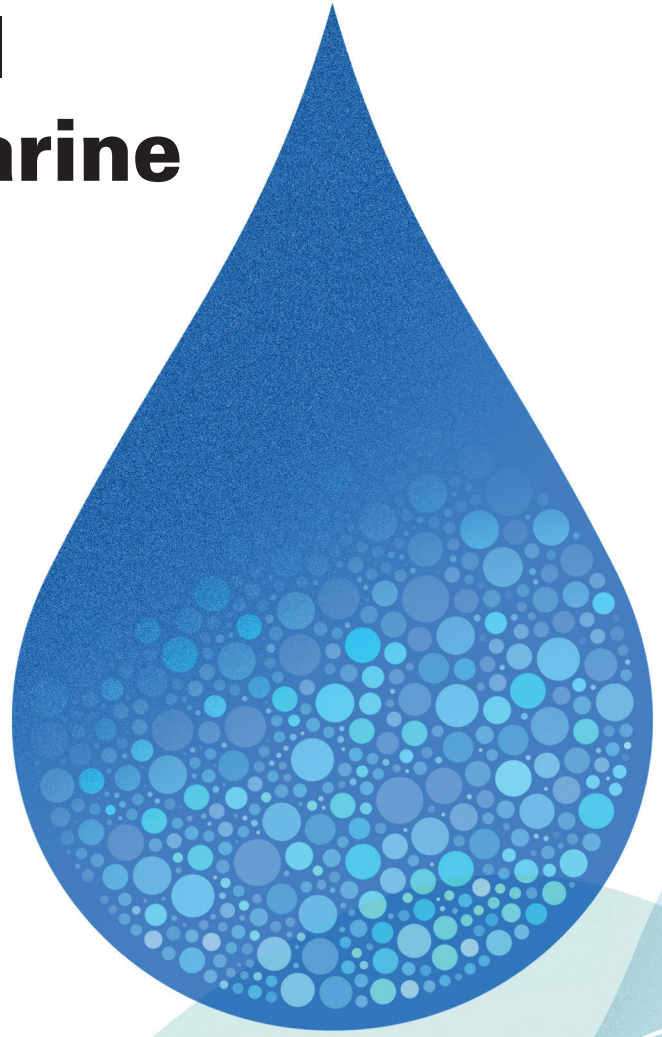


# Carbon Neutral Solution for Marine

Hydrogen Generation System  
& Carbon Capture, Utilization and Storage



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 environment to the water environment, and to our hydrogen business.

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 Quality Environment



Water treatment system



Measurement control system

## Air Quality Environment



De-SOx Scrubber system



De-NOx SCR system



Carbon Capture, Utilization and Storage system (CCUS)

