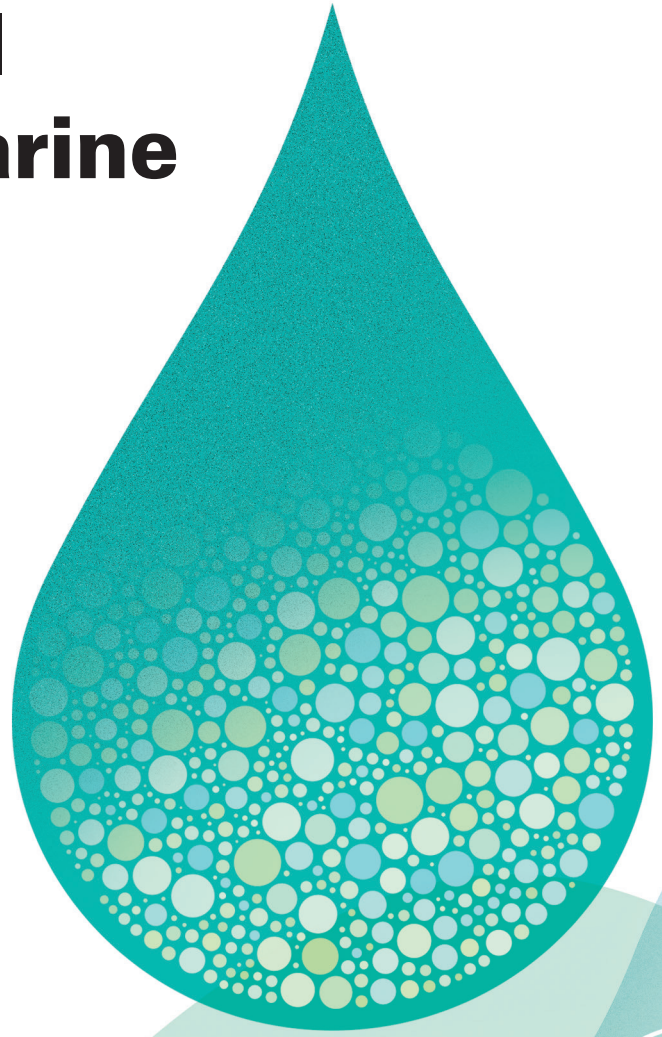


# Carbon Neutral Solution for Marine

Carbon Capture, Utilization and Storage  
& Fuel Supply System  
& Hydrogen Generation System



ENG

**PANASIA**

# Panasia: We are heading to the future with eco-friendly solutions

PANASIA is a green energy solution provider that leads the way in building a future in which humans and nature coexist.

At PANASIA, we are continuously working to take risks and develop technologies powered by nature based on the standards of nature across various areas, from the air solutions to the water solutions, and to our energy solutions.

We offer high-quality ICT-based products by adopting our unique "SMART PANASIA" system, which encompasses all processes from product planning to design, production, and to services, and allows our technologies to learn and evolve on their own.

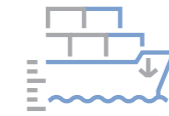
With its core technologies and years of experience, PANASIA has become a global leader that uses its technology to respond to demands in various environmental areas.



## WATER SOLUTIONS



Ballast Water Treatment System (UV type)



Measurement Control System



WTS for Exhaust Gas System (Chemical / Membrane)

## AIR SOLUTIONS



De-SOx System (Scrubber)



De-NOx System (SCR)



Engine Exhaust Recycling System (iCER)

## ENERGY SOLUTIONS



Hydrogen Generation System



Carbon Capture and storage System (CCS/OCCS)



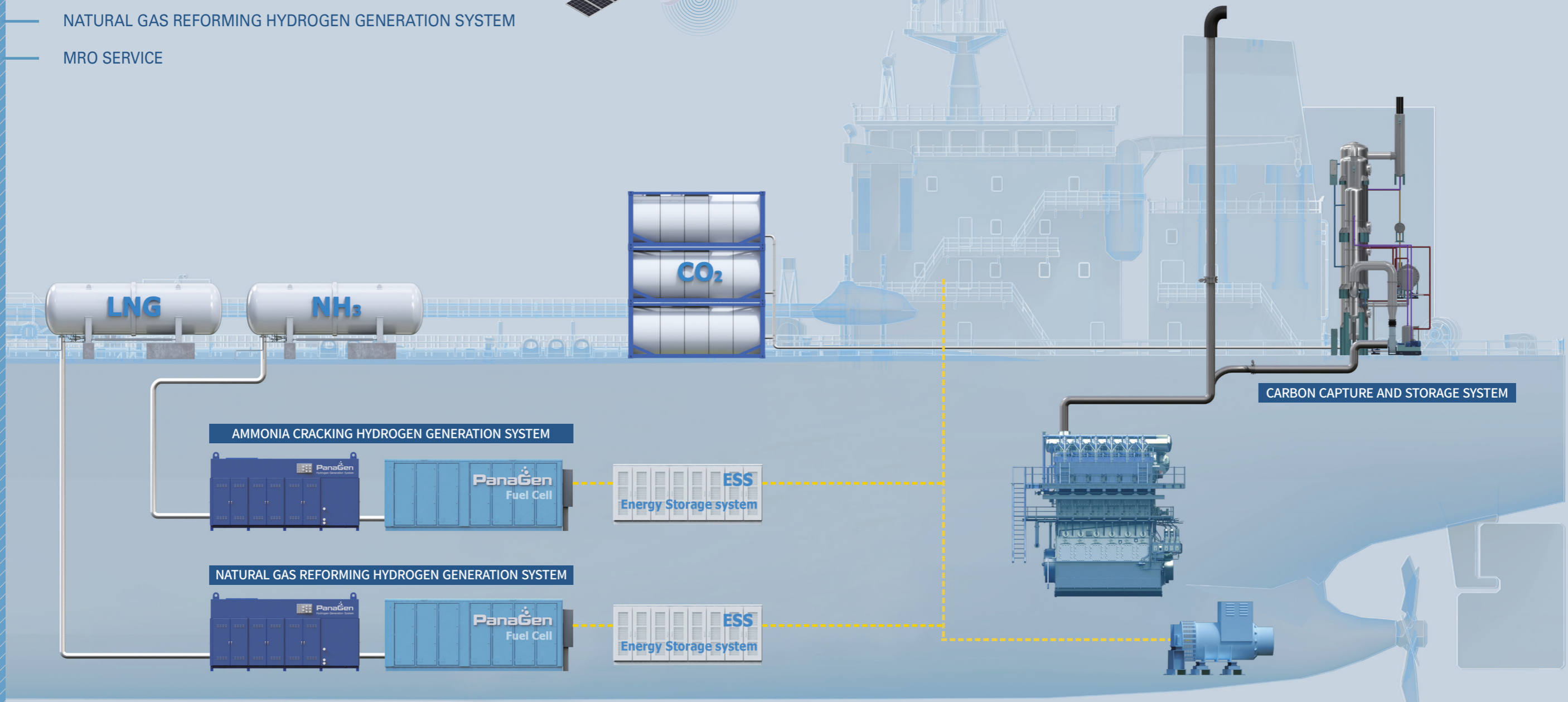
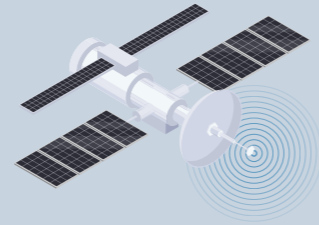
Fuel Supply System (LNG/Ammonia/Methanol)



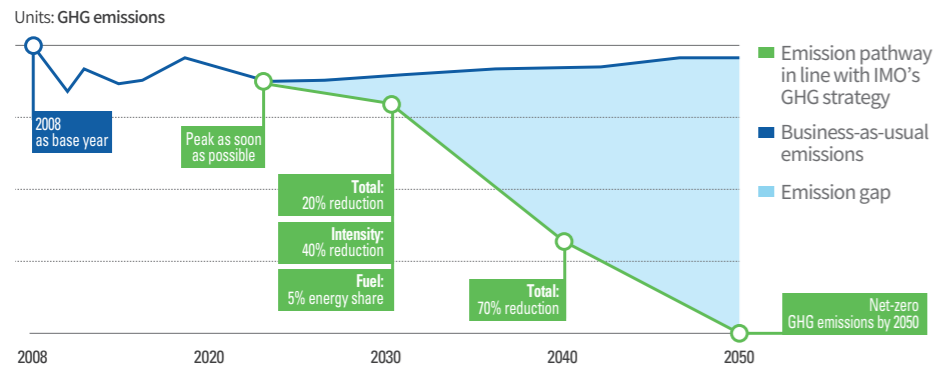
# CARBON-NEUTRAL SOLUTION CATEGORY FOR SHIP

Hydrogen Generation System  
& Carbon Capture and Storage System

- CARBON CAPTURE AND STORAGE SYSTEM
- AMMONIA CRACKING HYDROGEN GENERATION SYSTEM
- NATURAL GAS REFORMING HYDROGEN GENERATION SYSTEM
- MRO SERVICE



### Strengthened IMO strategy on GHG reductions



Total: Well-to-wake GHG emissions; Intensity: CO<sub>2</sub> emitted per transport work; Fuel: Uptake of zero or near-zero GHG technologies, fuels and/or energy sources

