HD HYUNDAI MARINE SOLUTION

ECO RETROFIT

HD HYUNDAI MARINE SOLUTION

FOR MARITIME DECARBONIZATION & SUSTAINABILITY

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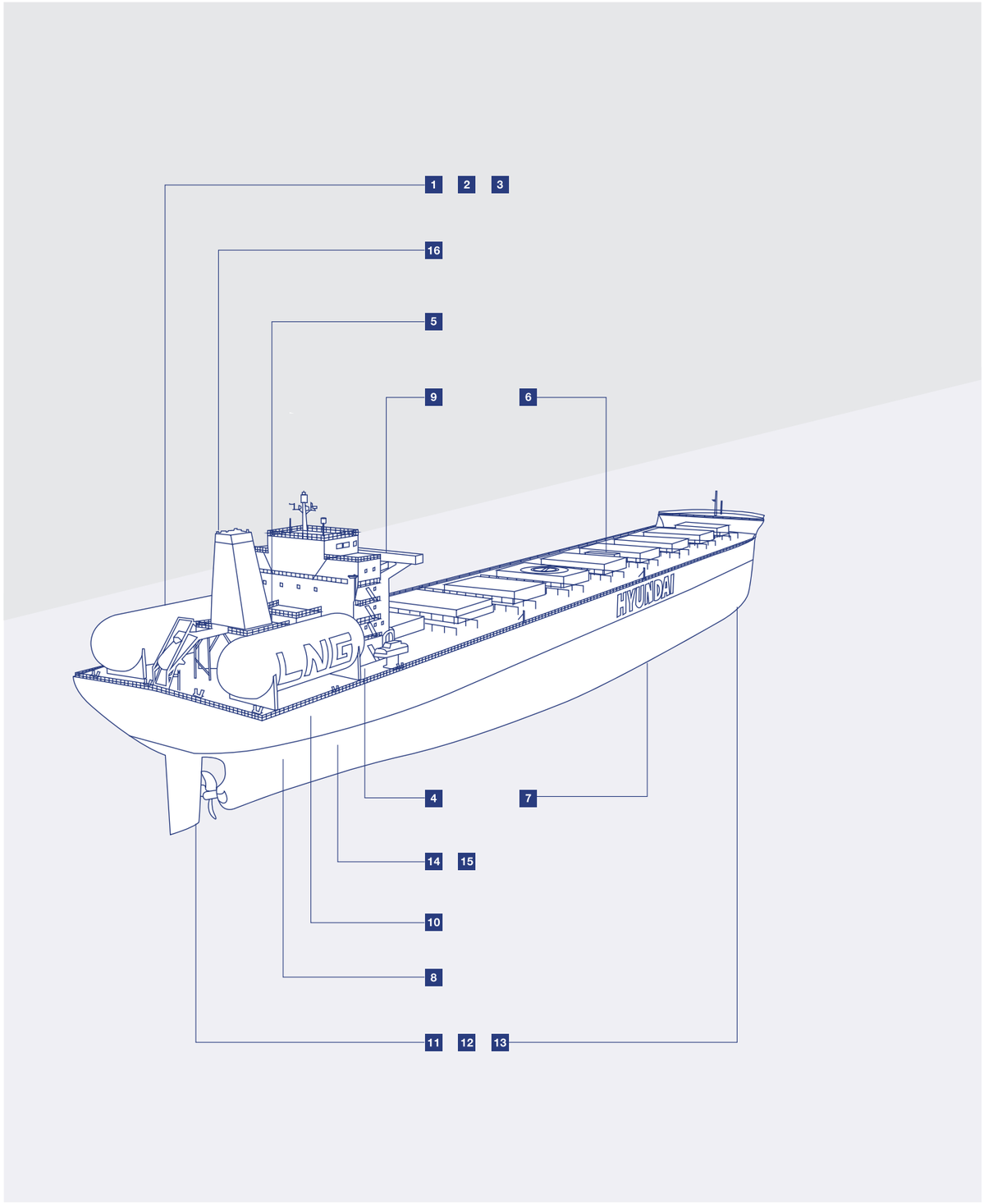
SOLUTION OVERVIEW



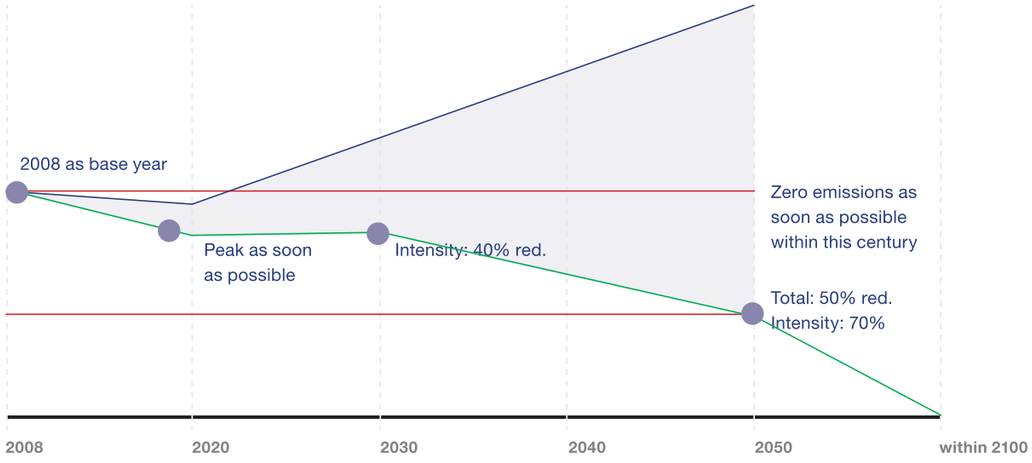
Category		CO_2 Reduction Efficiency (%)	Lead Time (Months)	Recommended Vessel
Dual Fuel Engine Conversion	1 LNG Dual Fuel Ship	20~25%	20~24	CNTR, VLCC, VLOC
	2 LPG Dual Fuel Ship	13~18%	18~21	VLGC
	3 Methanol Dual Fuel Ship	Abt. 11%/100% (Fossil/Bio-&e-)	20~24	15K CNTR, 50K MR PC
Emission Control at Berth	4 Alternative Maritime Power[1]	TBD	5	CNTR, PCTC, Tanker
	5 Alternative Maritime Steam Production[2]		6	All Except for Tanker
Miscellaneous	6 Rotor Sail	3~8%	13~14	Bulk Carrier, Tanker, PCTC
	7 Air Lubrication System	3~6%	11~12	LNGC
	8 Engine Part Load Optimization[3]	1~4%	6~14	All
	9 LED Light[4]	-	2~3	All
	10 Waste Heat Recovery System	-	8~9	All
Conventional Energy Saving Device	11 Hi-Fin	0.5~1.5%	4~5	All
	12 Hi-PSD	2~6%	9~11	All (excl. LNGC)
	13 Bulbous Bow+ Propeller Re-design	4~7%	10~12	CNTR
Basic Solution for EEXI	14 Engine Power Limitation	-	3~5	All
	15 Shaft Power Limitation	-	4	All
SOx Emission	16 Exhaust Gas Cleaning System	-	5	Above Aframax Tanker

