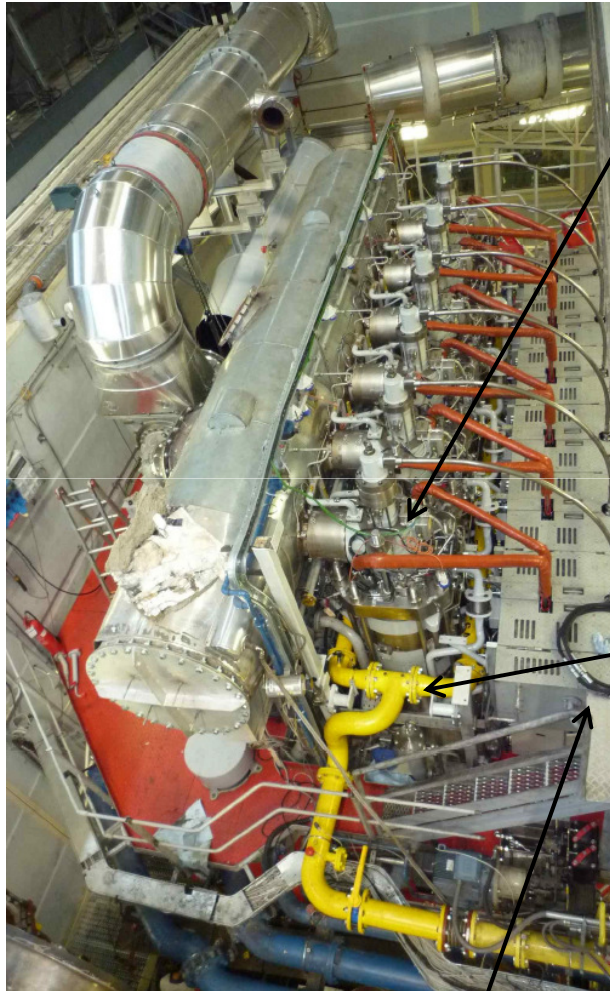
Gas admission system

Cyl. Liners

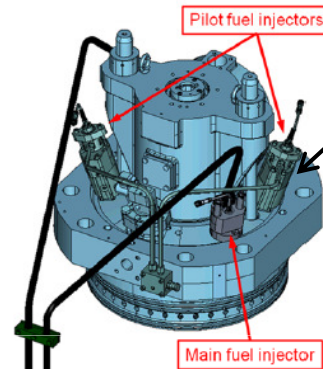
Piston & Rods

Engine control & Automation system

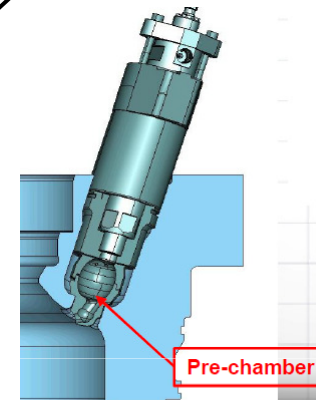
2S DF Engine



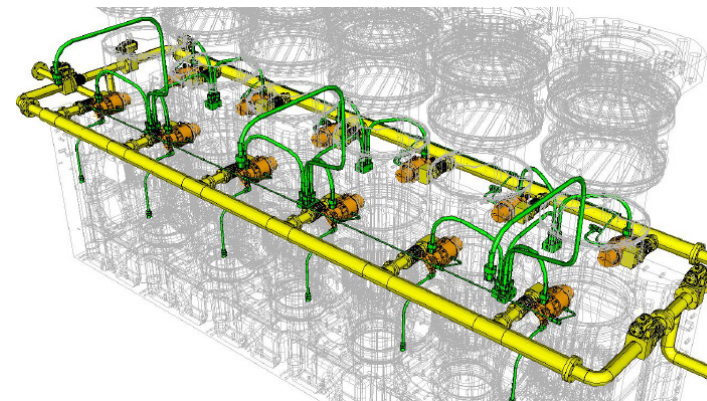
Micro-pilot + Common Rail



Pre-chamber technology

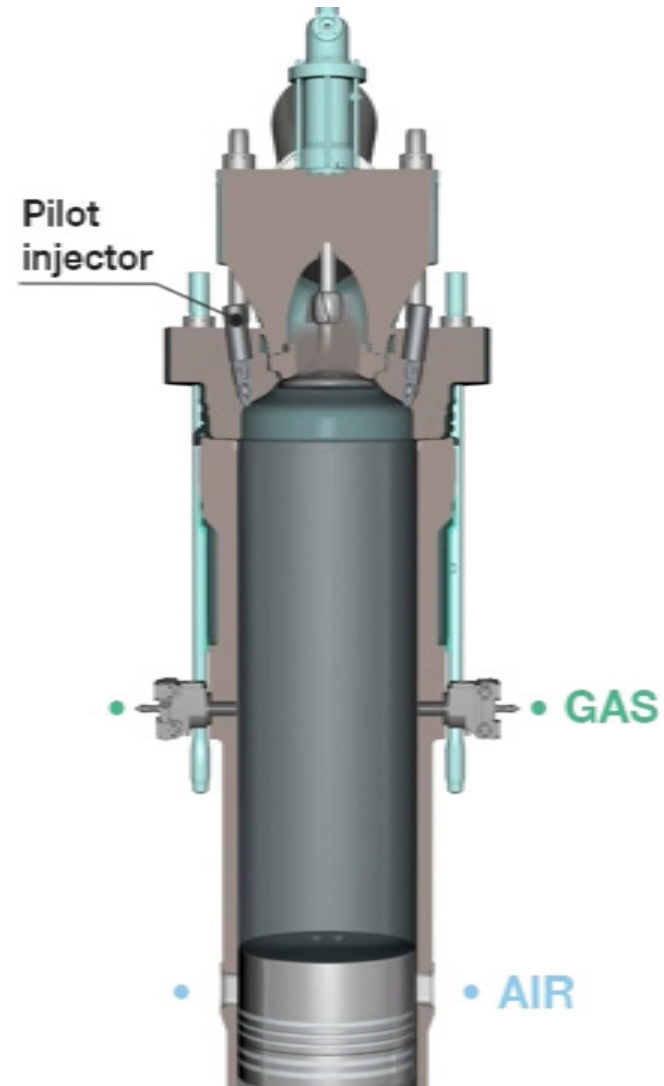
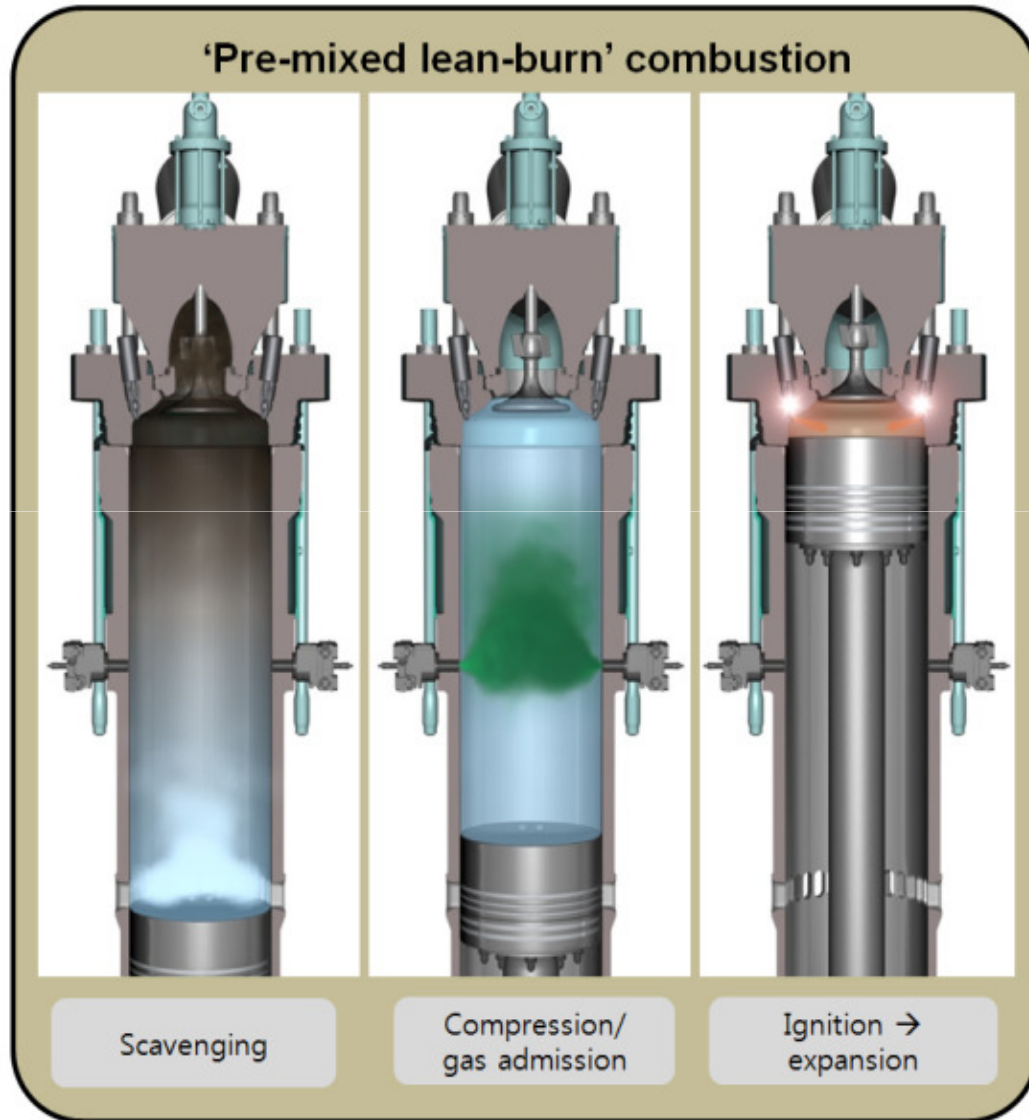


Gas admission system



Engine Control & Automation system

Combustion Process of 2S DF

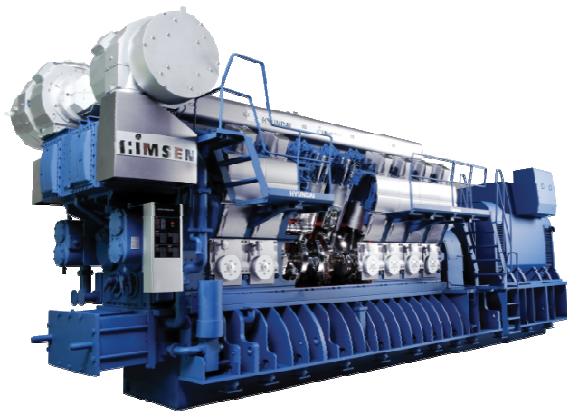


What is HiMSEN DF ?

HiMSEN

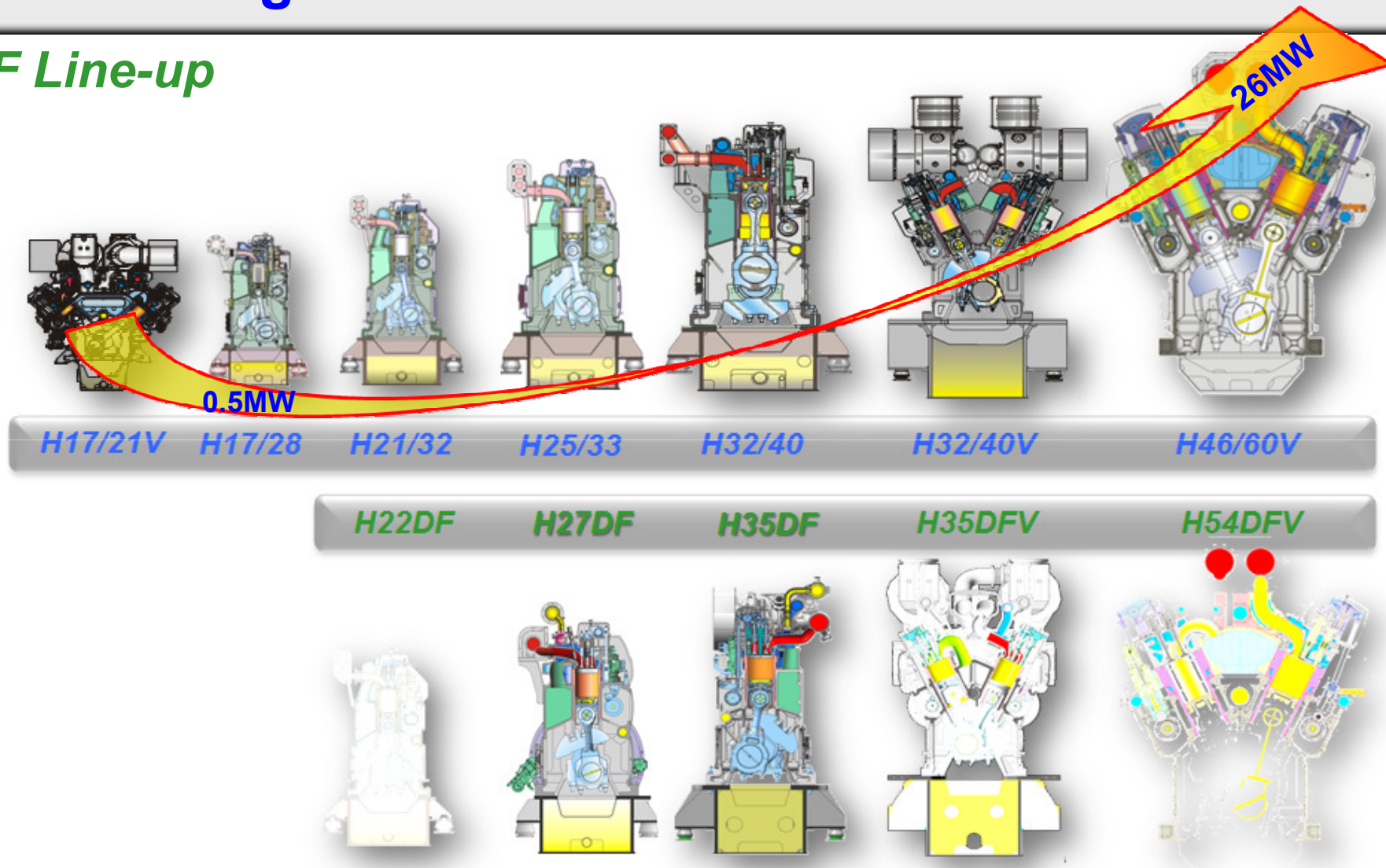
HiMSEN DF :