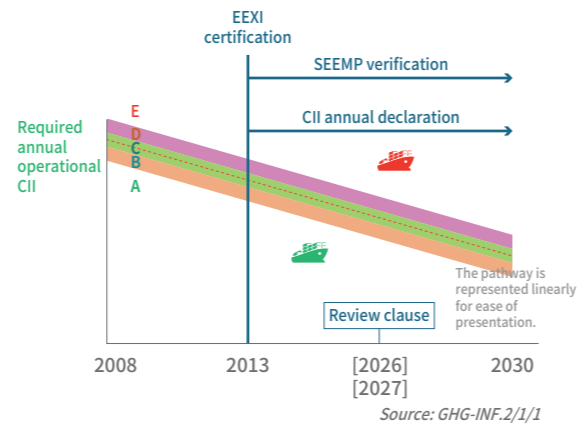
### CII Carbon Intensity Indicator

#### Carbon Intensity Indicator (CII)

- The Carbon Intensity Rating scheme is applicable to existing ships operating internationally above 5,000 GT.
- The Carbon Intensity Indicator (CII) is a measure of how efficiently a ship operates based on vessel traffic data.
- Each ship will be given an annual rating ranging from A to E, based on the annual CII rating achieved by the ship against the annual CII requirement.

$$CII = \frac{\text{Annual fuel consumption} \cdot CO_2 \text{ factor}}{\text{Annual distance travelled} \cdot Capacity} \cdot \text{Correction factors}$$

*To be developed*



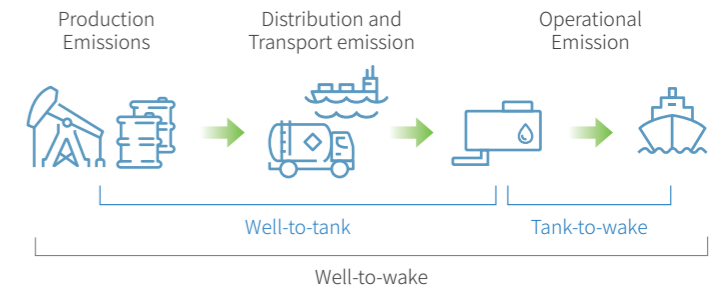
Source: GHG-INF.2/1/1

### GHG Reduction Technologies

Category	Technology	Details	GHG Reduction(%)
Ship energy efficiency improvement	Resistance efficiency	Ship design optimization	10-15
		Resistance reduction technology	2-7
		Structure lightening	0-10
	Propulsion efficiency	High efficiency propulsion development	0-20
		ESD Development	0-7
Clean, alternative and energy	Alternative fuel(1) low carbon fuel	LNG, LPG, CNG	20-30
		Hydrogen	0-100
	Alternative fuel(2) zero carbon fuel	Methanol	20-100
		Ammonia	20-100
		Bio	20-100
	Alternative fuel(3) non fossil fuel	Electricity(Battery)	0-100
		Fuelcell(Hydrogen)	0-100
		Wind power	1-32
		Solar power	0-12
		Nuclear power	0-100
Operating efficiency	Navigation optimization	Voyage and speed optimization	0-60
	Fleet optimization	Cargo volume optimization	0-30
	Operating optimization	Vessel-port interface, AMP	0-5
	Onboard CCS	Post combustion	0-60
	Ship operating system	Internal energy efficiency improvement, waste heat reclaimer	2-7

### The new FuelEU Maritime regulation (Fit For 55 by the European Union)

The FuelEU Maritime initiative is a new regulation proposal due to come into effect in 2025. The initiative will require all vessels of 5,000 GT and above to start reducing the GHG intensity of the energy they use onboard.



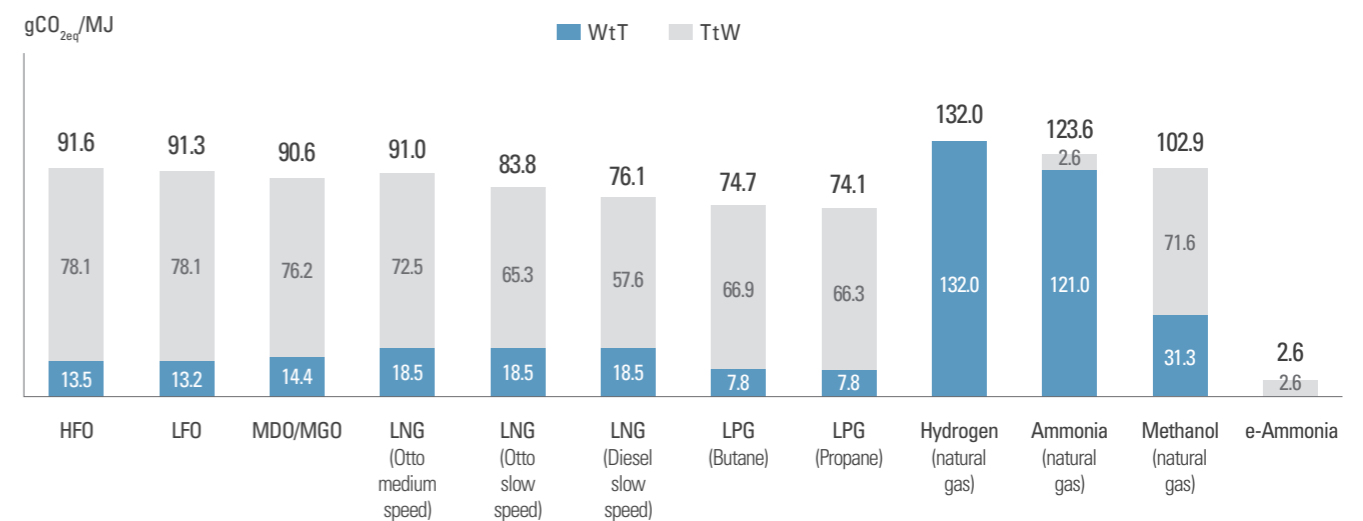
It makes use of a lifecycle analysis when evaluating the GHG intensity of fuels, taking into consideration all emissions 'from well to wake', or from when the fuel is produced to when it is burned.

### Emission Factors status by organizations

Fuel consumption	× Emission Factors (T-W or W-W)	= Carbon emission
Category		
Other sector (IPCC National GHG Inventory)		
Aviation	EU (EU-ETS)	•
	CORSIA*	
Shipping	EU (Fuel EU Maritime)	•
	EU (EU-ETS)	•
	IMO	•
		Under discussion

\* CORSIA : Carbon Offsetting and Reduction Scheme for International Aviation

### Fuel's GHG Intensity



(Source: Prepared by ClassNK based on the emissions factors listed in the FuelEU Maritime Regulations, etc.)

# Onboard Carbon Capture And Storage System



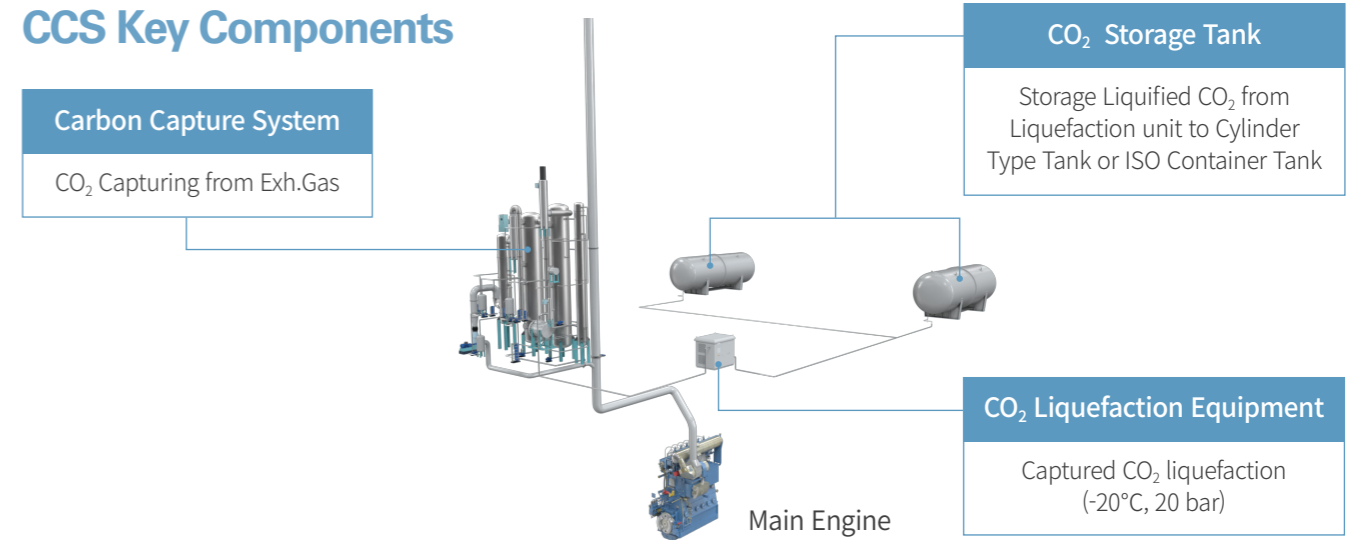
Pan-OCCS™

Onboard Carbon Capture and Storage System is a system that captures carbon dioxide generated during the combustion of fossil fuel, in order to reduce the amount of CO<sub>2</sub> released into the air.