## Hydrogen Business

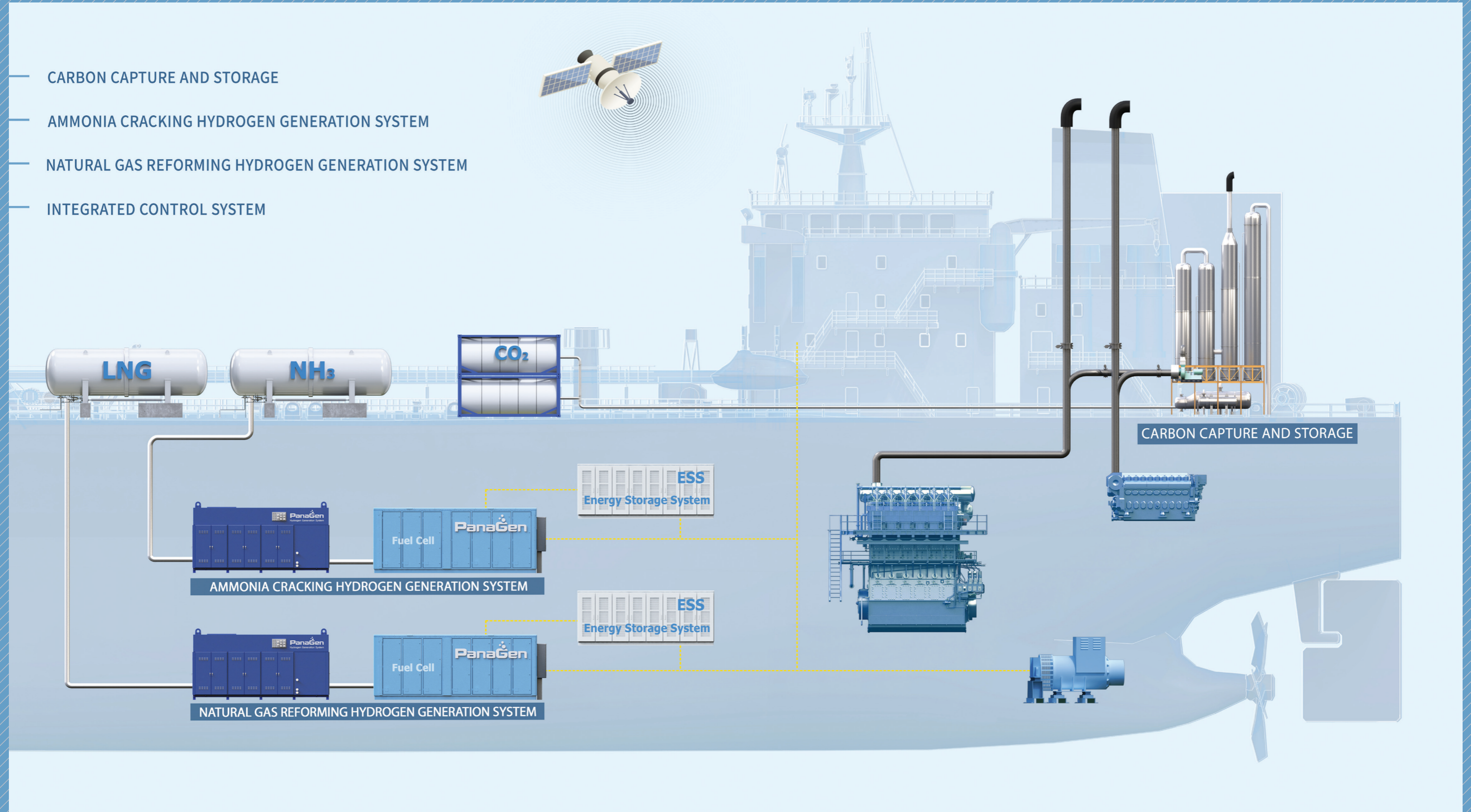


Hydrogen generation system



# CARBON-NEUTRAL SOLUTION CATEGORY FOR SHIP

Hydrogen Generation System  
& Carbon Capture, Utilization and Storage



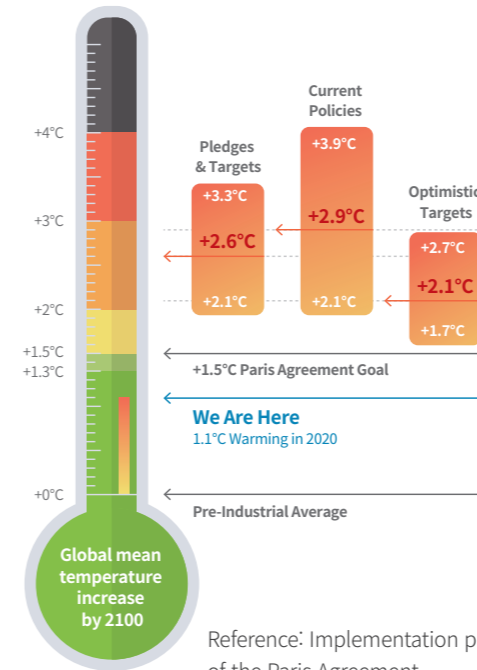


# Carbon Capture, Utilization and Storage (CCUS) System

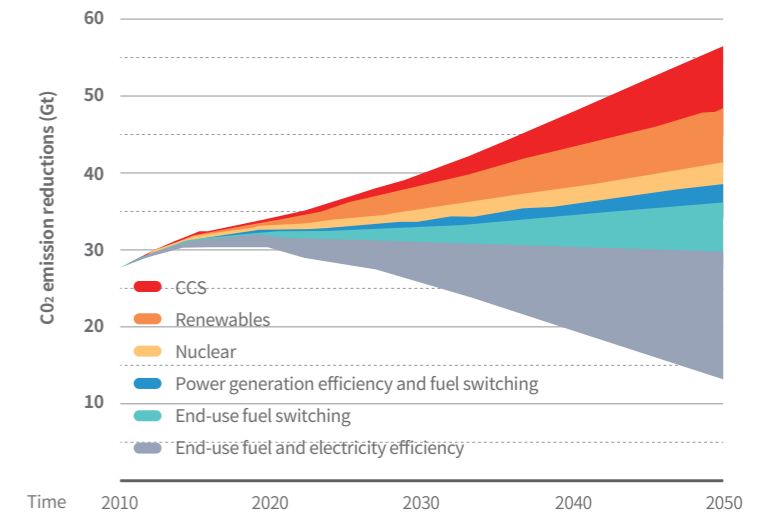


PANASIA's Pan-CCUS™

The Carbon Capture, Utilization and Storage system for ships is a system that captures and utilizes carbon dioxide generated during combustion of fossil fuel used to propel and generate power for ships and reforming to produce hydrogen, in order to reduce the amount of CO<sub>2</sub> released into the air.



Reference: Implementation prospects of the Paris Agreement








Reference: Predictions for greenhouse gas emissions mitigation measures

CCUS is predicted to contribute to 19% of the total CO<sub>2</sub> emission reductions globally by 2050. Without CCUS, the cost of reducing emissions would increase by more than 70%. In other words, CCUS will play a pivotal role in reducing CO<sub>2</sub> emissions.