High-touch Medium Speed ENgine Dual Fuel



HiMSEN Engine

DF Line-up



HiMSEN DF Engine

Power Range of HiMSEN DF Engine

H18DF



525 ~ 1,035 kW



H22DF



740 ~ 1,850 kW

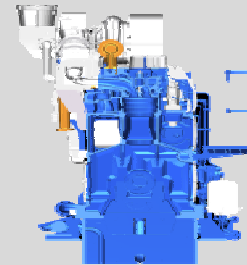


H27DF



1,365 ~ 2,850 kW

TAT : Sep. 2014

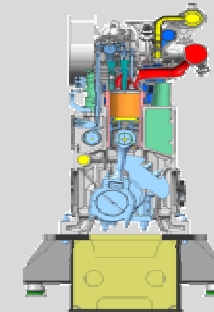


H35DF



2,880 ~ 4,320 kW

TAT : Oct. 2012

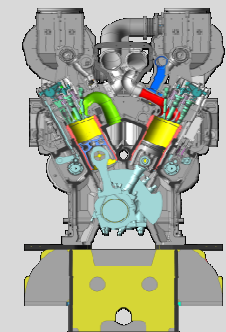


H35DFV



5,760 ~ 9,600 kW

FAT : Feb. 2015 (for power plant)



0

5

10

Power [MW]

HiMSEN DF Main Features

Fuel System

Fuel Gas System

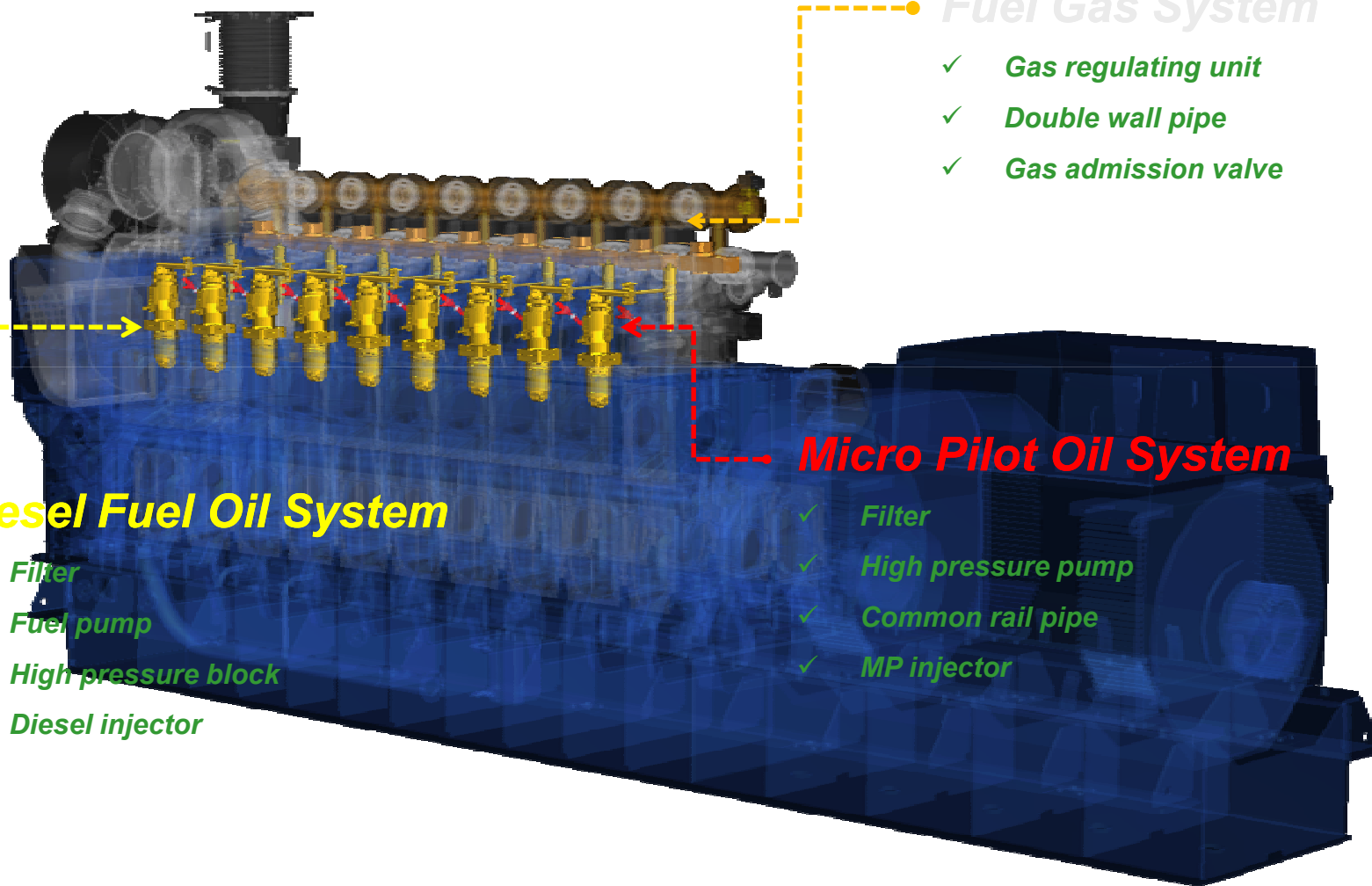
- ✓ Gas regulating unit
- ✓ Double wall pipe
- ✓ Gas admission valve

Diesel Fuel Oil System

- ✓ Filter
- ✓ Fuel pump
- ✓ High pressure block
- ✓ Diesel injector

Micro Pilot Oil System

- ✓ Filter
- ✓ High pressure pump
- ✓ Common rail pipe
- ✓ MP injector



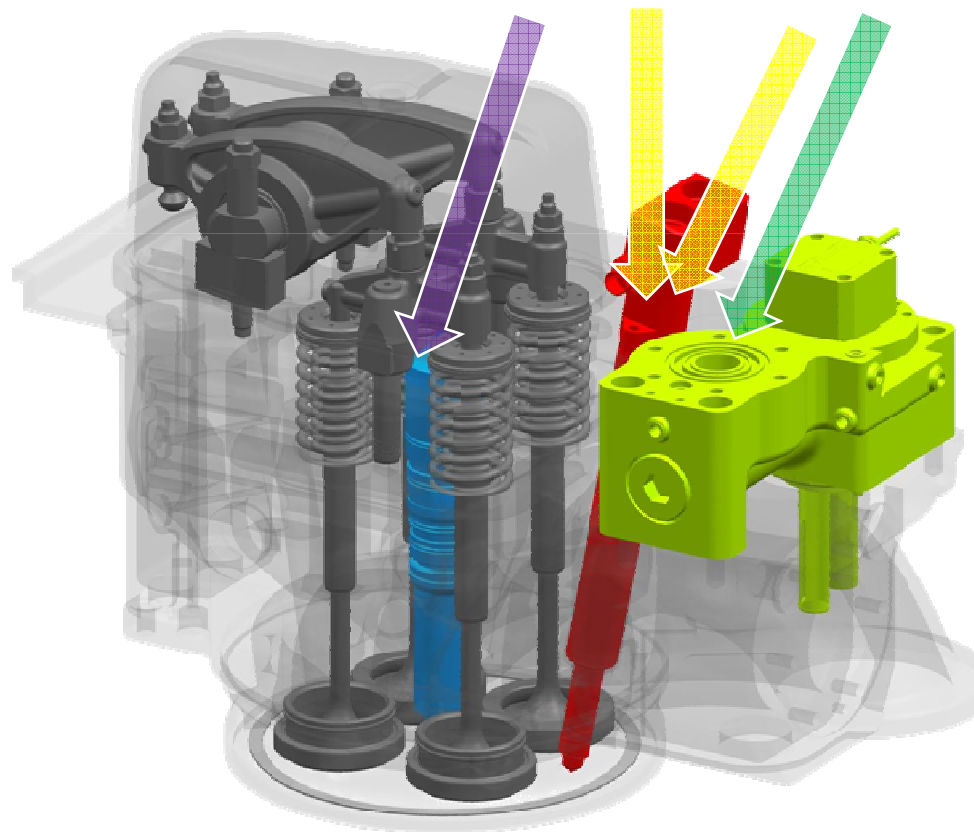
HiMSEN DF Main Features

Dual Fuel Operation

DIESEL MODE = **Fuel Oil** 99% + **Fuel Oil (Micro Pilot)** 1%



Diesel

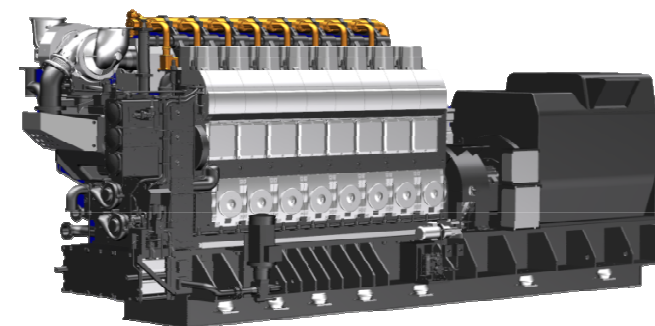
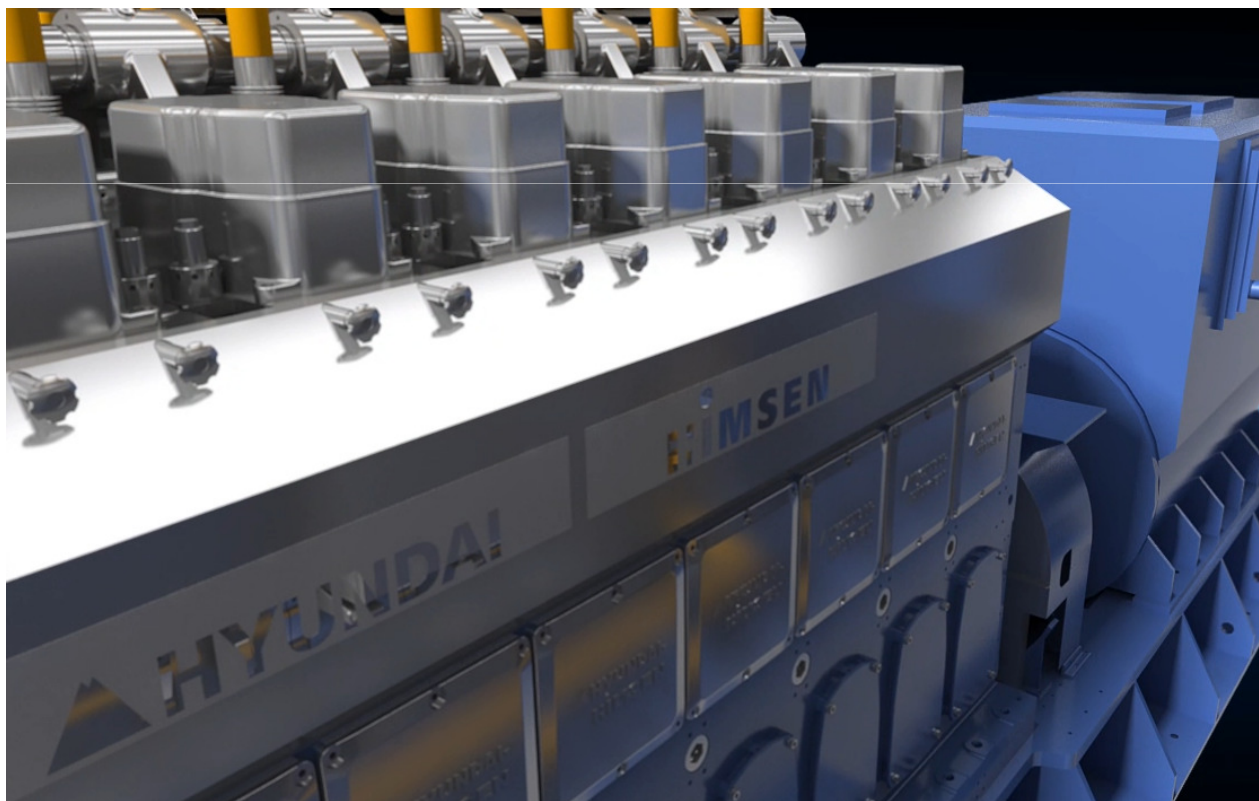


Otto

HiMSEN DF Engine

- **Hi-Touch Eco-friendly engine for . . .**

- **LNG fueled marine vessels**



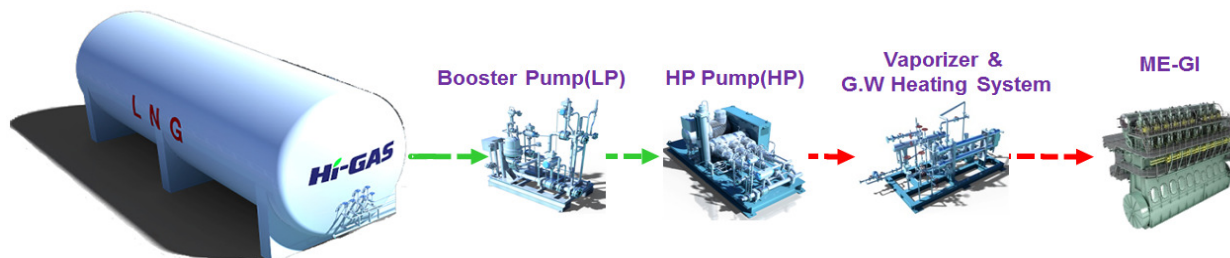
- **Fuel flexibility**
- **Electric control**
- **Low emission**
- **Easy maintenance**
- **High reliability**

What is Hi-GAS ?