## TECHNOLOGY

### CCS Key Components



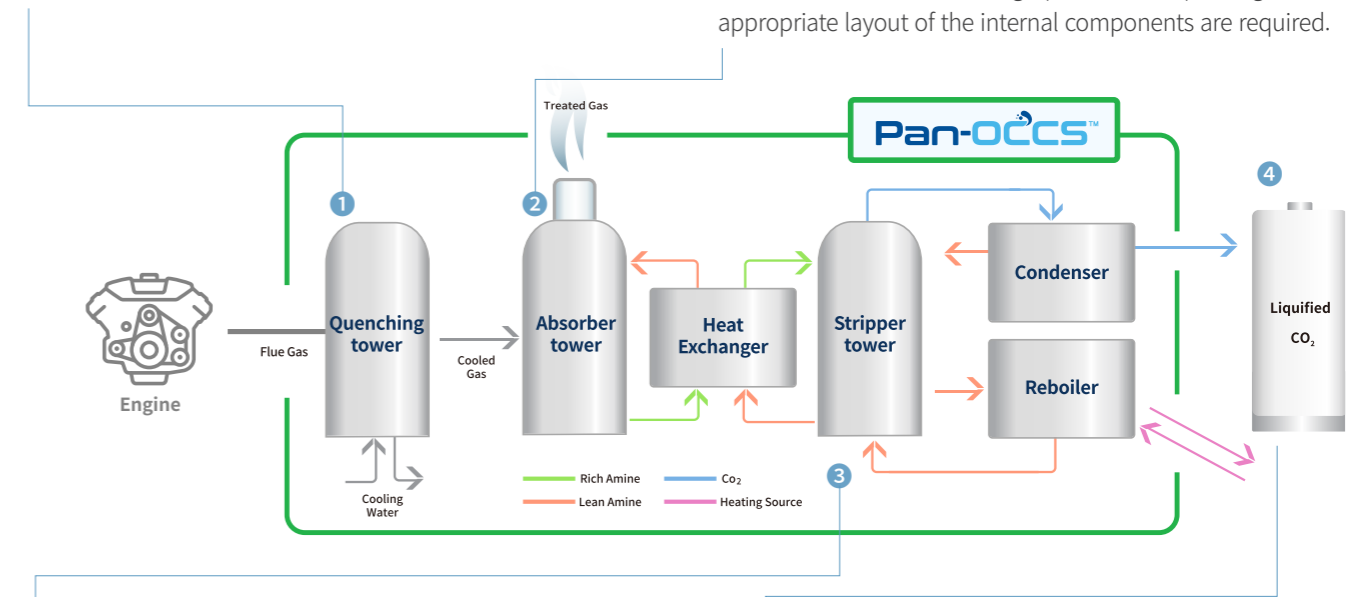
### Schematic Diagram of Carbon Capture Process

#### 1 Pre-treatment of flue gas

Flue gas is cooled in the quenching tower. When the particles and sulfur oxide are removed, the gas is pressurized by the intake fan and transferred to the absorber tower.

#### 2 CO<sub>2</sub> absorption

Once cooled, the gas comes into contact with the chemical solvent in the absorber, and CO<sub>2</sub> is selectively absorbed. To ensure efficient delivery of the substance and keep the tower size to a minimum, high-performance packing and an appropriate layout of the internal components are required.



#### 3 Regeneration

A solvent that has absorbed CO<sub>2</sub> is transferred to the stripper tower. The high-temperature vapor in the reboiler causes CO<sub>2</sub> to be removed from the solvent. In the cooling tower, it breaks down into water and CO<sub>2</sub>. Then, the water is recovered and sent to the stripper while CO<sub>2</sub> is transferred to the liquefaction process.

#### 4 Liquefaction & storage

Adding pressure and cooling for liquefaction purposes to meet the needs of storage containers and buyers.

# CCS Test Barge Facility



The Korean Register of shipping (KR) has awarded Approval In Principle (AIP) to PANASIA for the 'Onboard Carbon Capture and Storage System (OCCS)', and eco-friendly technology which captures CO<sub>2</sub> Emitted in the exhaust gases generated from the internal Combustion engines of ships

## Intake Gas Property

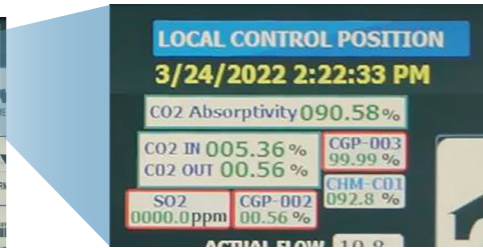
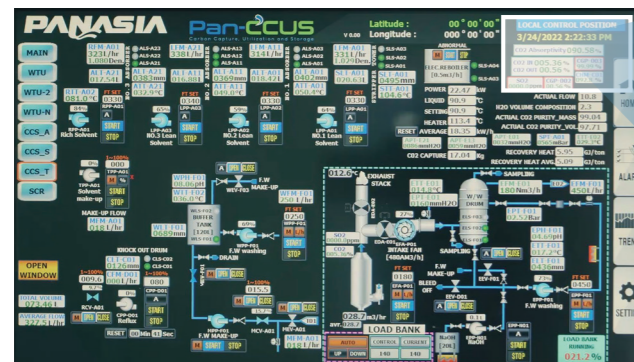
Item	Description
Mass Gas Flowrate	323 kg/hr
Flue Gas Flowrate (at 40°C)	250 Nm <sup>3</sup> /hr
Fuel Type	HSFO (3.5%)

## General Specification

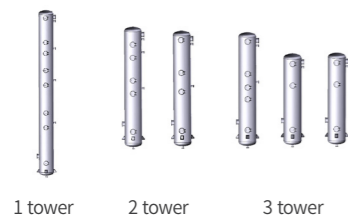
Item	Description
Capturing Level	90%
Pressure Drop	Under 500mmAq
Captured CO <sub>2</sub>	0.6 Ton/day

## Composition of Exh. Gas

Ingredient	Composition (Vol%)	Flowrate (L/h)	Flowrate (L/h@40°C)	Mol	Weight (kg)	Mass Fraction
N <sub>2</sub>	75.6	189000	216692	8437.5	236.42	73.2%
O <sub>2</sub>	12.6	31500	36115	1406.3	45.00	13.9%
Ar	0.8	2000	2293	89.3	3.57	1.1%
H <sub>2</sub> O	5.5	13750	15765	613.8	11.06	3.4%
CO <sub>2</sub>	5.5	13750	15765	613.8	27.02	8.4%
Summary	100	250000	286630	11161	323	100.0%



## Feature



Multiple absorber tower applications by the ship height

- Simple operation and maintenance
- Easy Installation on a vessel



Various solvent verification

- Flexible response to shipowner's requirements with various solvent



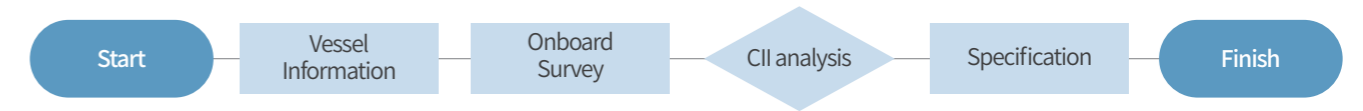
Full automation (HMI)

- Simple operation with HMI and the MSCS integration
- Easy maintenance with its system mode

\*MSCS: Marine Satellite Control System

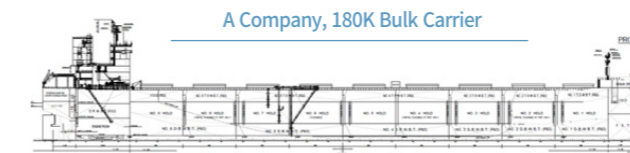
# Feasibility Study

## Study Process



## CII Calculation

Calculating CII based on the vessel information. provide CCS installation plan including CII scenario and reduction capacity for the vessel considering its target lifetime.