1) Mandatory item specified in ports (USA, Europe, China) / 2) Zero carbon emission with AMP /
3) Fuel saving at slow steaming operation / 4) Low OPEX

BACKGROUND

IMO REGULATION (EXISTING VESSEL)

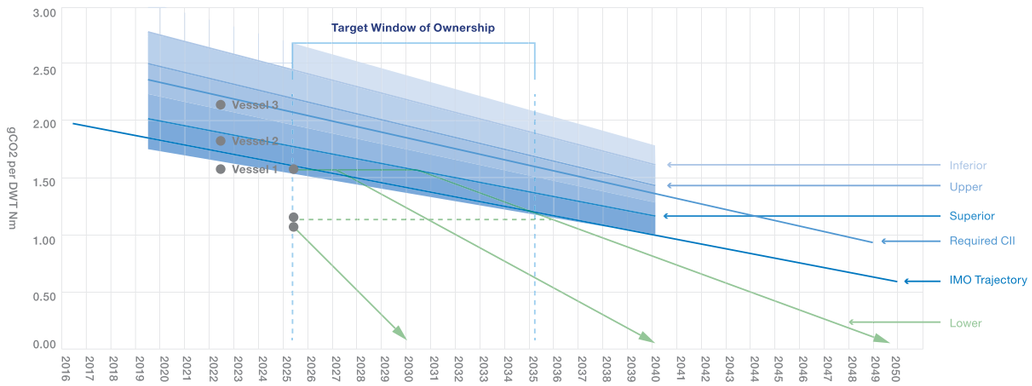
GHG Emissions



- Emission pathway in line with IMO's GHG strategy
- Business as usual emissions
- Emission gap

Carbon intensity is measured as CO_2 emission per tonne-mile, while the total is the absolute GHG emission from international shipping.

EEXI / CII (SHORT TERM MEASURE)



On 17 June 2021, the IMO adopted amendments to MARPOL Annex VI at MEPC 76. Vessels must demonstrate compliance with EEXI (Energy Efficiency eXisting Ship Index, Technical Measures) by their following survey from the first on or after 1 January 2023.

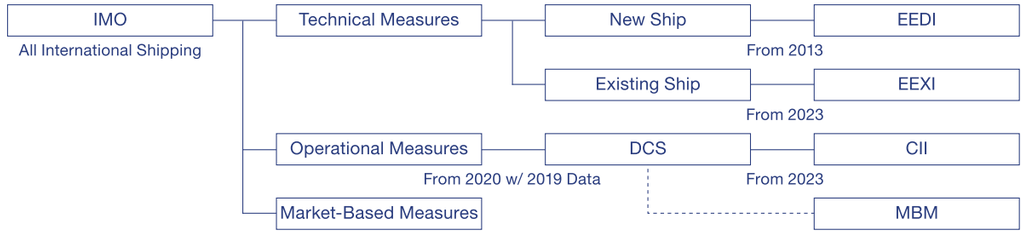
In addition, vessels will be classed "A" to "E" class with CII (Carbon Intensity Indicator, Operational Measures) from 2023 IMO DCS data. Until 2026 (Phase II), an 11% reduction of CO_2 emission is required for vessels above 5000 GT. Three consecutive years of "D" class or single year of "E" class vessel to do "Corrective action" and SEEMP to be re-approved. Phase III (After 2027) further strengthened and developed, considering the review.

MARKET-BASED MEASURES

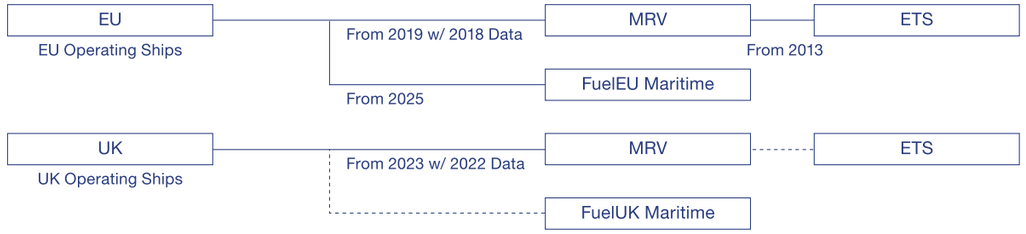
IMO prepares MBM (Market-Based Management) such as carbon pricing from 2026.

