PANASIA

Carbon Capturing Pioneer in Korea

Contents

01 GENERAL INTRODUCTIION

Business Category

Hydrogen Business

-Hydrogen generation systems

Air Quality Environment

- Carbon Capture, Utilization and Storage (CCUS) system
- De-SOx Scrubber system
- De-NOx SCR system

Water Quality Environment

- Water treatment system
- Measurement & Control System

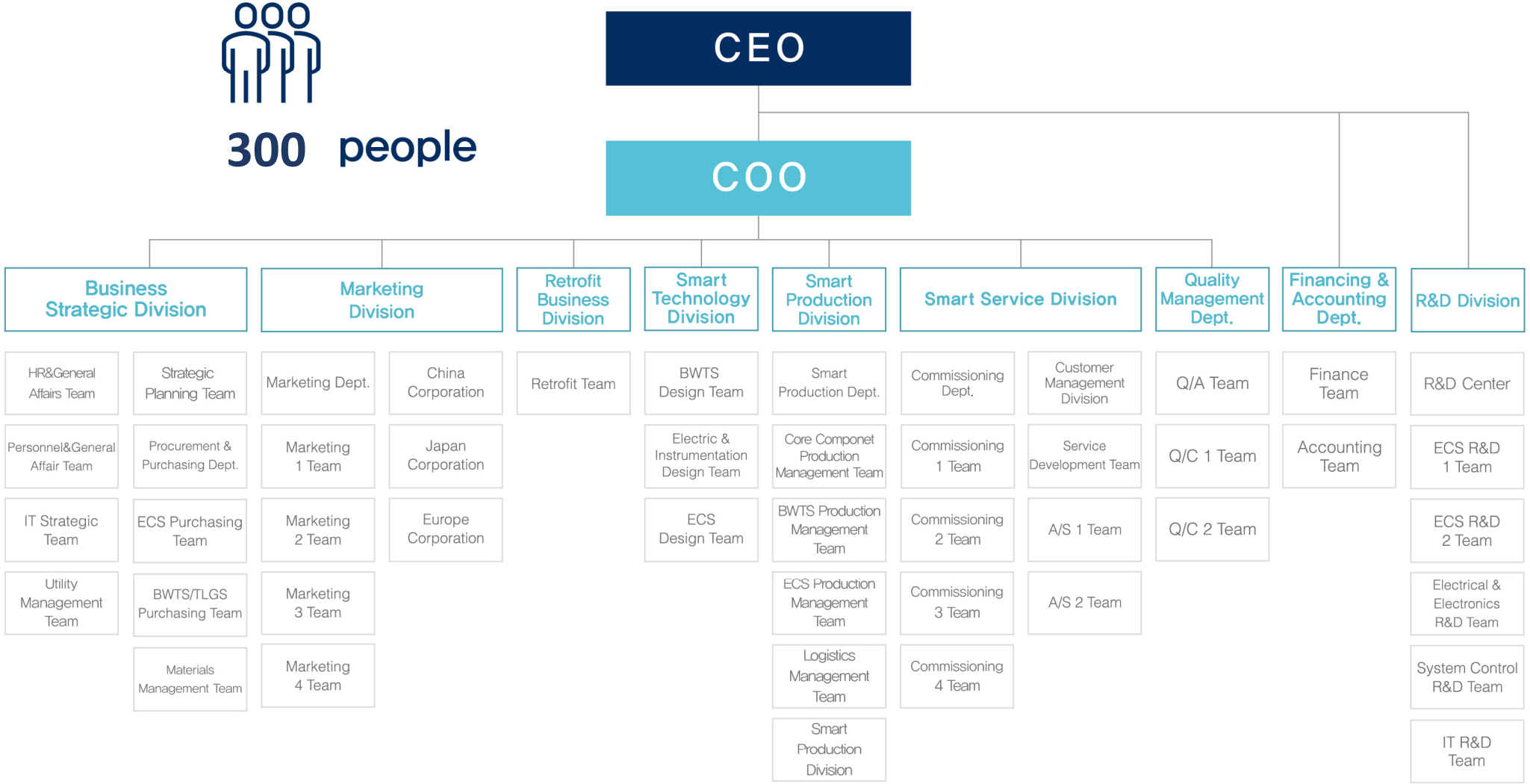
Services

- RETROFIT Service
- MRO Service
  - · Preventive Check-up Service & Calibration
  - · Training Center & Engineer Training
  - · E-Learning Program
  - · Integrated Control System

PANASIA Introduction

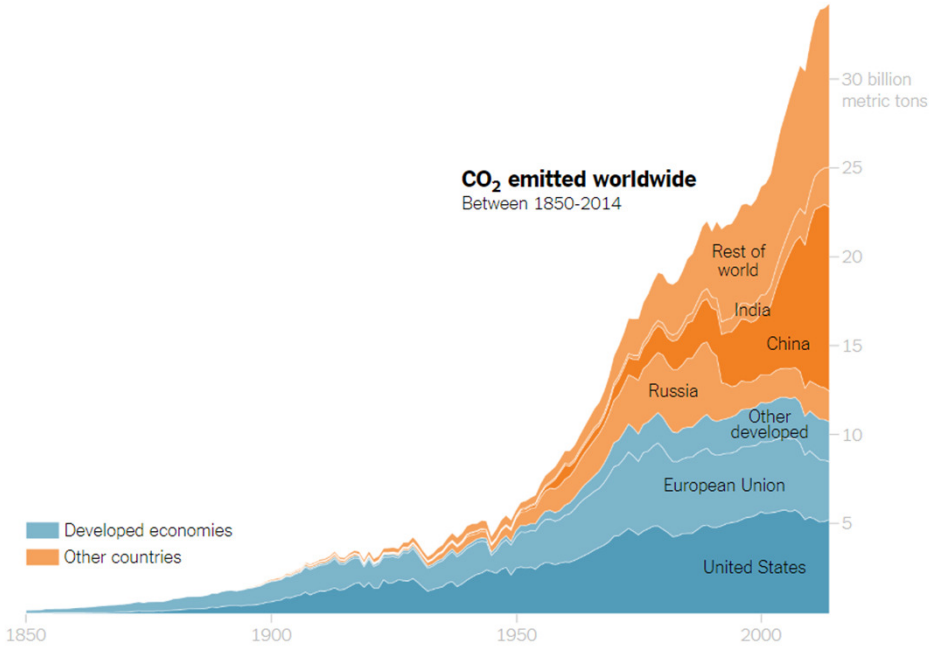
Organization

300 people



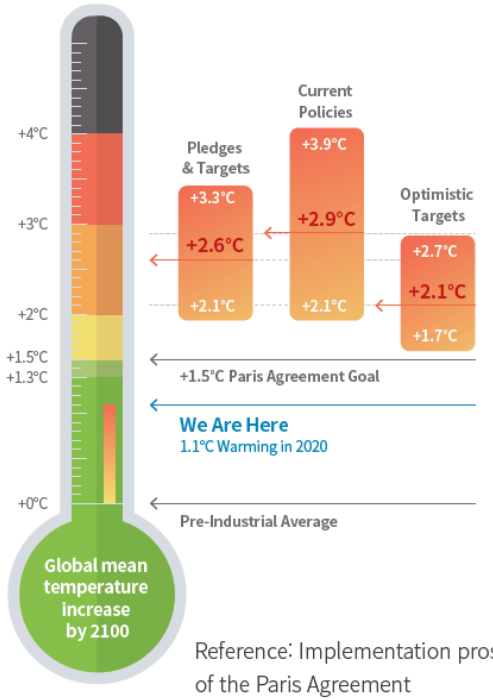
02 Rule & Regulation

Rule & Regulation

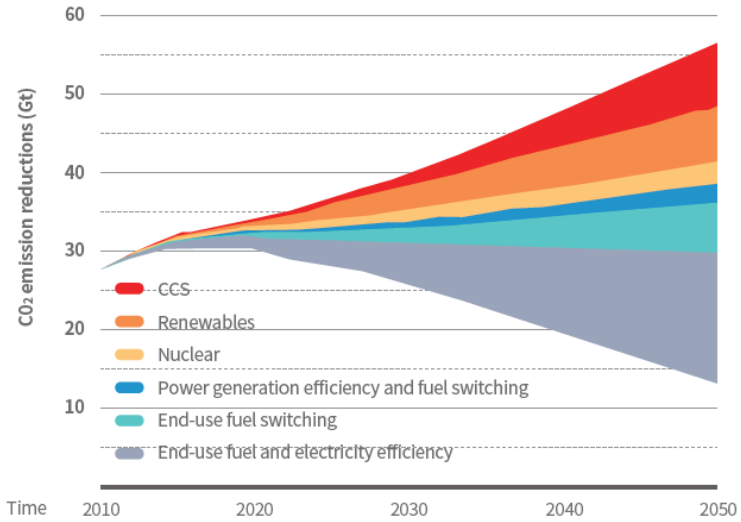


Human activities have increased the concentration of Carbon dioxide in our atmosphere, amplifying Earth's natural greenhouse effect.

Rule & Regulation



Reference: Implementation prospects of the Paris Agreement



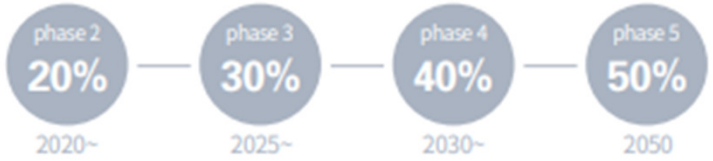
Reference: Predictions for greenhouse gas emissions mitigation measures

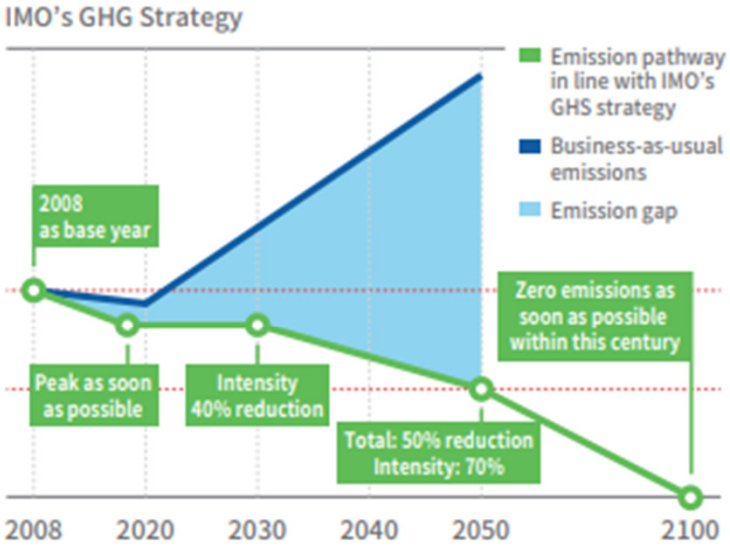
Paris Agreement aims to limit the increase in global mean temperature to a maximum of **2°C** and the primary target of **1.5°C** compared to before industrialization.
IEA(International Energy Agency) predicts that **C**arbon **C**apture and **S**torage method takes **17%** share of carbon dioxide reductions in 2050 as an efficient and economical way.

Rule & Regulation

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

- Setting targets to reduce CO_2 emissions per transport work by the nth year below the 2008 peak
- CO_2 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)

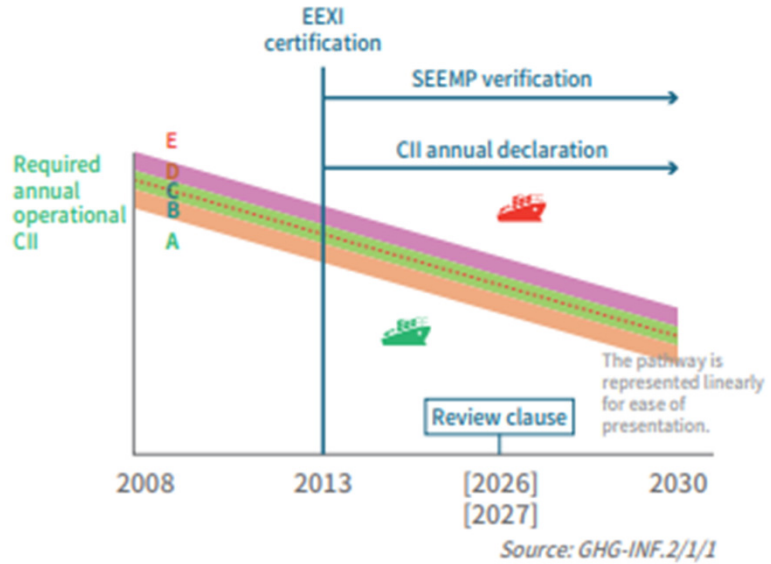
Carbon Intensity Indicator (CII)

- 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:

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

To be developed



Source: GHG-INF.2/1/1

03 PANASIA CCS Technology

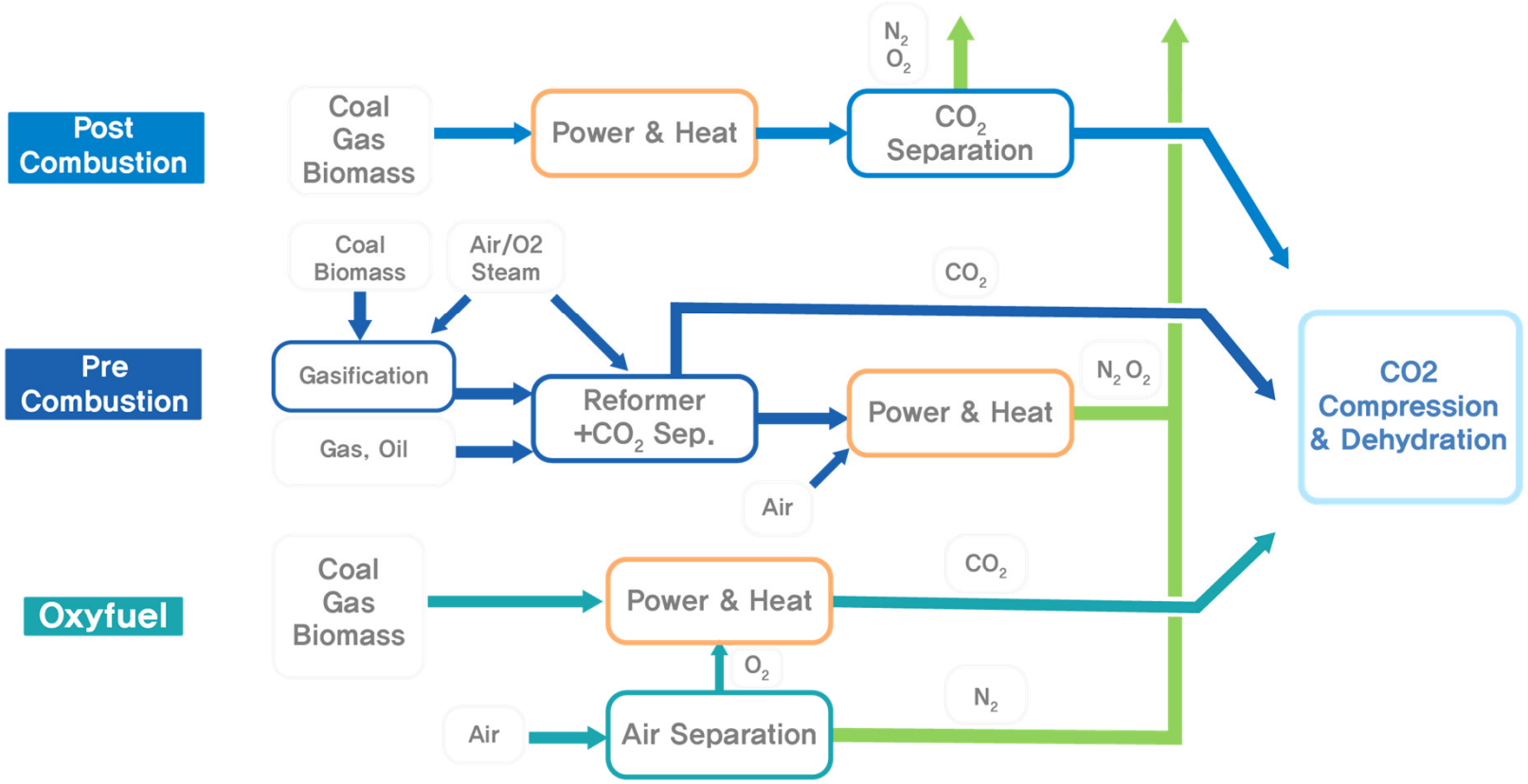
Pan-CCUS

Carbon Capture, Utility and Storage System

CCS

CO_2 Capturing technology

CO_2 Capturing Technology

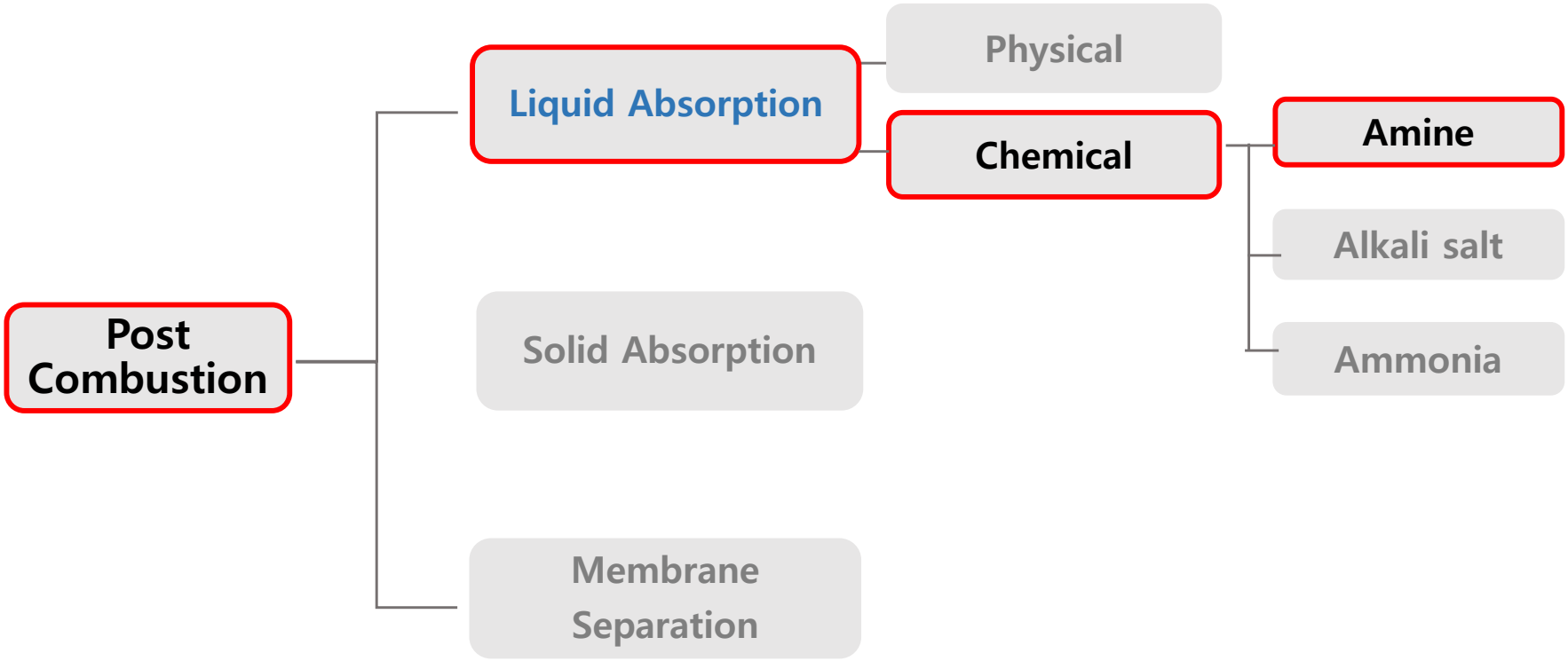


Post-Combustion	Pre-Combustion	Oxyfuel
CO_2 capturing from flue gas	CO_2 capturing before combution	N_2 separation from air before combution
Commercial stage	Low TRL	High energe sonsumption of N_2 separation

CCS

CO_2 Capturing technology

CO_2 Capturing Technology



"Feature of Liquid Absorption"

Strength

- Easy to handle large volume of gas
- Great applicable to change Carbon dioxide concentration

Weakness

- Large amount of energy loss to regenerate absorbent
- Absorbent deterioration and material corrosion

CCS

CO_2 Capturing technology

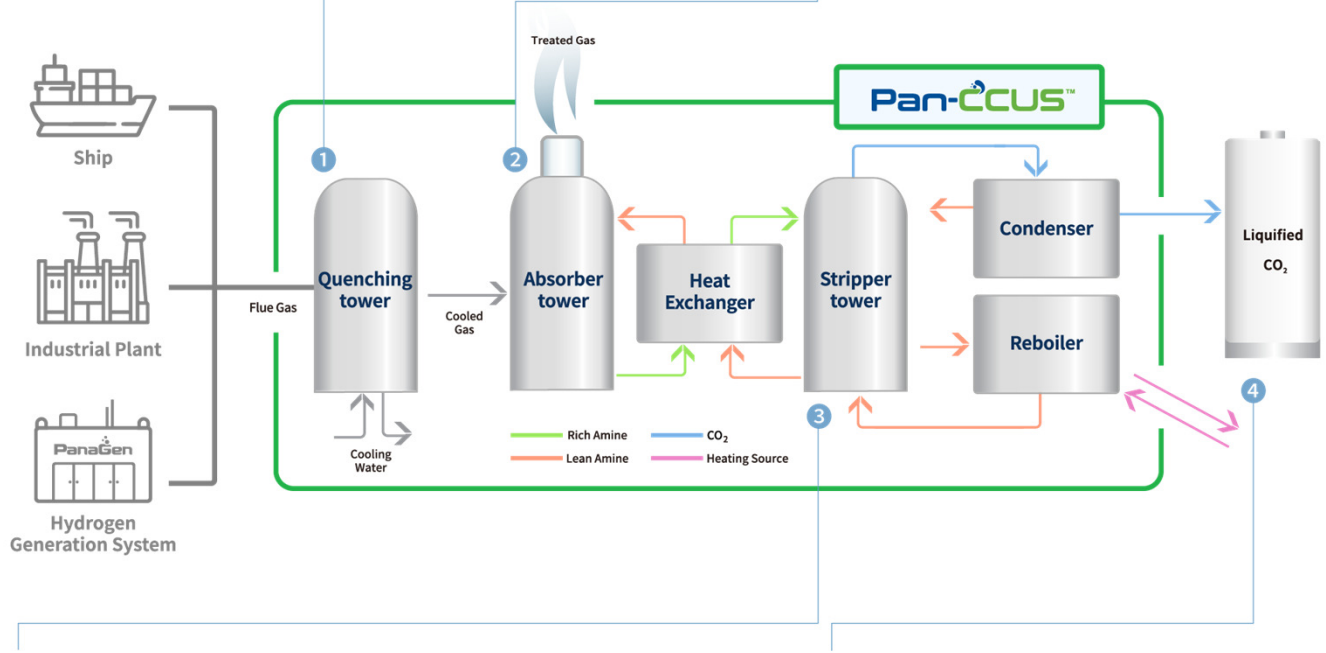
CCS Technical flow diagram

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_2 Absorption

Once cooled, the gas comes into contact with the chemical solvent in the absorber, and CO_2 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