CIIR	2023	2024	2025	2026	2027	2028	2029	2030
2.56	2.43	2.38	2.33	2.28	2.21	2.14	2.07	2.00

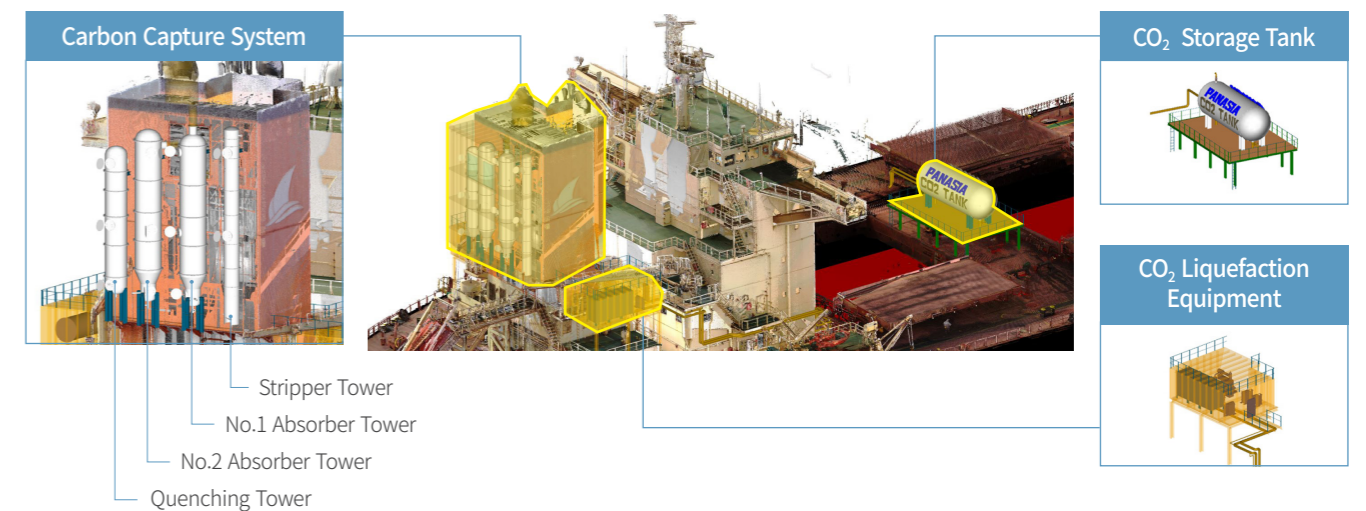
Vessel Type	Bulk Carrier
Vessel Size	179,147 (DWT)
Fuel Type	HSFO, MGO
Annual Fuel Consumption	Average 9,144 MT
Target Ship Speed	15.3 knots
CO <sub>2</sub> Emission	3.23 t/hr
1Cycle Voyage Period	20 Day
Annual Voyage Distance	Average 51,600 Nm
Vessel's Target Life Time	2030

CII Analysis

Type	Size	DWT	Reduction Rate	CO <sub>2</sub> -t/y	Reduction (CO <sub>2</sub> -t/hr)	CII <sub>A</sub>	CII <sub>E</sub>	CII(AER) Scenario(~2030)									
								2023	2024	2025	2026	2027	2028	2029	2030		
BC	Cape	179,147	Base	28,325	0.00	2.86	2.563	D	E	E	E	E	E	E	E	E	
			5%	27,133	0.21	2.74		D	D	D	E	E	E	E	E		
			10%	25,941	0.41	2.62		D	D	D	D	E	E	E	E		
			15%	24,750	0.62	2.50		C	C	D	D	D	E	E	E		
			20%	23,558	0.83	2.38		C	C	C	C	D	D	D	E		
			25%	22,366	1.04	2.26		B	C	C	C	C	C	D	D		
			30%	21,175	1.24	2.14		B	B	B	B	C	C	C	D		
			35%	19,983	1.45	2.02		A	A	B	B	B	C	C	C		

\* In the case of a rating result of E in any year or a rating of D for 3 consecutive years, it is necessary to fill out a corrective action plan in the SEEMP III and obtain the confirmation by the Administration or an RO.

## Components Concept



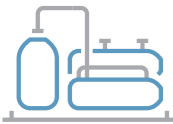
Carbon Capture System

- Stripper Tower
- No.1 Absorber Tower
- No.2 Absorber Tower
- Quenching Tower

CO<sub>2</sub> Storage Tank

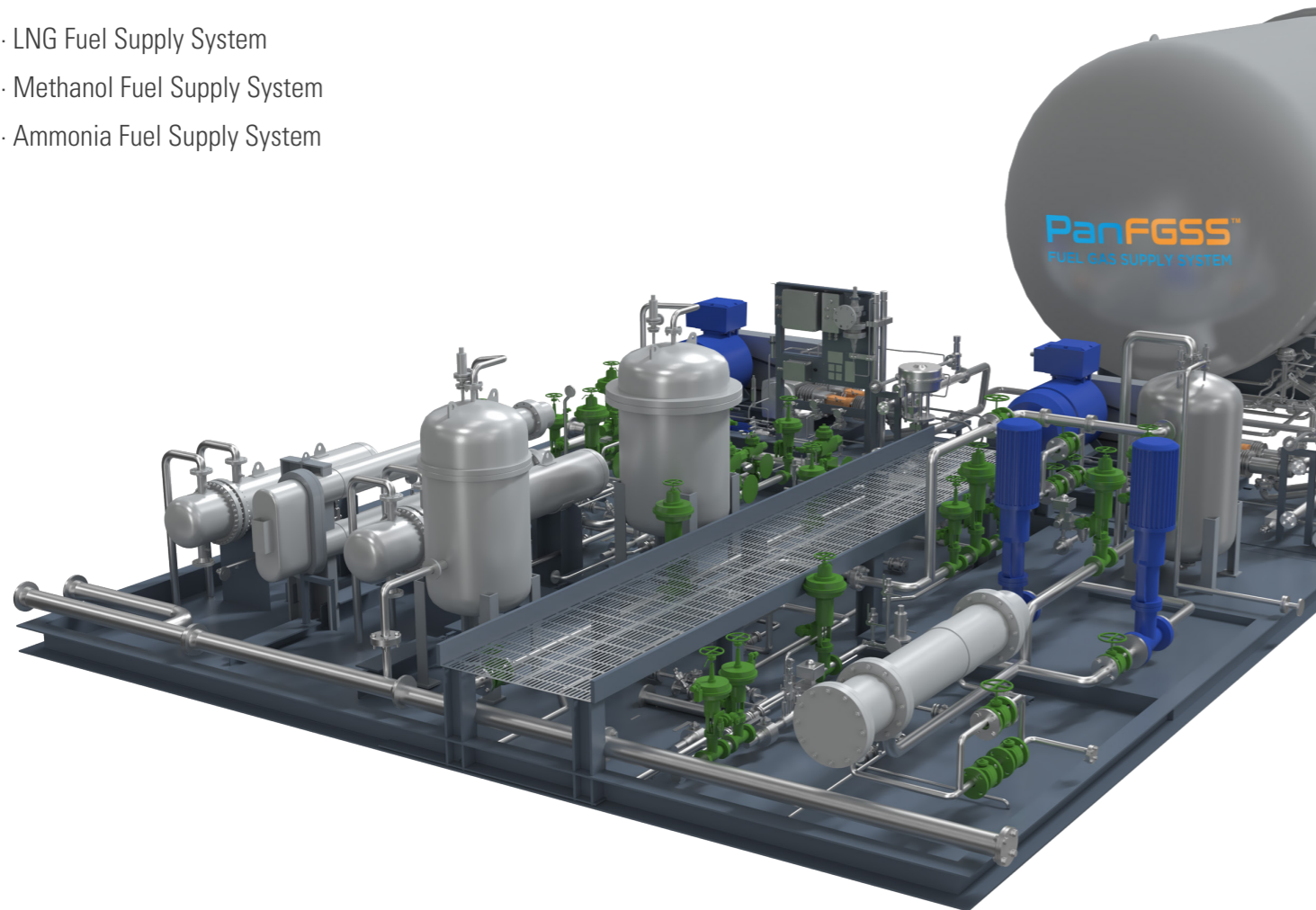
CO<sub>2</sub> Liquefaction Equipment

## Fuel Supply System



The fuel gas supply system of PANASIA is a device that vaporizes alternative energy such as LNG, ammonia, and methanol and supplies it to the ship engine.

- LNG Fuel Supply System
- Methanol Fuel Supply System
- Ammonia Fuel Supply System



## LNG Fuel Supply System

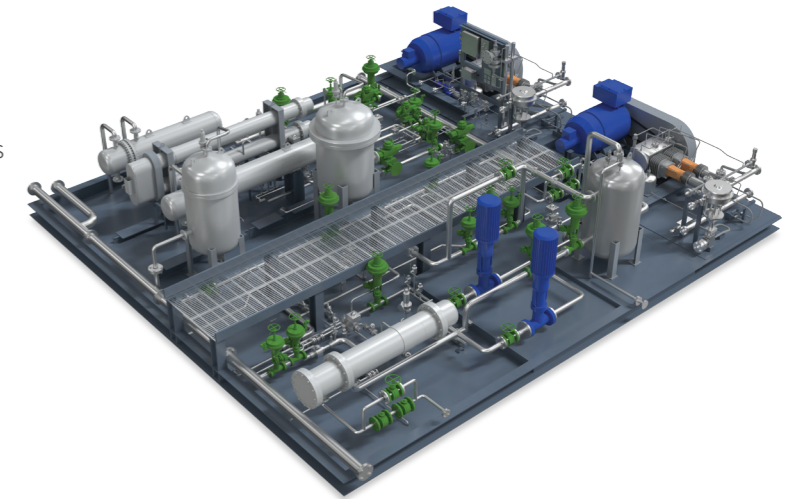
PanFGSS™

The LNG Fuel Supply System refers to the facility on vessel using LNG (Liquefied Natural Gas) as a ship fuel. Depending on the engine model, it is divided into HP (high pressure) & LP (low pressure) Type.