PANASIA's Pan-CCUS™ will lead the way to a carbon-neutral world.

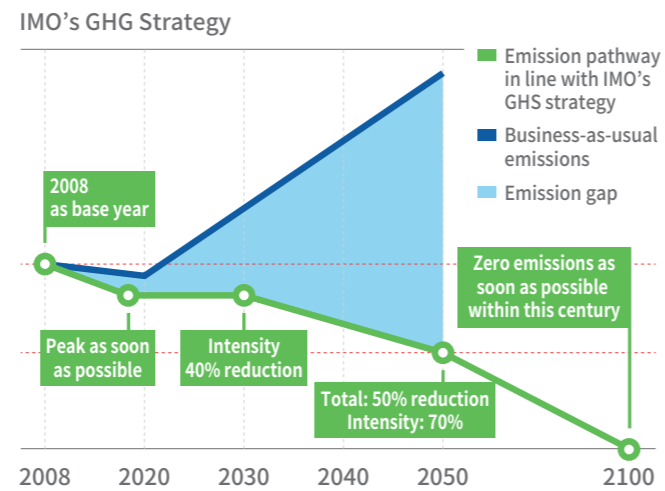
### Features

-  High purity of product CO<sub>2</sub>
-  Compact size of tower and configurations
-  Low energy consumption
-  Simple and reliable operation
-  Full automation

# REGULATION

## EEDI (Energy Efficiency Design Index) & EEXI (Energy Efficiency Existing ship Index)

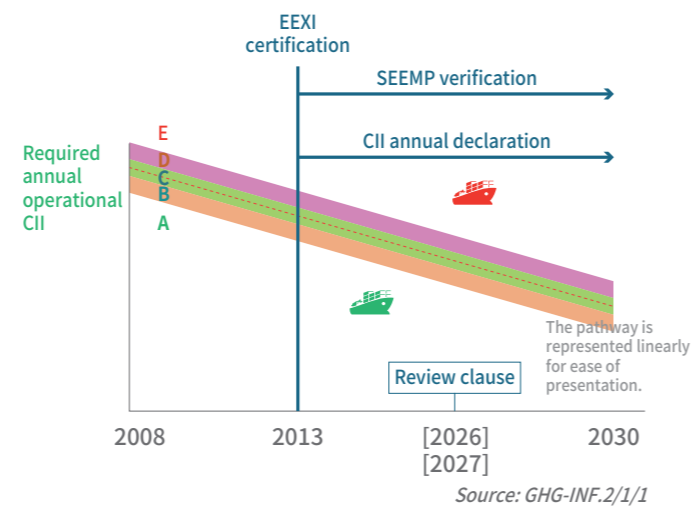
- Setting targets to reduce CO<sub>2</sub> emissions per transport work by the nth year below the 2008 peak
- CO<sub>2</sub> emissions generated by a ship when transporting 1 ton of cargo 1 nautical mile; for 13 types of ships with gross tonnage more than 400 tons, the EEDI must be calculated for each new ship
- The EEDI applies to ships built since 2015, targeting a 30% reduction of greenhouse gas emissions by 2025 (with the base year of 2013)