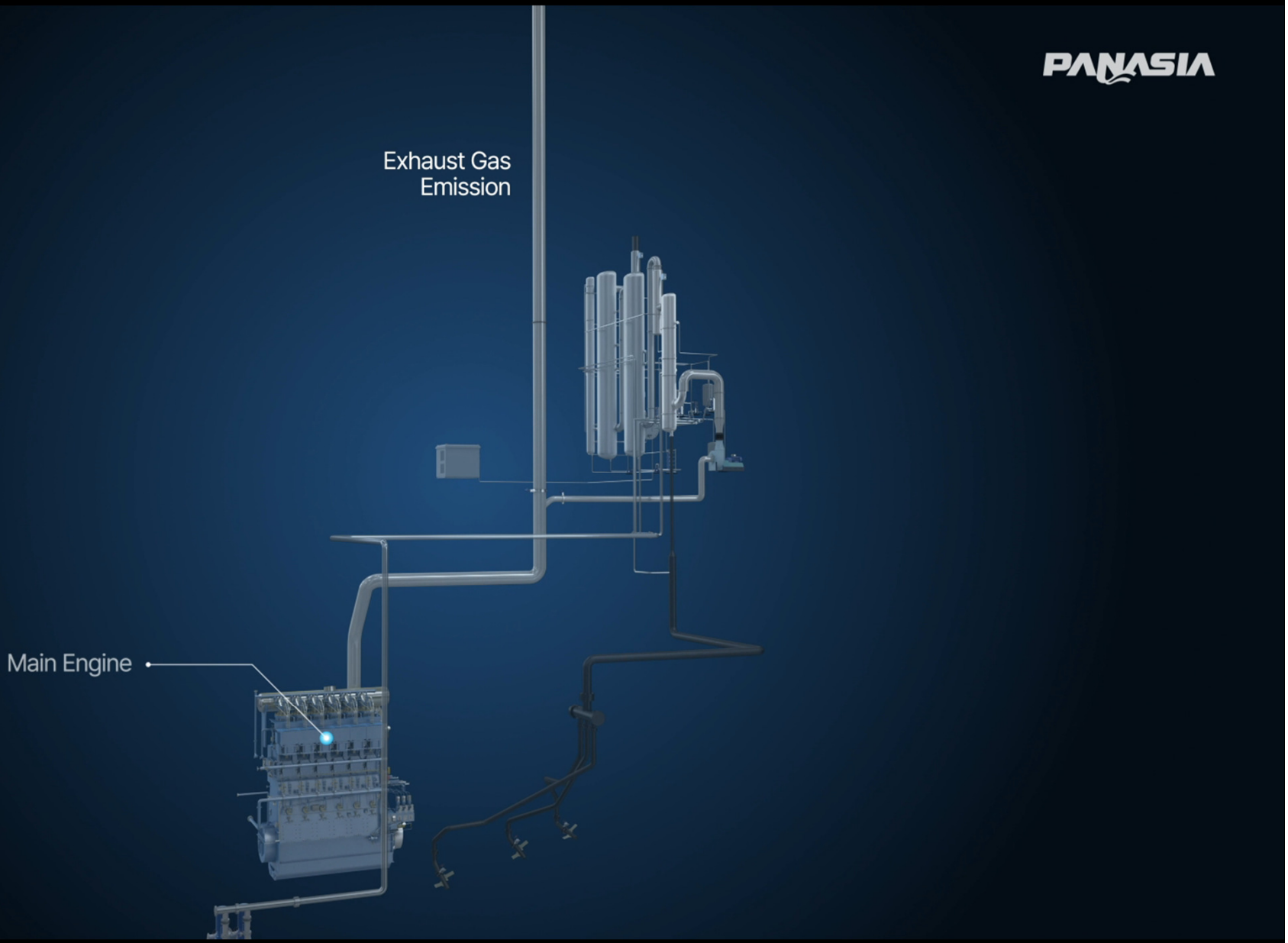
A solvent that has absorbed CO_2 is transferred to the stripper tower. The high-temperature vapor in the reboiler causes CO_2 to be removed from the solvent. In the cooling tower, it breaks down into water and CO_2. Then, the water is recovered and sent to the stripper while CO_2 is transferred to the liquefaction process.

④ Liquefaction & Storage

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

CO_2 CAPTURE

PANASIA



CCS

CCS Line-up

CCS Line-up & Target Industry

CCS for Hydrogen Genration System

Capacity : 80 / 200 / 300 CO_2 kg/hr

Purity : 99.99% CO_2(Liquefaction)

Type : Liquid / Membrane

Key feature

- High concentration CO_2 capturing
- Optimized design
- High concentration CO_2 requefaction

CCS for Ships

Capacity : 1 / 2 / 3 CO_2 ton/hr

Purity : 99.99% CO_2(Liquefaction)

Type : Liquid

Key feature

- Various CO_2 concentration technology
- Optimized design
- System design as per vessel resource
- Flexibility against load data according to vessel operation

CCS for Industrial Plant

Capacity : 5 / 10 / 15 CO_2 ton/hr

Purity : 99.99% CO_2(Liquefaction)

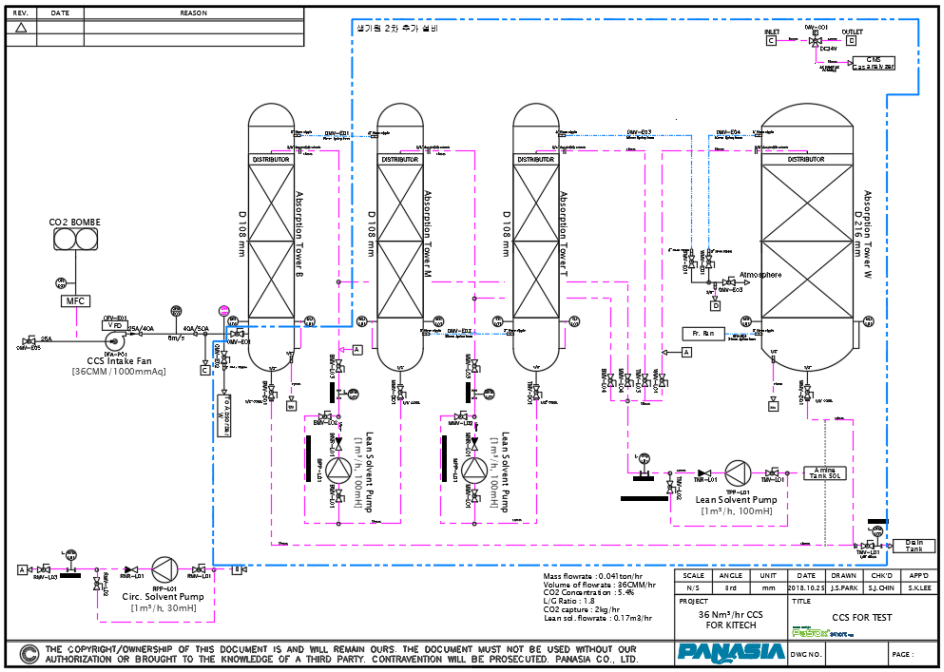
Type : Liquid

Key feature

- High capacity CO_2 capturing
- Long term operation stability
- Operating Point–Economical operation point

CCS

Lap Scale CCS



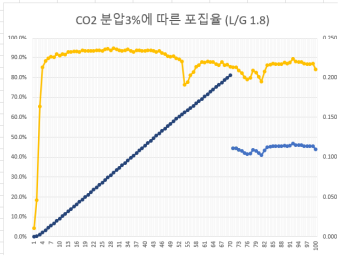
<36Nm3/h Pilot CCS P&ID>

<36Nm3/h Pilot CCS>

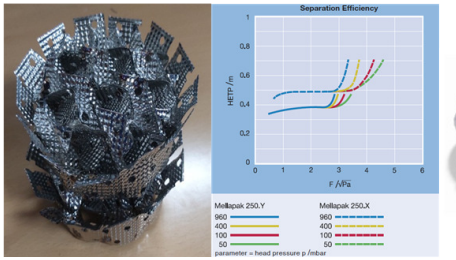
Composition of Air with CO2									
	Total Flowrate	36	m3/h	600 L/min		Solvent Flowrate		1.1 L/min	1.833333
Test 생기원 (Air)	Member	Composition (%)	Molcular weight	Flowrate (Liter/h)		mol		mol%	Weight (kg)
	Air	97.0%	28.9647	34.920		1558.9		95.5%	45.15
	CO2	3.0%	44.011	1,080		48.2		4.5%	2.12
	temp.	30degC		18 L/min	actual. 33mL/min	Final solvent Vol.(L)			
Start time	12:54 PM		0.19		CO2 Loading 0.2 m/m	45 L 251 MEAmol	38 L 212 MEAmol	Remark	
Test lap(Min)	Sweet gas %	Diff %	포집율	Added CO2	CO2mol/MEAmol	CO2 Loading	0.189399968		
1	2.87	0.13%	4.3%	0.035		0.000	250.820	12:55 PM	
2	2.45	0.55%	18.3%	0.147		0.001	250.630	12:56 PM	
3	1.04	1.96%	65.3%	0.525		0.003	250.441	12:57 PM	
4	0.45	2.55%	85.0%	0.683		0.006	250.251	12:58 PM	
5	0.35	2.65%	88.3%	0.710		0.008	250.062	12:59 PM	
6	0.31	2.69%	89.7%	0.721		0.011	249.873	1:00 PM	
7	0.29	2.71%	90.3%	0.726		0.014	249.683	1:01 PM	
8	0.3	2.70%	90.0%	0.723		0.017	249.494	1:02 PM	
9	0.25	2.75%	91.7%	0.737		0.020	249.304	1:03 PM	
10	0.27	2.73%	91.0%	0.731		0.023	249.115	1:04 PM	
11	0.25	2.75%	91.7%	0.737		0.026	248.926	1:05 PM	
12	0.26	2.74%	91.3%	0.734		0.029	248.736	1:06 PM	
13	0.22	2.78%	92.7%	0.745		0.032	248.547	1:07 PM	
14	0.22	2.78%	92.7%	0.745		0.035	248.357	1:08 PM	
15	0.21	2.79%	93.0%	0.747		0.038	248.168	1:09 PM	
16	0.21	2.79%	93.0%	0.747		0.041	247.979	1:10 PM	
17	0.22	2.78%	92.7%	0.745		0.044	247.789	1:11 PM	
18	0.19	2.81%	93.7%	0.753		0.047	247.600	1:12 PM	
19	0.2	2.80%	93.3%	0.750		0.050	247.410	1:13 PM	
20	0.2	2.80%	93.3%	0.750		0.053	247.221	1:14 PM	
21	0.2	2.80%	93.3%	0.750		0.056	247.032	1:15 PM	
22	0.2	2.80%	93.3%	0.750		0.059	246.842	1:16 PM	
23	0.19	2.81%	93.7%	0.753		0.062	246.653	1:17 PM	
24	0.19	2.81%	93.7%	0.753		0.065	246.463	1:18 PM	
25	0.2	2.80%	93.3%	0.750		0.068	246.274	1:19 PM	
26	0.18	2.82%	94.0%	0.755		0.071	246.085	1:20 PM	
27	0.17	2.83%	94.3%	0.758		0.074	245.895	1:21 PM	

증유량	36 Nm^3/h		
CO2	33mL/min	5.70%	13:05
배압	50 mmaq		CO2 INLET 6.40%
온도	30 degC	26	
		1:03 PM	
포집율	90%	mol	
아민	1.1 L/min	0.1022	mol
CO2	18 L/min	0.0121	mol
5.55%	포집율에 따른 CO2 L	0.1180	m/m
평균 값	86.9%		
중위 값	88.0%		