EU REGULATION

INTERNATIONAL



REGIONAL

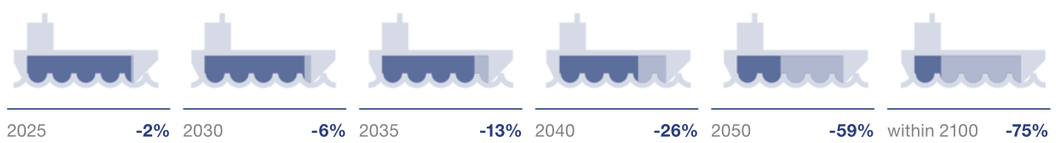


EU-ETS

From 2023, EU ETS (Emission Trading System) will include the maritime sector (Vessel above 5,000 GT) using EU-MRV data for GHG emission based on a Tank to Wake including CH_4 & N_2O as CO_2 equivalent (Expected).

FuelEU MARITIME

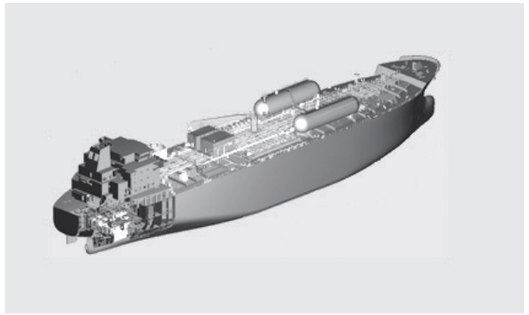
In parallel with EU-ETS, the EU will regulate GHG intensity (Well to Wake) of fuel to expedite change to Low carbon/ Zero carbon fuel (Expected). FuelEU Maritime targets the limits on GHG intensity of the energy used onboard compared to 2020.



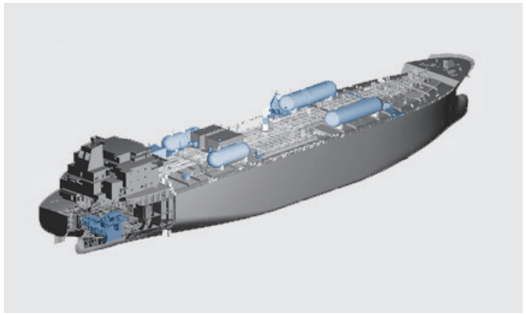
DUAL FUEL CONVERSION

LNG FUELED RETROFIT

With rich experiences and advanced technology accumulated from the shipbuilding and marine engine industry over the past decades, HMS, a total solution provider, provides engineering, procurement, and commissioning packages.



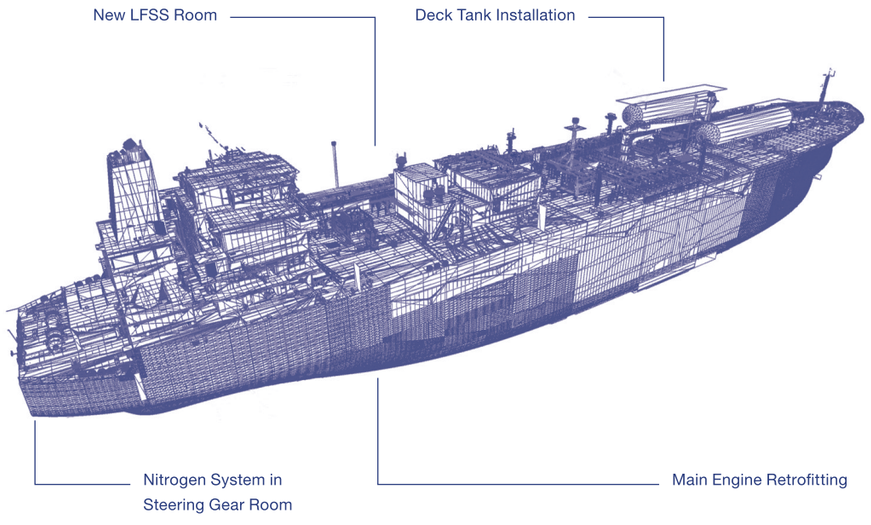
Case 1. Two Tanks



Case 2. Four Tanks

HMS does provide a total dual fuel retrofit package that ‘JUST FIT YOUR NEEDS’ in the way of the most economical and optimized solutions to the LNG propulsion systems, having appropriate and rich resources from HD Hyundai Group.

LPG FUELED RETROFIT



METHANOL / AMMONIA FUELED RETROFIT

Methanol and Ammonia fuel system/retrofit solution is under development in cooperation with the HD Hyundai Group.

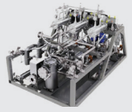
Hi-GAS

Hi-GAS & Hi-LFSS is an LNG/LPG fuel gas supply system for dual-fuel engines based on high and low-pressure gas supply. The Hi-GAS & Hi-LFSS are designed to be the most optimized for both CAPEX and OPEX.

BENEFIT

- **Proven Reliability Through Full Scale Test & Most Advanced Design**
- **Design & Documents with Full Automatic Interface Within Engine System**
- **Proven Technology & the World Best Reference**
- **Qualified Marine Service Provider in the Shipping Industry**

DUAL FUELED SHIP PACKAGE

DESIGN CAPABILITY	GAS FUELED SHIP PACKAGE		
▫ Fuel Tank ▫ Fuel Gas Supply System ▫ Ship to Ship Compatibility ▫ Bunkering & BOG Handling ▫ Safety Verification	 LNG / LPG Fuel Tank Deck Tank	 Fuel Supply System	 Bunker Station
	 DF Main Engine	 DF Generator Engine	 DF Boiler

ALTERNATIVE MARITIME POWER (AMP)

World widely, port regulation forces to s hut down auxiliary diesel engines to reduce emissions from the vessel. Mainly CARB (California Air Resources Board, USA) has been applied mandatory. Other regions, including the EU and China, will be applied soon. AMP would bring the most promising effects for air pollution and meet the mandatory requirement at the port. HMS is a turnkey provider for AMP retrofit and provides AMP retrofit solutions for all kinds of vessel, including as following.