## 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.



### Calculation of annual CII:

$$CII = \frac{\text{Annual fuel consumption} \cdot \text{CO}_2 \text{ factor}}{\text{Annual distance travelled} \cdot \text{Capacity}} \cdot \text{Correction factors}$$

*To be developed*

## Solution

Classification	Area	Green ship technologies
Propulsion and hull	Hull form / Lightweight construction	Wave-making resistance / frictional resistance / air resistance / Lightweight hull construction using advanced materials and composites
	Auxiliary power	Auxiliary propulsion using solar and wind power
	Hull coating / Hull decontamination / Propeller polishing	Coatings made of advanced materials applied to reduce hull resistance / Hull surface decontamination / Propeller decontamination to improve propulsion efficiency
Energy efficiency improvement	Shaft generator	Technology of generating power from the main engine
	Waste heat recovery system	Recovering heat energy from exhaust gas and converting it into electricity
	Hydrogen fuel cell system	Generating electricity using hydrogen fuel cells
Greenhouse gas emissions reduction	CO <sub>2</sub> capture system	Combustion gas after-treatment, CO <sub>2</sub> capture and storage
Alternative fuel	Ammonia	Propulsion technology using ammonia

※ CCUS has a significant capacity to reduce GHG emissions and can be applied directly.

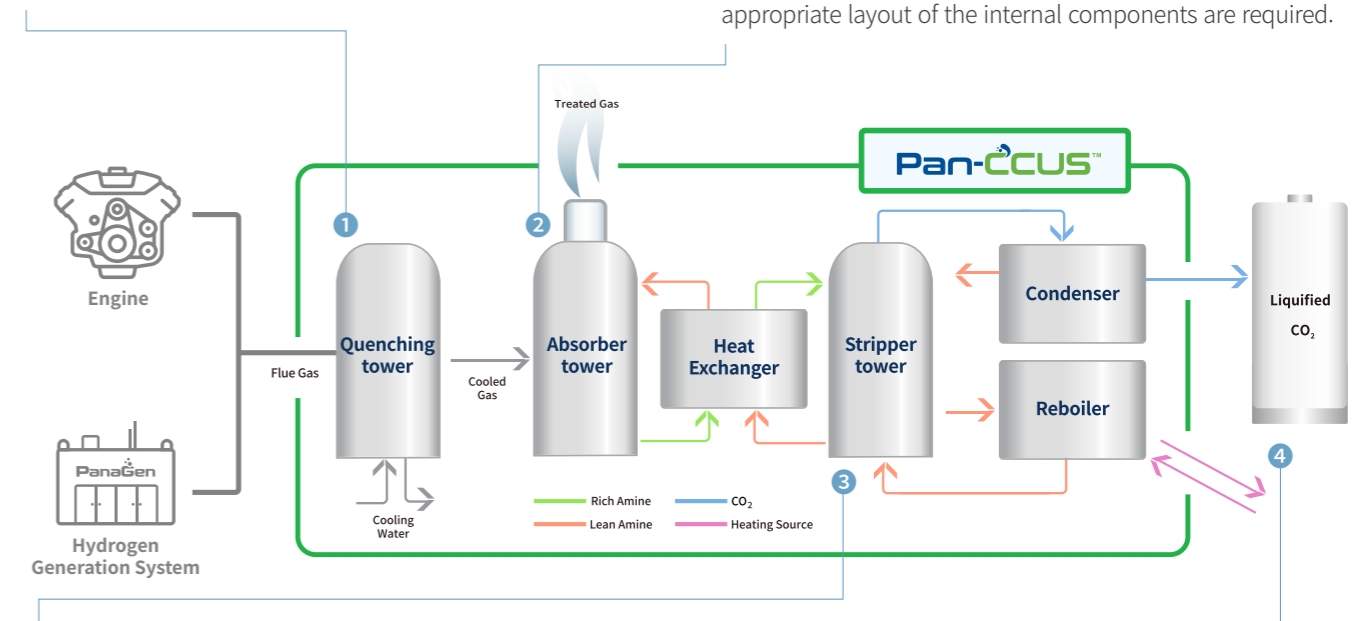
# TECHNOLOGY

## 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.

## Applications



### for Hydrogen Generation System

Capacity 80 / 200 / 400 CO<sub>2</sub> kg/h  
 Purity 99.9% CO<sub>2</sub>  
 Feature High concentration of CO<sub>2</sub>  
 Modular design  
 High purity of CO<sub>2</sub>



### for Ship

Capacity 1 / 2 / 3 CO<sub>2</sub> ton/h ~  
 Purity 99.9% CO<sub>2</sub>  
 Feature Changing concentration of CO<sub>2</sub>  
 Space limitation  
 CCS for marine condition  
 Load change of engine



### for Industrial Plant

Capacity 5 / 10 / 15 CO<sub>2</sub> ton/h ~  
 Purity 99.9% CO<sub>2</sub>  
 Feature Large scale of CCS  
 Long-term Stability  
 Cost efficient

# Hydrogen Generation System



Hydrogen is generated from fuels such as natural gas and ammonia through hydrogen reforming process, and the hydrogen energy supplies power to ships through fuel cells and ESS(Energy Storage Systems).

This will replace or support conventional main and generator engines of the ships to meet stricter environmental regulations.