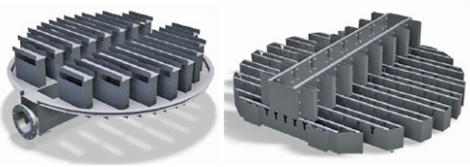
0.3m/m Open Loop



<TEST REPORT>

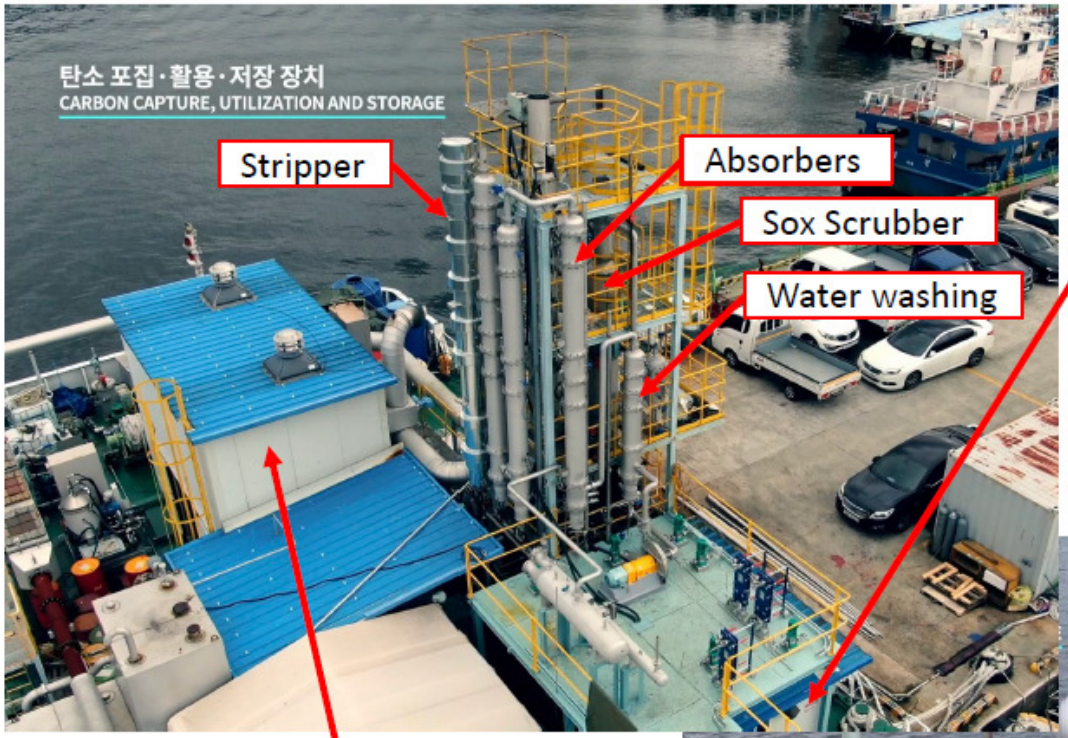


<Packing & internal components>



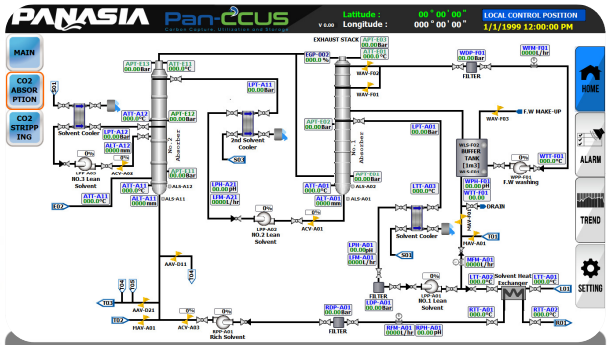
CCS

Pilot CCS for test barge



Control Room

* Engine 및 CCS system Control

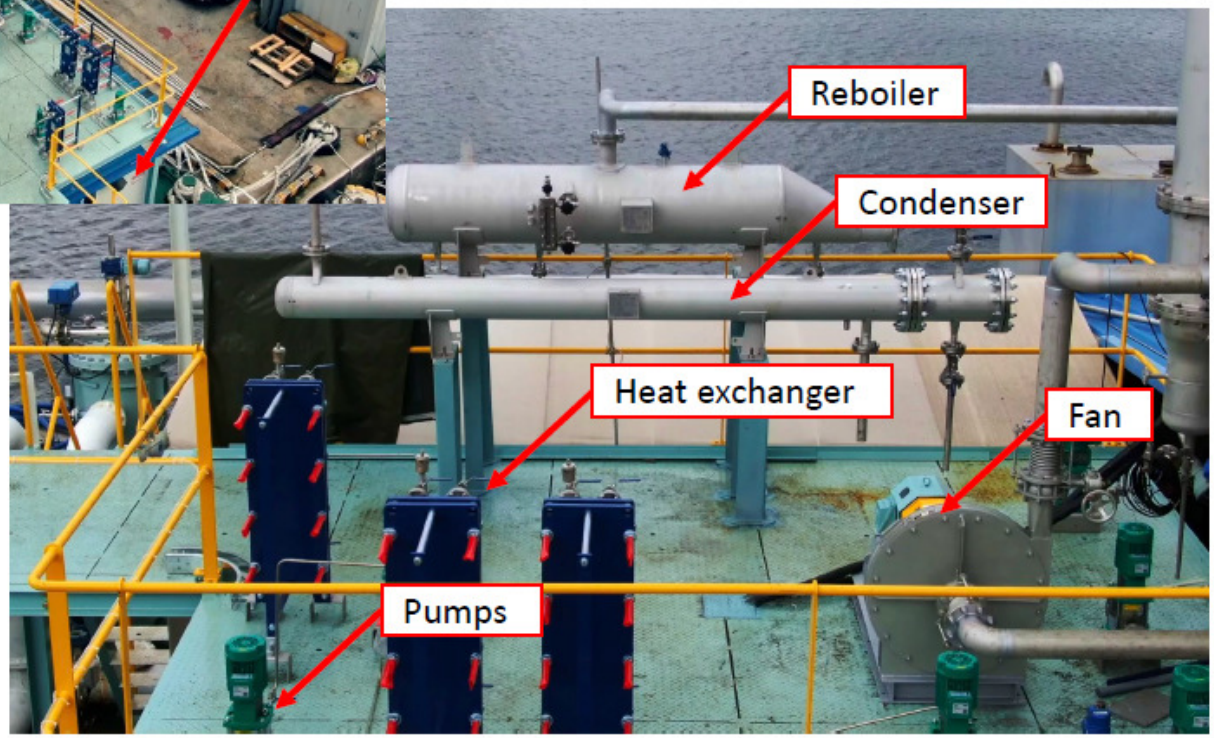


HMI

* Test data logging & Test throu HMI

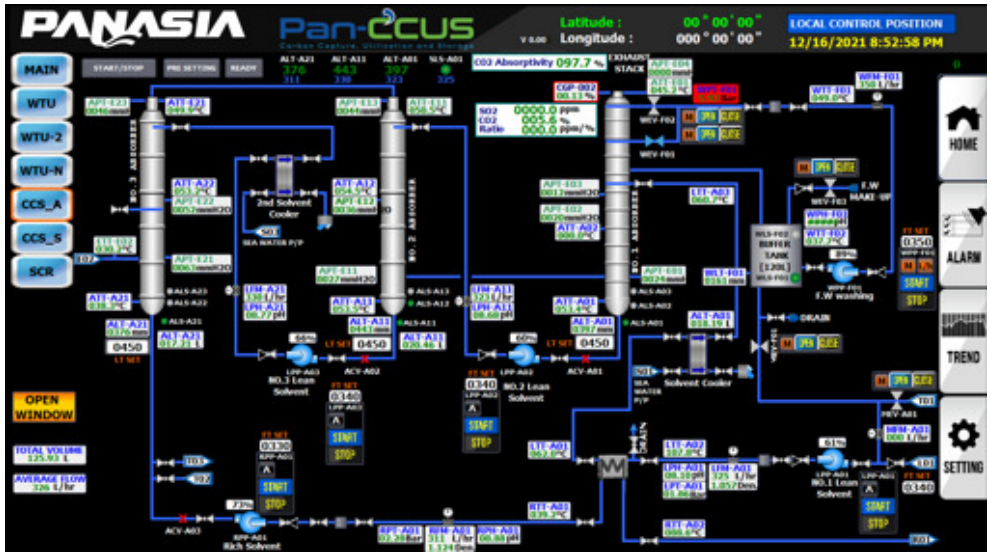
5L 23/30H STX MAN Engine

* 650kW
* 720 rpm
* Diesel / HFO Operating



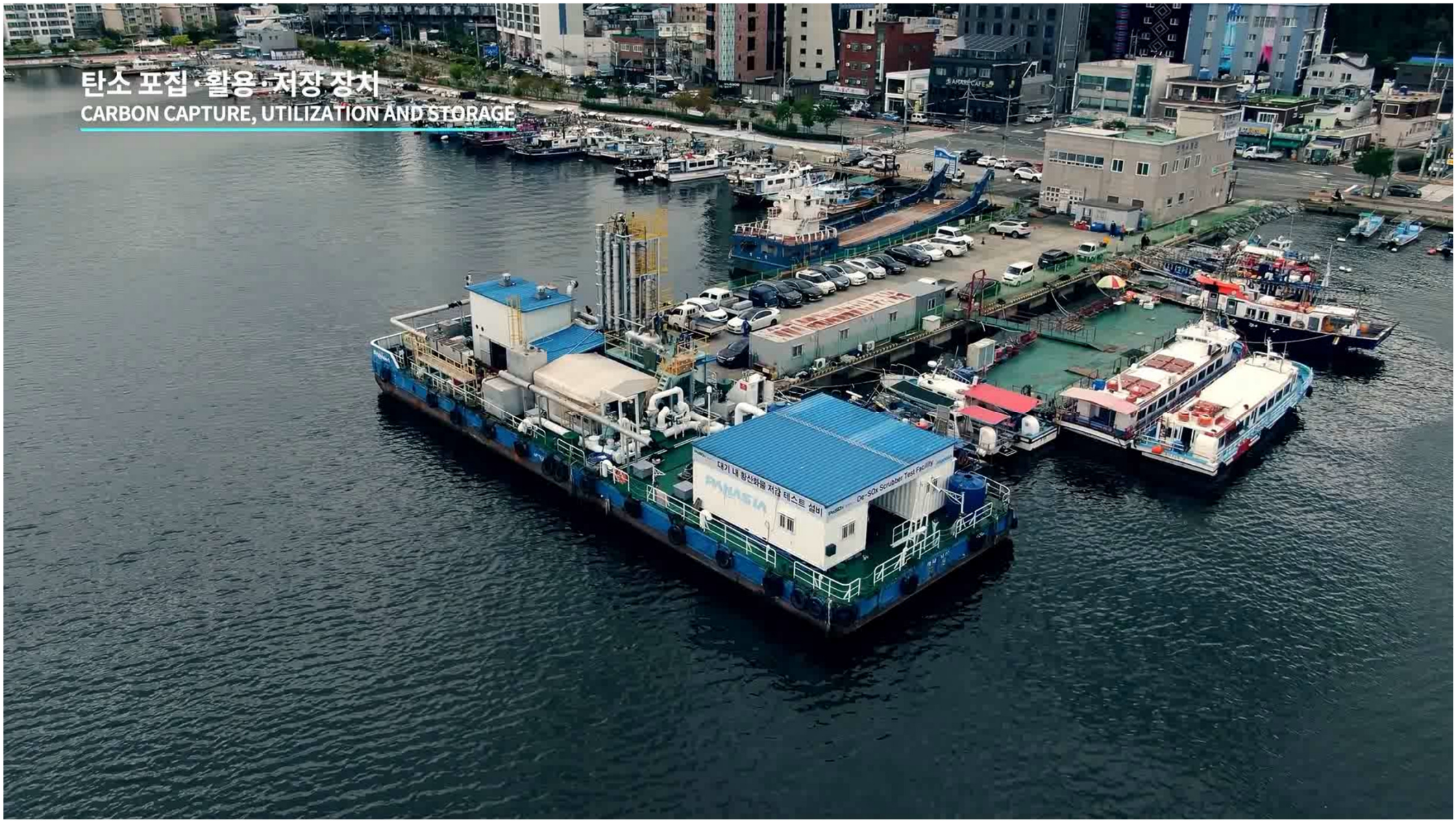
CCS

Pilot CCS for test barge



CCS

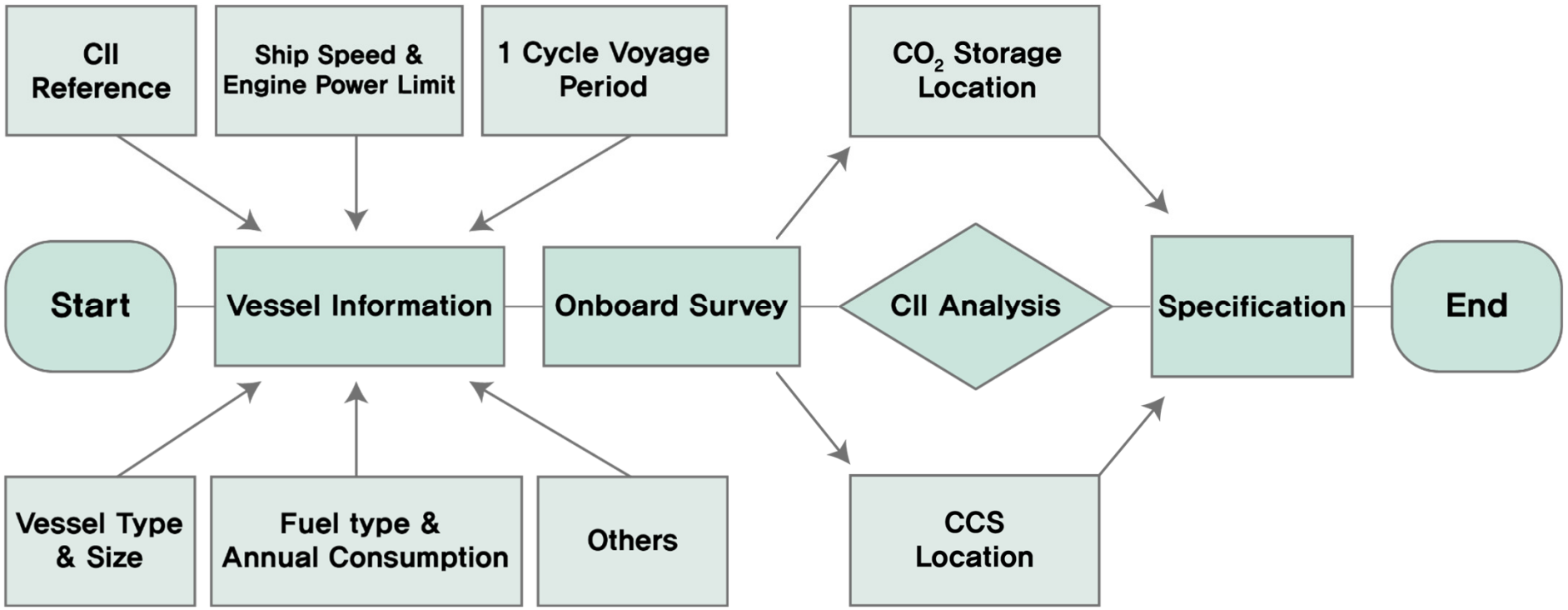
Pilot CCS for test barge



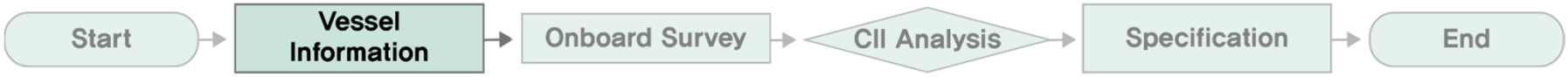
04 DESIGN PROCESS

2 Design Process

Design Process



Pan-OCCS Design Process



CCS Feasibility questionnaire

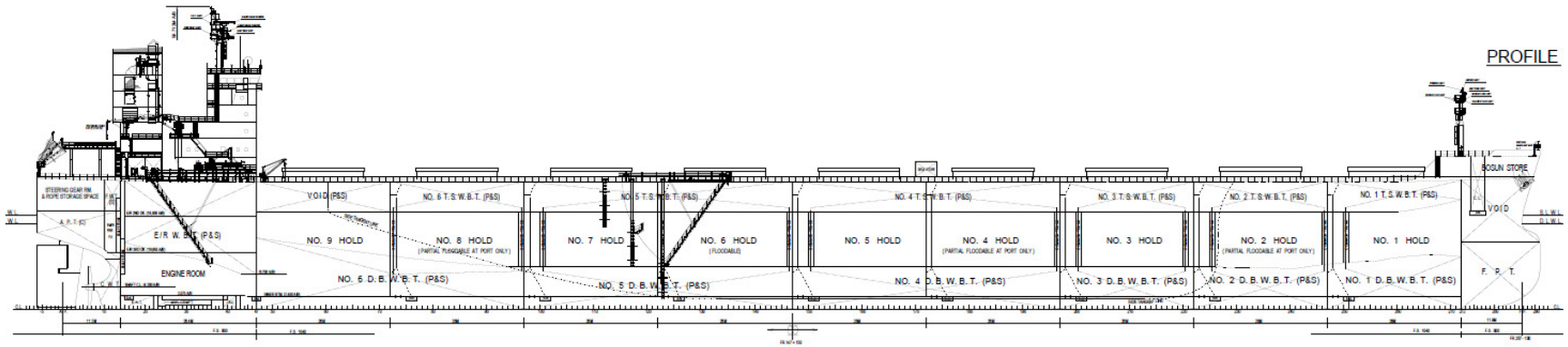
From	
To	PANASIA

No.	Category	Subject
1	**Vessel Information**	Vessel Type
2		Vessel Size
3		Class
4		Vessel Age
7		Fuel Type
8		Annual Fuel Consumption
9		Target Ship Speed
10		1cycle Voyage Period
11		Annual Voyage Distance
12		Main Engine Info
13		Gas Property
14		Generate Engine Capacity
15		Boiler Capacity
16		Fresh Water Generator Capacity
17		Sea Water Capacity
18		Vessel's Target Life Time

No.	Category	Subject
19	Required Regulation	Reference EEDI / EEXI
20		Target Vessel's EEDI / EEXI
21		Reference CII
22		Target Vessel's Attained CII
23		Comparing Vessel's Target Lifetime CII to Attained CII
24	CO_2 Reduction Plan	Optimized Voyage Route& Schedule
25		EPL(Engine Power Limit)
26		Using Auxiliary Equipment
27		Energy Efficient Improvement Technology Adoption
28	Target CO_2 Capturing Volume	Target CII Calculation
29		
30		Target Capture Amount/hr
31		CCS Off, Warm-up Time Logic Setting

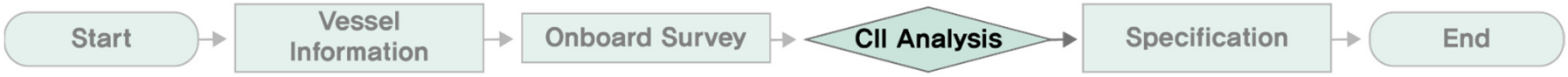
Start → Vessel Information → **Onboard Survey** → CII Analysis → Specification → End

GENERAL ARRANGEMENT



Vessel Type	180K Bulk Carrier
Construction Date	2010
Targeted Operating Date	2035
Vessel Size	179,147 (DWT)
Fuel Type	HSFO, MGO
1Cycle Voyage Period	70 Day (280 day voyage/year)
Target CO_2 Capture Per Hour	1.35 Ton/Hour
Target CO_2 Capture Per Year	8,400 Ton/Year

Pan-OCCS Design Process

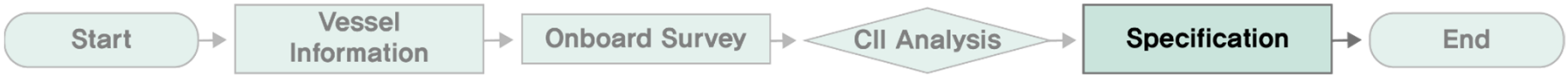


CII_R	2022	2023	2025	2027	2029	2031	2033	2035
2.56	2.43	2.38	2.33	2.28	2.21	2.14	2.07	2.00

Range	Rating	2022	2023	2025	2027	2029	2031	2033	2035
86%	A	2.09	2.05	2.01	1.96	1.90	1.84	1.78	1.72
94%	B	2.29	2.24	2.19	2.14	2.08	2.01	1.95	1.88
100%	C	2.43	2.38	2.33	2.28	2.21	2.14	2.07	2.00
106%	D	2.58	2.53	2.47	2.42	2.34	2.27	2.19	2.12
118%	E	2.87	2.81	2.75	2.69	2.61	2.53	2.44	2.36

Type	Size	DWT	Reduction Rate	CO_2.t/y	Reduction (CO_2.t/hr)	CII_A	CII_R	CII(AER) Scenario(~2030)							
								2022	2023	2025	2027	2029	2031	2033	2035
BC	Cape	179,147	Base	28,459	0.00	3.08	2.563	E	E	E	E	E	E	E	E
			5% Reduction	27,299	0.19	2.95		E	E	E	E	E	E	E	E
			10% Reduction	26,138	0.39	2.83		D	E	E	E	E	E	E	E
			15% Reduction	24,978	0.58	2.70		D	D	D	E	E	E	E	E
			20% Reduction	23,818	0.77	2.58		C	D	D	D	D	E	E	E
			25% Reduction	22,657	0.97	2.45		C	C	C	D	D	D	E	E
			30% Reduction	21,497	1.16	2.33		C	C	C	C	C	D	D	E
			35% Reduction	20,337	1.35	2.20		B	B	C	C	C	C	D	D

Pan-OCCS Design Process



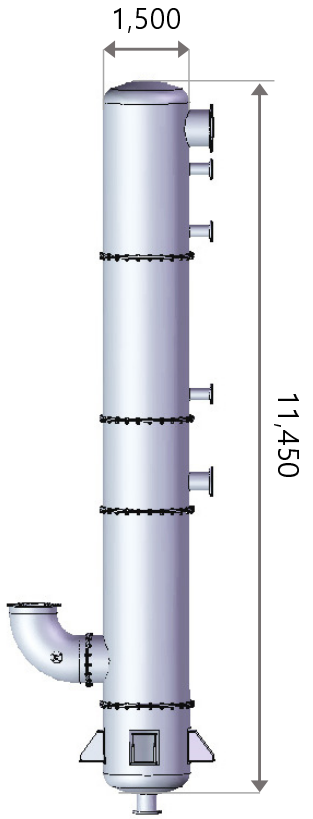
Category	Item	Value	Unit
Quenching	Tower Dia	1500	mm
	Tower height	11.45	mH
	Pressure Drop	200	mmAq
	S.W flowrate	144.32	t/hr
	W.W flowrate	35.43	t/hr
	Washing water bleed off	354.262	t/hr
	Sump capacity	2.5	M^3
NO.1 & 2 Absorber	Tower Dia	2400	mm
	Tower height	14.45	mH
	Pressure Drop	470	mmAq
	Sump capacity	6.0	M^3
Stripper	Tower Dia	1150	mm
	Tower height	14.5	mH
	Operating Pressure	450	mbar.g
	Sump capacity	1.2	M^3
Regeneration	Heat Duty	961731	kcal/hr
	Steam Consumption	1864	kg steam/hr
Solvent	Solvent Flow rate	17.71	t/hr
	Solvent Make-up	2.7	L/hr
Sea Water Consumption		144.3	t/hr
Each Solvent Tank(Storage, Drain) Capacity		32	M^3 for 2 tower

Pan-OCCS Design Process

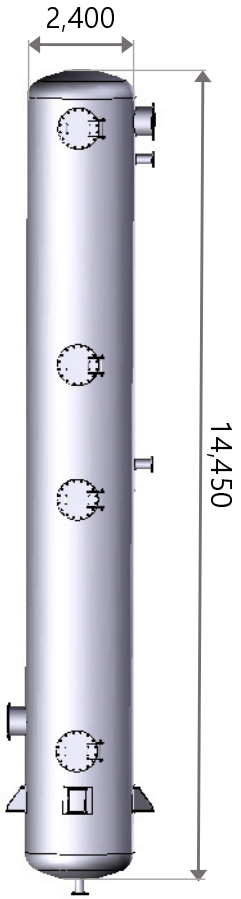
Start → Vessel Information → Onboard Survey → CII Analysis → **Specification** → End

Unit : mm

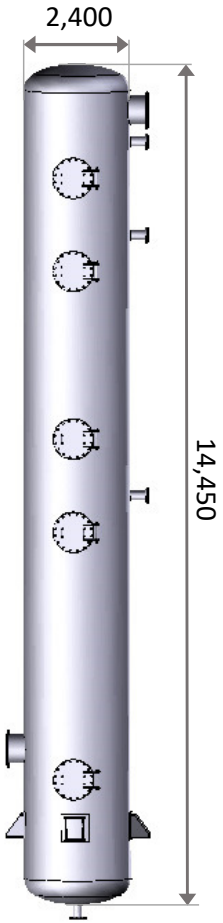
Quenching Tower



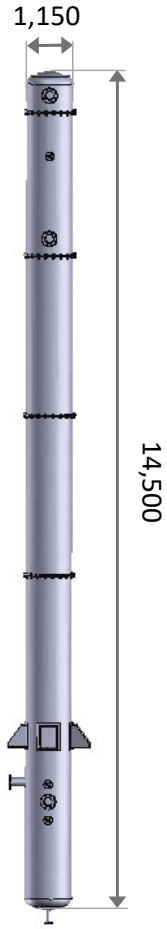
No.1 Absorber Tower



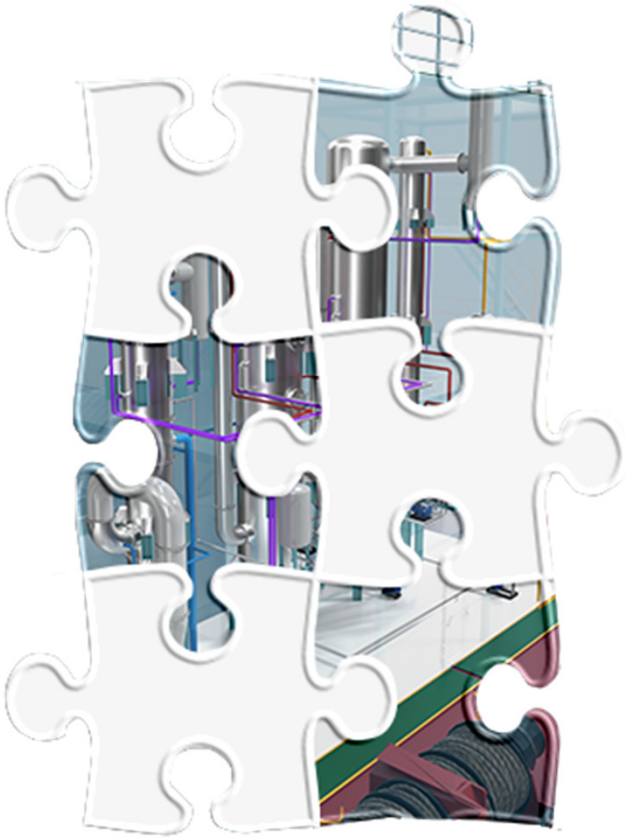
No.2 Absorber Tower



Stripper Tower



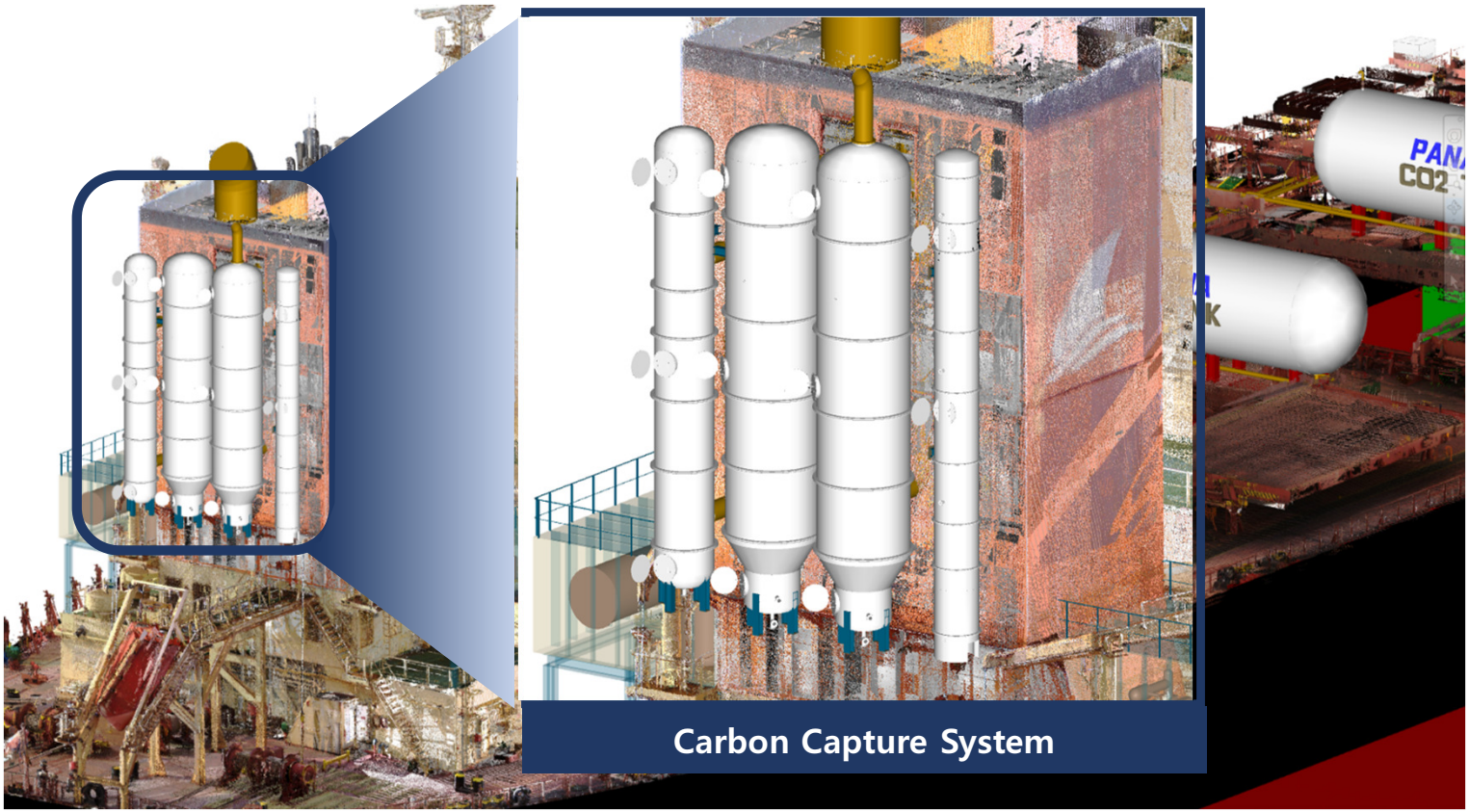
3 Application Concept with another case study