VESSEL TYPE

1	2	3	4	5
CONTAINER SHIP USING HIGH VOLTAGE	CONTAINER SHIP USING LOW VOLTAGE	PCTC & RORO	BULK CARRIER	TANKER & ETC.

HMS can customize engineering with references for retrofit items, own equipment including switchboard, cooperation with cable reel maker and various experience in installation even sailing and optimal engine and its auxiliary equipment performance, thus minimizing our clients' CAPEX and OPEX.

CONSTRUCTION PROCESS FOR CONTAINER & BULK CARRIER

Complete Construction During the Voyage

1	2	3	4
Onboard Equipment & Materials in Port	Switchboard Modification in Port or at Sea	Installation Equipment & Cables During Sailing	Commissioning And test in Port
Port	Sea		Port

CONSTRUCTION PROCESS FOR PCTC & TANKER

Complete Construction Dry dock & Quay side

1	2	3	4
Onboard Equipment & Materials in DD or Quay side	SWBD Modification & AMP RM installation in DD or Quay side	Cable laying & connection During sailing	Commissioning And test in Port
DD or Quay side		Sea	Port

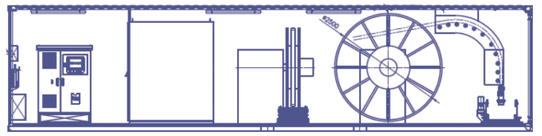
BENEFIT

- **No Loss of Commercial as Construction on Sailing**
- **Simple System Configuration for AMP**
- **Simple Synchronization for PMS**
- **Compatible AMP CNTR and Reel (Movable Type)**

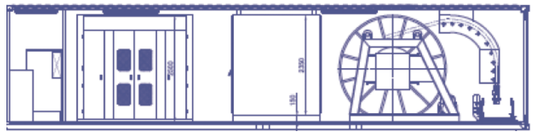
TYPE OF CABLE REEL & AMP CONTAINER

HMS will apply proper cable reels for AMP applied to each type of the ship and will cooperate with cable reel manufacturers, CAVOTEC, and other Korean companies.

Type of Cable Reel	Type of AMP Container
▫ Fixed ▫ Movable	▫ Fixed ▫ Mobile ▫ Full Packaged and etc.



Mobile Type AMP Container

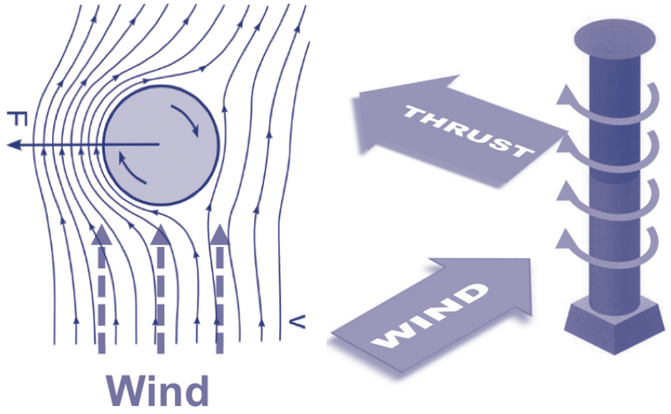


Full Package Type AMP Container Including Transformer

SWITCHBOARD MODIFICATION & AMP CONTROL SYSTEM

All kinds of switchboard modifications, such as MV switchboard, LV switchboard, etc. to be applied to the ship's AMP system by HMS. The existing main switchboard should be modified to connect the AMP system accordingly. We add a section panel or cubicle for AMP receiving on the current main switchboard, but a new separated panel is to be installed if not possible to connect directly. Also, HMS provides a power management system and AMP control system with PLC.

WIND ASSISTED PROPULSION SYSTEM (WAPS) - ROTOR SAIL



Rotating cylinders create thrust eco-friendly using wind power.

BENEFIT

Total 3~8% Fuel Cost Saving

Improvement in EEXI

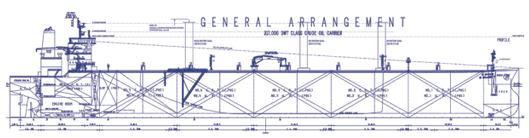
No Limitation of Air Draught (Tilting / Folding)

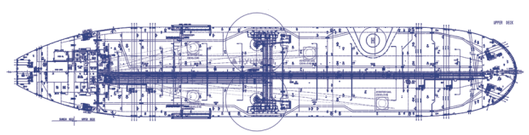
Easy Operational Monitoring and control

PERFORMANCE

Vessel Type	Rotor Size	Max. Installable Quantity	Net Power Saving Efficiency at EEDI Global Route
VLCC	30 (H) X 5 (D) m	3 ~ 4	Avg. Abt. 5.5%
VLOC	30 (H) X 5 (D) m	3 ~ 4	Avg. Abt. 4.8%
AFRAMAX	24 (H) X 4 (D) m	3 ~ 4	Avg. Abt. 3.2%

SPECIFICATION

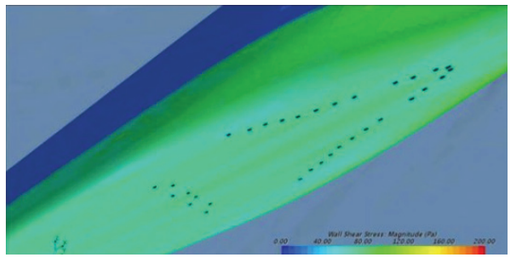




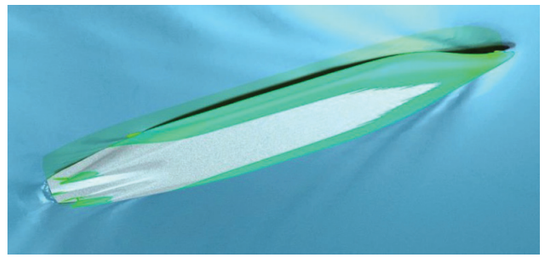
AIR LUBRICATION SYSTEM (Hi-ALS)

Hi-ALS reduces the frictional resistance of the bottom surface of a vessel by using air bubbles.