### – 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

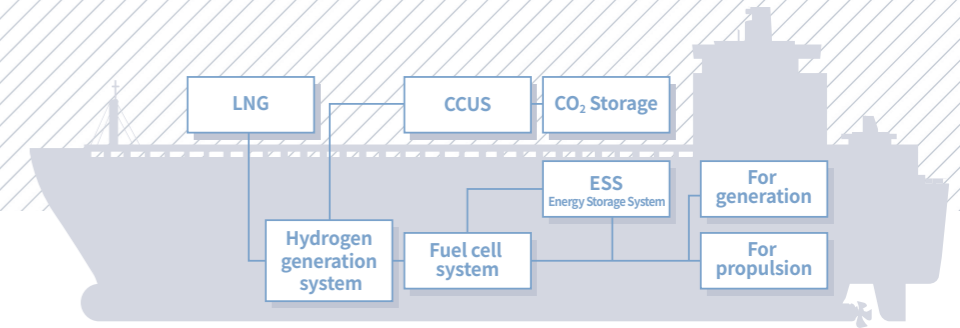


Fast initial and warm start up

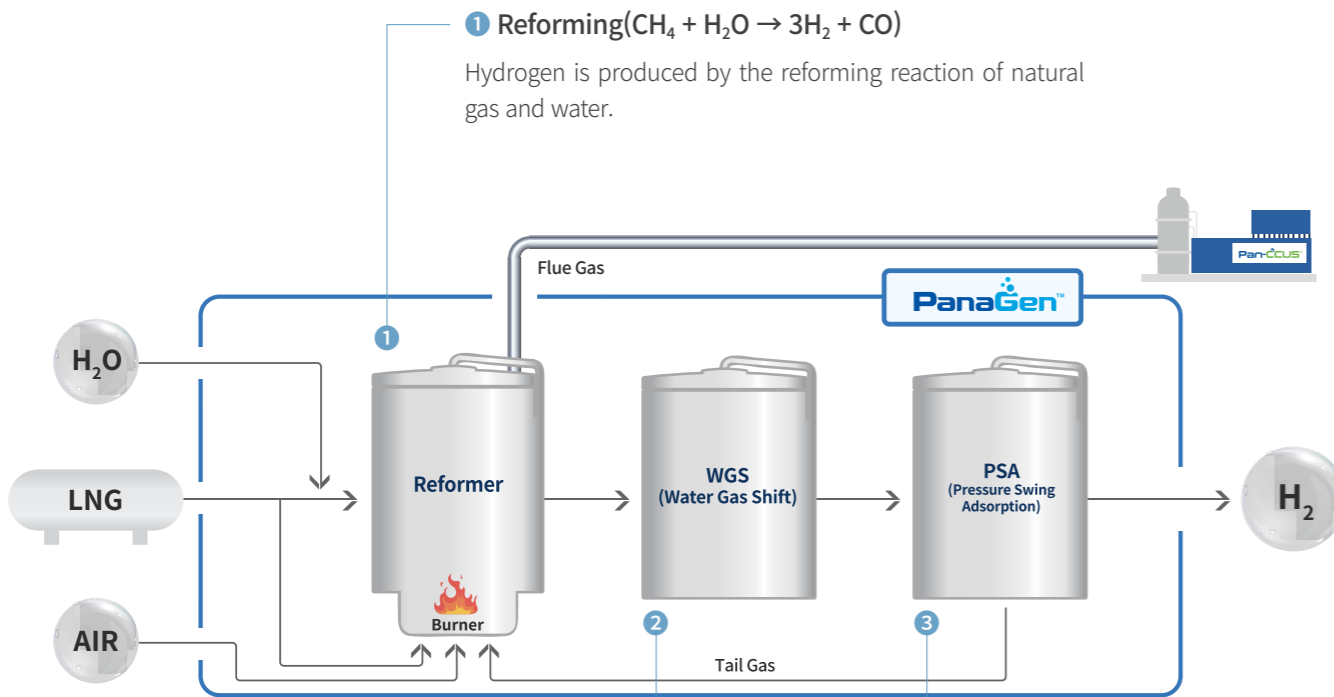


Real time monitoring & control through “Smart Control Center”

— Natural gas-reforming hydrogen generation system



High Pressure System for High Purity Fuel Cell