General View

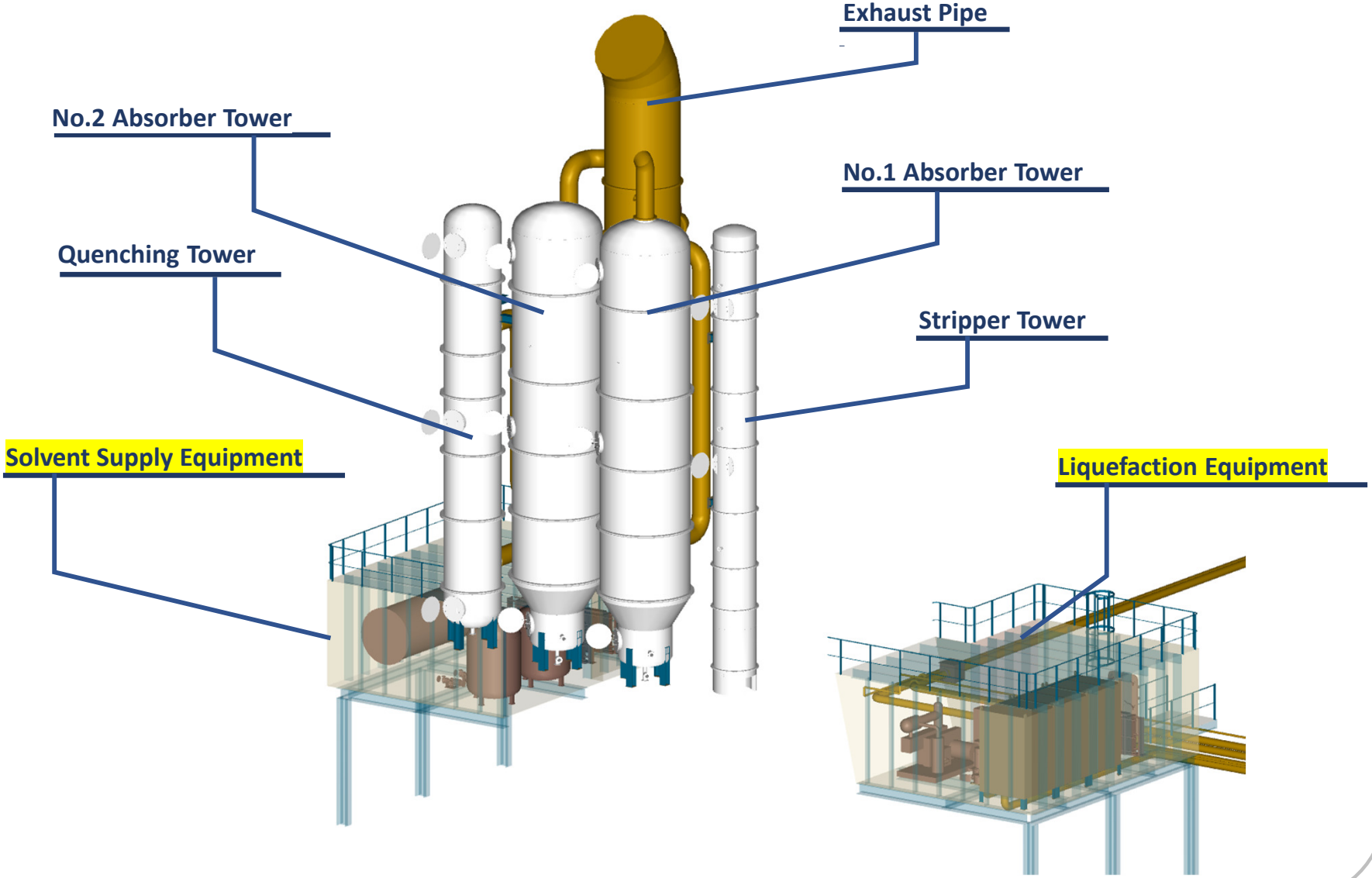
1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	Consideration ship's stability and hull strength Liquefaction unit to Cylinder Type Tank or ISO Container Tank

Carbon Capture System

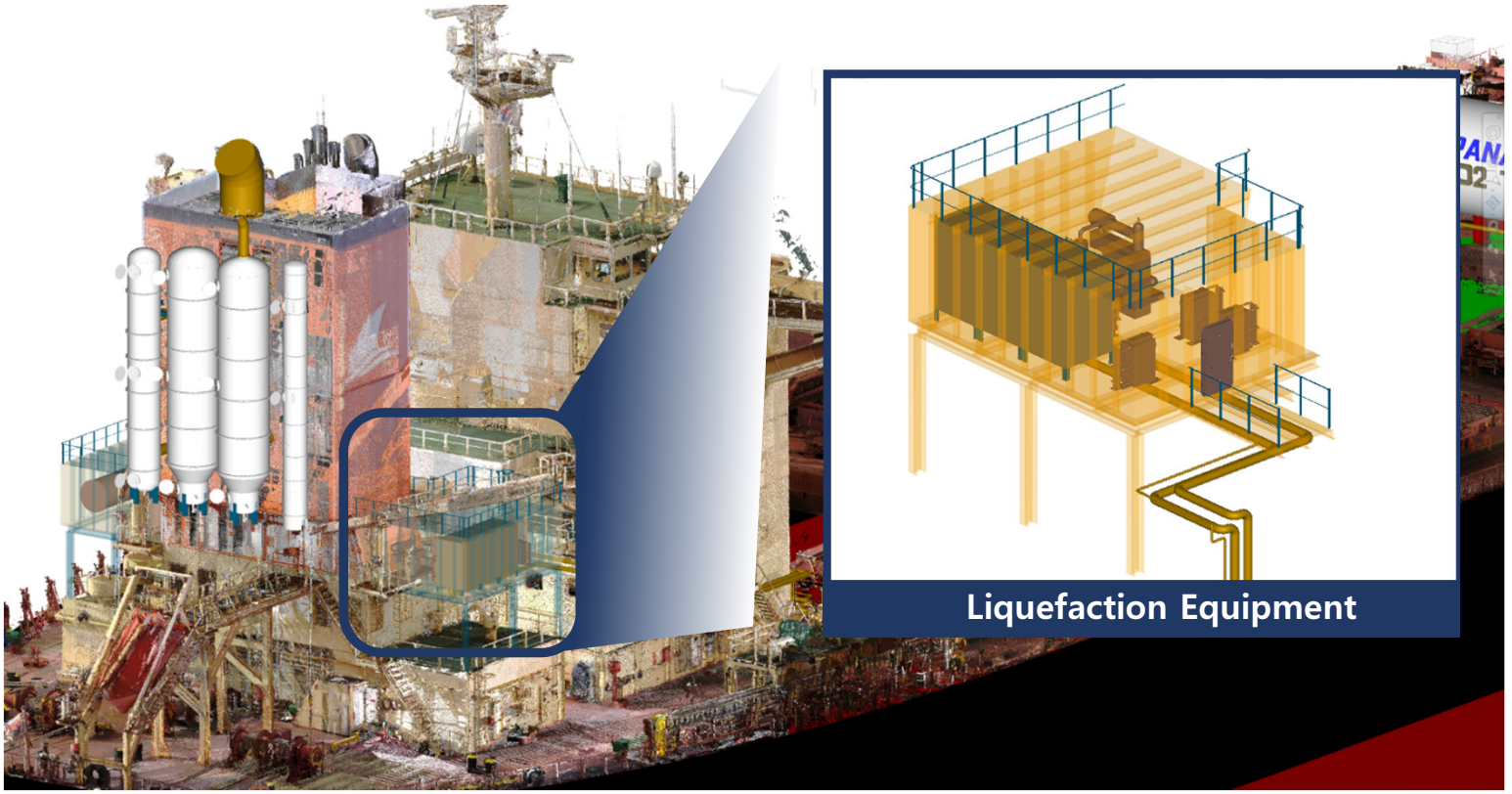


1. Carbon Capture System	**CO_2 Capturing from Exh.Gas**
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	Consideration ship's stability and hull strength Liquefaction unit to Cylinder Type Tank or ISO Container Tank

Carbon Capture System

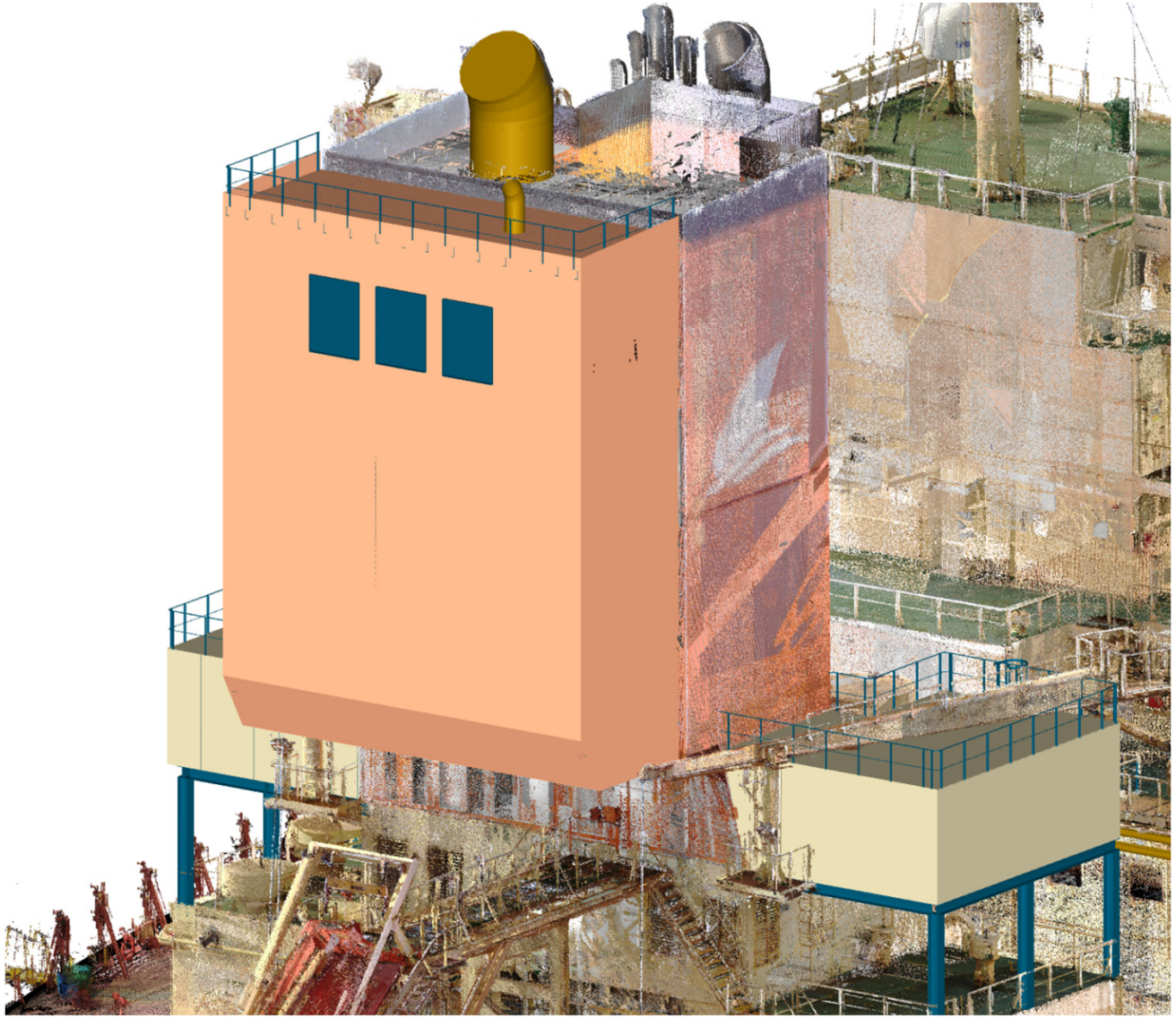


Liquefaction Equipment



1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	**Captured CO_2 liquefaction (-49℃, 7 bar)**
3. Storage	Consideration ship's stability and hull strength Liquefaction unit to Cylinder Type Tank or ISO Container Tank

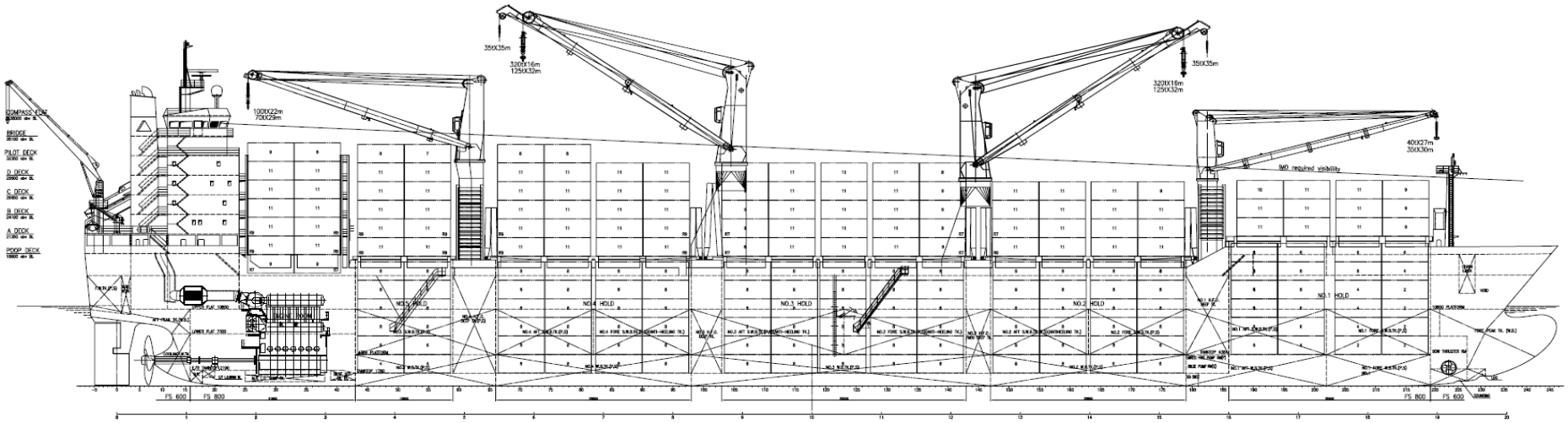
Carbon Capture System



PANASIA

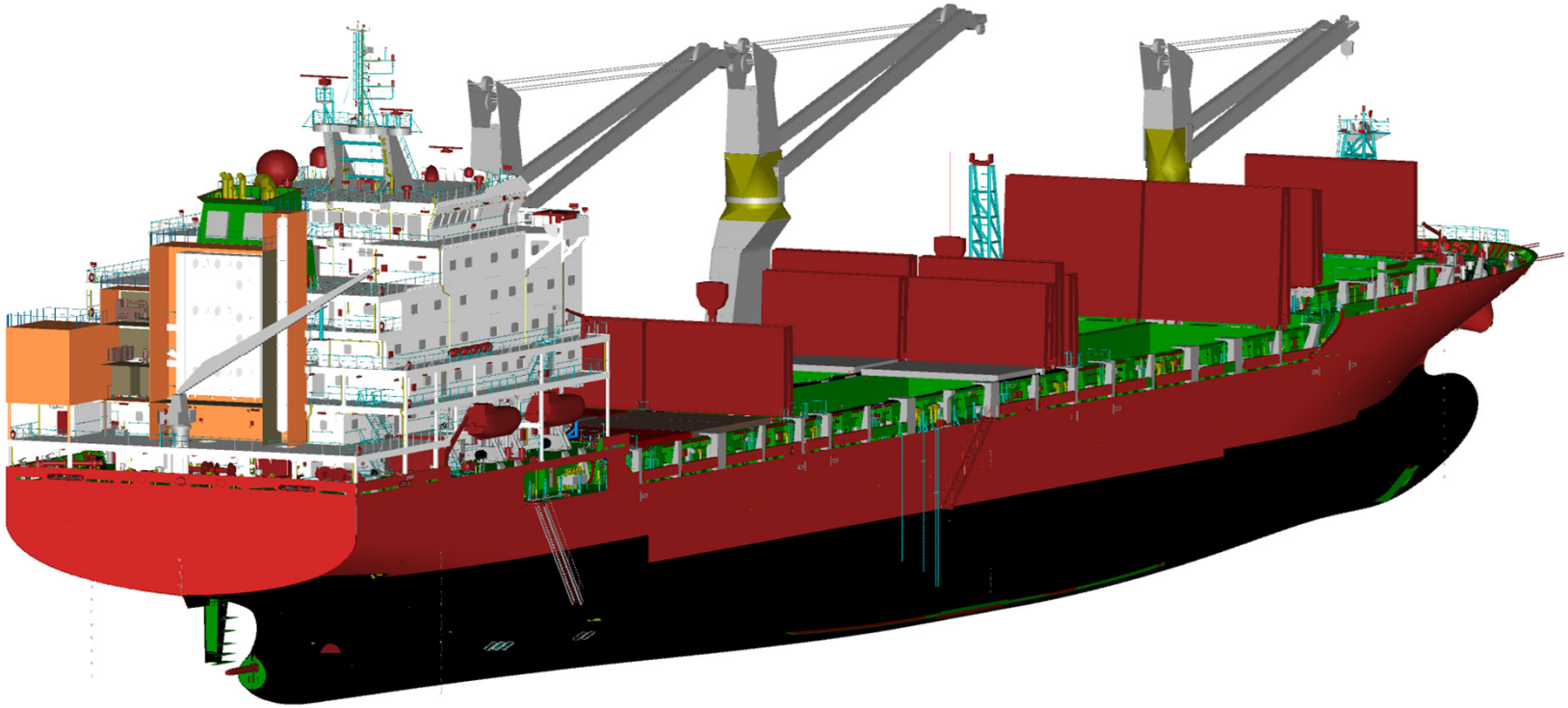
Start → Vessel Information → **Onboard Survey** → CII Analysis → Specification → End

GENERAL ARRANGEMENT



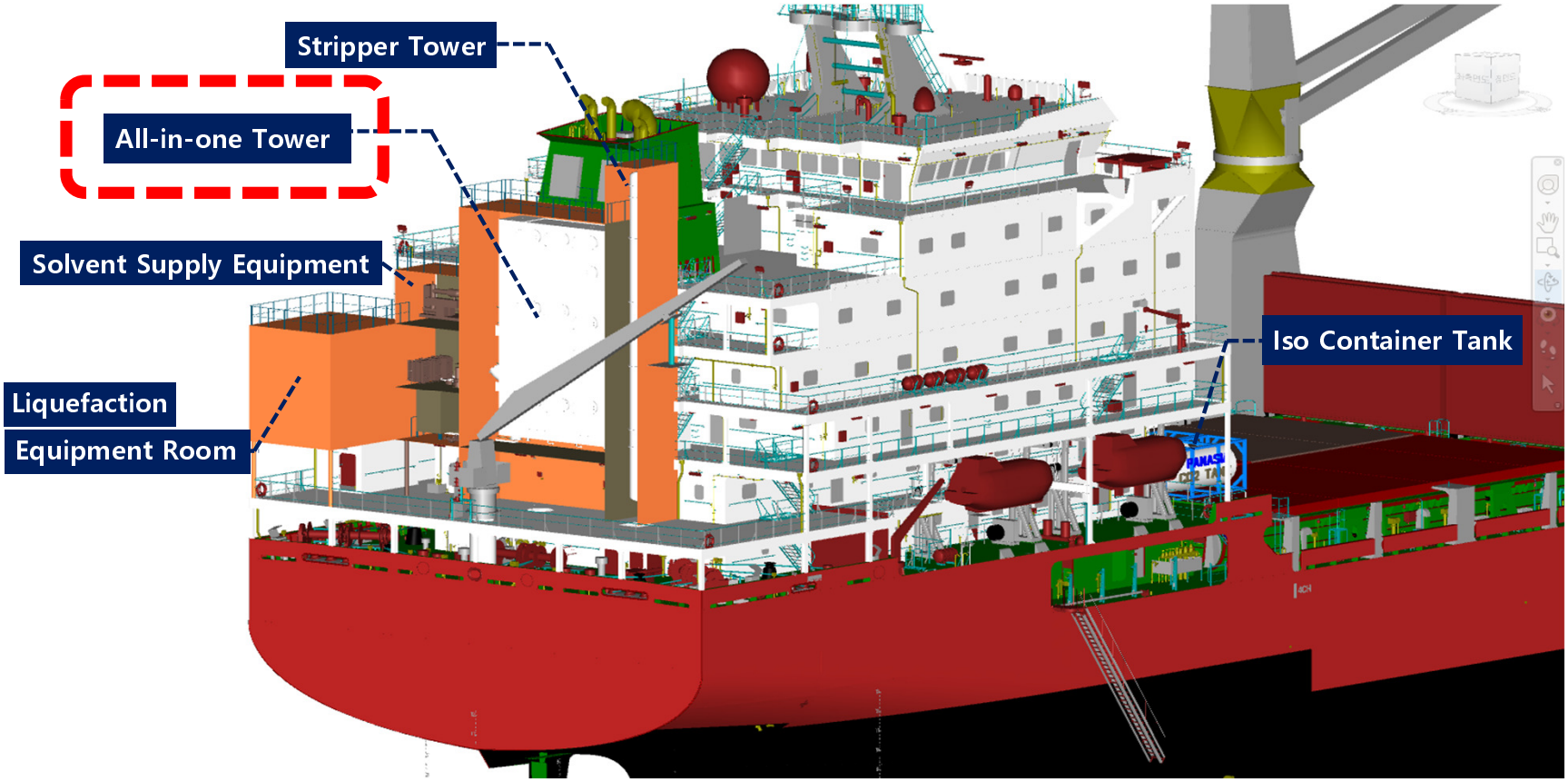
Vessel Type	Multi Purpose Vessel
Vessel Size	30,152 (DWT) (1,800Teu Container)
Fuel Type	MGO
Target CO_2 Capture Per Year	5,500 Ton/Year
1Cycle Voyage Period	40 Day (270 day voyage/year)
Target CO_2 Capture Per Hour	0.85 Ton/Hour