Hi-GAS

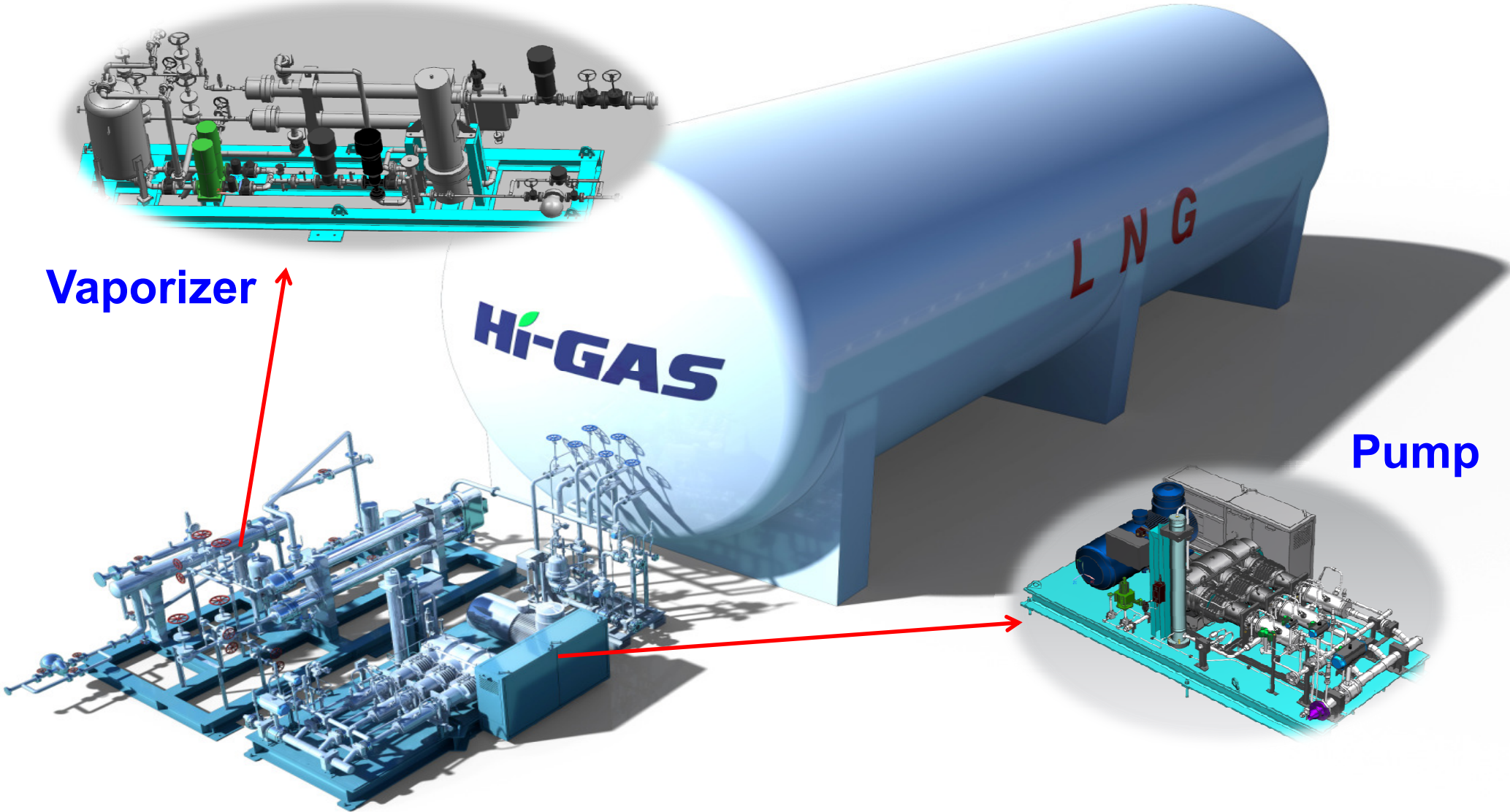
Hyundai integrated

GAs Supply system for LNG Fueled Ship

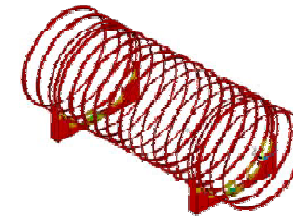
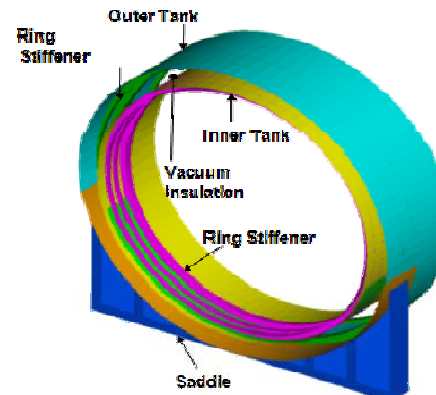
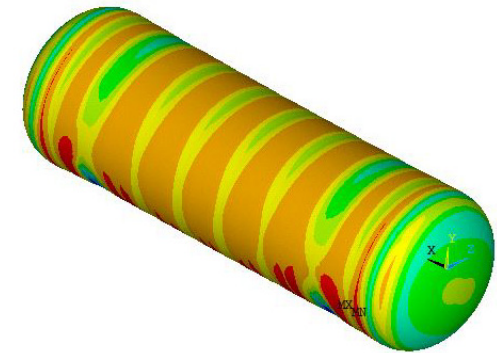
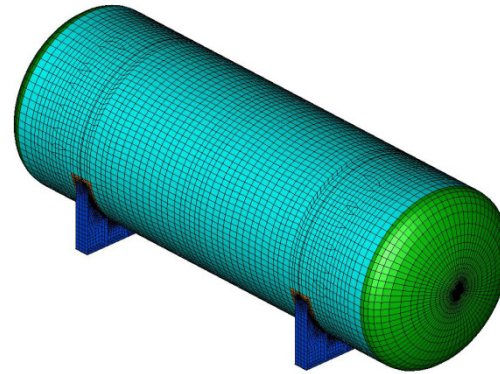
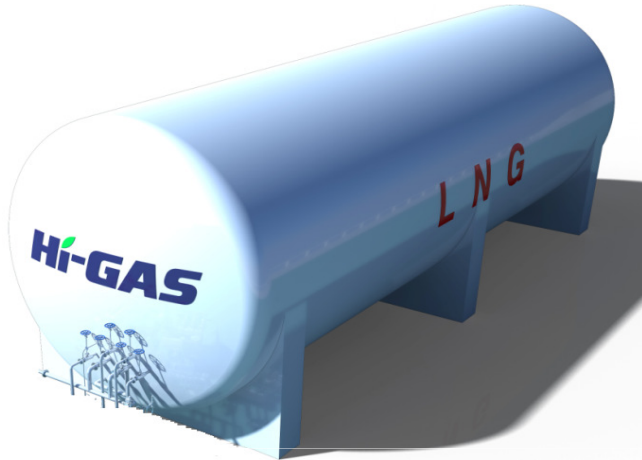


Proven System

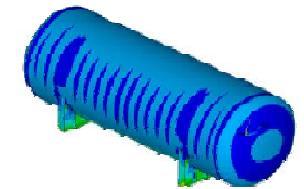
Fuel Gas Supply System(Hi-GAS)



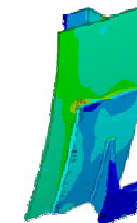
Proven System Type C Tank



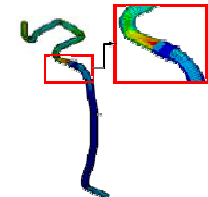
Thermal Distribution



Structural Safety Assessment



Fatigue Assessment



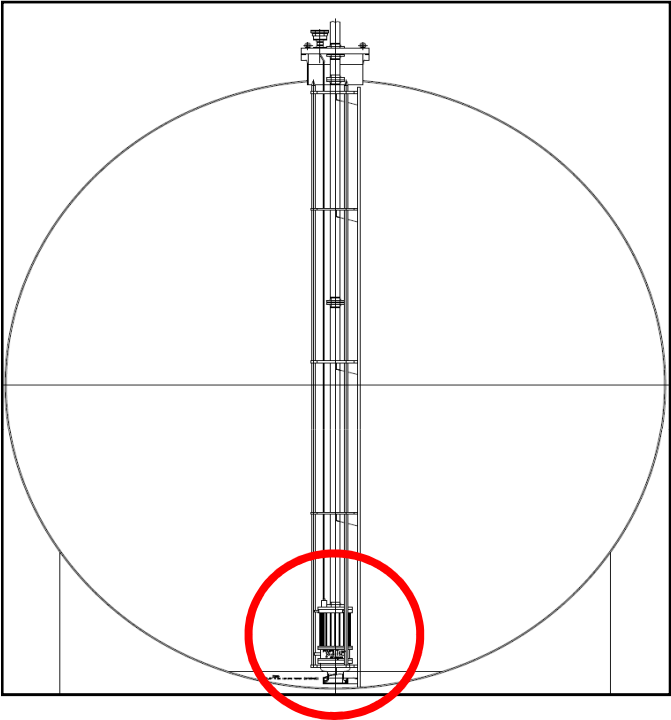
Safety Assessment
for Piping System

Proven System

LNG Supply Pump

- Supply sufficient pressure above the boiling pressure at any given temperature.
- Two(2) LNG supply pump shall be installed in each LNG tank with 100% redundancy.

Principle layout

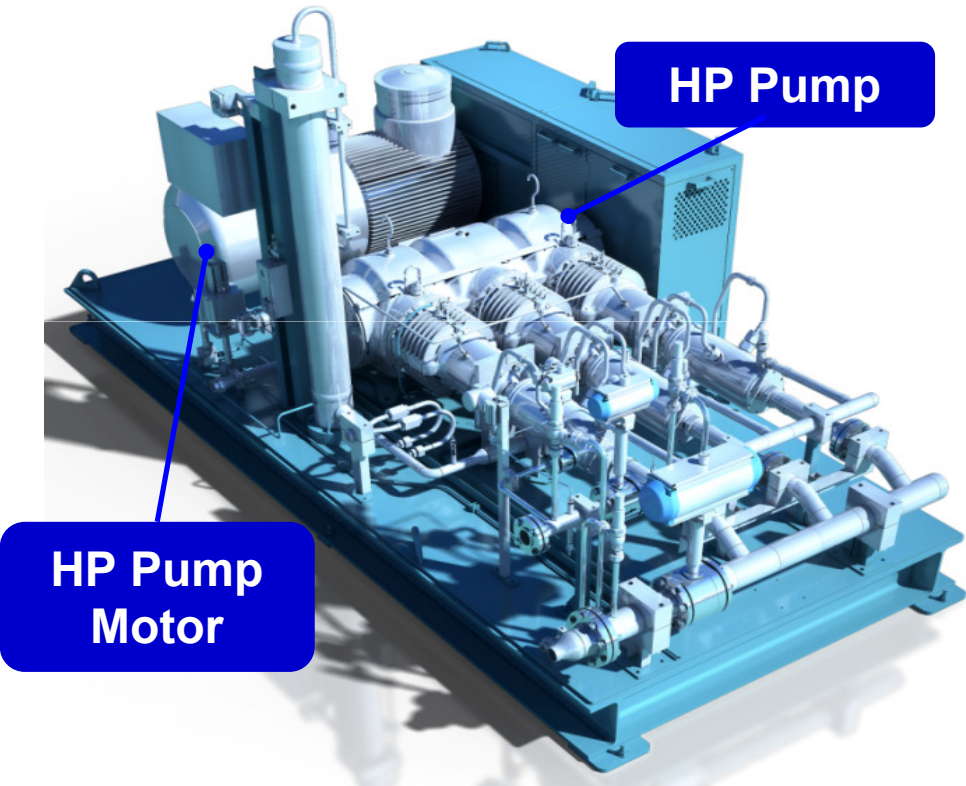


Type	Submerged Centrifugal Pump
Pressure	Low Pressure

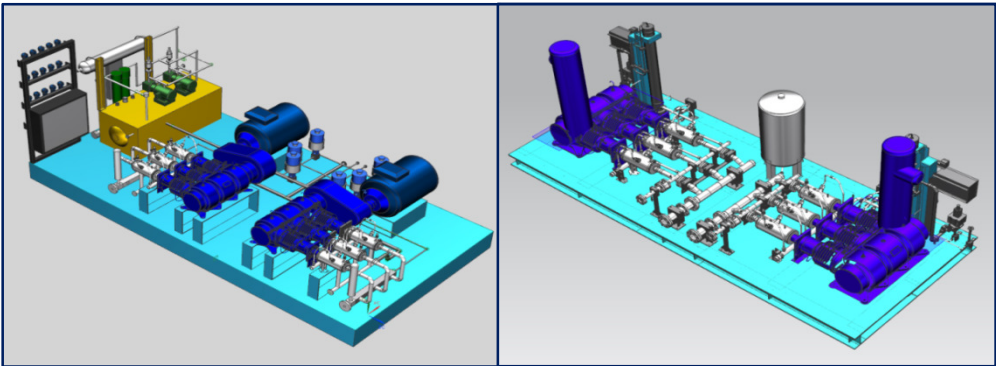
Proven System

Fuel Gas Supply System(Hi-GAS)