**1 Reforming**( $\text{CH}_4 + \text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{CO}$ )  
 Hydrogen is produced by the reforming reaction of natural gas and water.

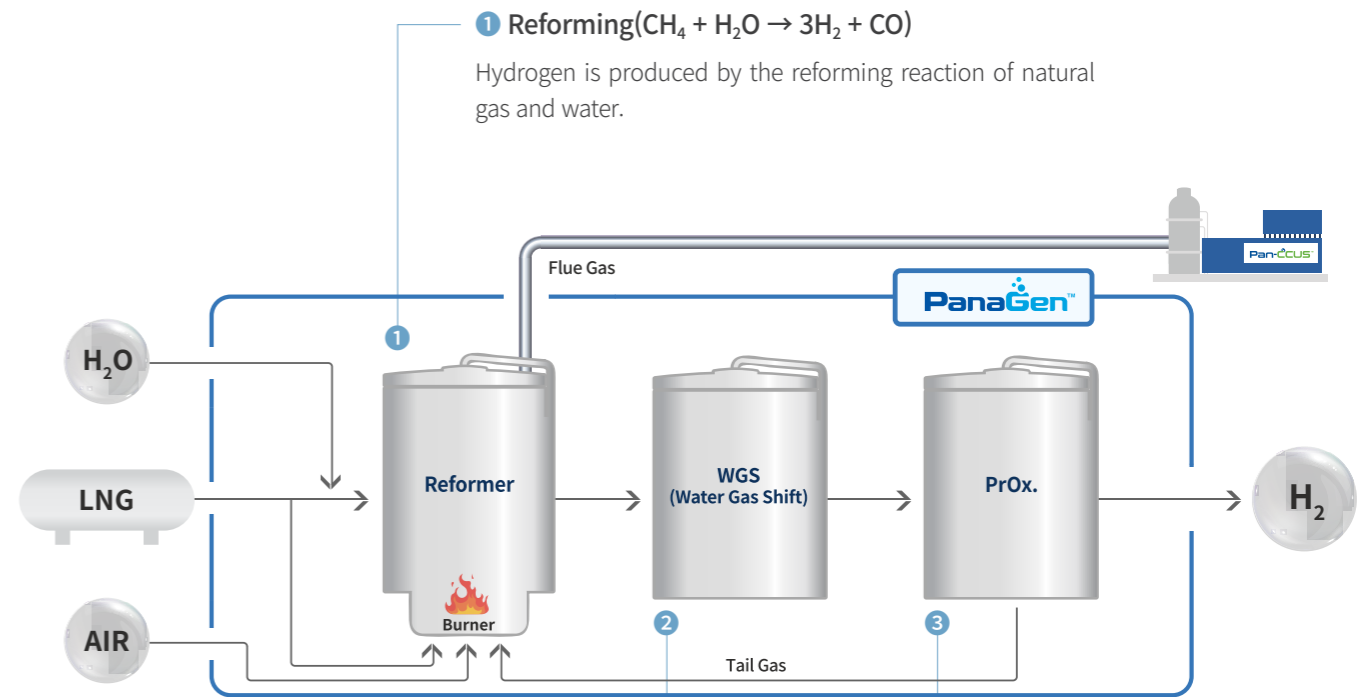
**2 Water-Gas Shift**( $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$ )  
 Through the water-gas shift(WGS) reaction of CO<sub>2</sub> inside the syn-gas, additional hydrogen can be produced.