BENEFIT



The frictional resistance ratio over total ship resistance is over 70%.



Hi-ALS reduces the frictional resistance due to water via air supply to the bottom surface of a ship.

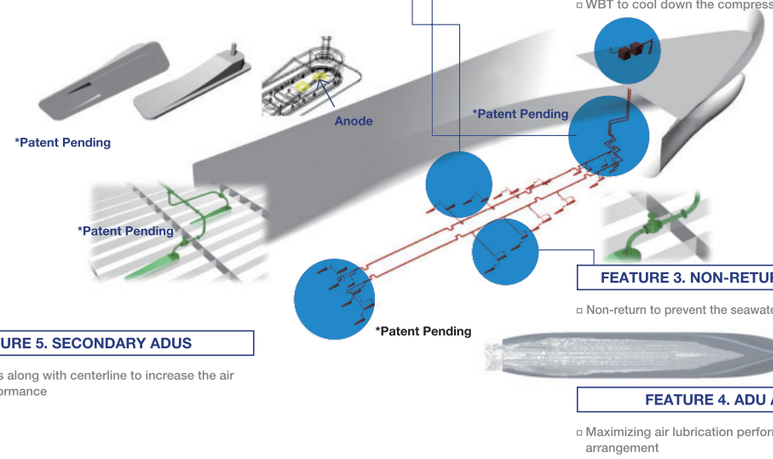
SYSTEM OVERVIEW

FEATURE 7. Air Dispense Unit (ADU)

- Hydrodynamic design to make stable air layer & bubbles
- Total 32 unit of ADU to be installed
- One or two anode per unit for anti-corrosion measure

FEATURE 6. No Structural Damage on Hull

- ADUs to be located between Logi. & Stiffeners without strustural change



FEATURE 1. Optimization of Air Compressors

- 1.4 barg for compressor design pressure with VFD control
- Lower power consumption of abt. 1.0-1.2 barg at normal operation

FEATURE 2. PIPE ARRANGEMENT

- Pipe arrangement optimization through the FWD
- WBT to cool down the compressed air without BOG increase

FEATURE 3. NON-RETURN VALVE ON ADU

- Non-return to prevent the seawater backflow through the pipe

FEATURE 5. SECONDARY ADUS

- Additional ADUs along with centerline to increase the air lubrication performance

FEATURE 4. ADU Arrangement

- Maximizing air lubrication performance with △shaped arrangement

PERFORMANCE

Loading Condition	Vs (knots)	M/E Power Reduction	Net Power Gain
Laden & Ballast	19.5	Avg. Abt. 9.0%	Avg. Abt. 5.5%

NOTE

- Above performance is based on 174K LNG carrier.
- Net Power Gain = M/E Power Reduction-Compressor Power Input

ENGINE PART LOAD OPTIMIZATION (EPLO)

The existing vessels were designed based on higher speed as per the market needs in the past. However, those vessels have often operated under reduced speed/power demand in the present. Consequently, engines and turbochargers are not running at the optimal point on both fuel consumption and emissions.

EPLO provides fuel saving and reduced emission per the engine operating range for the individual vessels. Applicable for HYUNDAI-MAN B&W engines mechanical controlled (MC type) and equipped with ABB Turbocharger.

OPTIONS

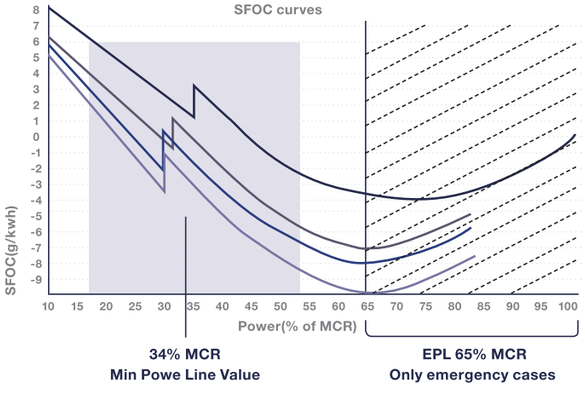
Variant	To be Optimized	Assumed Fuel Saving
Variant 1 - Minor Derating	Nozzle Ring	2g/kwh SFOC savings
Variant 2 - Medium Derating	Nozzle Ring, Compressor Wheel, Diffusor, Wall insert, Cover Ring	4g/kwh SFOC savings
Variant 3 - Full Derating	Nozzle Ring, Compressor Wheel, Diffusor, Wall insert, Cover Ring, Turbine Diffusor, Blased Shaft	5~6g/kwh SFOC savings

WORK SCOPE

EPLO can reduce engine fuel consumption and emission at the optimized part-load range. HMS provides a packaged service for the customer's convenience.

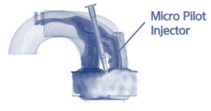
- Project management
- Tailored engine part load optimization to fit customer's needs
- Engineering of engine and turbocharger upgrade
- Complete documentation support for IMO NOx re-certification
- Delivery and installation of upgraded turbocharger parts
- Supervision for upgrade and commissioning at site

SFOC CURVES

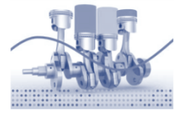


METHANE SLIP SOLUTION (MSS) FOR HiMSEN DF ENGINE

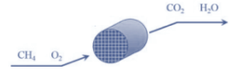
HMS Provides Methane Slip Control technology for GHG emission reduction.