### 1. HP/LP Type

#### — Design Data

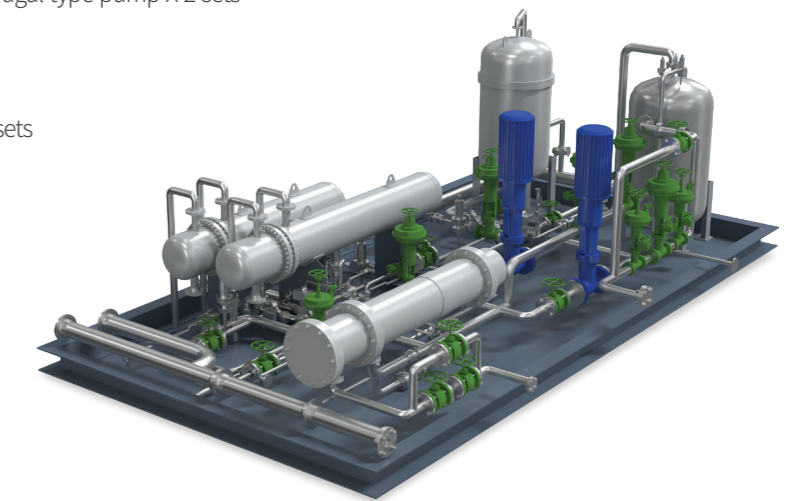
- **HP Pump** Dis. Press. 300 bar reciprocating pump X 2 sets
- **LNG Feed Pump** Dis. Press 12 bar submersible centrifugal type pump X 2 sets
- **LP Vaporizer** Temp : -163°C → 45°C (Cold side)
- **HP Vaporizer** Temp : -163°C → 45°C (Cold side)
- **Glycol Skid** Glycol Water (Water 50 : Glycol 50)  
Glycol Water Pump : Vertical Inline Centrifugal type X 2 sets  
Heat Exchanger : Shell&Tube or Equivalent  
Glycol Water Tank : abt. 0.5 m<sup>3</sup>
- **LNG Storage Tank** IMO Type-C Single Shell Tank  
IMO Type-C Double Shell Tank  
IMO Type-C Lattice Tank  
Material 9% Nickel Steel or Equivalent



### 2. LP Type

#### — Design Data

- **LNG Feed Pump** Dis. Press 18 bar submersible centrifugal type pump X 2 sets
- **LP Vaporizer** Temp : -163°C → 45°C (Cold side)
- **Glycol Skid** Glycol Water (Water 50 : Glycol 50)  
Glycol Water Pump : Vertical Inline Centrifugal type X 2 sets  
Heat Exchanger : Shell&Tube or Equivalent  
Glycol Water Tank : abt. 0.5 m<sup>3</sup>
- **LNG Storage Tank** IMO Type-C Single Shell Tank  
IMO Type-C Double Shell Tank  
IMO Type-C Lattice Tank  
Material 9% Nickel Steel or Equivalent
- **LP BOG Comp.** Injected Screw Type (16 bar) X 1 set



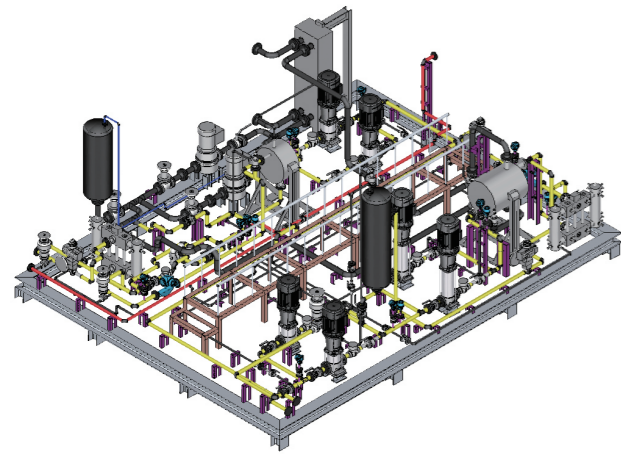
## Methanol Fuel Supply System



## Ammonia Fuel Supply System

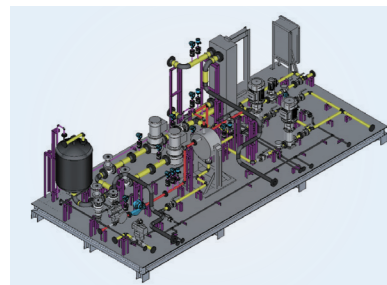
The Methanol Fuel Supply System uses liquid methanol as a fuel for ships and requires advanced technology.

The Ammonia Fuel Supply System uses ammonia with a flash point of approximately 130 degrees, as a ship fuel, and it has commons of LNG, LPG, and methanol supply system in aspect of supplying liquefied forms of fuels into the engine.



Items	Value
Pressure to engine	13 ± 0.5 bar.g
Temperature to engine	25 ~ 50 °C
Inert Gas Used	Nitrogen
Heating Media	Glycol Water (25wt.%)
Cooling/Heating Water	L.T.C.F.W(36°C)
ATEX Classification	Zone 1

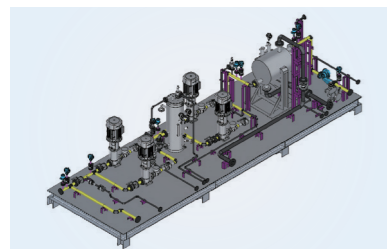
### Reference



G/E+G.W LINE SKID

#### Propulsion Engine Fuel Supply Application

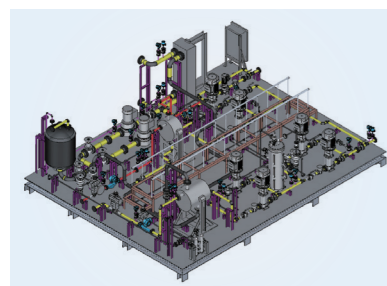
Methanol Supply Pump	Dis. Press. 6 bar.g / Sealless VFD Control
Methanol Fuel Pump	Dis. Press. 13 bar.g (Diff. Head 71 m) / Sealless VFD Control
Fuel Heater	Temp : -18 deg.C -> 25 deg.C / Glycol water 25~40%wt. Shell & Plate or Equivalent
Fuel Filter	Duplex / 10 micron
Fuel Strainer	100 micron
Fuel Pipe Material	Austenite Stainless Steel (A213-TP316)



M/E LINE SKID

#### Generator Engine Fuel Supply Application

Methanol Supply Pump	Dis. Press. 8 bar.g / Sealless VFD Control
Fuel Heater	Temp : -18 deg.C -> 25 deg.C / Glycol water 25~40%wt. Shell & Plate or Equivalent
Fuel Filter	Duplex / 10 micron
Fuel Strainer	Y Strainer / 100 micron
Fuel Pipe Material	Austenite Stainless Steel (A213-TP316)
Main Frame Material	SS400 or eq.



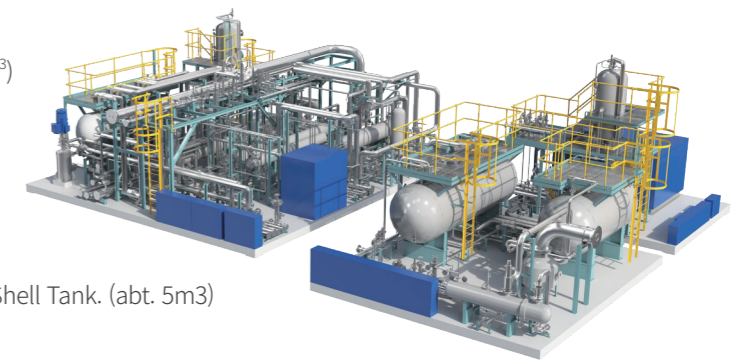
ONE SKID

#### Common Utility System for MeOH LFSS

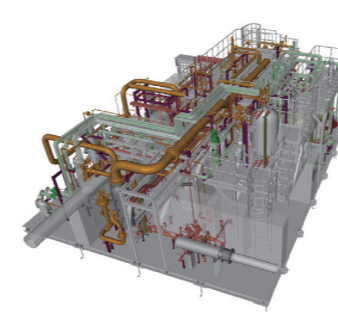
Glycol water system	Vertical Inline Centrifugal x 2 set Medium : Glycol water 25~40%wt. / LT water (36 deg.C) Glycol water tank : abt. 0.5 m3
N <sub>2</sub> Purge & Drain System	N <sub>2</sub> Supply train with valve (Automatic Purge system as an option) Pneumatic acting drain pump : 60LPM Drainage level control buffer
Safety Automation	Leak Detection Sensor (LEL 25% H/C) Control Panel & HMI

### Design Data

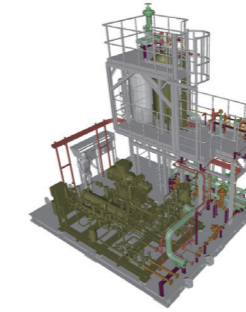
- **LP Pump** Dis. Press. 18 bar Multi-stage centr. Pump X 1 set
- **HP Pump** Dis. Press. 88 bar Metering Pump X 1 set
- **BOG Compressor** Dis. Press. 18 bar Oil Injection Screw Water Cooled X 1 set
- **Vaporizer** Temp: -24°C → -18.7°C
- **Water seal** Temp: -24°C → 60°C
- **NH<sub>3</sub> Supply Skid** IMO Type-C Single Shell Tank. (abt. 5m<sup>3</sup>)  
Material 9% Nickel Steel or Equivalent  
LP, HP Pump
- **Heat Exchanger** Shell&Tube or Equivalent
- **NH<sub>3</sub> Liquefaction Skid** BOG Compressor & Separator
- **NH<sub>3</sub> Dilution Skid, NH<sub>3</sub> Catch Skid** IMO Type-C Single Shell Tank. (abt. 5m<sup>3</sup>)
- **Heat Exchanger** Shell&Tube or Equivalent
- **Aqueous NH<sub>3</sub> Pump** Dis. Press 7 bar Diaphragm pump X 1 set