**3 Purification**(PSA : Pressure Swing Adsorption)  
 Through the PSA purification process, which utilizes the adsorption difference caused by pressure, pure hydrogen(99.999%) is separated. The remaining impurities, including H<sub>2</sub>, CO, CO<sub>2</sub>, and CH<sub>4</sub> (tail gases) are supplied to the burner so they can be used as sources of heating.

— SPECIFICATIONS

Feed Gas	Pressure	Product(H <sub>2</sub> )		
		Capacity	H <sub>2</sub> Purity	Pressure
Natural Gas	8.5~10 bar.g	Customized	99.999%	6 bar.g

Low Pressure System for High Efficiency Fuel Cell



**1 Reforming**( $\text{CH}_4 + \text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{CO}$ )  
 Hydrogen is produced by the reforming reaction of natural gas and water.

**2 Water-Gas Shift**( $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$ )  
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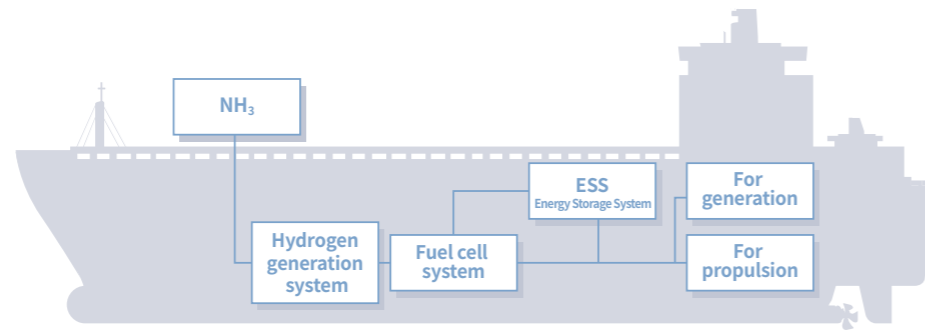
**3 PrOx.**(Preferential Oxidation)  
 In order to get rid of remained CO in the reformed gas, additional oxygen is supplied to selectively oxidize.