High Pressure Pump



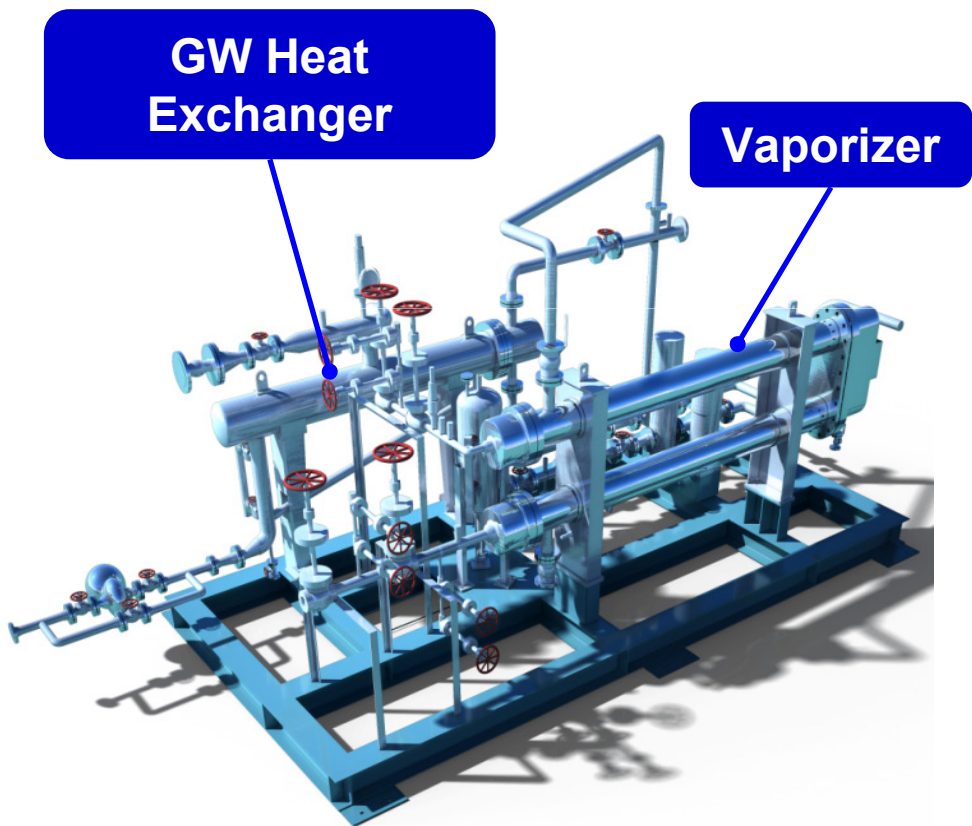
Type	Reciprocating Pump
Discharge Pressure	~ 320barg
Driver	Gear Driven
Motor	With VFD control
Power supply	440V/60Hz/3Ph



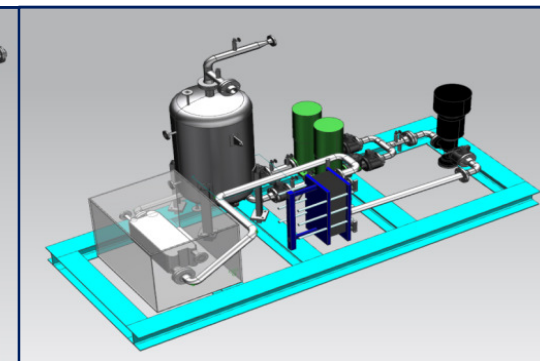
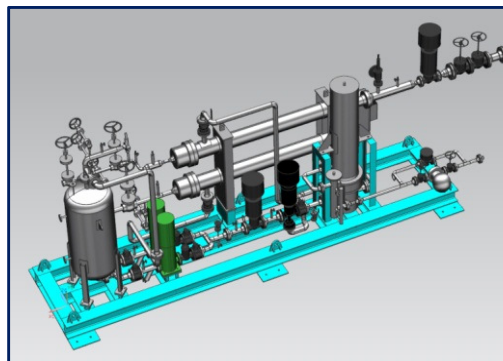
Proven System

Fuel Gas Supply System(Hi-GAS)

Vaporizer & Glycol Water (GW) Heating System

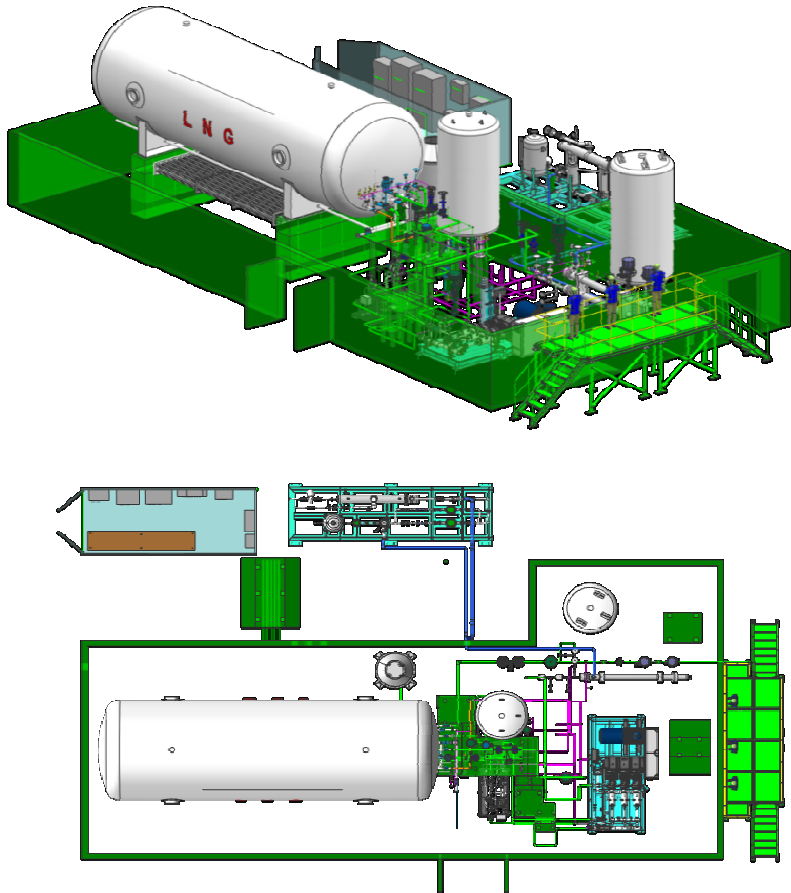


High Pressure Vaporizer	Shell & Tube Type	
	Tube Side	Shell Side
	LNG	GW
Glycol Water Heating System	Shell & Tube Type	
	Tube Side	Shell Side
	GW	Steam



Proven System

Fuel Gas Supply System(Hi-GAS)



Proven System

Safety Study & Certificates of Hi-GAS

HAZID & FMEA Report

HAZID Workshop(GL)

DET NORSKE VERITAS

Report No: PIMAE403-20110505-1-HHI_rev. 2

TECHNICAL REPORT

Failure Mode	Failure	Effect	Sev	Cause	Occ	Control	Control Type	Det	SPM	Recommended Action	Det	SPM
Installation of equipment on deck may lead to extension of hazardous area/ change of zone classification	Possible existing equipment	Ensure that the unit does not										
Cryogenic leakage to structural steel	Cracking											
Too low suction head for HP pump	Vapour fo on pump	Loss of su head cau pump can LNG/Gas to heating causing b of vapour heating n side Dynamic in piping ; and pres variation to engine										
Low level in suction drum caused by failure of level control system.												
Vapouriser failure due to over pressurisation												
Not sufficient damping in vapouriser												