Multi Pilot Injection (MPI)

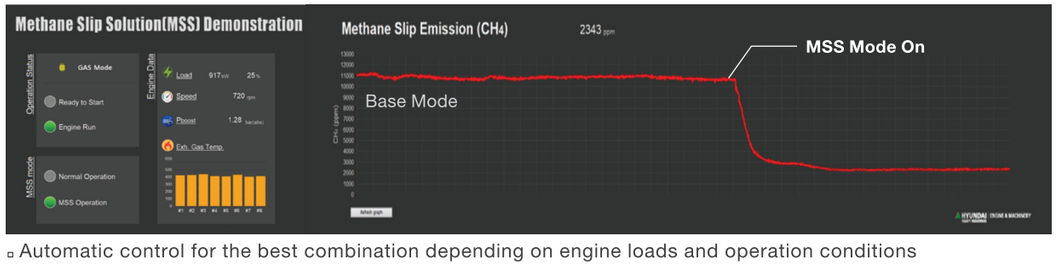


Cylinder Cut-Off (CCO)



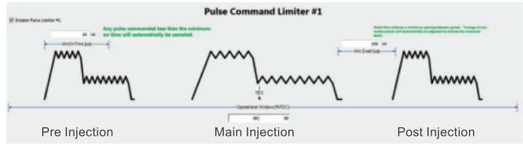
HP Methane Oxidation Catalyst (MOC)

Combination of CCO and MPI

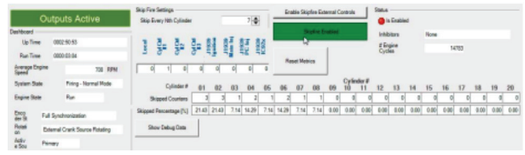


- Automatic control for the best combination depending on engine loads and operation conditions
- Available from 2022 as an option
- Applicable 0 to 50% load

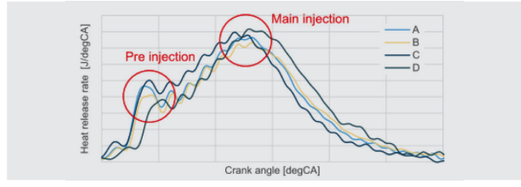
Parameter Setting Window for MPI



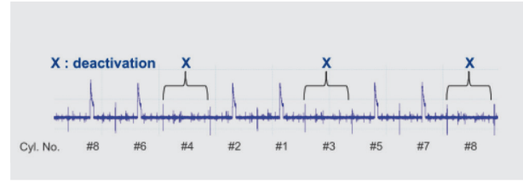
Parameter Setting Window for CCO



Combustion Simulation with MPI (e.g. pre and main injection)

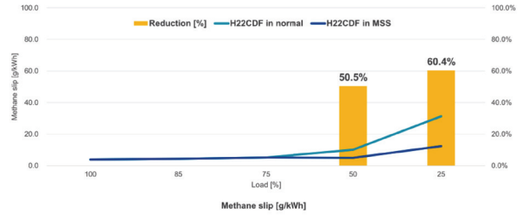


Signal of Gas Admission Valve (e.g. engine with 8 cyl., N=3)

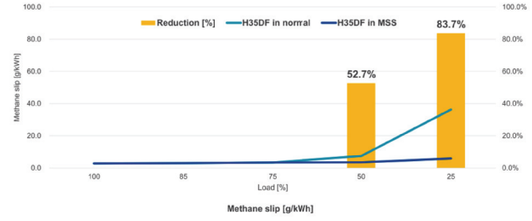


RESULT OF MSS

H22CDF

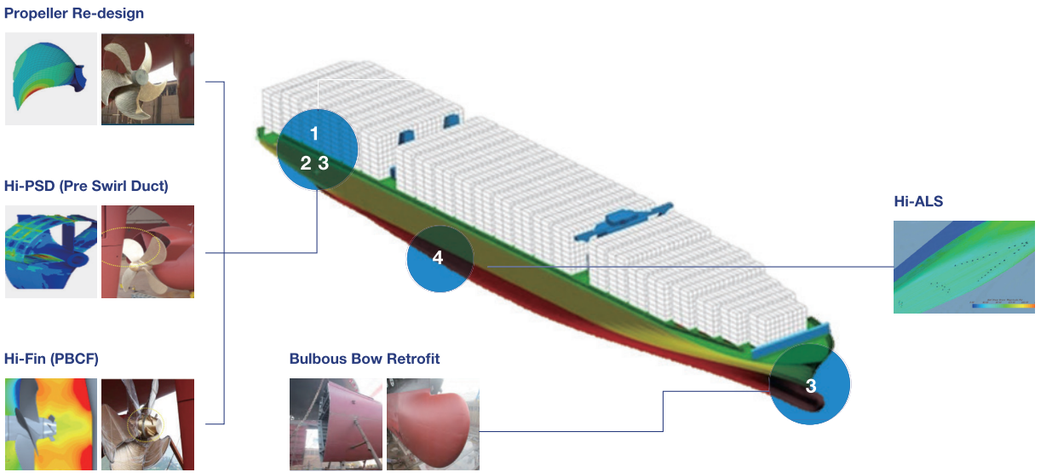


H35DF



ENERGY SAVING DEVICE (ESD)

HMS is fully capable of providing the most efficient performance improvement solution.



1 Hi-Fin

- Approximately 0.5~1.5% reduction of fuel consumption
- Reduction of hub vortex cavitation to minimize erosion on the rudder
- Reduction of acoustic noise
- Easy Installation

2 Hi-PSD (Pre-Swirl Duct)

- Approximately 2~6% reduction of fuel consumption
- One of the most effective devices for ship fuel saving
- Reduce hull vibration and propeller cavitation through wake distribution improvement
- HMS provides Hi-PSD only on HD Hyundai Group built vessels (Group policy)

3 Bulbous Bow and Propeller Re-Design

- Approximately total 4~7% reduction of fuel consumption
- Recommend for slow steaming vessel
- MCR Power should be lowered permanently for the propeller re-design
- HMS provides structure drawing of the bulbous bow and newly designed propeller
- HMS provides these engineering services only on HD Hyundai Group built vessels (Group policy)

4 Hi-ALS (Air Lubrication System)

- Approximately 5~8% reduction of fuel consumption
- The air bubbles, dispensed from the optimally designed and arranged Air Dispense Units(ADU), effectively cover the bottom surface of ship
- Reduce the frictional resistance of the hull significantly

ELECTRIC HEATING SYSTEM

Steam heating is the most popular heating system for vessels. The auxiliary boiler generates steam by burning fuels or exhaust gas from engines depending on the vessel's operating condition.