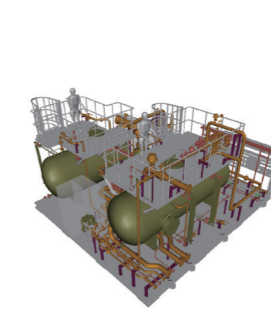
### Reference



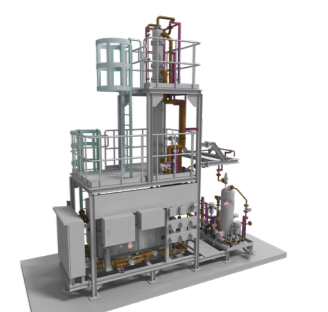
NH<sub>3</sub> Supply Skid



NH<sub>3</sub> Liquefaction Skid



NH<sub>3</sub> Dilution Skid



NH<sub>3</sub> Catch Skid



# Hydrogen Generation System



PANASIA's hydrogen generation system "PanaGen™" is a renewable energy solution designed to generate hydrogen and achieve carbon neutrality in the hydrogen energy industry. The hydrogen generation system that employs natural gas reforming combines the reforming system and fuel cells.

The hydrogen generation system for use in buildings to generate power and the small&mid sized hydrogen generation system that can store and utilize the hydrogen generated on site can be used on ships that use hydrogen as a propulsion fuel.

### – Features



Ultra-high purity (99.999%)



Fully automatic with fail-safe control



Fully skidded, modular design for low cost installation



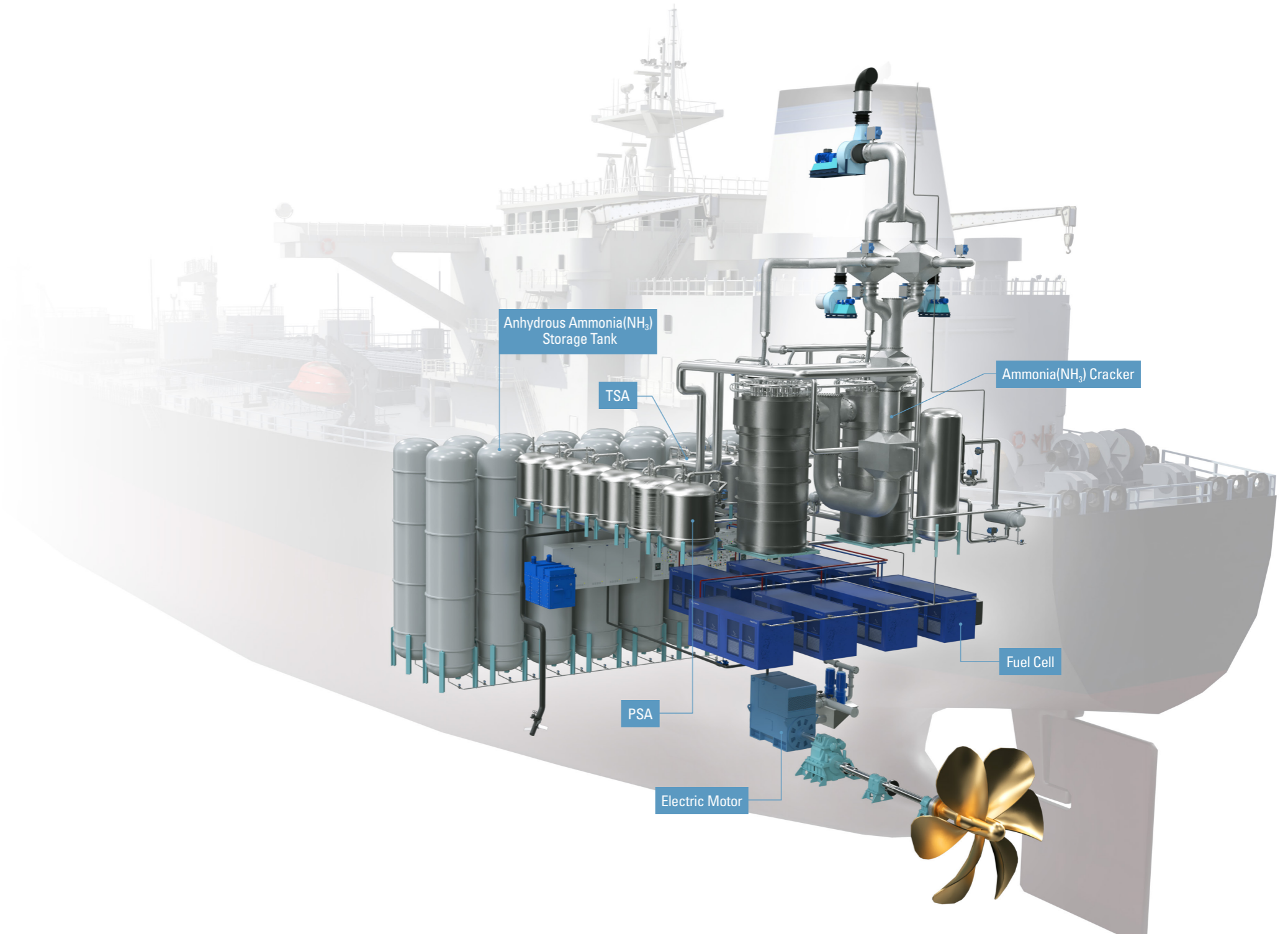
Low life cycle cost for catalyst

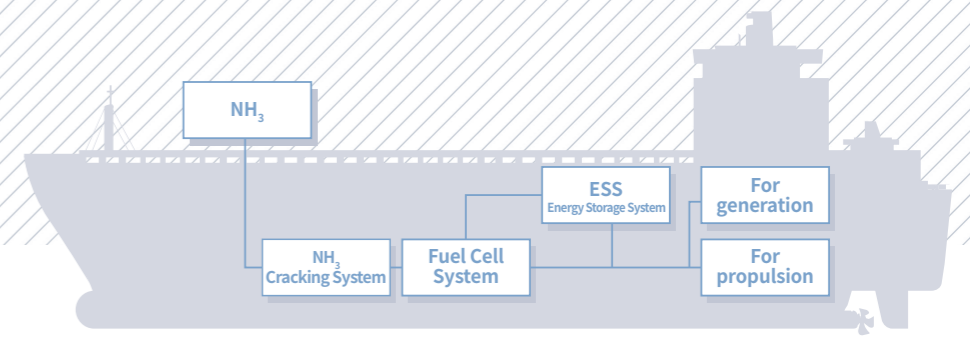


Fast initial and warm start up



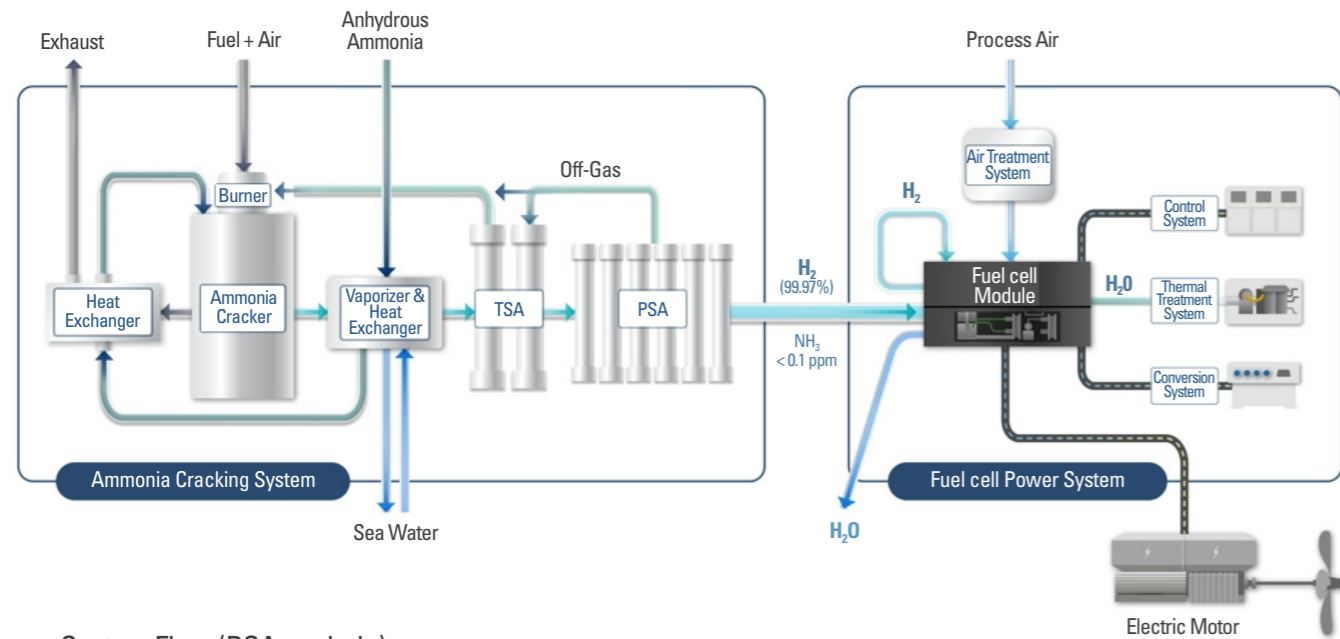
Real time monitoring & control at "Smart Control Center"