— SPECIFICATIONS

Feed Gas	Pressure	Product(H <sub>2</sub> )		
		Capacity	H <sub>2</sub> Purity	Pressure
Natural Gas	0.3 bar.g	Customized	~80%	atm

# TECHNOLOGY

## Ammonia cracking hydrogen generation system

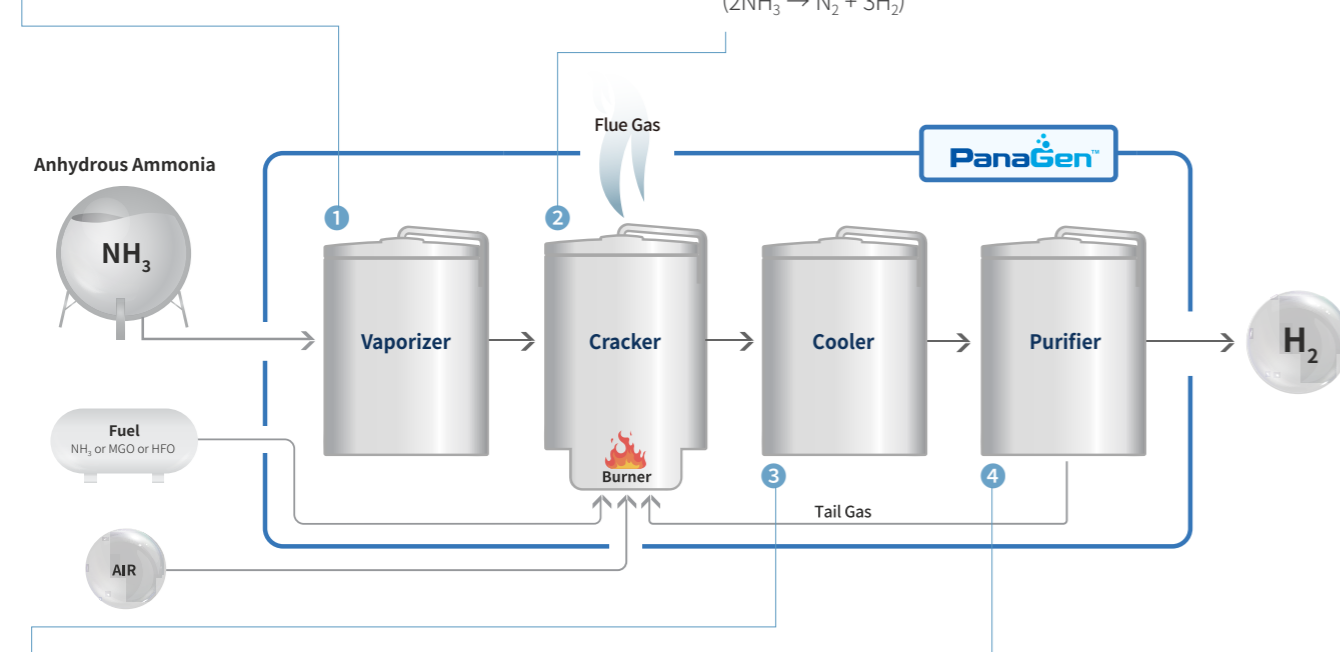


### 1 Vaporizer

The process of vaporizing liquefied ammonia, converting it into gas, and preheating the gas for an efficient reaction.

### 2 Ammonia Cracker & Burner

The process by which ammonia decomposes into nitrogen and hydrogen through the decomposition of ammonia gas.  $(2\text{NH}_3 \rightarrow \text{N}_2 + 3\text{H}_2)$



### 3 Cooler

The process of cooling generated gas at room temperature to prepare for the purification process.

### 4 Purification (PSA & Absorber)

The process of separating and absorbing non-reactive ammonia and the generated nitrogen to increase the purity of hydrogen.

## SPECIFICATIONS

Feed Gas	Pressure	Product(H <sub>2</sub> )		
		Capacity	H <sub>2</sub> Purity	Pressure
Ammonia	~10 bar.g	Customized	75% / 98% / 99.5% (NH <sub>3</sub> < 0.1 ppm)	6 bar.g or atm

## Integrated Control System

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



At PANASIA, we offer outstanding 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™**

DE-SOx SYSTEM  
**PaSOx™**

DE-NOx SCR SYSTEM  
**PaNOx™**

**Pan-CCUS™**

**PanaGen™**

**PANASIA**  
Smart Integrated Control System

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 power generated, efficiency, etc.
- Fault diagnosis and analysis

### Efficient management

- Supporting online remote updates
- Big data-based maintenance and control
- Spare parts replacement notifications
- Keeping operational losses to a minimum



# PANASIA

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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.