General View



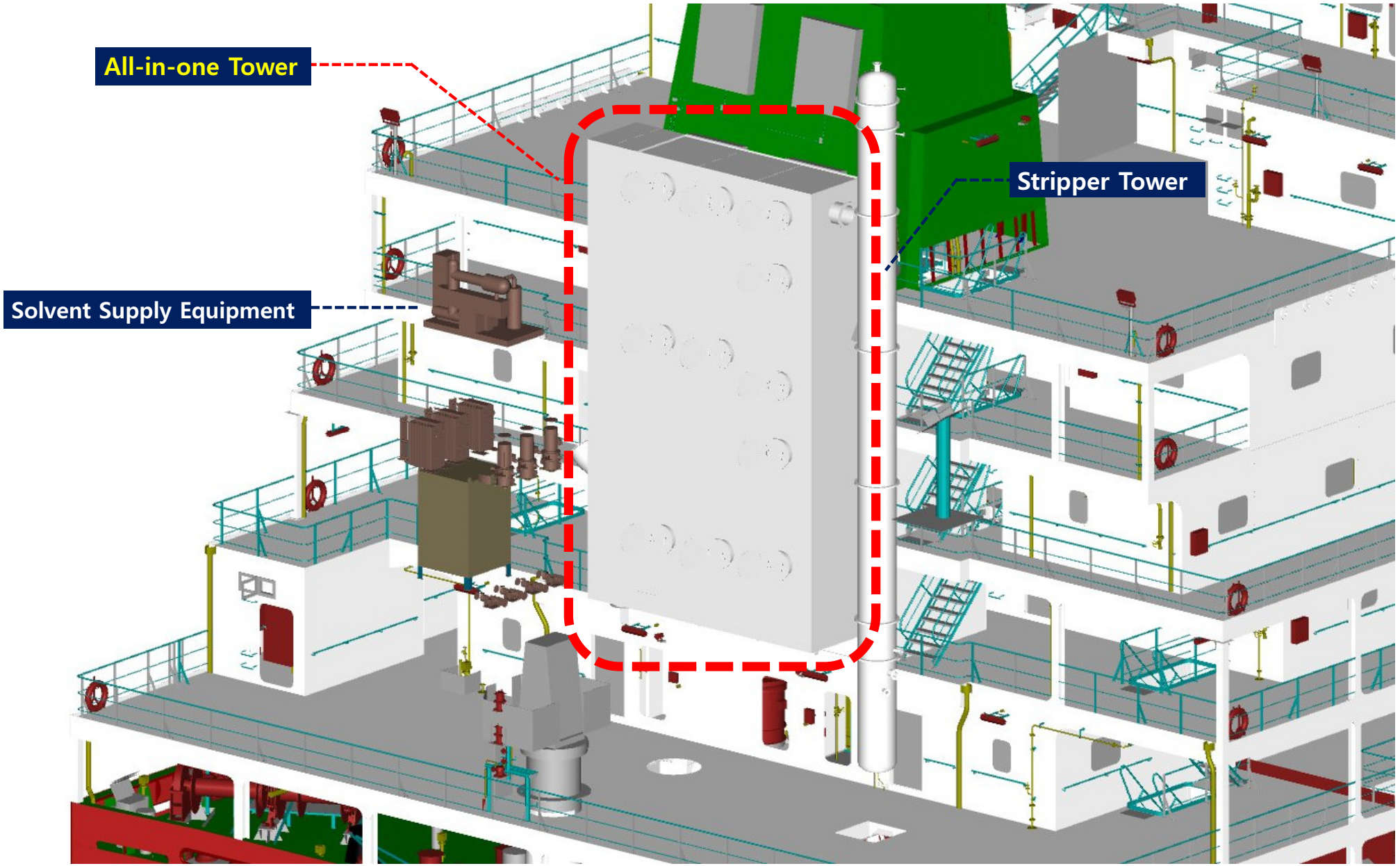
1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	Consideration ship's stability and hull strength Liquefaction unit to Cylinder Type Tank or ISO Container Tank

Pan-OCCS Application Concept



1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	Consideration ship's stability and hull strength Liquefaction unit to Cylinder Type Tank or ISO Container Tank

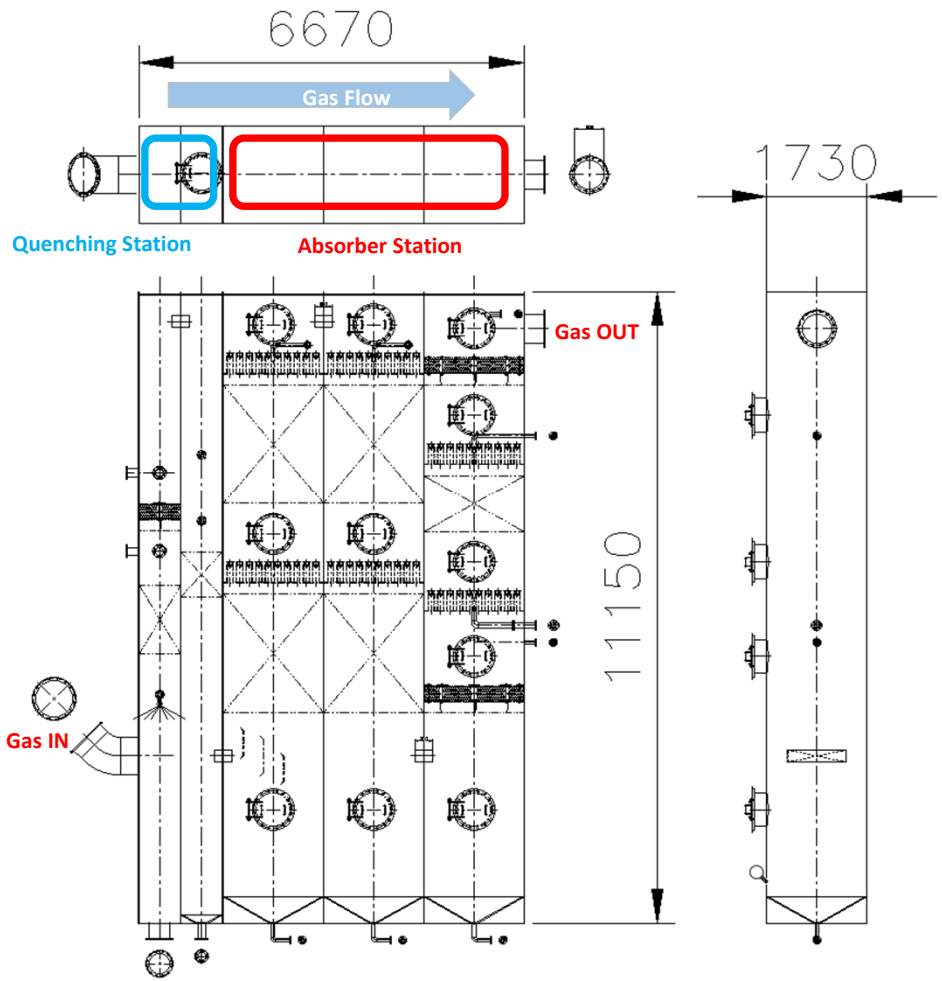
Carbon Capture System



Carbon Capture System

All-in-one Type of Quenching & Absorber Tower

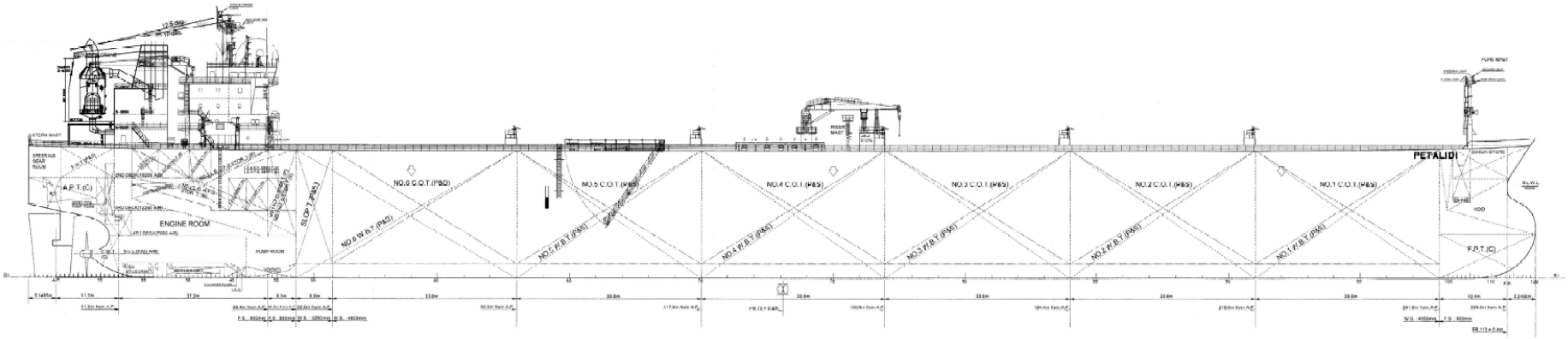
Unit : mm



#Advantages

- Easy to deploy
- Rectangle type & Square type
- To save installation time

3. Another Case

B Company, 158K Tanker	
	
Vessel Type	Tanker
Vessel Size	158,425 (DWT)
Fuel Type	HSFO, MGO
Target Ship Speed	14.5 knots
CO_2 Emission	3.37 t/hr
1Cycle Voyage Period	20 Day
Vessel's Construction Date	**2012**
Vessel's Target Life Time	**2030**

3. Another Case

CII Analysis

CII_R	2023	2024	2025	2026	2027	2028	2029	2030
3.53	3.36	3.28	3.21	3.14	3.04	2.93	2.83	**2.75**

Range	Rating	2023	2024	2025	2026	2027	2028	2029	2030
82%	A	2.76	2.69	2.63	2.57	2.49	2.40	2.32	2.26
93%	B	3.12	3.05	2.99	2.92	2.83	2.72	2.63	2.56
100%	C	3.36	3.28	3.21	3.14	3.04	2.93	2.83	2.75
108%	D	3.63	3.54	3.47	3.39	3.28	3.16	3.06	2.97
128%	E	4.30	4.20	4.11	4.02	3.89	3.75	3.62	3.52

Type	Size	DWT	Reduction Rate	CO_2.t/y	Reduction (CO_2.t/hr)	CII_A	CII_R	CII(AER) Scenario(~2030)							
								2023	2024	2025	2026	2027	2028	2029	2030
COT	Suez	158,425	Base	29,497	0	3.73	**3.53**	D	D	D	D	D	D	E	E
			5%	28,022	0.32	3.54		C	C	D	D	D	D	D	E
			10%	26,547	0.65	3.36		C	C	C	C	D	D	D	D
			15%	25,072	0.97	3.17		C	C	C	C	C	D	D	D
			20%	23,598	1.3	2.98		B	B	B	C	C	C	C	D
			25%	22,123	1.62	2.8		B	B	B	B	B	C	C	C
			30%	20,648	1.95	2.61		A	A	A	B	B	B	B	C

3. Another Case

CII Analysis

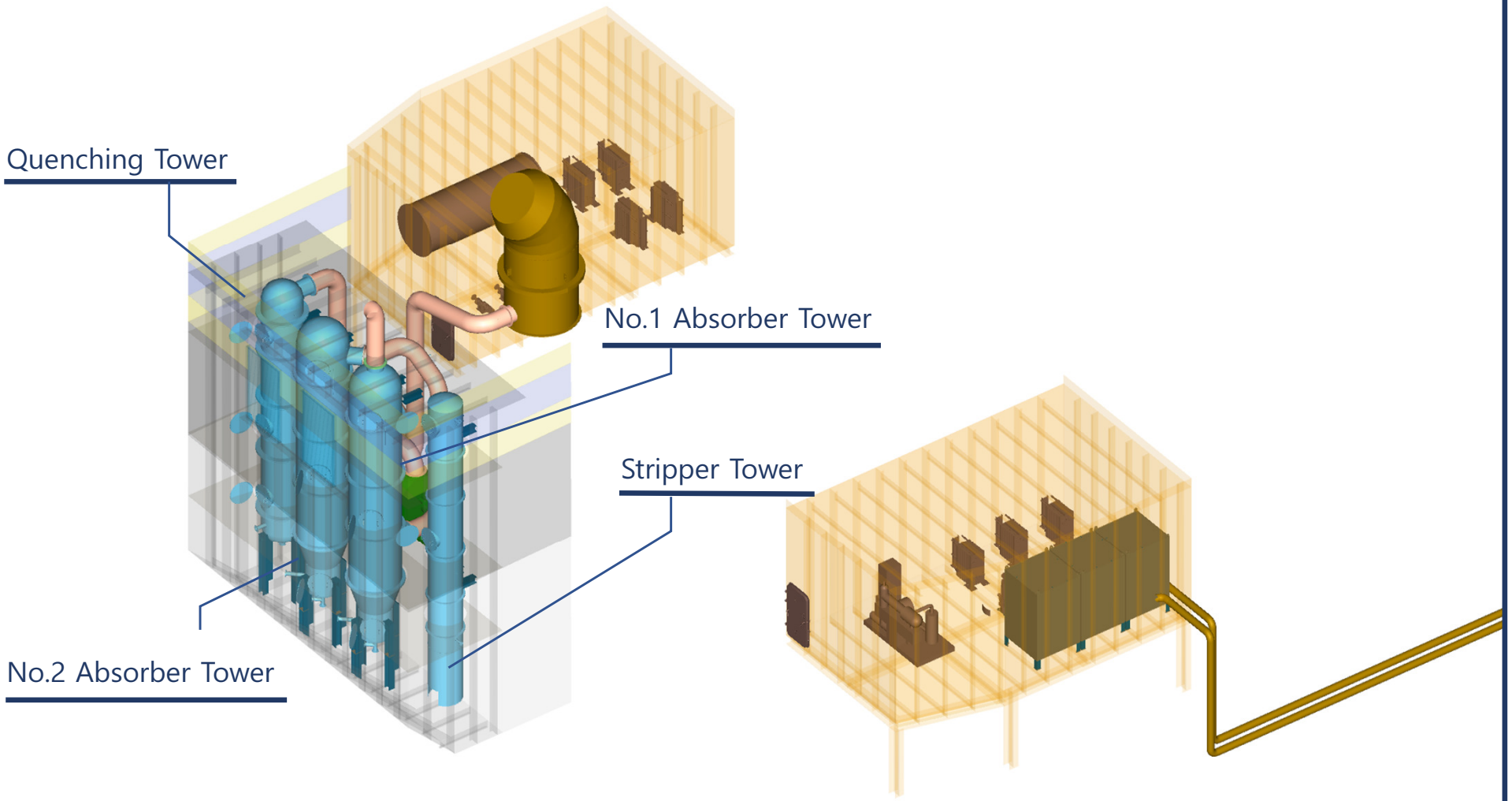
CII_R	2023	2024	2025	2026	2027	2028	2029	2030
3.53	3.36	3.28	3.21	3.14	3.04	2.93	2.83	**2.75**

Range	Rating	2023	2024	2025	2026	2027	2028	2029	2030
82%	A	2.76	2.69	2.63	2.57	2.49	2.40	2.32	2.26
93%	B	3.12	3.05	2.99	2.92	2.83	2.72	2.63	2.56
100%	C	3.36	3.28	3.21	3.14	3.04	2.93	2.83	2.75
108%	D	3.63	3.54	3.47	3.39	3.28	3.16	3.06	2.97
128%	E	4.30	4.20	4.11	4.02	3.89	3.75	3.62	3.52

Type	Size	DWT	Reduction Rate	CO_2.t/y	Reduction (CO_2.t/hr)	CII_A	CII_R	CII(AER) Scenario(~2030)							
								2023	2024	2025	2026	2027	2028	2029	2030
COT	Suez	158,425	Base	29,497	0	3.73		D	D	D	D	D	D	E	E
			5%	28,022	0.32	3.54		C	C	D	D	D	D	D	E
			10%	26,547	0.65	3.36		C	C	C	C	D	D	D	D
			15%	25,072	0.97	3.17	3.53	C	C	C	C	C	D	D	D
			20%	23,598	1.3	2.98		B	B	B	C	C	C	C	D
			25%	22,123	1.62	2.8		B	B	B	B	B	C	C	C
			30%	20,648	1.95	2.61		A	A	A	B	B	B	B	C

3. Another Case

Carbon Capture System & Liquefaction Equipment



3. Another Case

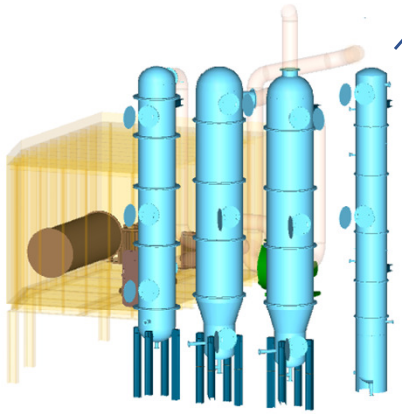
Storage Location

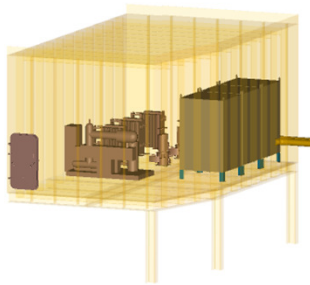
Hazardous Area

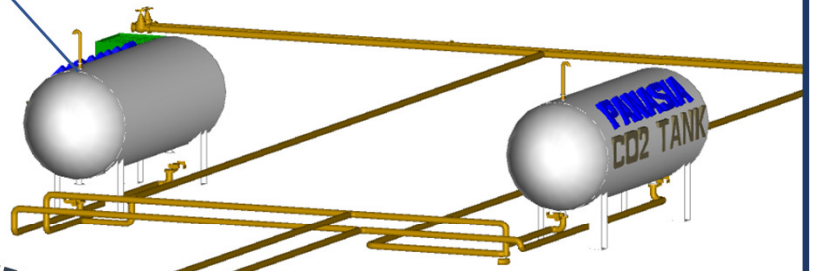
all electrical equipments relate to tanks apply to ex-proof equipment.

Carbon Capture System

Storage tank



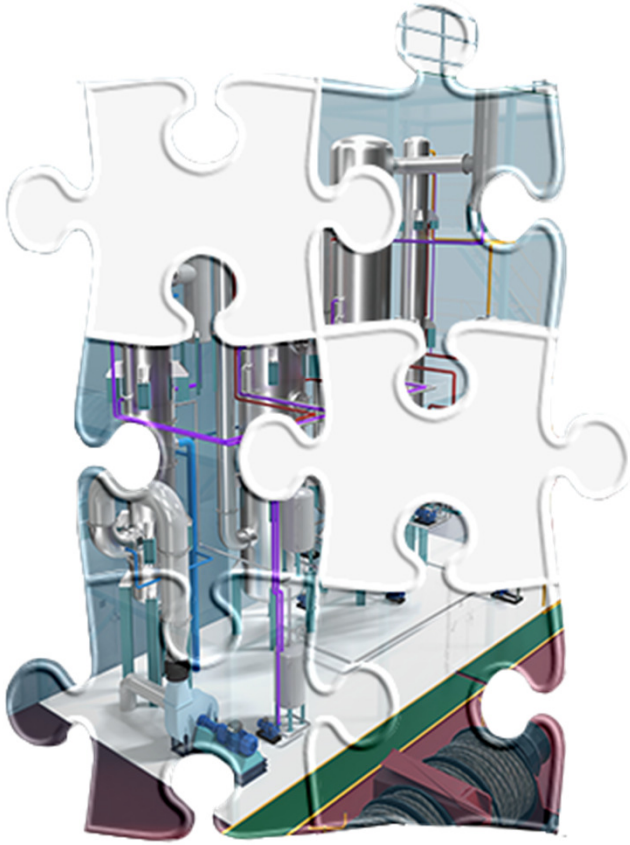




Safety Area

Liquefaction Equipment

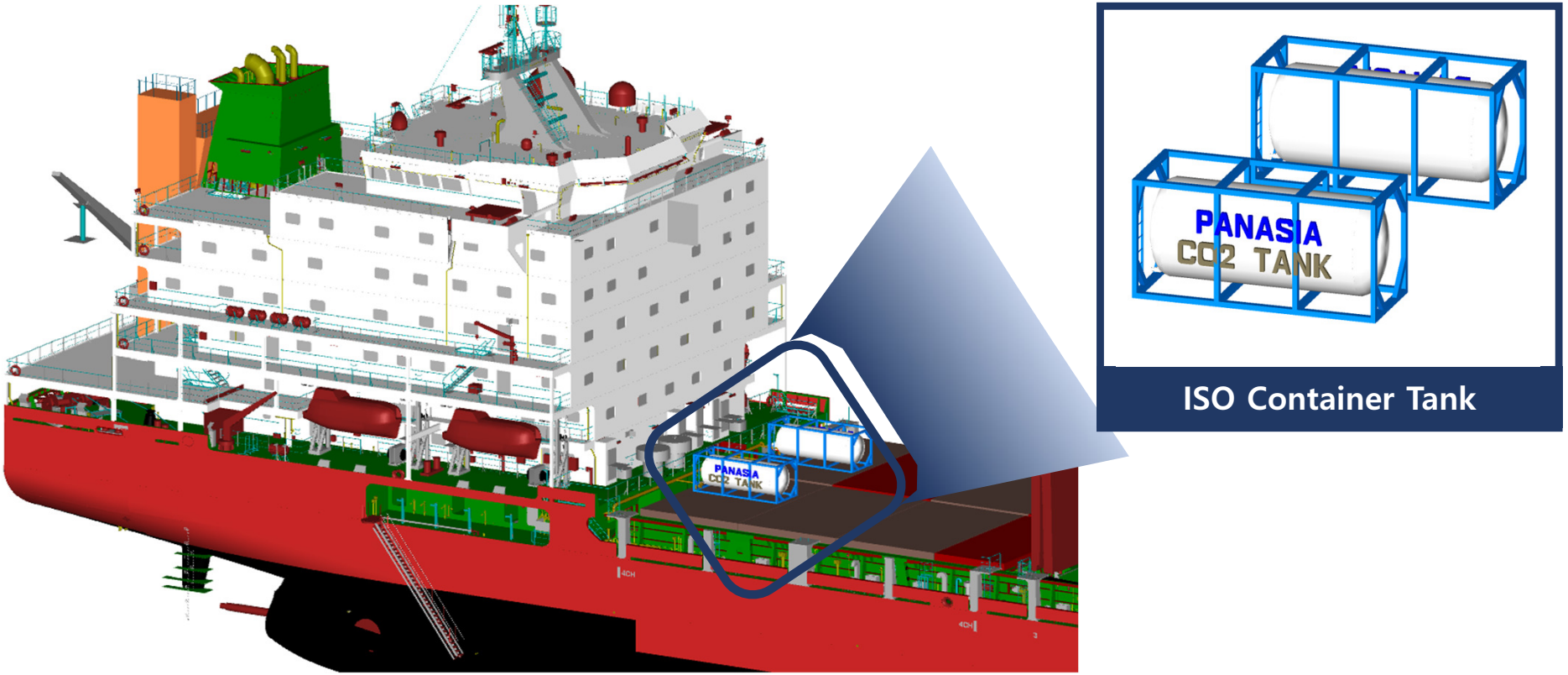
4 LCO_2 Storage



Cylinder Tank Type Storage

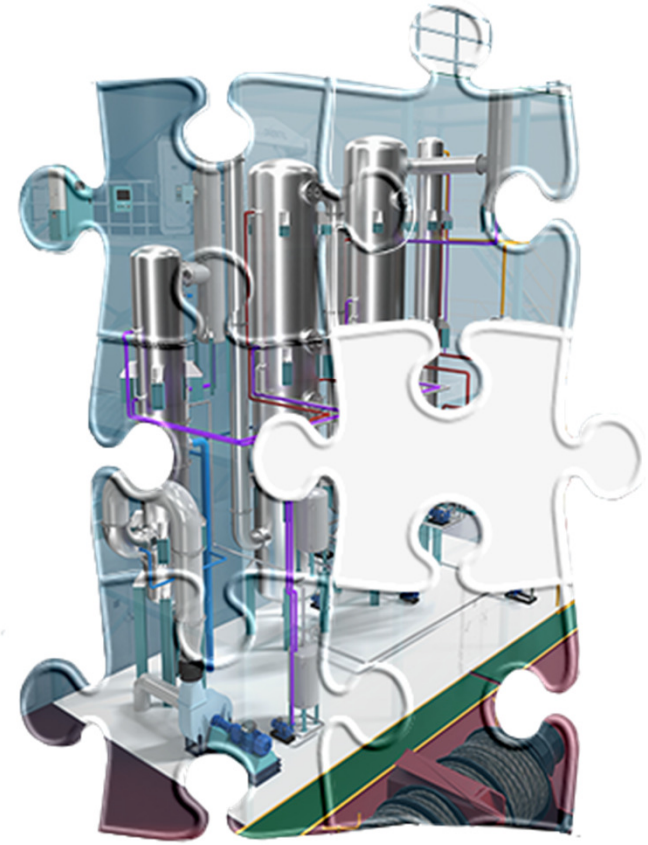
1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	**Consideration ship's stability and hull strength** **Liquefaction unit to Cylinder Type Tank**