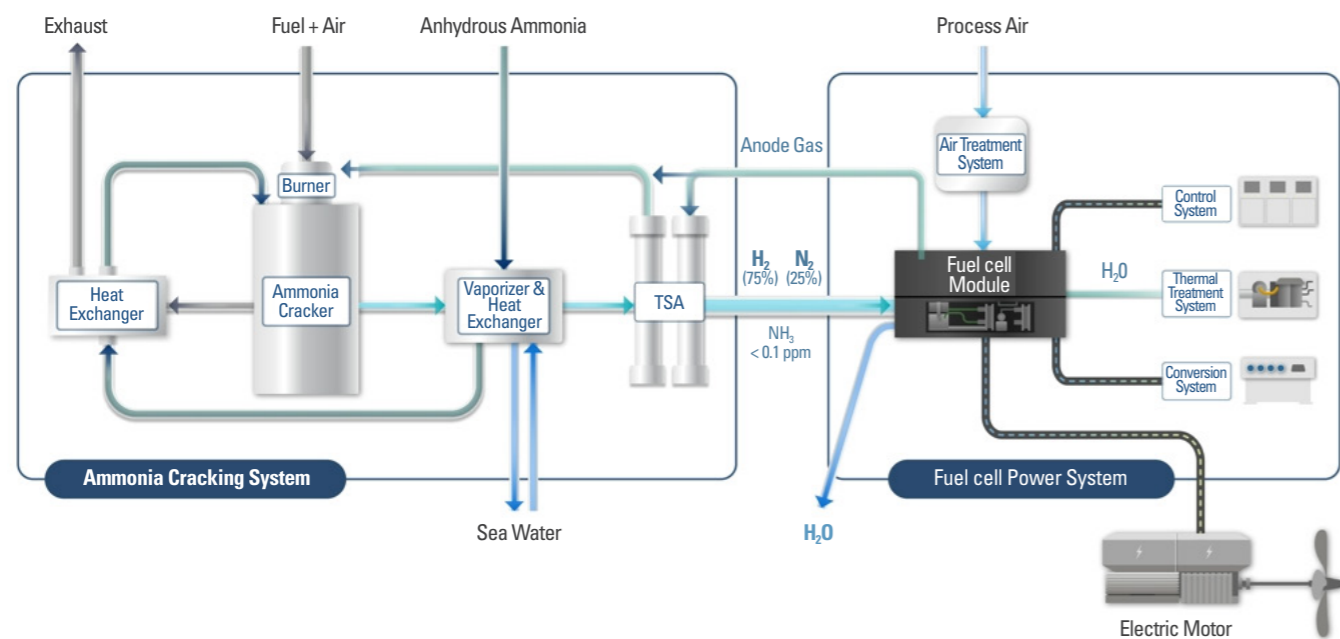


## Ammonia Cracking Hydrogen Generation System

### System Flow (PSA include)



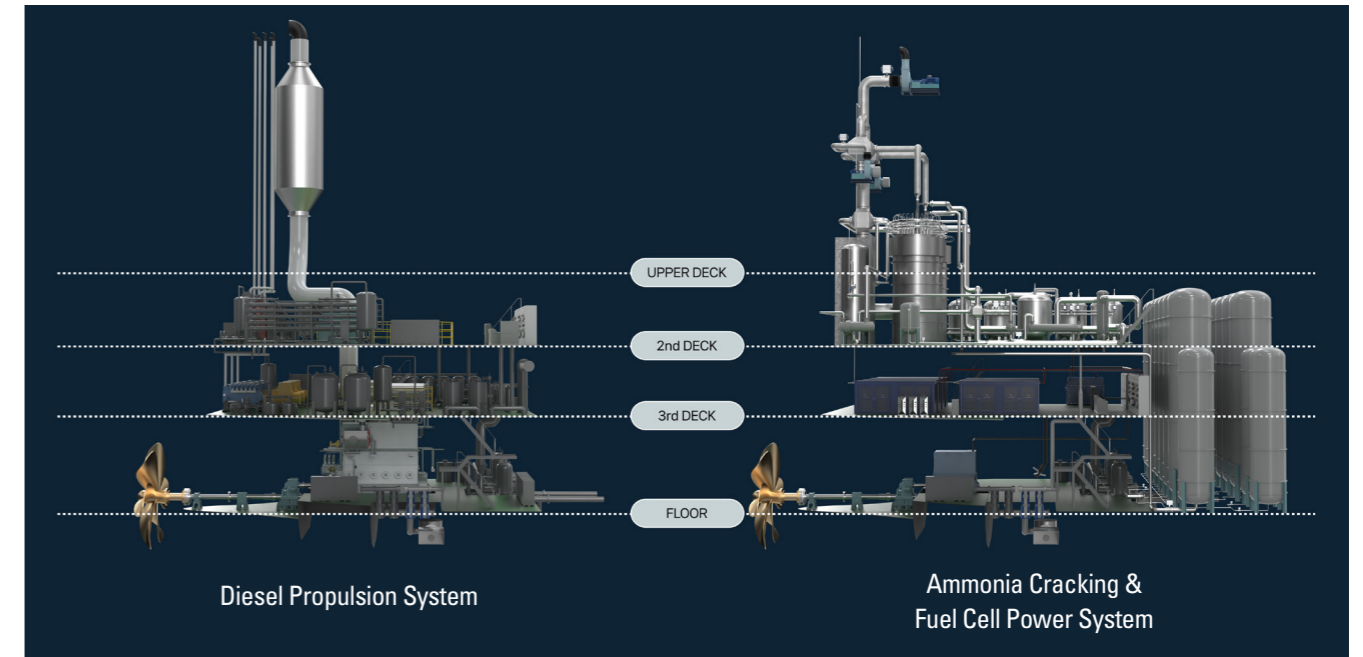
### System Flow (PSA exclude)



### Specifications

Feed Gas	Pressure	Product(H <sub>2</sub> )		
		Capacity	H <sub>2</sub> Purity	Pressure
Ammonia	~15 bar.g	Customized	Above 99.97-8% (NH <sub>3</sub> <0.1 ppm)	10 bar.g

## Installation Comparison



## Development

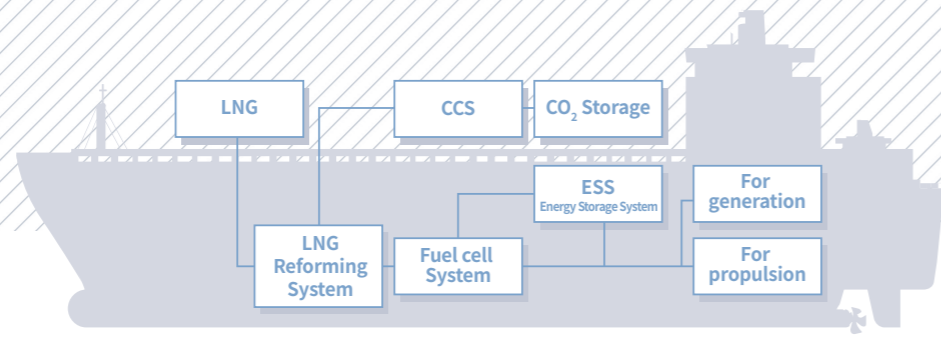
[ Busan Ammonia Eco-Energy Business ]

50 Nm<sup>3</sup>/h NH<sub>3</sub> Cracking System Manufacturing / Task



### Specifications

Type	50 Nm <sup>3</sup> /h NH <sub>3</sub> Cracking System
Cracker with TSA/PSA	High Pressure
H <sub>2</sub> Capacity	50 Nm <sup>3</sup> /h
H <sub>2</sub> Purity	Low : above 99.97-8%
Residual NH <sub>3</sub> concentration	Below 0.1 ppm



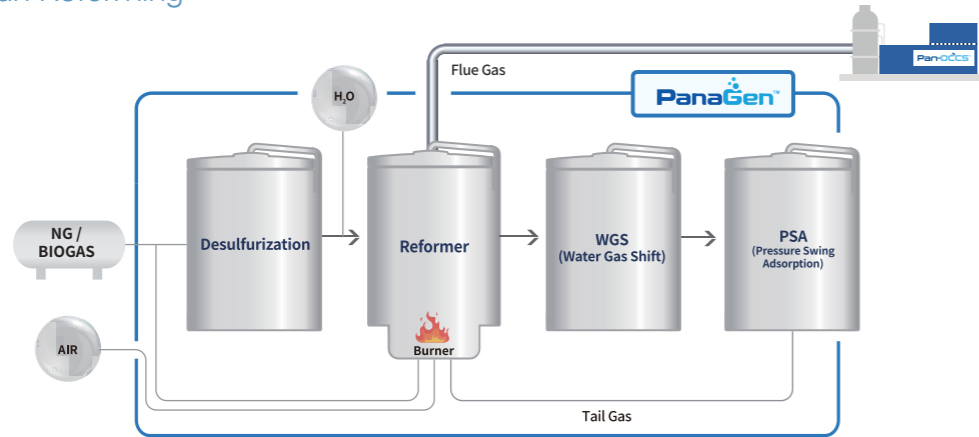
# MRO Service



PANASIA's integrated control system is a customized ICT-based service available 24/7, which collects product data in real time and checks the status of system remotely to provide customers with prompt and accurate solutions anytime, anywhere.