Certificates from Major Classification Societies

Proven System



Dynamic Modeling & Operation sequence

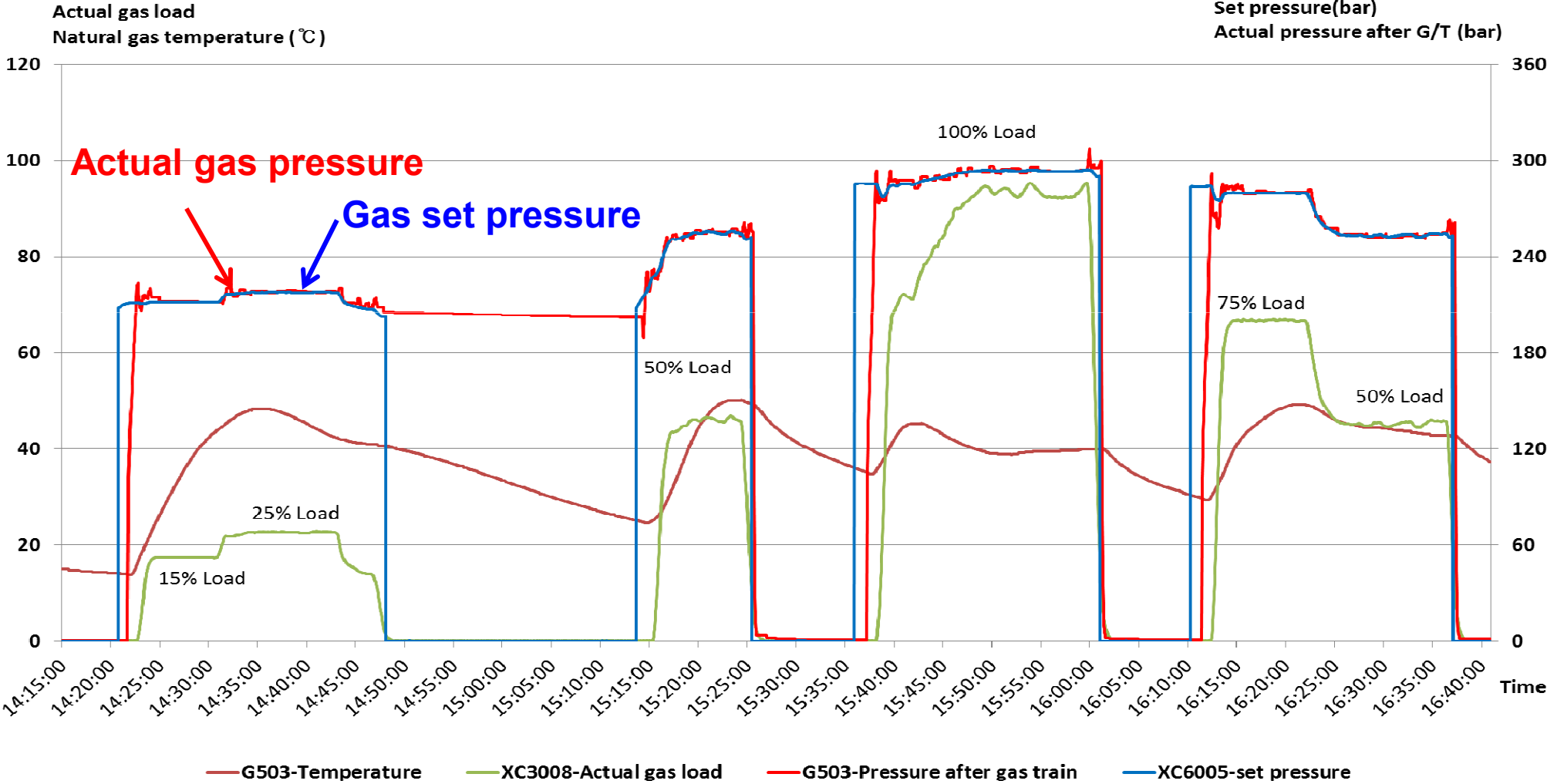
Hi-GAS

Dynamic Modeling & Operating Sequence

Proven System

Test Result ME-GI & Hi-GAS

Test results during TAT on 2012.11.27



Proven System

Demonstration

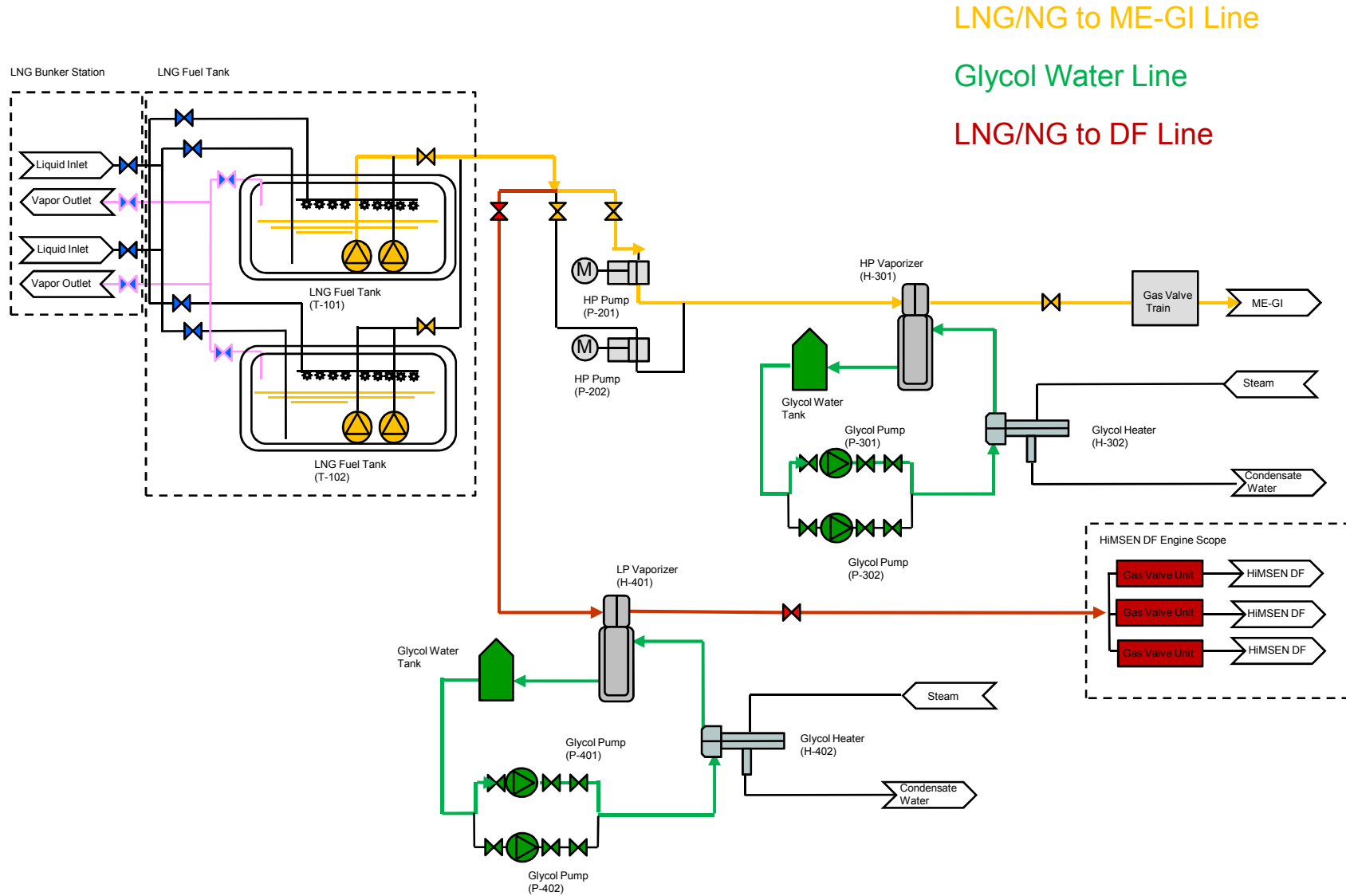


The world's first demonstration of ME-GI with FGSS designed by HHI

9th November 2012

Proven System

Fuel Gas Supply System for ME-GI



LNG/NG to ME-GI Line

Glycol Water Line

LNG/NG to DF Line

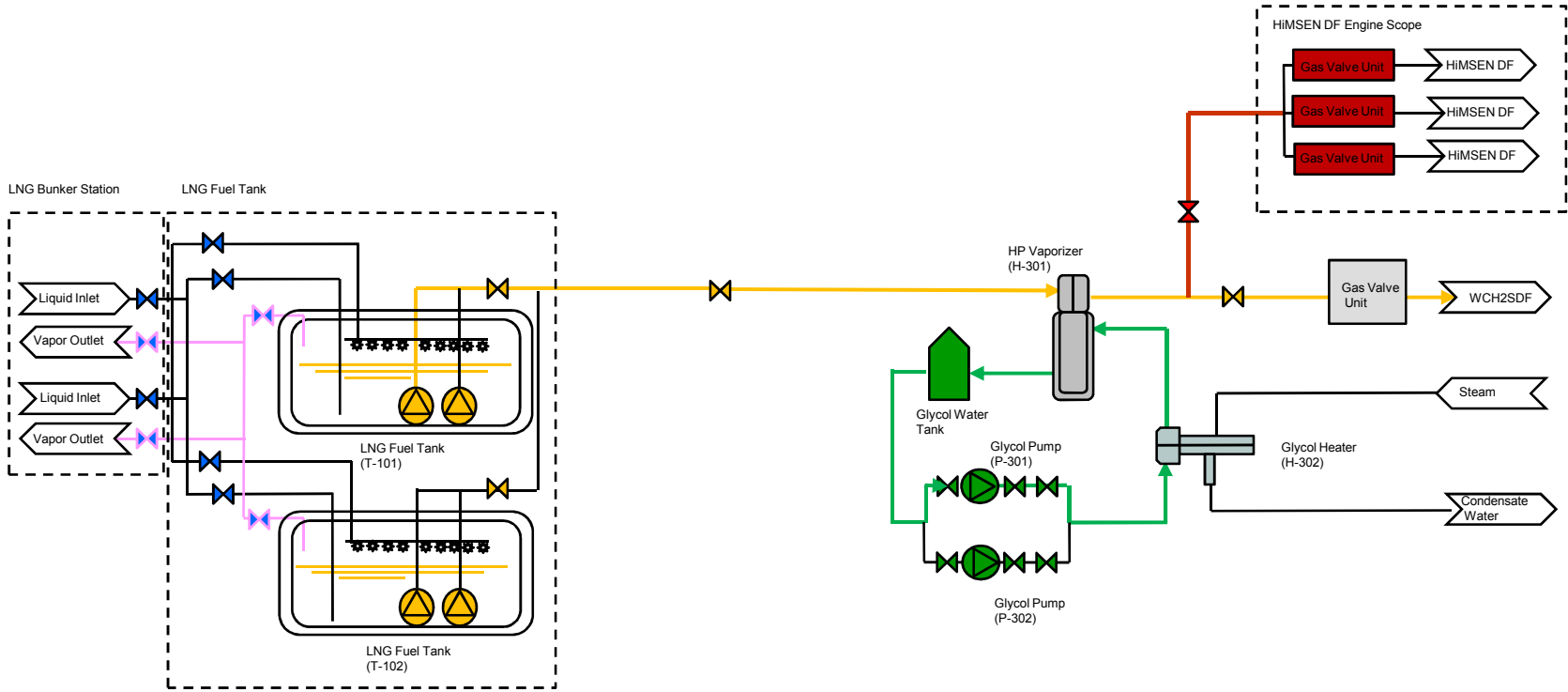
Preliminary

Fuel Gas Supply System for WCH 2S DF

LNG/NG to 2S DF Line

Glycol Water Line

LNG/NG to DF Line

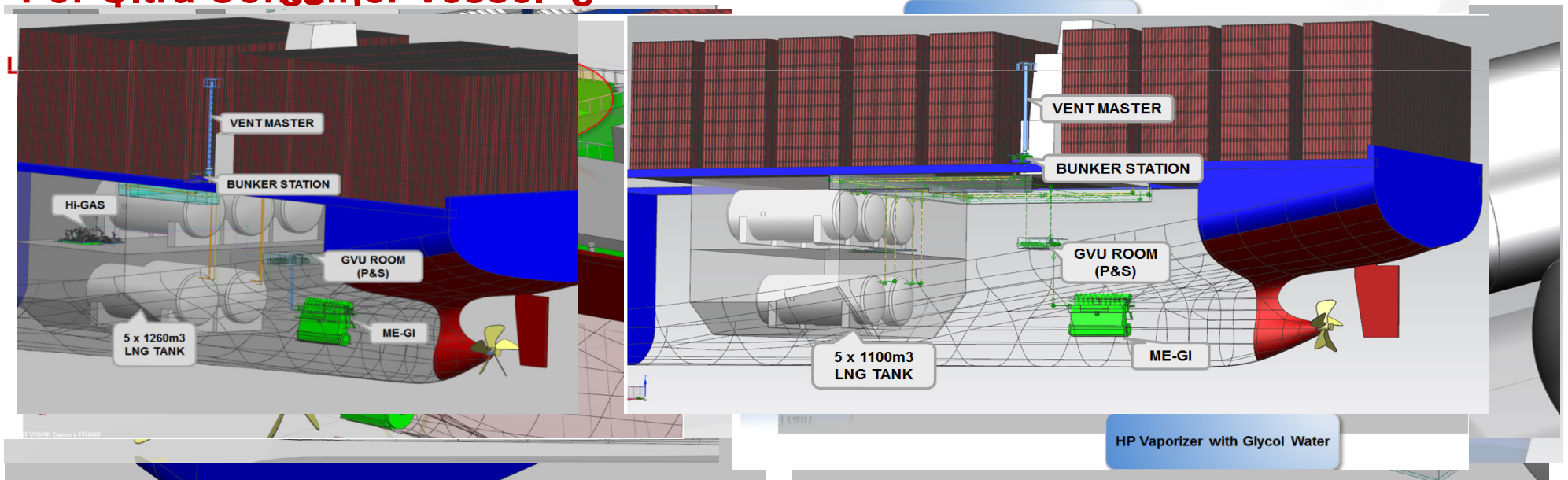


What's Better ?

- Flexibility

Welcome ! Any kinds of LNG fueled ships

Comparison of LNG Carrier

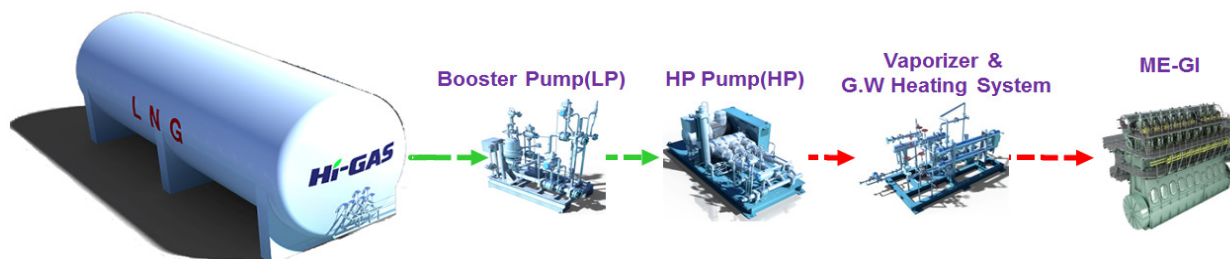


What is Hi-GAS ?

Hi-GAS

Hyundai integrated

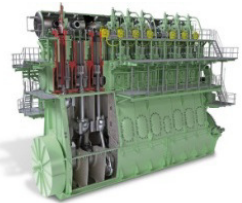
GAs Supply system for LNG Carrier



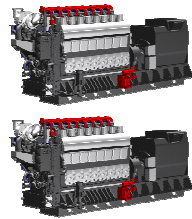
Reference Order Status

LNG Carrier

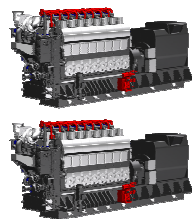
Shipyard	Hull No.	Vessel Type(No.)	Engine Type	Delivery	Remark
HHI-SBD	2733/2734	176.3k LNGC (2)	7G70ME-C9.2-GI	2015-09	Twin engines



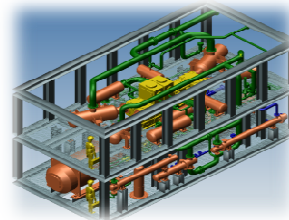
7G70ME-C9.2-GI (2 sets)



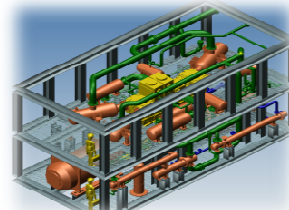
7H35DF (2 sets)



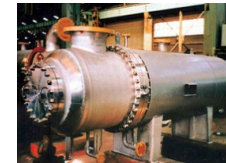
6H35DF (2 sets)



HP Compressor (2 sets)



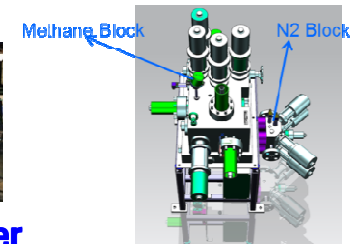
HPP (2 sets) & HPV (1 set)



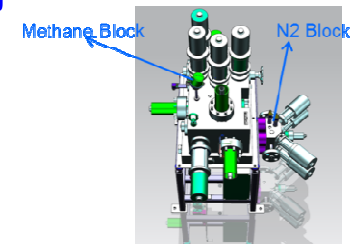
Forcing Vaporizer System (1 set)



Control System



Gas Valve Train (2 sets)