ISO Container Tank Type Storage



1. Carbon Capture System	CO_2 Capturing from Exh.Gas
2. Liquefaction Equipment	Captured CO_2 liquefaction (-49℃, 7 bar)
3. Storage	**Consideration ship's stability and hull strength** **Liquefaction unit to ISO Container Tank**

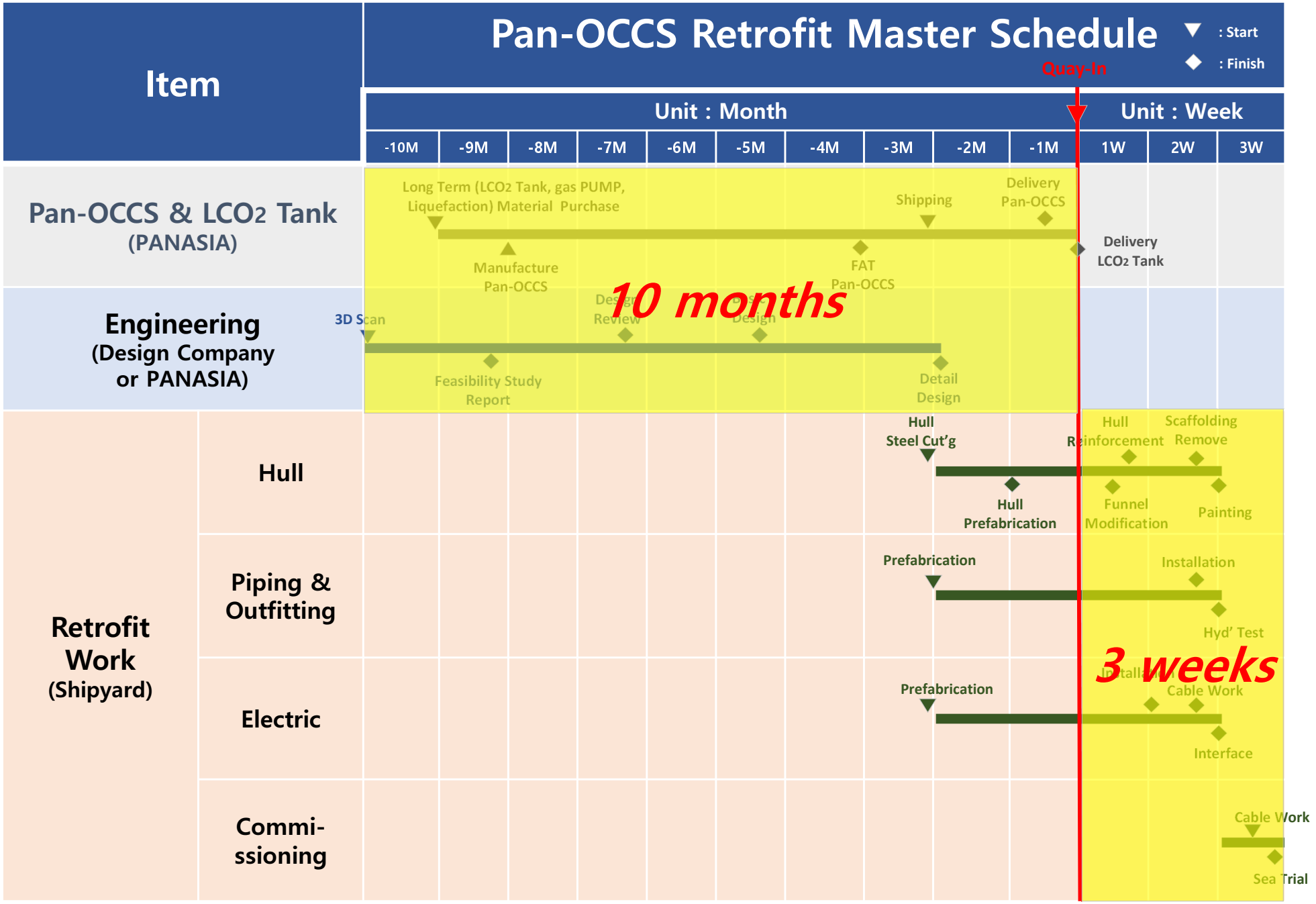
5 Class approval & Lead time



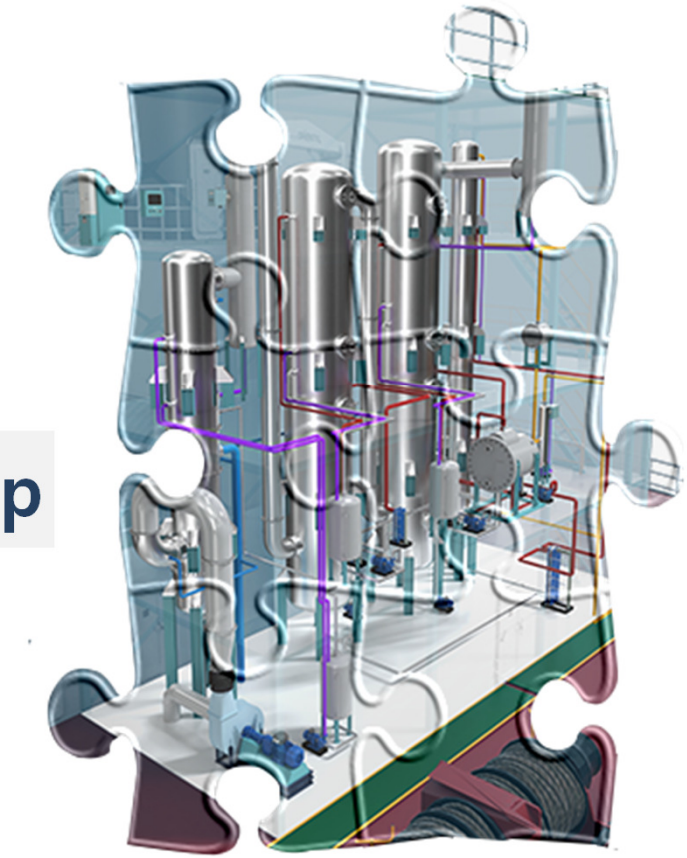
Drawing work for CCS Retrofit

Item	Description	Remarks
LWT & Stability Calculation	Class Re-Approval	
Loading Manual	Class Re-Approval	1. ISO Container Tank Lashing Manual & Lashing Strength Calculation 2. ISO Container Tank Loading Manual
Loading Computer	Software Update & Class Re-Approval	
Hull Strength Calculation	Class Re-Approval	
Genenal Arrangement	Class Re-Approval	
Risk Assessment	1. Installation of CO_2 Detector 2. Installation of Ventilation Fan	1. LCO_2 is Applied to IMDG Code IMO Class 2.2 2. Onboard Waste 3. Consideration for Toxicity and Asphyxiation Relief

Pan-OCCS Retrofit Master Schedule

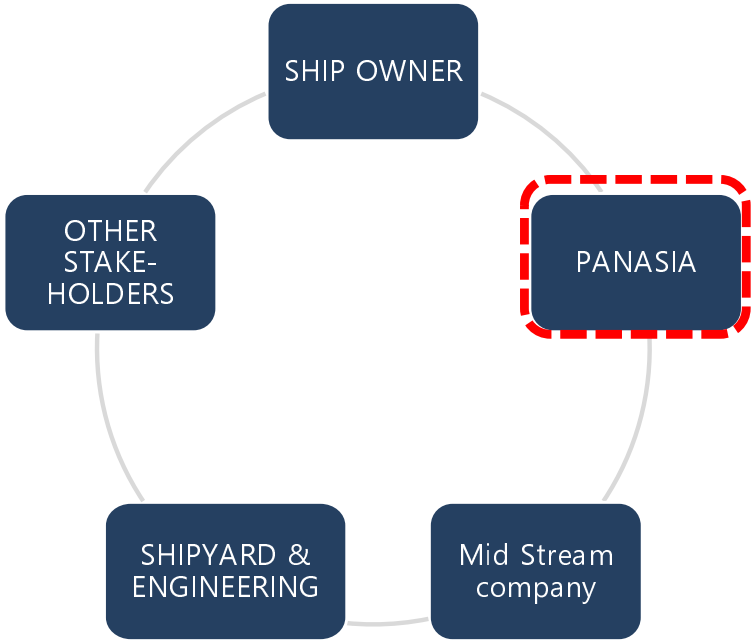


6 CO_2 Supply chain partnership

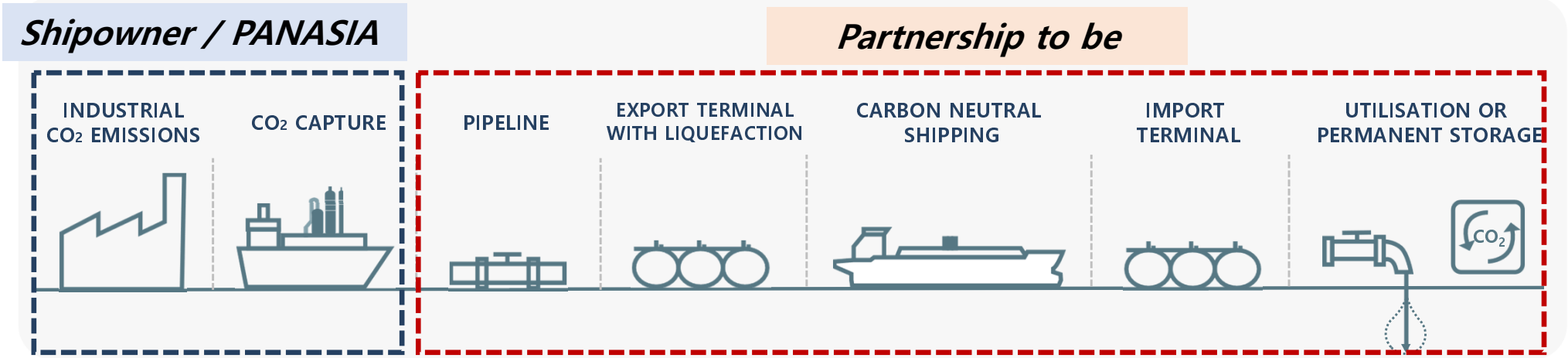


Capture Carbon Networks Partnership : Global Hubs and Cluster

Shipowner	CO_2 supply
PANASIA	**Capturing & Storage onboard**
Mid Stream company	Transportation(CO_2 Carrier), Sequestration, Storage and Utilization
Shipyard & Engineering	Feasibility study
Other stakeholders	Funding, Testing, rule etc.

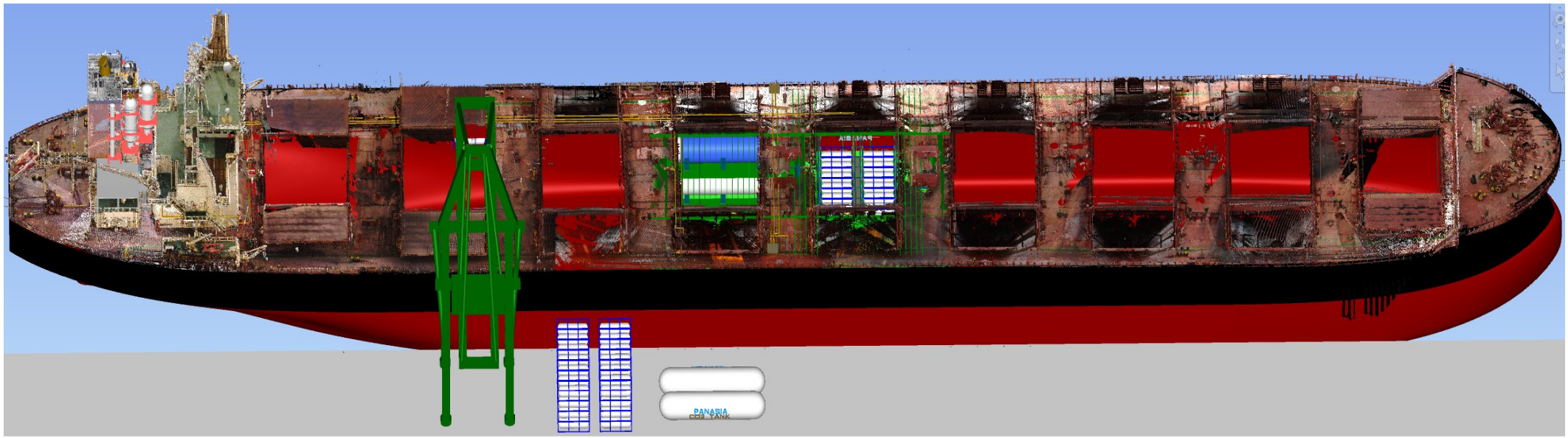


Proposal of Partnership for Supply Chain



05 Development Status

Initial concept arrangement

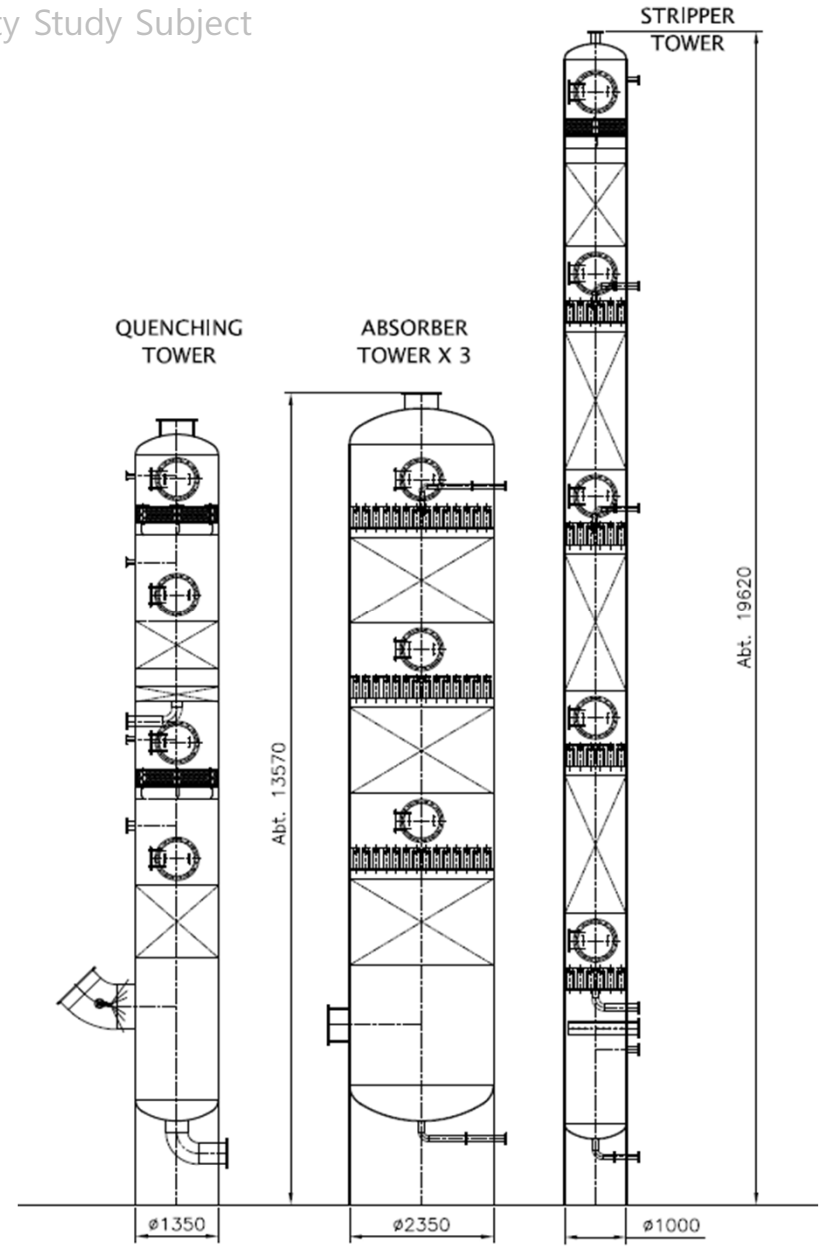


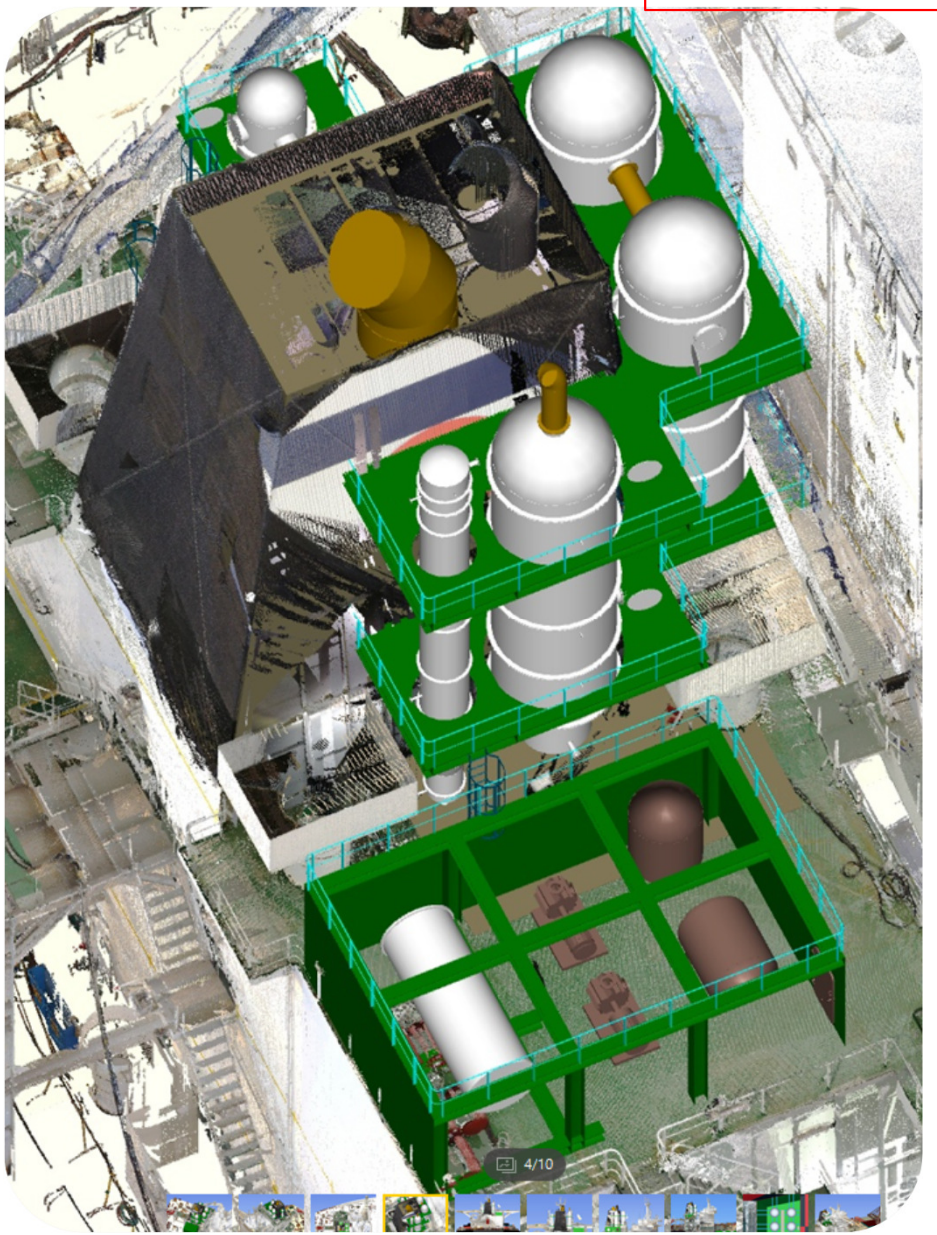
- ✓ Vessel Type : 325k Ore Carrier (LNG Ready)
- ✓ Design Capacity : 1.2t / hr (CO2 Capturing capacity base)
- ✓ Annual net CO2 Reduction : 9,000t / year base
- ✓ CO2 Storage Capacity : 60 Days Voyage base