The electric heating system provides heating to the fuel oil system or engine jacket water and generates steam without fuel burning by the auxiliary boiler.

It minimizes fuel burning to generate steam and reduces fuel consumption and exhaust gas emissions from the existing auxiliary boilers on the customer's fleet.

Mainly, 'Zero Emission' can be carried out by the electric heating system combined with AMP during a port operation.

BENEFIT

- Fuel Saving for Aux. Boilers
- Emission Reduction from Aux. Boilers
- Zero Emission in Port (In Case Electric Power Supply by AMP)
- Operational Flexibility & Reliability
- Less Operation Cost (Chemical Dosing in Feed Water)

COMPONENT

1. Electric Fuel Oil Heater for Engines
2. Fuel Oil Purifier Electric Heater
3. Main Engine Jacket Water Electric Heater
4. Electric Steam Generator

VESSEL TYPE

Applicable for dry bulk carriers, container carriers, PCTC, Ro-Ro carriers, and any vessel type with the steam heating system, including auxiliary boilers. For tankers, steam demand by cargo oil pump turbines cannot be supplied by the electric heating system.

BALLAST WATER TREATMENT SYSTEM (BWTS)

NEW DEVELOPMENT OF “HiBallast NF (Non-Filter)”

HD Hyundai Group has recently developed HiBallast NF, Non-Filter type BWTS. Approved by IMO and USCG in December 2021, HiBallast NF has received excellent responses and support from clients worldwide.

HiBallast NF provides both technical and financial benefits to the clients. As the system no longer requires the filter units, the clients are free from filter clogging problems and maintenance of the filter units. In addition, Ballast Pump Head Modification and Remote Control Valve are not required in the system. All above considered, low CAPEX and OPEX can be realized (Particularly for the MR Tankers, BWTS room on deck and Framo Modification are not required).

APPLICABLE ALL BWTS MAKERS

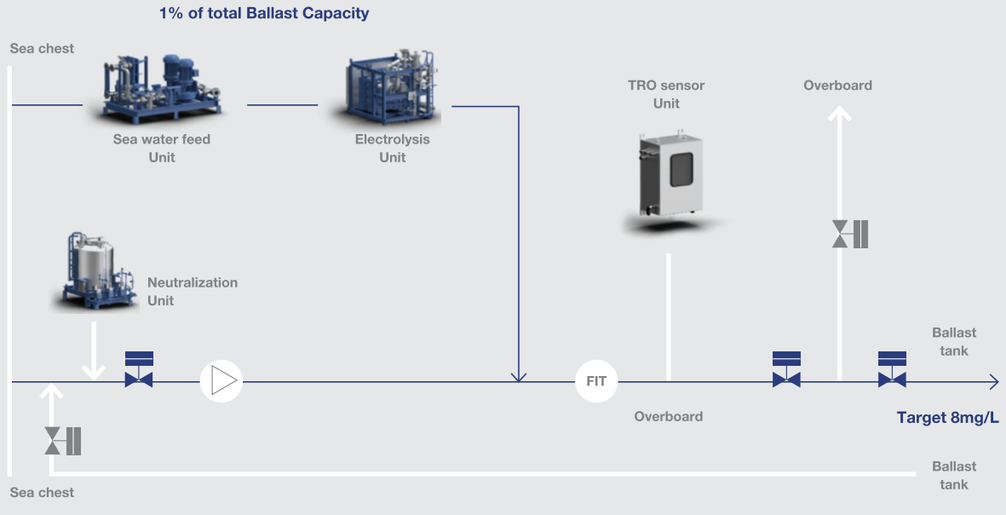
ELECTROLYSIS TYPE

1 Filter + Indirect Electrolysis

- Ability to Treat High Flow Rate
- Stable & Low Power Consumption
- Strong Disinfection

2 Indirect Electrolysis (Non-Filter Type)

- Filter Clogging Free
- Low CAPEX & OPEX
- Low Installation Cost
- No Ballast Pump Head Modification



RECORD

946	614	332
NEW BUILDING + RETROFIT	NEW BUILDING	RETROFIT

INSTALLATION DURING SAILING OR AT REPAIR SHIPYARD

PROCEDURE

1. Primary Equipment Arrangement Study
2. Survey and Scanning Onsite
3. Installation and Commissioning
4. Approval Process
5. Recompose & Reproduce Piping Lines to Be Installed with Existing Pipes

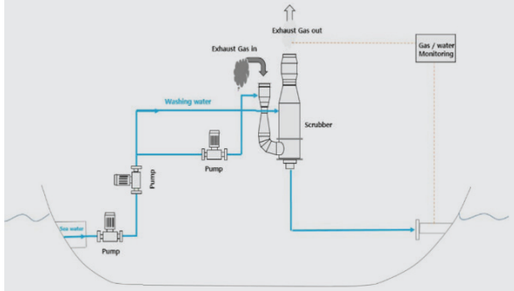
EXHAUST GAS CLEANING SYSTEM (EGCS)

HMS provides an optimal solution to make a cleaner ocean air by reducing SOx emission from the ship along with the regulation of 'IMO Sulphur Cap 2020'. HMS provides a tailored solution in response to customers' needs and safe, fast, and reliable installation with a lot of experience and knowledge in the retrofit business field.