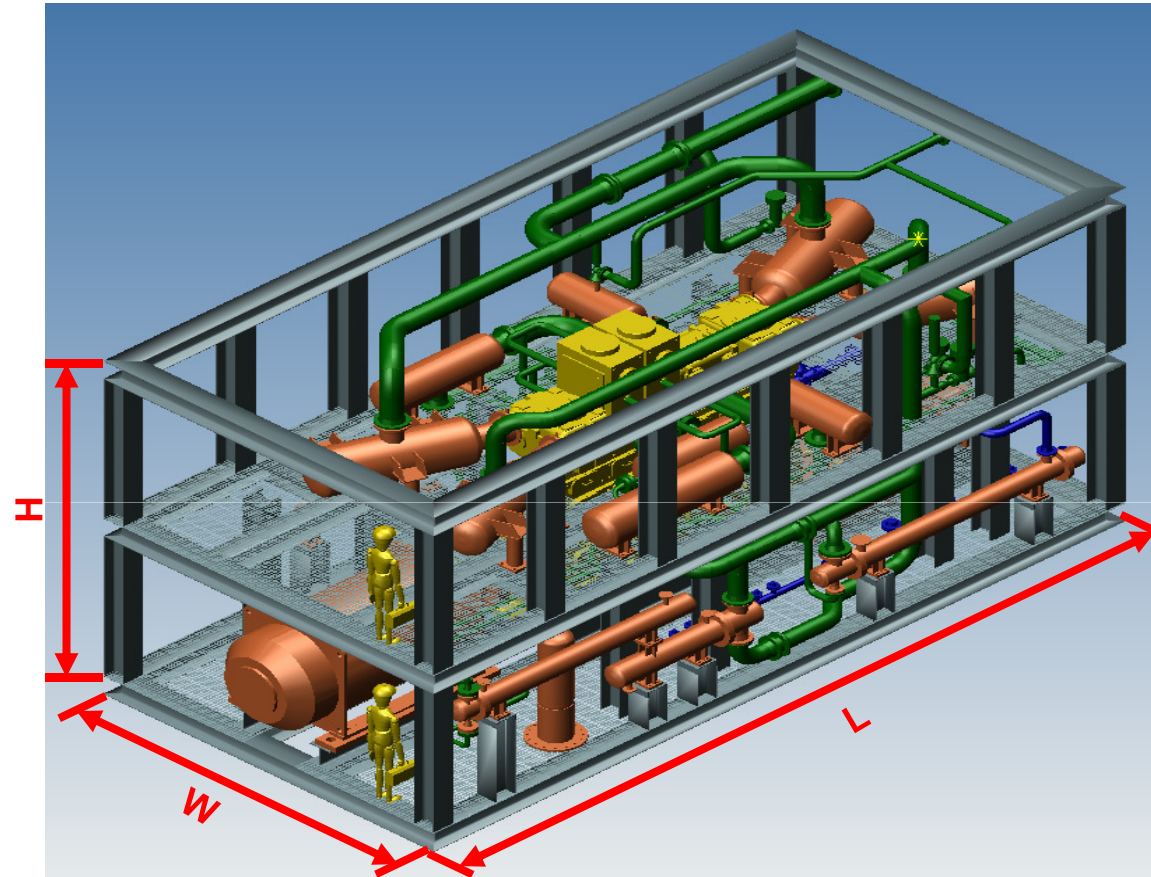
Reference Order Status

System Configuration



Reference Order Status

HP Compressor



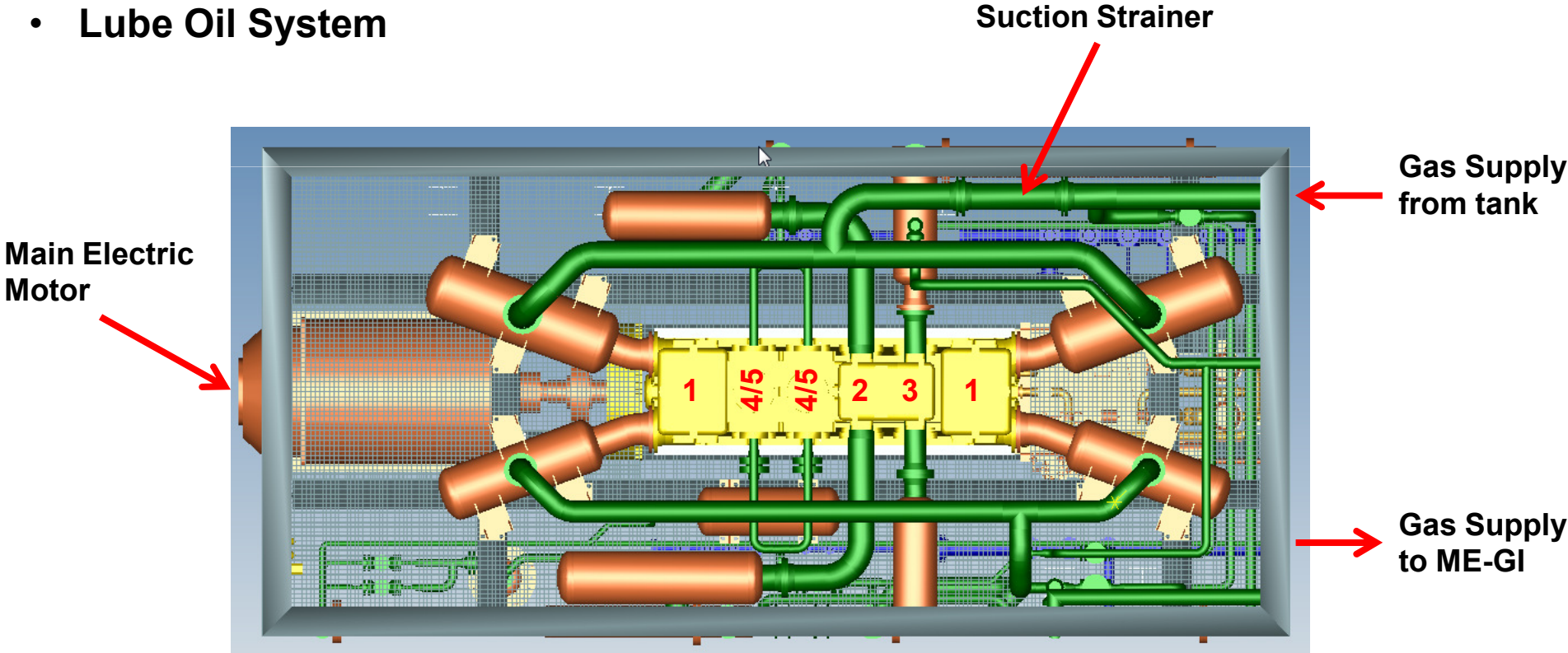
	Compressor Package			Weight	Capacity
	Length	Width	Height		
HP Compressor	10.5 m	3.3 m	4 m	Abt. 86 ton	Abt. 3,000 kg/hr

Reference Order Status

HP Compressor

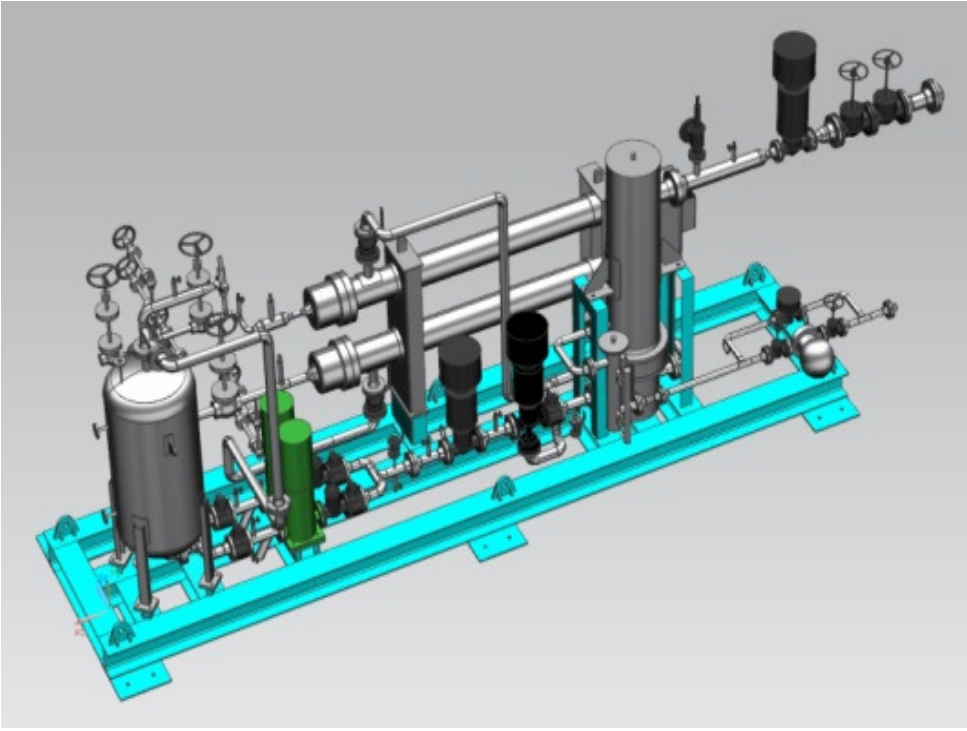
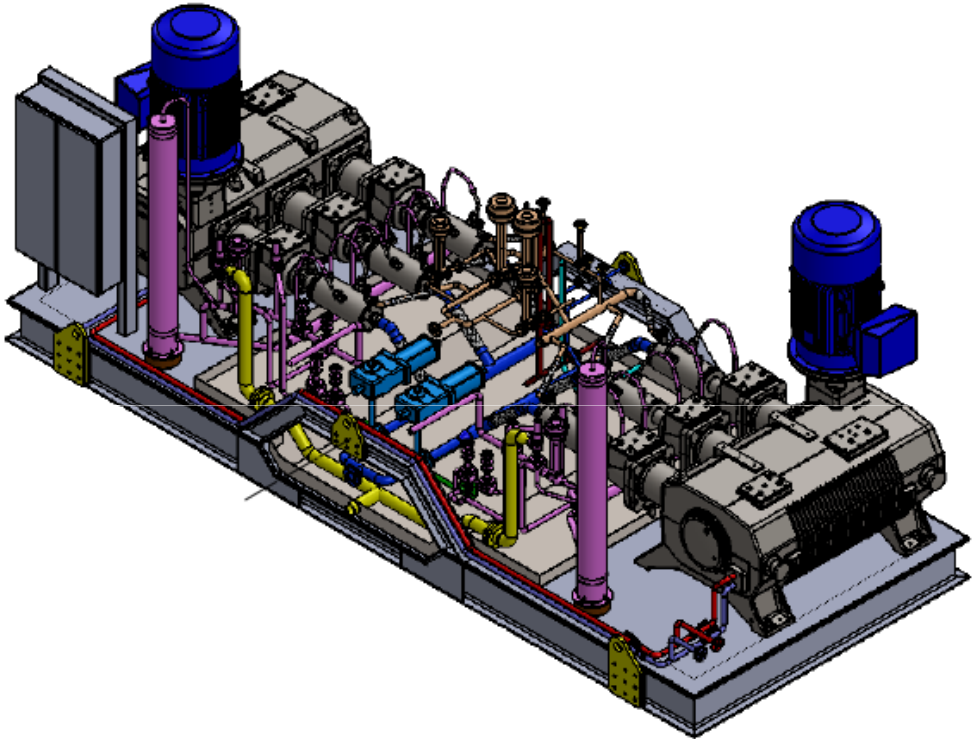
Main Equipment on skid

- Pulsation Damper
- Separator
- Gas Cooler
- Control Valves
- Lube Oil System



Reference Order Status

HP Pump & LNG Vaporizer

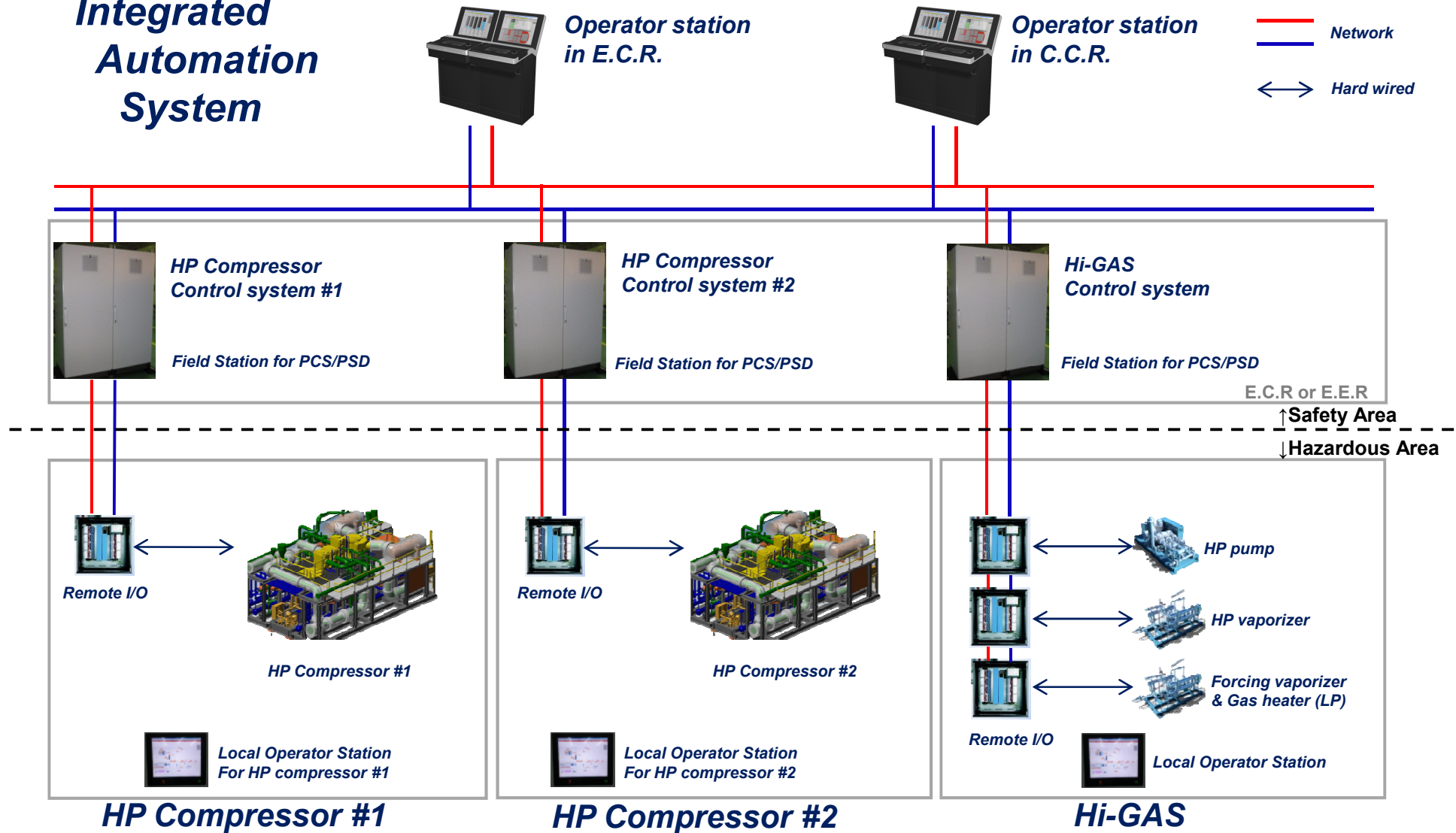


	FGSS Package			Weight	Capacity
	Length	Width	Height		
H.P. Pump + H.P. Vaporizer	6.8 m	5.5 m	3 m	Abt. 26.5 ton	Abt. 5,000 kg/hr