CCS

Confidential

Feasibility Study Subject

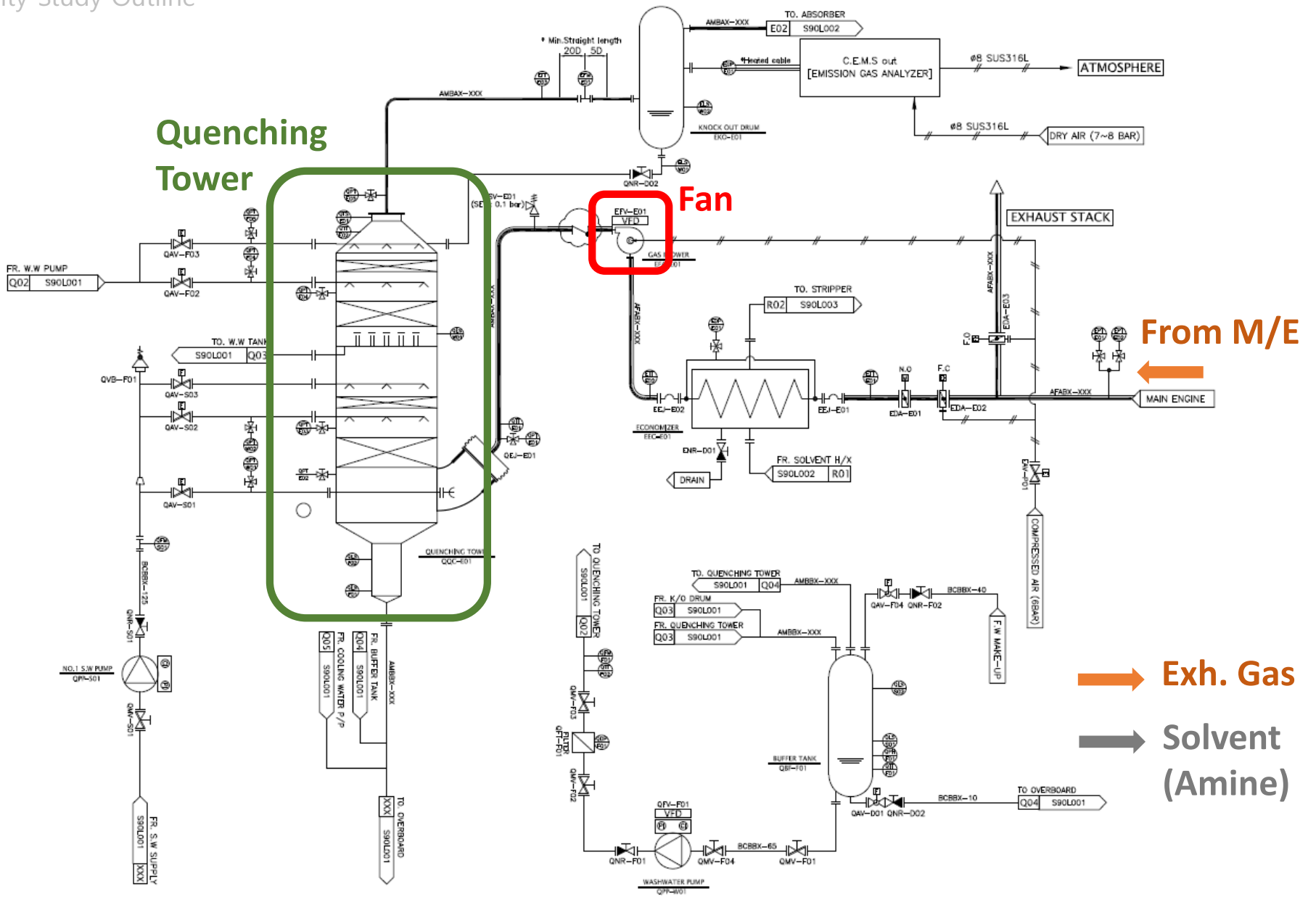




CCS

Feasibility Study Outline

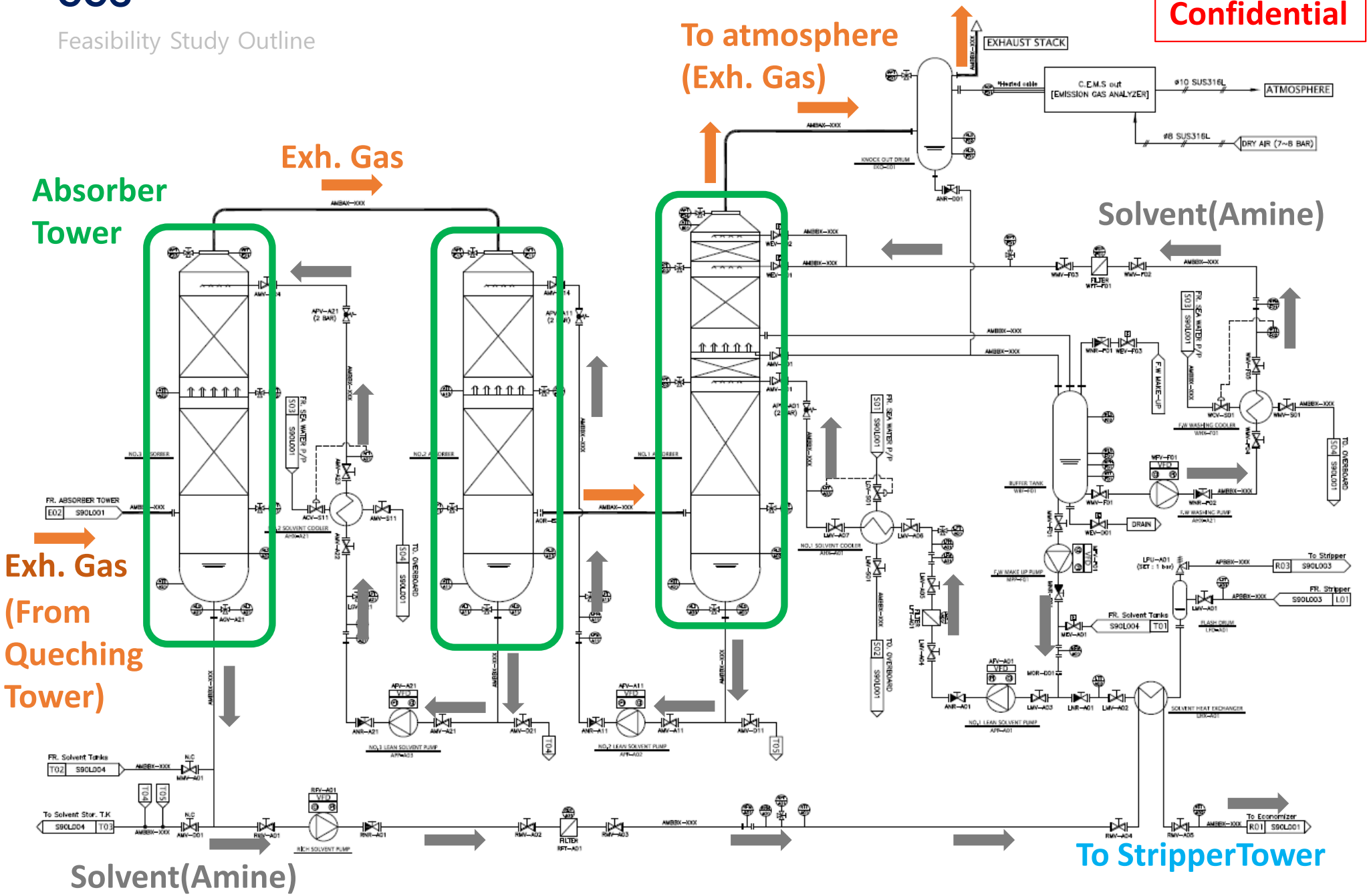
Confidential



CCS

Feasibility Study Outline

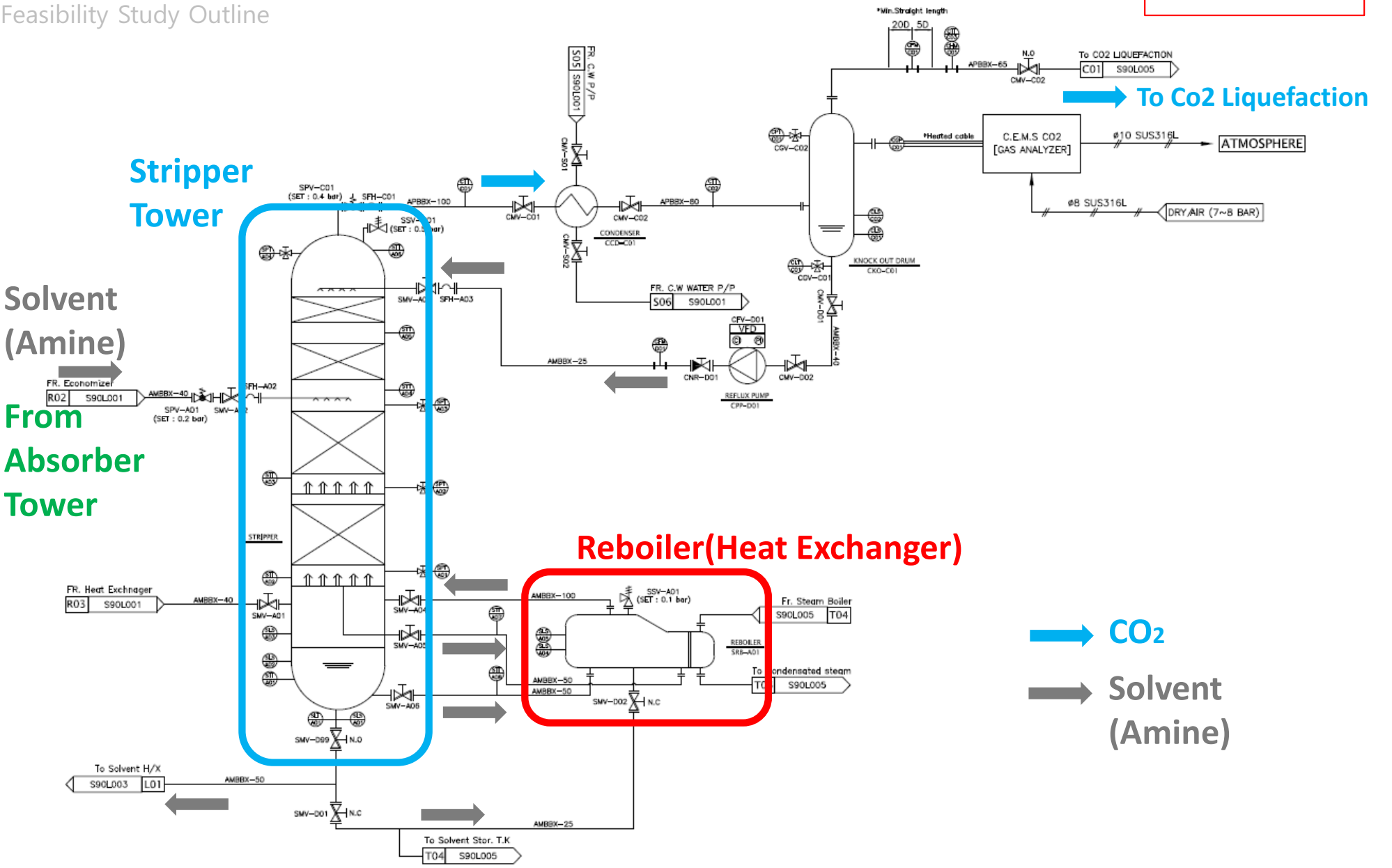
Confidential



CCS

Feasibility Study Outline

Confidential



Confidential

Development Status

With SHI

➢ **PANASIA + SHI CCS joint research**

Task 1	Samsung Heavy Industries	PANASIA
Title	**Basic design of OCCS for 174k LNGC**	
Scope	- Conceptual design progress for materialize the design - In the future, Panasia will develop skid-type products - and draw up a design plan	
R&R	- Design Specification Determination (CO2 Capture) - Provision of design requirements - Examination of the impact on layout and hull structure - Economic analysis	- detailed design of skid type system - Control Concept, Safety Study
Deliverables	- FFED Design Document - G/A - Economic analysis report	- Skid-shaped detailed design drawing (2D,3D) - Equipment Data Sheet (Cost,Weight,Size) - Control & Safety Study Report (HAZID)
Benefits	**Preoccupation of CCUS Technology for marine industry**	

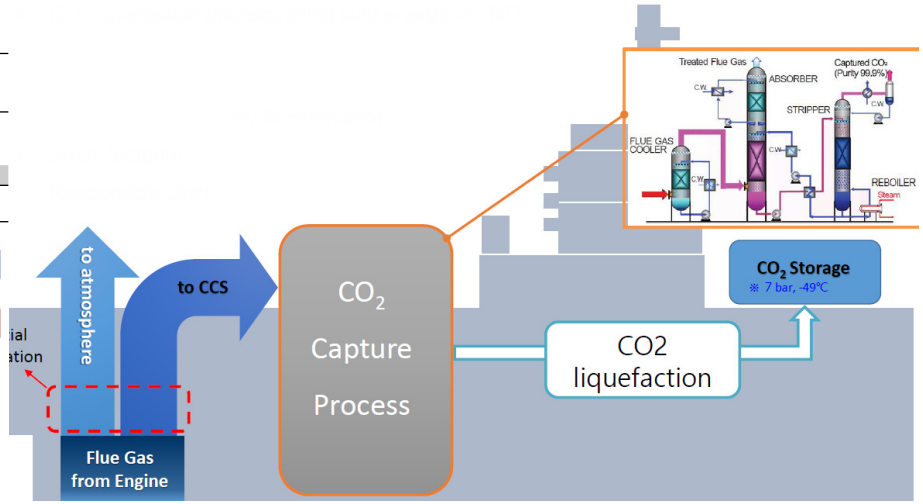
■ Target Ship - Samsung LNG fueled A-max COT

Flue gas	Gas mode	
Component	Mass fraction	Mass flow (ton/hr)
N_2	0.7522	60.73
O_2	0.1611	13.52
H_2O	0.0371	3.04
CO_2	0.0486	3.62
Total mass flow	82 ton/hr (110,000 m³/hr)	

High O_2 fraction

Low CO_2 fraction

	Item	Unit	Capture process
Design Condition	Absorber performance	%	90
	Total CO_2 mass rate	ton/hr	3.6
	Flue gas separation	%	56
	Captured CO_2 mass rate	ton/hr	1.8
	Captured CO_2 / Total CO_2	%	50

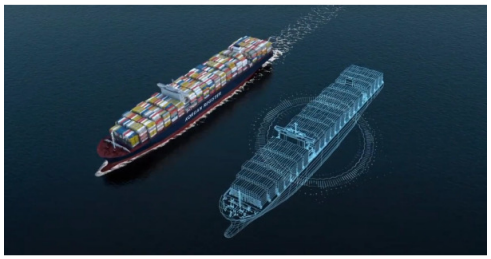


Development Status

With SHI

➢ **PANASIA + SHI on-board CCS collaboration(AIP)**

Providing the best services, Creating a better world



RISK ANALYSIS FOR ONBOARD CARBON CAPTURING SYSTEM

HAZID Report

SYSTEM SAFETY RESEARCH TEAM
KOREAN REGISTER

KR-HSE-HAZI

APPROVAL IN PRINCIPLE

Certificate No. : GCH0004454-SSR-AIP0139 Date : 10 January 2022

2Product : Onboard CCS (Pan-CCS™)

Designer : PANASIA Co., Ltd.
55, Miumsandan3-ro, Gangseo-gu, Busan, Republic of Korea
: SAMSUNG HEAVY INDUSTRIES Co., Ltd.
23, Pangyo-ro 227 beon-gil, Bundang-gu Seongnam-si, Gyeonggi-do, Republic of Korea

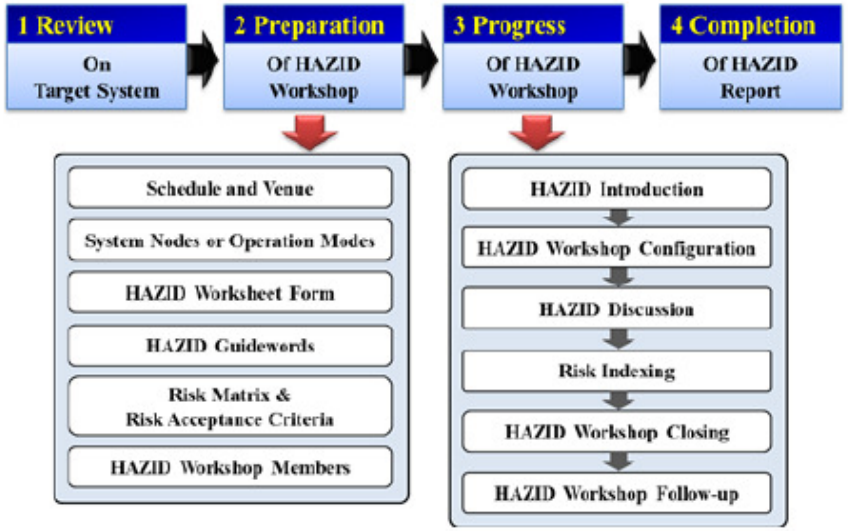
This is to certify that the concept design of Onboard CCS (Pan-CCS™) has been evaluated and approved in accordance with the following Regulations :

- KR rules (2021) - Rules and Guidance for the Classification of Steel Ships
  : Pt 5 Ch 6 Machinery Installations
- KR Guidance for Prevention System of Pollution from Ships
- Res. MEPC.259(68) Guidelines for Exhaust Gas Cleaning Systems

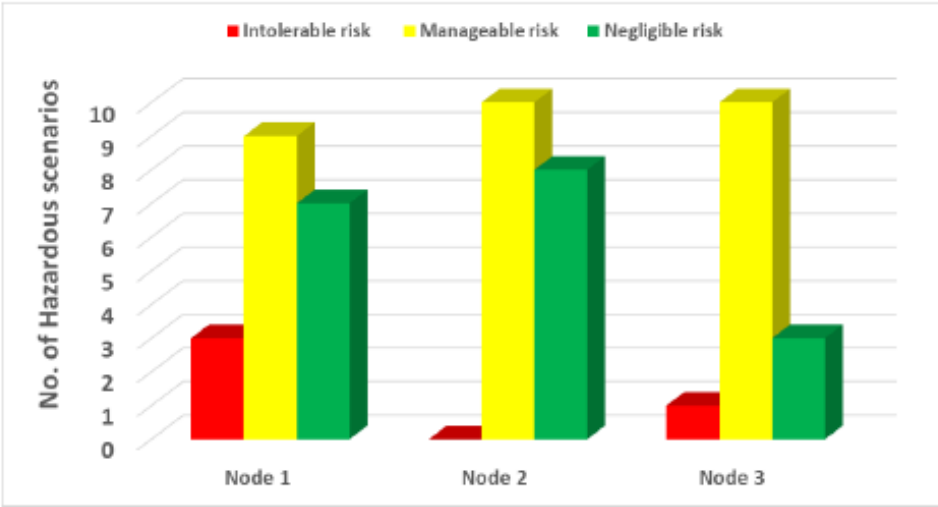
The evaluation has been based on the submitted technical documents. The approval conditions are described on a separate document titled "Statement for Approval in Principle".

Issued at Headquarters of KR

한 국 선 급
KOREAN REGISTER
SONG Kanghyun
Head of Decarbonization · Ship
R&D Center, R&D Division



[Figure 3-1] Overall Schematic Diagram of HAZID Study Procedure



[Figure 6-2] Risk Levels by System Node

➢ CCS Design Condition

Target ship – Samsung 174k LNG Carrier / 2022 SHI Standard

- BOR : 0.085%
- M/E : DMCR 11,400 kW x 2 sets (5G70ME-C10.5-GA EGR x 2)
- G/E : 6L34DF x 4 sets
- Shaft Generator : 2.2MW x 2 sets
- Air Lub. System : Samsung SAVER Air
- Reliquefaction System : Subcooler 1,500 kg/hr

Design conditions for OCCS

- Gas mode only operation = approx. 263 days per year
- Service speed = 17.0 knots (laden), 15.0 knots (ballast)
- Main Engine Power = 16,168 kW (71% of DMCR)
- Daily fuel consumption = 51.2 tCH4/day + 0.5 tMGO/day (G/E off)
- Total CO2 emission = 141 tCO2/day (5.9 tCO2/hr)
- Exhaust gas flow = 45,525 ton/hr per M/E

Data Source: SAMSUNG SAMSUNG HEAVY INDUSTRIES

➢ CCS Design Condition

■ Exhaust gas condition in gas mode (71% load)

Contents	Design condition (weight)	Design condition (mol)
Flowrate	45,525 kg/hr (38,317 Nm3/hr)	1,602 kmol/hr
Temperature	205 degC	
CO2	6.4 wt%	4.2 mol%
N2	74.0 wt%	75.1 mol%
O2	12.7 wt%	11.3 mol%
H2O	5.3 wt%	8.3 mol%
CO	64 ppm wt	65 ppm mol
NO	349 ppm wt	330 ppm mol
NO2	25 ppm wt	16 ppm mol
N2O	39 ppm wt	25 ppm mol
CH4	235 ppm wt	416 ppm mol