## Natural Gas-Reforming Hydrogen Generation System

Steam Methan Reforming



### Specifications

Feed Gas	Pressure	Product(H <sub>2</sub> )		
		Capacity	H <sub>2</sub> Purity	Pressure
Methane (Biogas and etc)	9.5 bar.g	Customized	99.999%	6 bar.g

### Line-Up

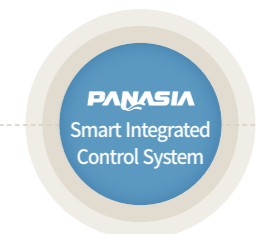
Line up	PanaGen™ -30	PanaGen™ -100	PanaGen™ -250	PanaGen™ -500	PanaGen™ -2300	
<b>Output(product)</b>						
Product(H <sub>2</sub> ) Flow	Nm <sup>3</sup> /hr	~30	~100	~250	~500	~2300
	kg/day	~60	~200	~500	~1000	~4600
Purity	%vol	99.999				
Pressure	bar.g	-6.5	-6.5	-6.5	-6.5	-20
<b>General Specifications</b>						
Feed NG flow	Nm <sup>3</sup> /hr	~12	~40	~	~	~
Feed NG Pressure	bar.g	8.9 ~ 9.5				
DI Water	L/hr	~33	~100	~250	~490	~2200
Water Quality (Feed/DI)	uS/cm	Feed Water : <650, Deionized Water : <1				
Comp. Air Quality		ISO 8573-1 Class 3/3/4				
Operating Amb. Temp.	°C	-20 ~ 40				
<b>Electricals</b>						
Power Source		380VAC 3phase 60Hz				
Electricity	kWh	~14	~30	~60	~150	~300



At PANASIA, we offer unique services aimed at increasing customer convenience.

This customized ICT-based service, which is available 24/7, collects product data in real time and checks the system status remotely to provide customers with prompt and accurate solutions anytime, anywhere. It also provides early diagnosis of problems using accumulated data to assist customers in system control to help their systems run at their optimal performance.

- BALLAST WATER TREATMENT SYSTEM  
**GLOEn-Patrol™**
- DI-SDX SYSTEM  
**PaSDx™**
- DI-HDX SCR SYSTEM  
**PaNOx™**
- Pan-OCcs™**
- PanaGen™**
- PanFGSS™**



- Network
- Tablet PC
- Mobile

#### Safety control

- Safety controls for issues including hydrogen leakage
- Real-time checking and issuing alert notifications
- Advance prediction and prevention of problems

#### Product diagnosis

- Real-time monitoring of output, amount of generated power, efficiency, etc.
- Fault diagnosis and analysis

#### Efficient management

- Supporting online remote updates
- Big data-based maintenance and control
- Replacement notifications for spare parts
- Keeping operational losses to a minimum

## MRO Service E-Learning Program

At PANASIA, we offer product training programs you can access anytime, anywhere. PANASIA's training program service called the "E-Learning Program" is available both online and on-site, allowing you access training anytime, anywhere. You can also watch videos and try running products on site using a tablet PC or a laptop. Our E-Learning Program contains product descriptions, operating instructions, crisis response, and other details so you can operate products professionally.



### Learning Program Contents

Chapter	Contents
1	Understanding system of product
2	Standard operating procedures
3	Compliance issues
4	Installation requirement
5	Maintenance requirement
6	Troubleshooting for the system/unit
7	Troubleshooting for the component/device

### CBT (Computer Based Training Program)



### IBT (Internet Based Training Program)



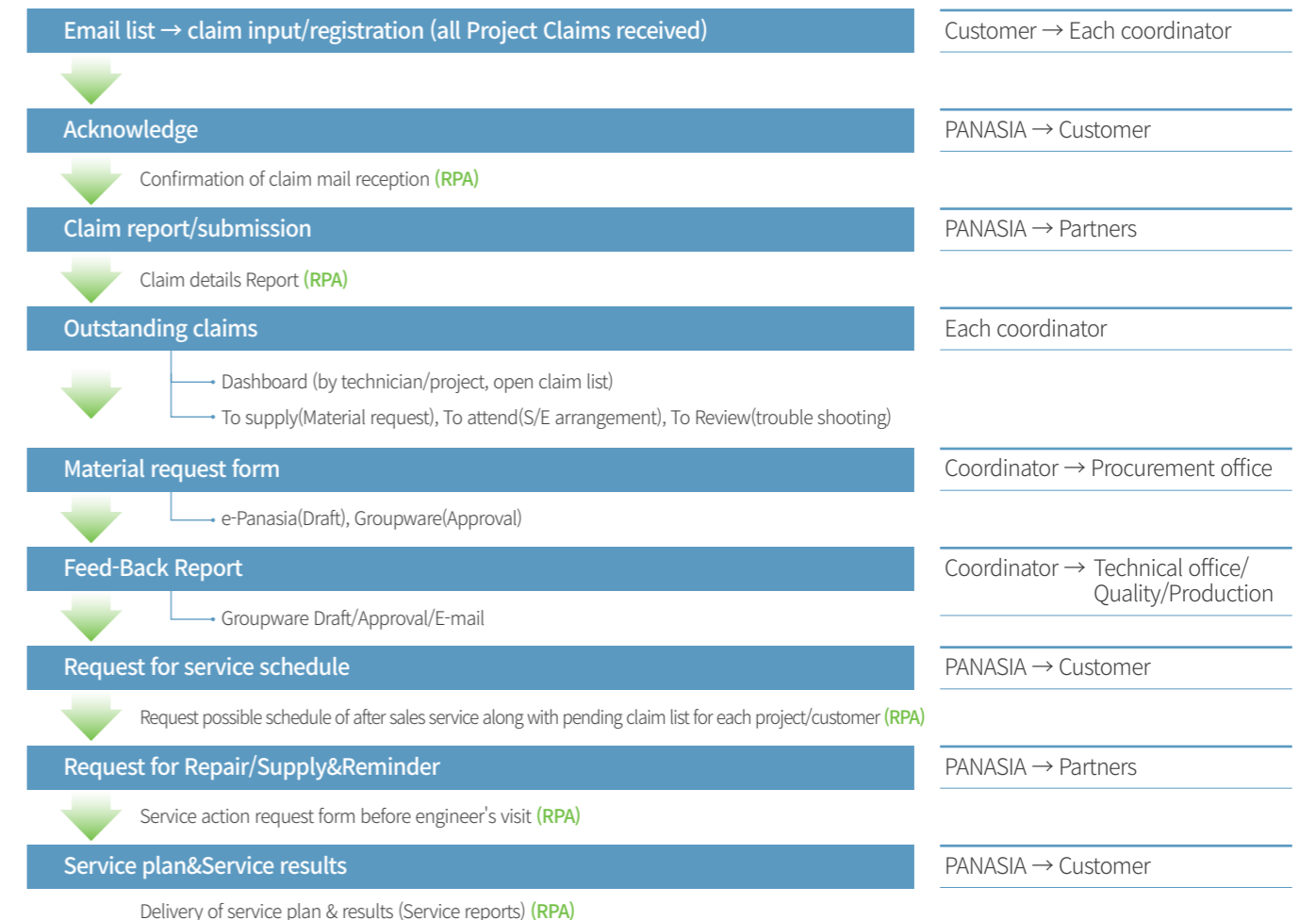
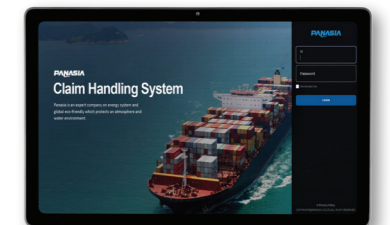
## Claim Handling System



All service and maintenance are performed digitally to minimize human error. After the product has been delivered, the customer receives an ID and password for the Claim Handling System in our maintenance system providing them with access. In the event of a problem with the product, if the customer registers the problem in the CHS, a technician will be assigned, and the technician will resolve the problem through the management and continuous monitoring of the claim. We also deliver quality services to our customers with faster, more convenient operations and management through the introduction of an RPA system.

### Maintenance work process

After the conclusion of maintenance, the service report is automatically delivered to the customer so that the customer can verify the processing details in real time. We also use the report for product improvement through internal feedback to prevent the recurrence of service issues.





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To reflect PANASIA's corporate philosophy of seeking eco-friendly and sustainable value, this booklet was printed with naturally biodegradable soy ink that makes paper recycling easier.

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