Reference Order Status

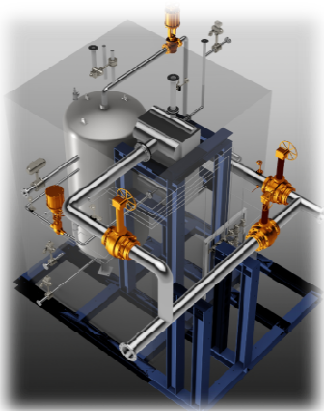
FGSS Control System

Integrated Automation System

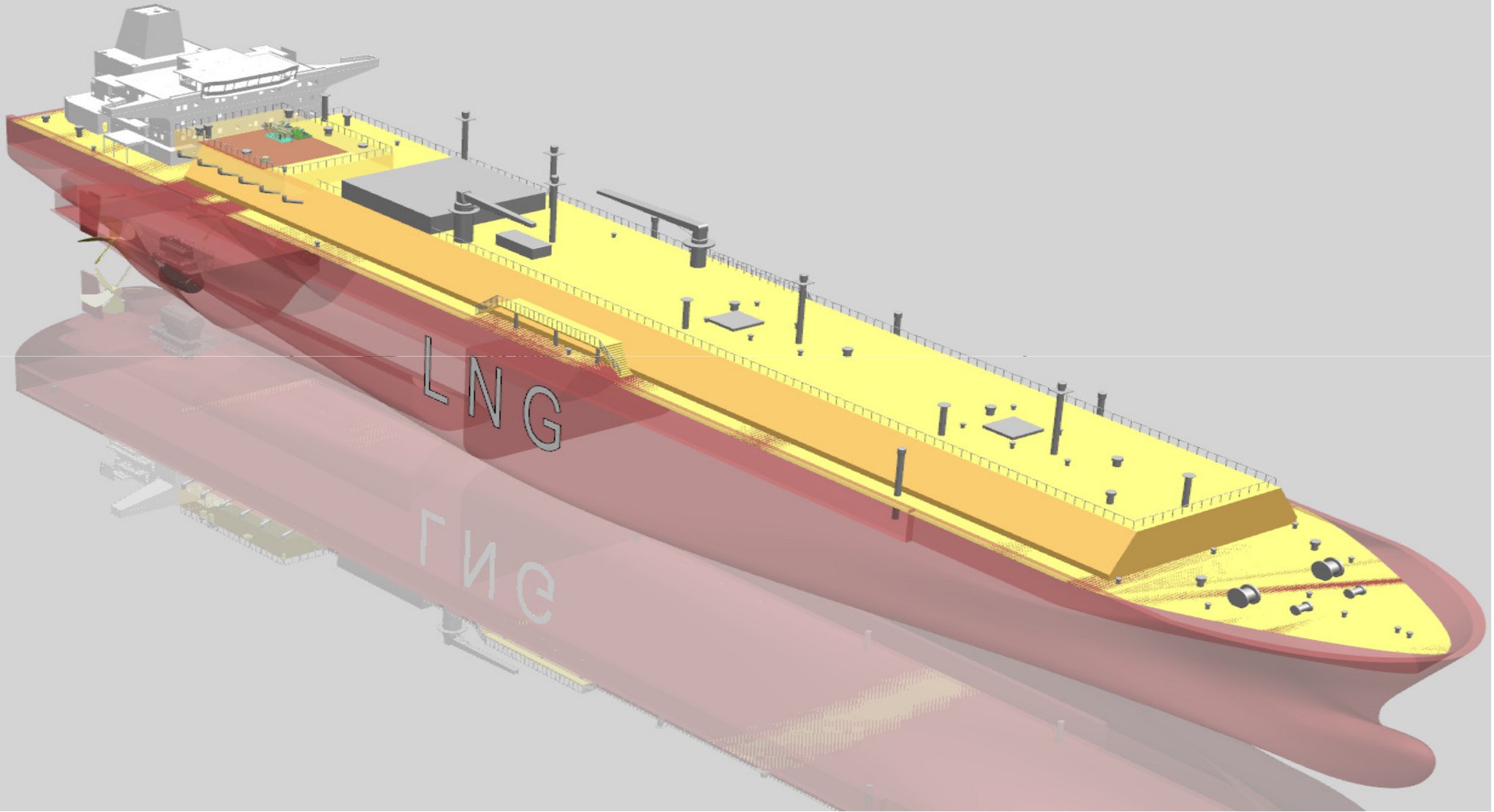


New technology of
What is Hi-ERS ?

Hi-ERS
Hyundai innovative
Economical Re-liquefaction System



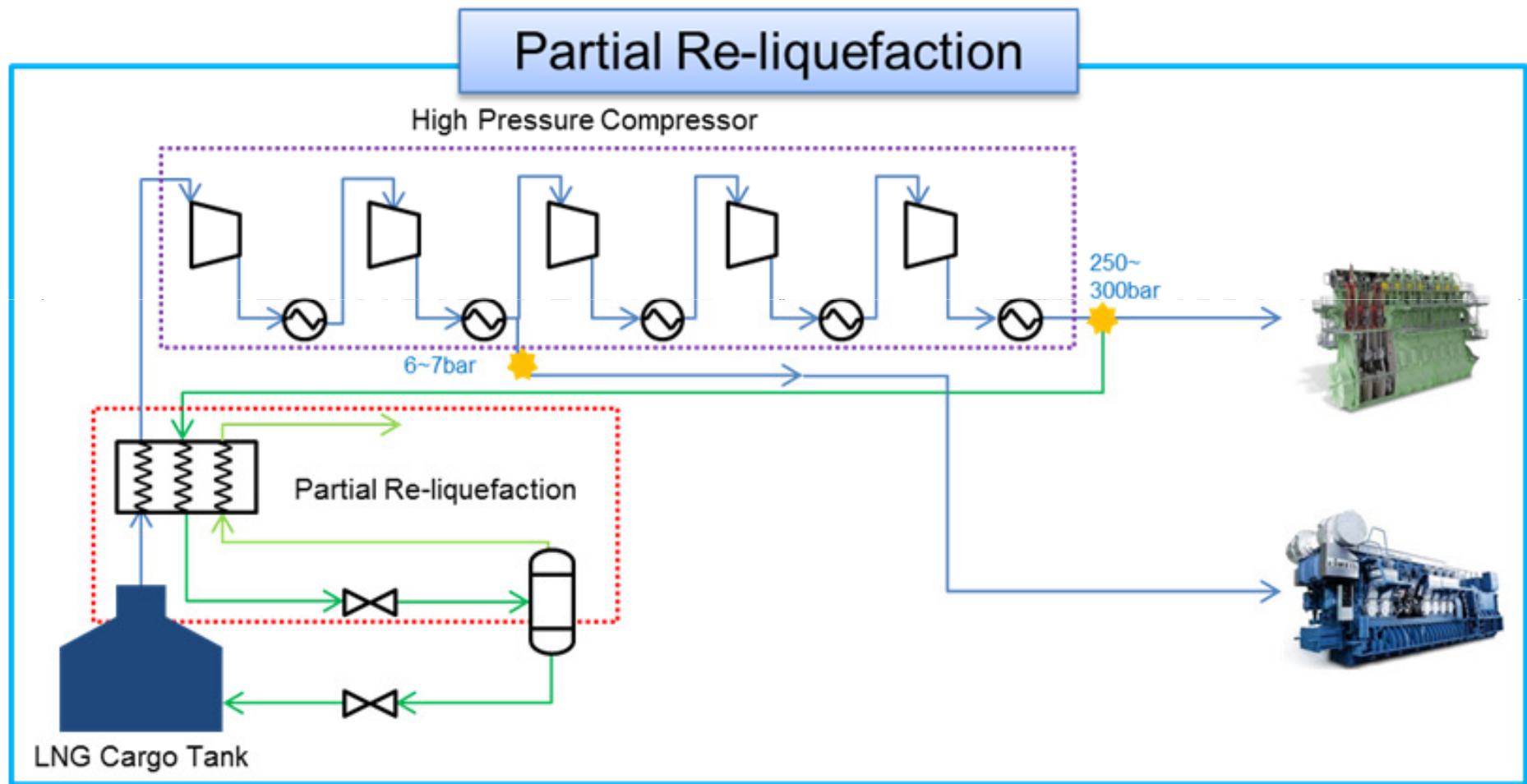
System configuration



Economical Re-liquefaction Unit

Hi-ERS

PFD (Process Flow Diagram)