CONCEPT

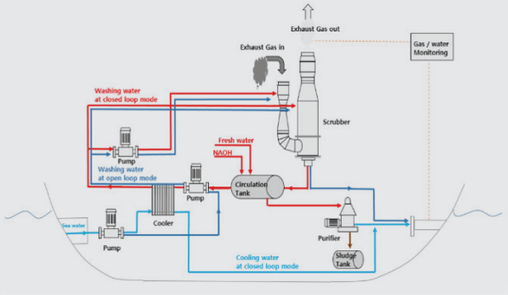
1 Open Loop Type

- Seawater treated in the scrubbing system is directly discharged back to sea.



2 Hybrid Type

- Water treated with alkali is re-circulated for scrubbing within a closed system



QUALIFIED MAKERS

HYUNDAI POWER SYSTEMS | ALFA LAVAL | WÄRTSILÄ

PANASIA | MS-SOx SCRUBBER | HYUNDAI MATERIALS

RECORD

NEW BUILDING + RETROFIT	290

GHG SOLUTION PLATFORM (HiGSP)

HiGSP (Hyundai GHG Solution Platform) consists of a data logger agent and a workstation based on the server, which collects and transmits the navigation and machinery operation data of a vessel. The solution can generate reports such as EU MRV, IMO DCS, Noon Log, Voyage, Departure, Arrival, and GHG Regulation to assist the user's document work. HiGSP helps monitor and manage ship operation status in response to GHG regulations and saves your time for reporting.

BENEFIT

- **Cost-Efficient Solution**
- **Simple Retrofit**
- **Easy System Integration for Data Recorder**
- **GHG Solution**

FEATURES

ONSHORE MONITORING & MANAGEMENT SERVICE

- Onshore monitoring with Hi4S
- Annual efficiency ratio (AER) monitoring to estimate carbon intensity indicator (CII)

VARIETY OPERATIONAL REPORTS

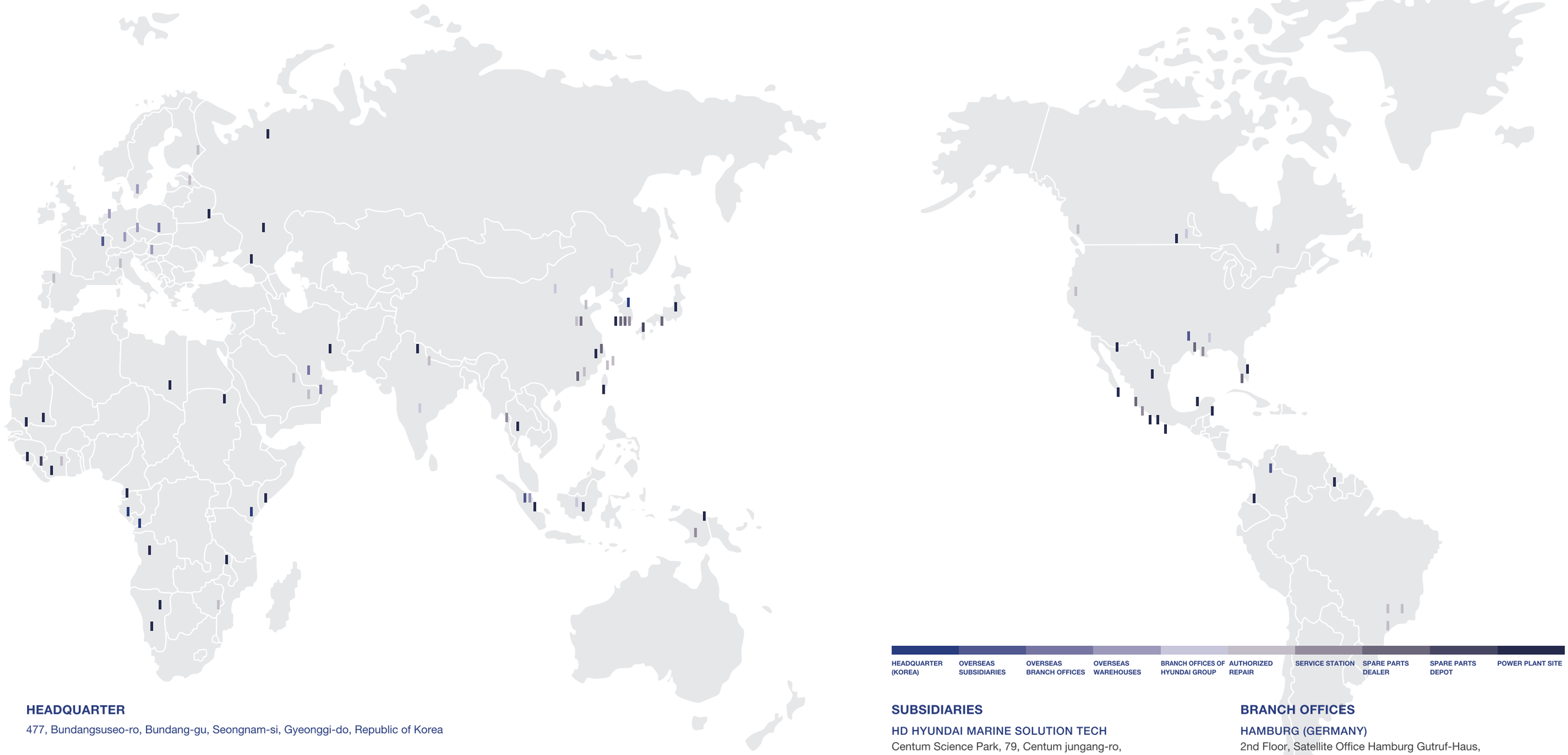
- Operational report – Noon report, Voyage report, Departure report, Arrival report
- GHG regulation report – Report for IMO ship fuel oil consumption database, EU MRV

EASY SYSTEM INTEGRATION FOR DATA RECORDER

- Data logger for SPM, VDR, BMS and AMS
- EPL & SHaPoLi data recorder
- Available for manual data input instead automatic data logging

CONVENIENT CUSTOMER SERVICE

- Main page for overview
- Monitoring & analysis on voyage data



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