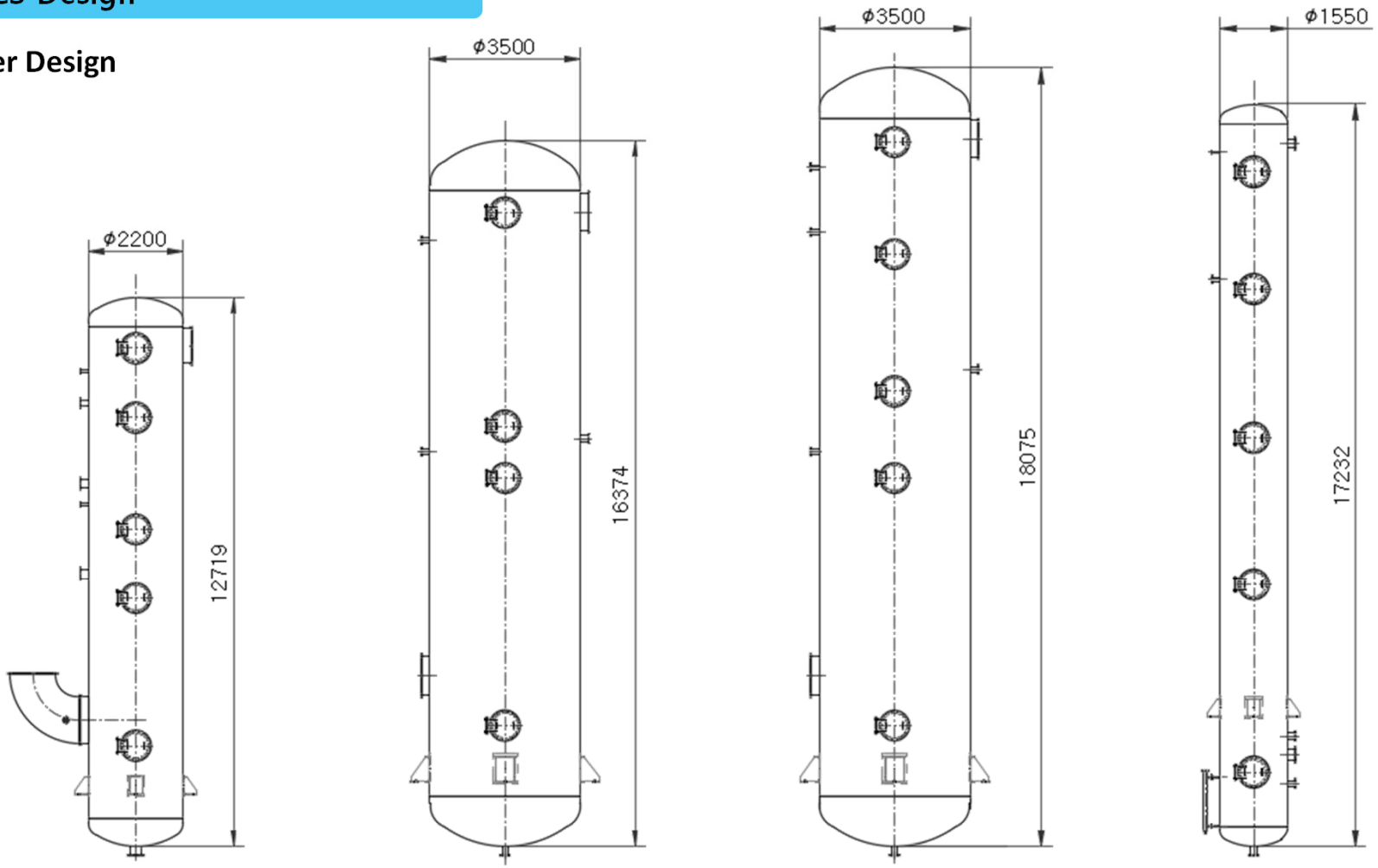
■ CO2 capture condition

- ✓ Design capacity= 2.5 tCO2/hr (60 tCO2/day)
- ✓ Feed gas flow rate = 43.1 ton/hr (95% separation from single M/E) = 36,278 Nm3/hr
- ✓ Net CO2 reduction = 1.68 tCO2/hr (67% energy efficiency, 29% reduction from Laden 17 kts)
- ✓ Annual net CO2 reduction = 10,573 tCO2/yr

Data Source: SAMSUNG SAMSUNG HEAVY INDUSTRIES

➢ CCS Design

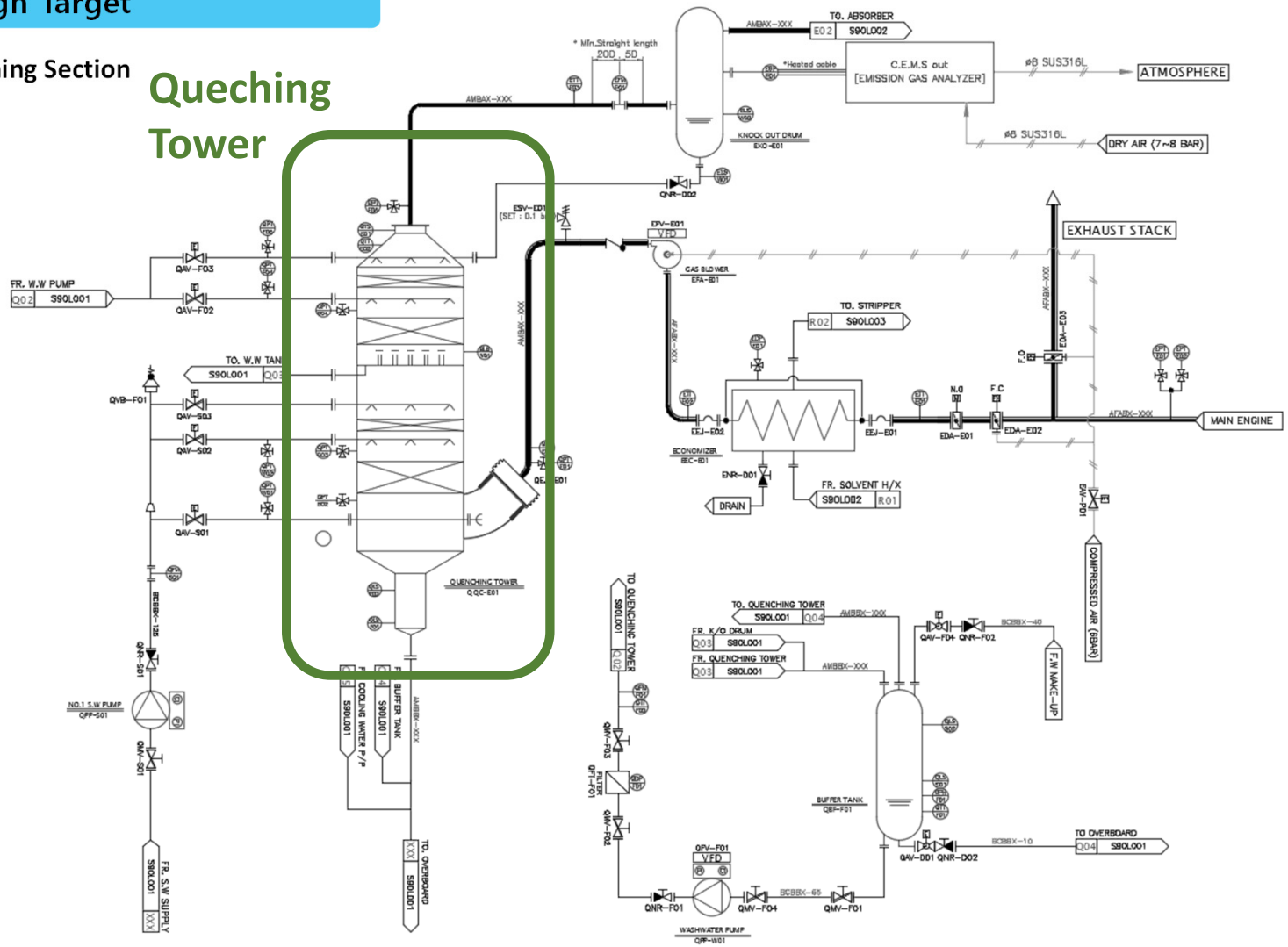
Tower Design



TOWER	TOWER DIAMETER (m)	TOWER HEIGHT (m)	TOWER WEIGHT (TON) (DRY CONDITION)	TOTAL WEIGHT (TON) (OPERATING CONDITION)
QUENCHING TOWER	2.2	12.8	8.6	14.6
No.1 ABSORBER TOWER	3.5	18.1	24.6	39.2
No.2 ABSORBER TOWER	3.5	16.4	23.3	37.9
STRIPPER TOWER	1.55	17.5	6.8	9.8

➢ CCS Design Target

P&ID – Quenching Section

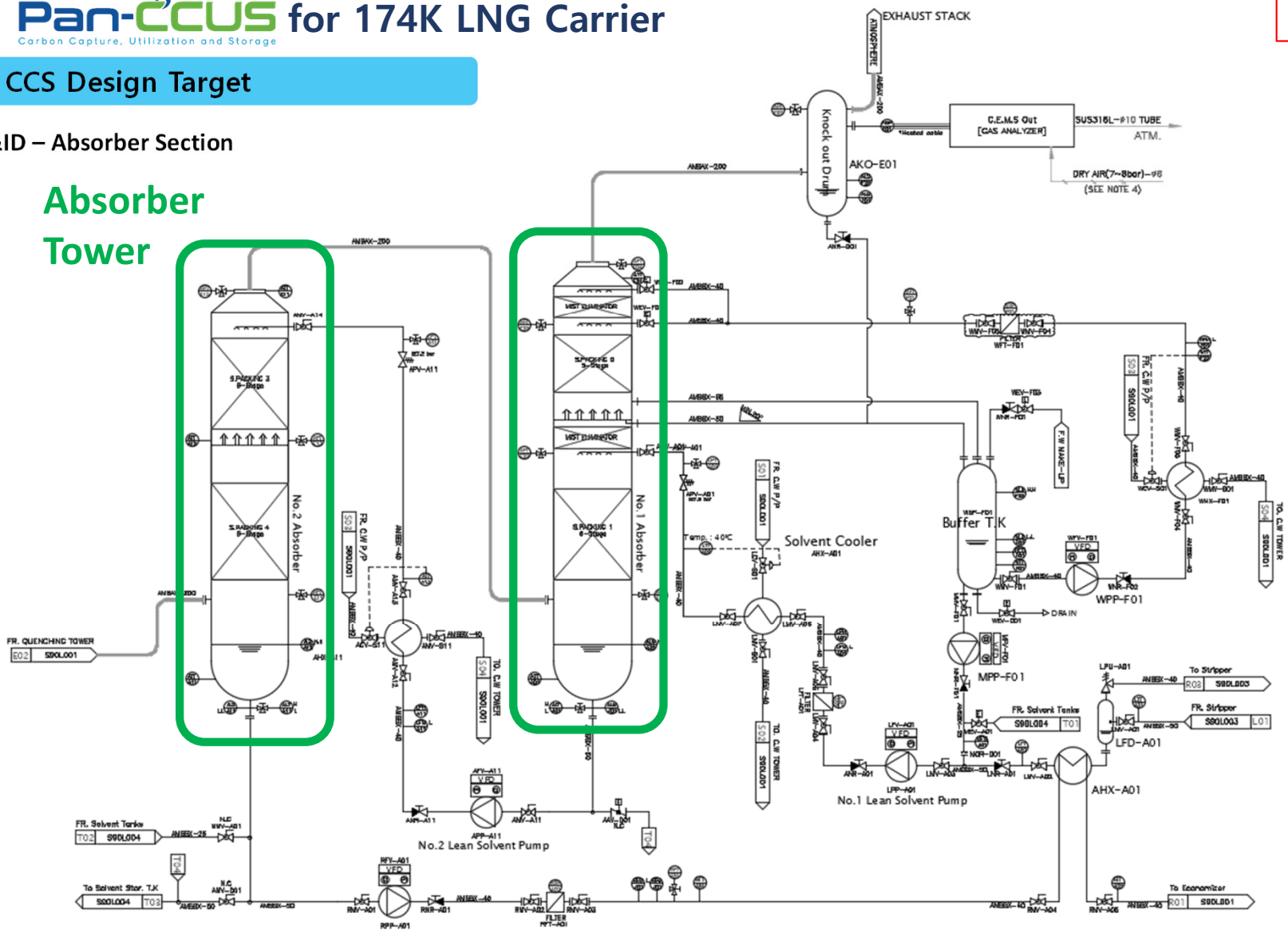


- Optional Economizer for Solvent Heating
- Intake fan operated by Gas Flowrate and engine Exhaust gas Pressure
- Seawater cooling and Fresh water washing section
- Mist separator after Quenching tower

➢ CCS Design Target

P&ID – Absorber Section

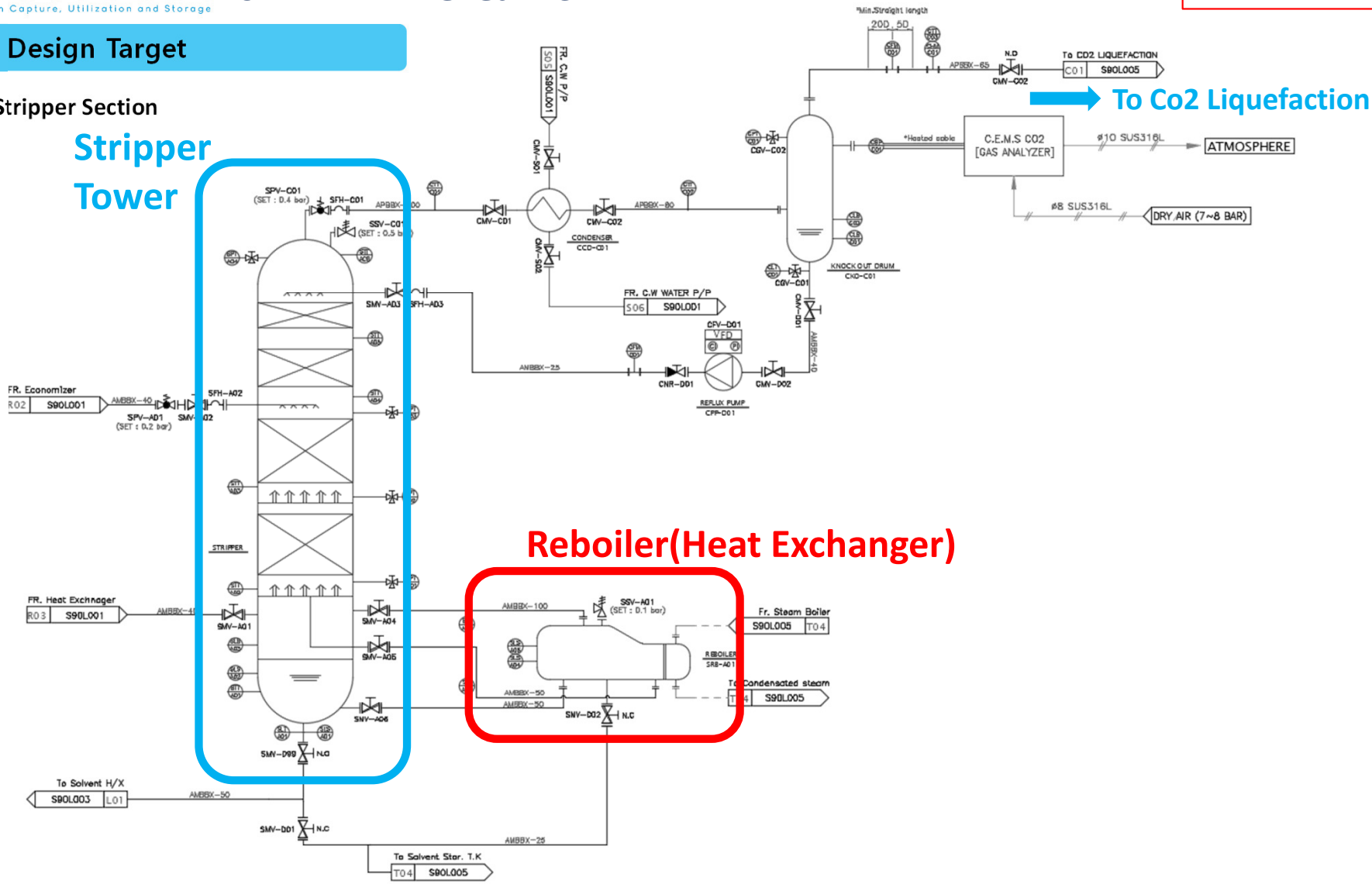
Absorber Tower



- Fresh water washing section for Solvent droplet
- Mist separator after Quenching tower
- Anti-Sloshing type Liquid distributor
- Plate type cooler for liquid heat exchange

➢ CCS Design Target

P&ID – Stripper Section



- Low Pressure operation (0.4 bar.g)
- Shell & Plate Type Heat exchanger(Reboiler and Condenser) for High efficiency
- After Mist separation, Purity of carbon dioxide is over 97% and 3% of H2O

➢ PANASIA + HMM CCS collaboration

We are researching the CCS feasibility study for Heavy Lift vessel with HMM

Engine information

No & Type of Engine	1D: 2 SA 7 CY
Bore & Stroke	600 X 2400
Output kW/rpm	15820.00 / 105.0

No. & Kind of Boiler	1 Auxiliary Boiler WTB	2 Auxilary Boiler WTB
Pressure(bar)	9.0	9.0
Heating Surface Area(㎡)	19.1	375.0
No. & Capacity of Generator	1 X AC 1137KVA 450VOLT, 2X AC 1325KVA 450VOLT	

Capture target designation

	'23	'24	'25	'26	'27	'28	'29	'30
CII average	11.69	11.69	11.69	11.69	11.69	11.69	11.69	11.69
CII R	8.60	8.42	8.24	8.06	7.81	7.56	7.31	7.06
CII C	9.12	8.93	8.74	8.54	8.28	8.02	7.75	7.49
CC Rate	22%	24%	25%	27%	29%	31%	34%	36%

* We are investigating how to decrease maximum output for meeting the EEXI regulation

- Project schedule

Feasibility study(~'21)
(Target, LCO_2 Storage, Power consumption)

→

Design (~'22)
(Equipment design, Arrangement)

→

Application (in '23)
(According to target vessel's Docking schedule)

05 Other Competitiveness

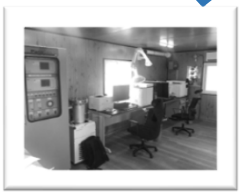
Smart Control Center

Panasia competitiveness

Smart Control Center

CCS

S/W
Remote update



CCS FOR SMR
Control panel

Data
collector

CCS
Control panel
[VESEL / PLANT]

Data
collector

SMART MONITORING AND CONTROL CENTER

Main server

Integrated control
center

Feed Back

User
Operating data
feedback
Minimize operating
failure/loss

Diagnosis

System status/operating data
System real time monitoring
Fail diagnosis & trouble shooting

Management

Online update
Big Data analysis
Consumables alarm
Minimize operating loss

Safety

H2 leakage alarm
Real time system monitoring
Prior estimation of error

CREDIT RATE

Panasia competitiveness

KOREA RATING & DATA

CREDIT RATING

Corporate Credit Rating

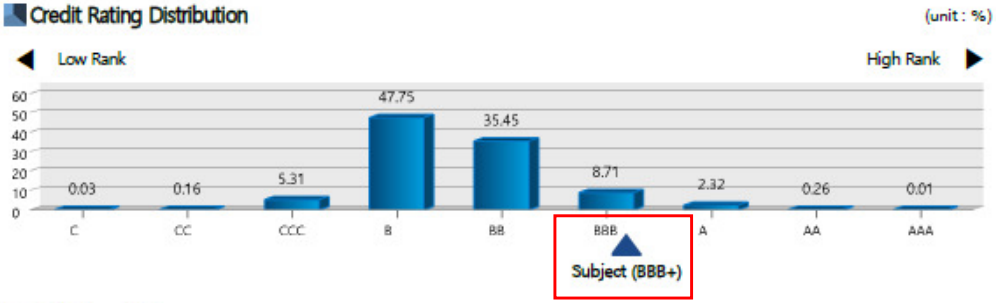
Corporate Credit Rating	BBB+
Date of Rating	Apr. 08, 2022
Fiscal Year-end	Dec. 31, 2021
Rating Explanation	The company has adequate capacity to meet financial commitments, but expected to have less stability in the future than companies in higher rated categories.

Historical Corporate Credit Ratings

Date of Rating	Fiscal Year-end	Corporate Credit Rating	Fluctuation
Apr. 07, 2022	Dec. 31, 2021	BBB+	—
Mar. 14, 2022	Dec. 31, 2020	BBB+	⬇
Sep. 09, 2020	Dec. 31, 2019	A-	⬆
Aug. 26, 2019	Dec. 31, 2018	BBB	⬆

Credit Rating Distribution

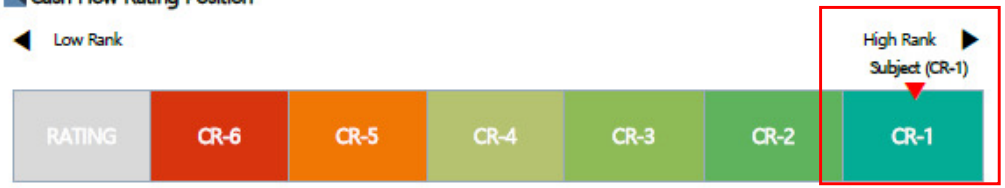
(unit : %)



Cash Flow Rating

Cash Flow Rating	CR-1
Fiscal Year-end	Dec. 31, 2021
Rating Explanation	The company has exceptionally strong capacity and stability for generation of cash flow.

Cash Flow Rating Position

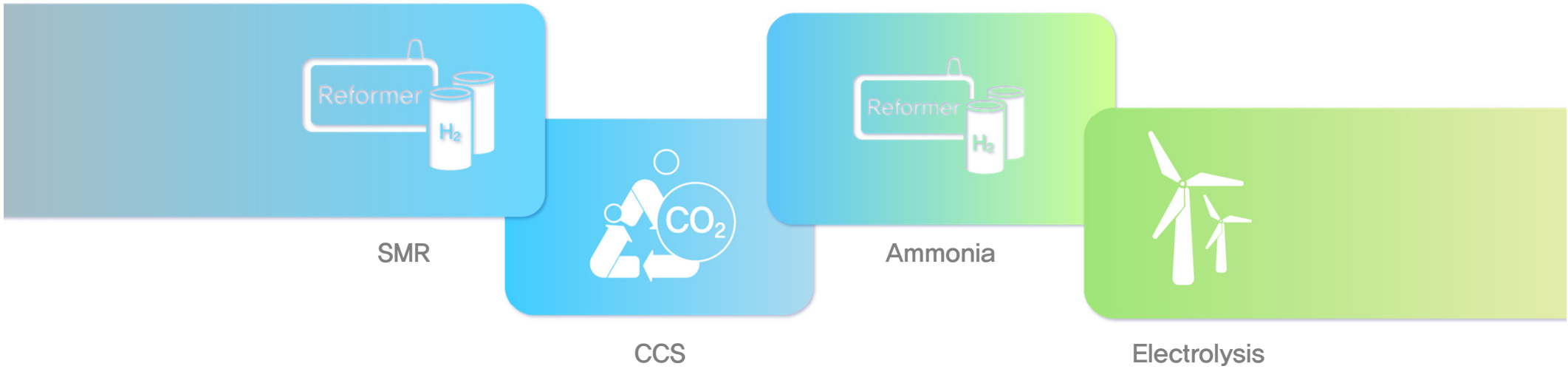


08. APR. 2022 Korea Rating & Data

Strong CREDIT RATING & CASH FLOW RATING
Can show PANASIA's future potential

PANASIA, a company challenges the technologies that didn't exist in the world

All Colors Hydrogen & Carbon Capturing Pioneer in Korea



THANK YOU