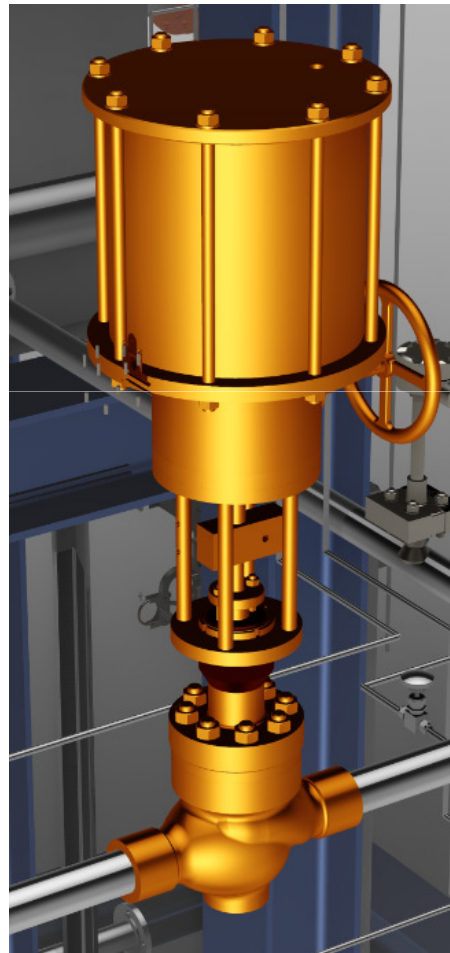


Main Equipment

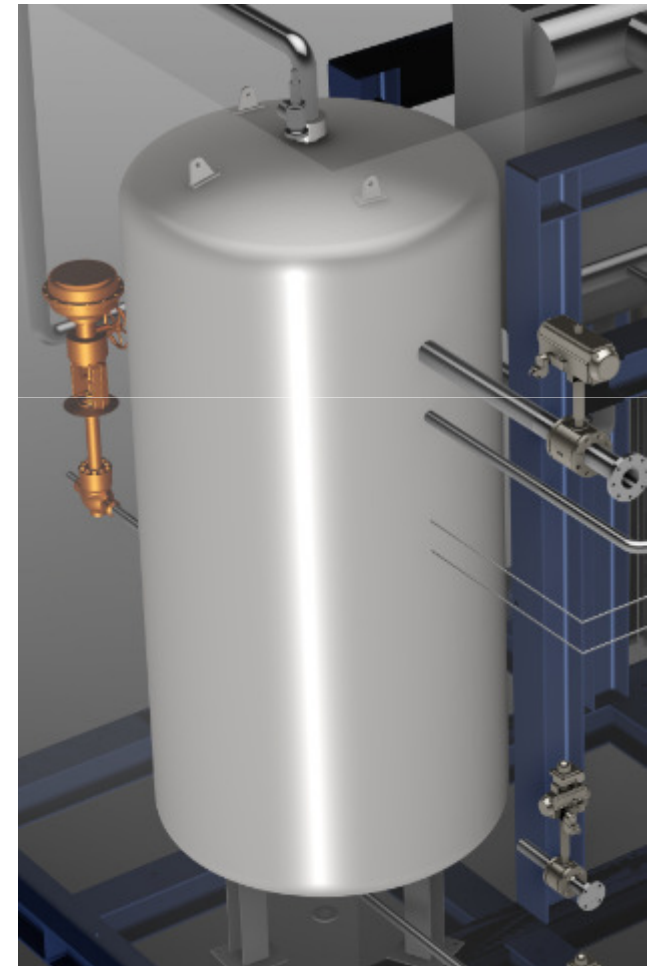
BOG Heat Exchanger



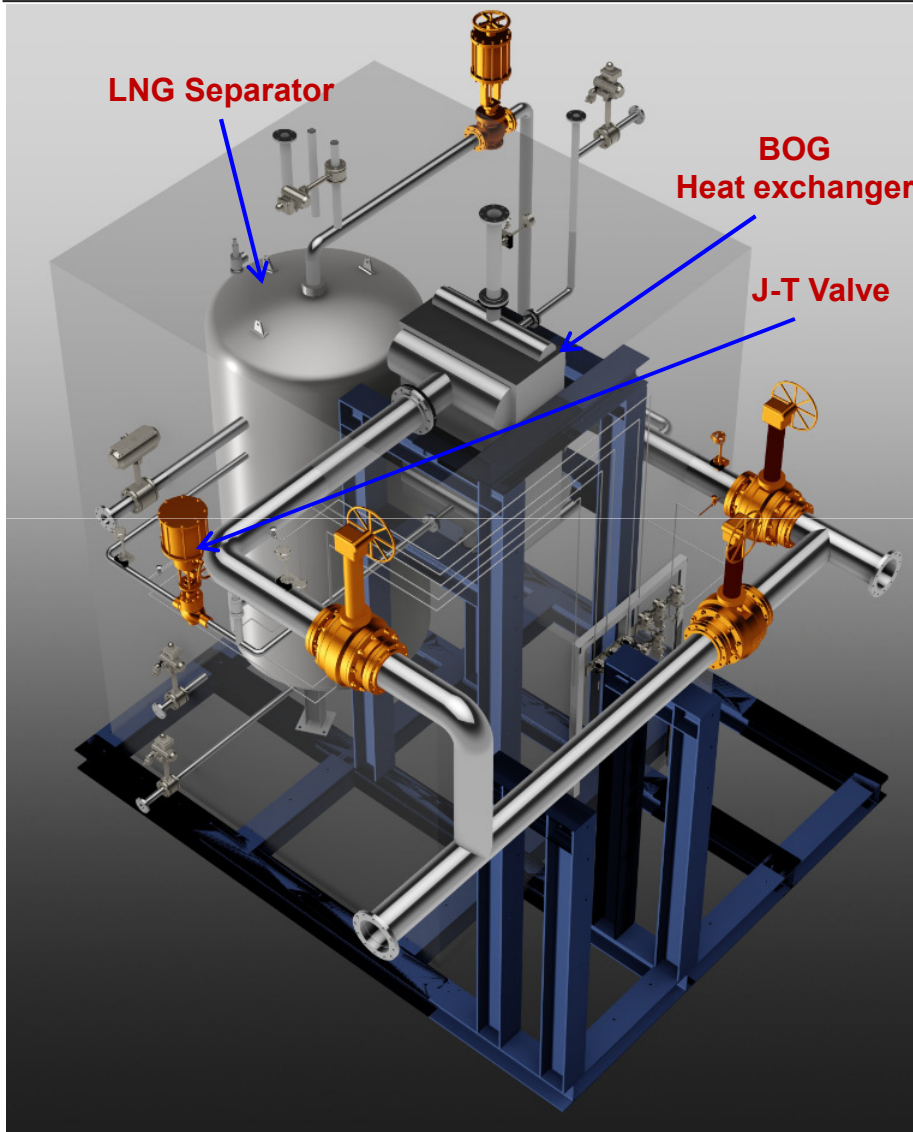
J/T valve



LNG separator



Main advantages



1) Simplicity

- Simple process and control

2) Economic cost

- No necessary for other refrigerant cycle

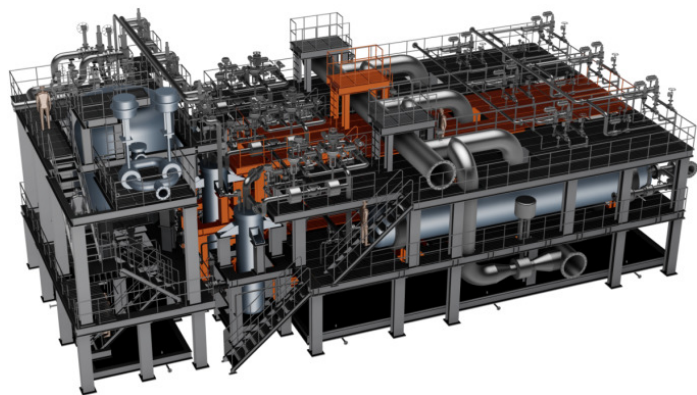
3) Compact design

- Small installation space and reducing the number of main equipment

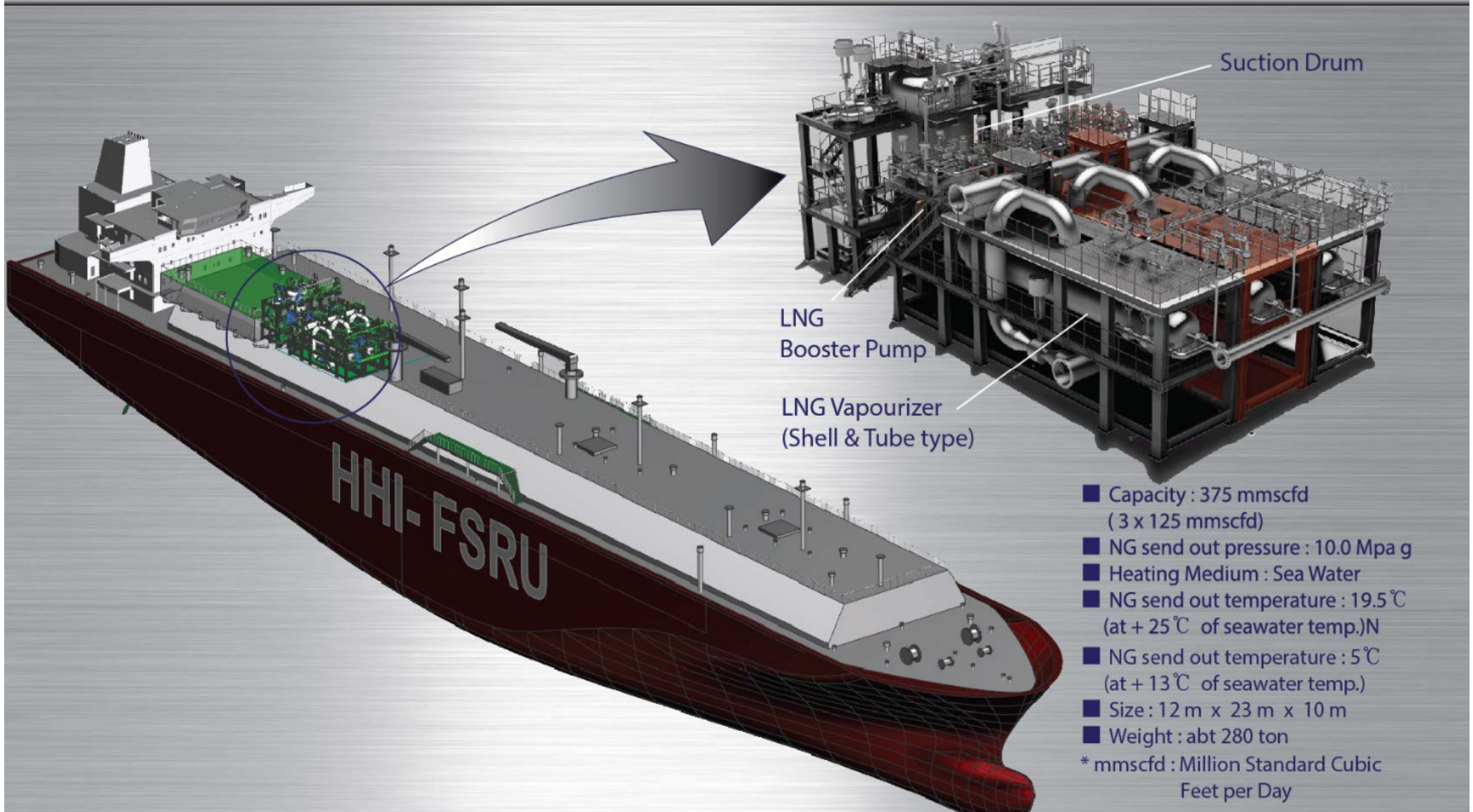
What is Hi-ReGAS ?

*Hi-**Re**GAS*

Hyundai Integrated
ReGASification system



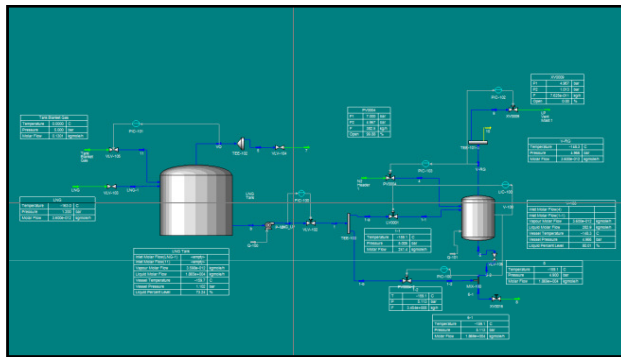
What is Hi-ReGAS ?



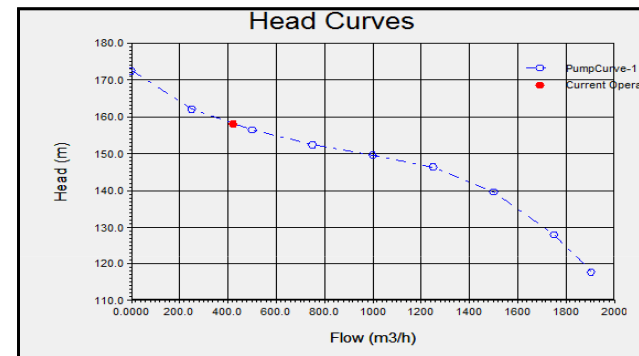
- Capacity : 375 mmscfd
(3 x 125 mmscfd)
 - NG send out pressure : 10.0 Mpa g
 - Heating Medium : Sea Water
 - NG send out temperature : 19.5 °C
(at + 25 °C of seawater temp.)N
 - NG send out temperature : 5 °C
(at + 13 °C of seawater temp.)
 - Size : 12 m x 23 m x 10 m
 - Weight : abt 280 ton
- * mmscfd : Million Standard Cubic Feet per Day

Dynamic Simulation

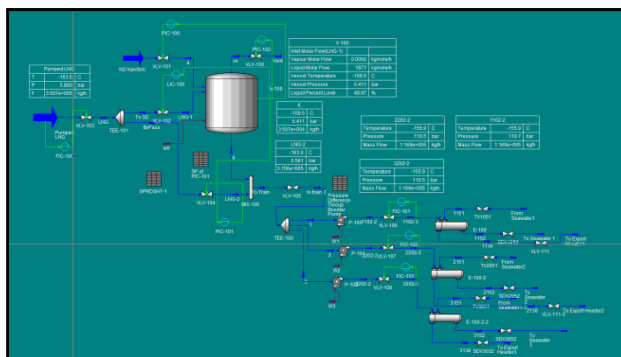
- Load Change / Start-up / Emergency Shut down Simulation
- HAZID FMEA Study Result Applied



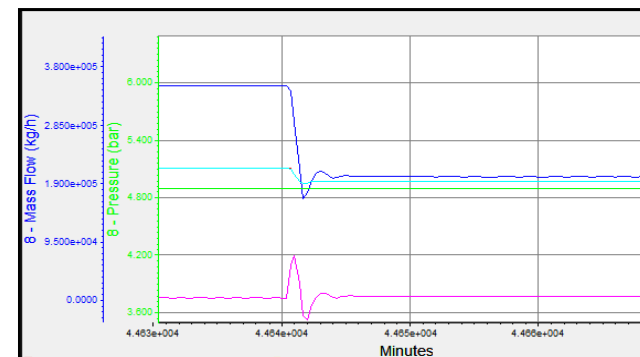
[LNG Cargo Tank / Suction Drum]



[Booster Pump Curve]



[Suction Drum / Booster Pump]



[Load Change]

FMEA / AIP



Class : GL

Member : HHI-EMD
 HHI-SBD
 HHI-R&D

Approval Certificate

This is to certify, that the undernoted company has been approved in accordance with the relevant requirements of the GL Approval System.

Certificate No. **61 716 - 14 HH**
 Company **Hyundai Heavy Industries Co., Ltd.**
 1, Jeonha-Dong, Dong-Ku
 Ulsan 682-792, REPUBLIC OF KOREA

Description **LNG Regasification System**
 Type/Equipment/System **Approval in Principle**
 Technical Data/ Application **Process and Control Description**
Examined Systems: Piping and Instrumentation Diagrams (P&ID) for LNG Regasification

The assessment of the submitted documents indicates that the concept for the regasification system is technically feasible. No showstoppers have been identified during the executed assessments. The remarks to this document have to be considered.

Approval Standard **GL VI-3-1; MSC.285(86); GL I-1-6**
 Documents **see Annex 1**
 Remarks **see Annex 2**
 Valid until **2019-03-20**
 File No. **XIII.S.01**

ALYSIS
 ervation

Germanischer Lloyd
 Hamburg, 2014-03-21

Olaf Drews

Henning Pewe

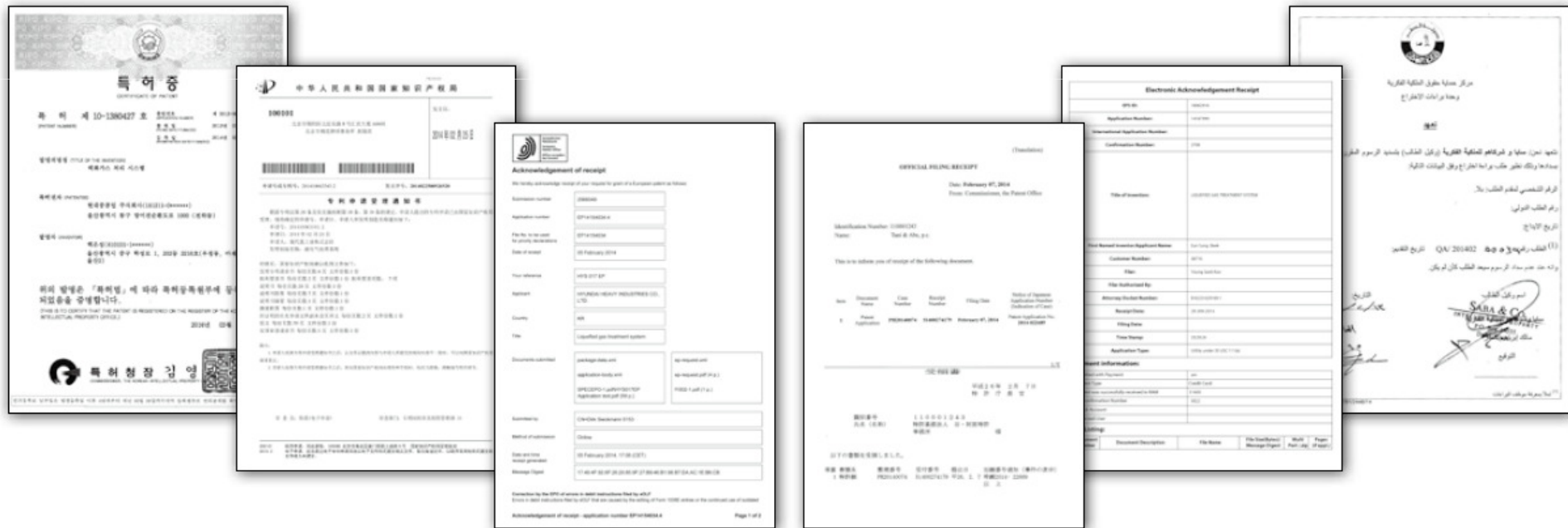
Page 1 of 3

Ref.	Control	Control Type	SE	RE	Action
1	Pre fire device	Prevention	3	1	Set of temperature
2	Gas	Prevention	3	1	Set of temperature
3	Stop	Prevention	4	1	Stop connection
4	Stop	Prevention	4	1	Stop connection
5	Stop	Prevention	3	1	Stop connection
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99	Stop	Prevention	3	1	Stop connection
100	Stop	Prevention	3	1	Stop connection

Patent pending for FGSS, REL, REGAS

Number of Patents

FGSS	Re-liquefaction Unit	Re-gasification Unit	Others
132	55	6	15

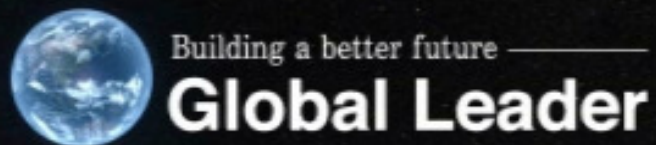


HHI is . . . Ready !



**HHI-EMD is total solution provider
for LNG fueled ships.**

Thank you!



Total Marine Solution Provider