Current Status and Vision of CCUS in Republic of Korea

Kwon Yi Kyun

Kongju National University

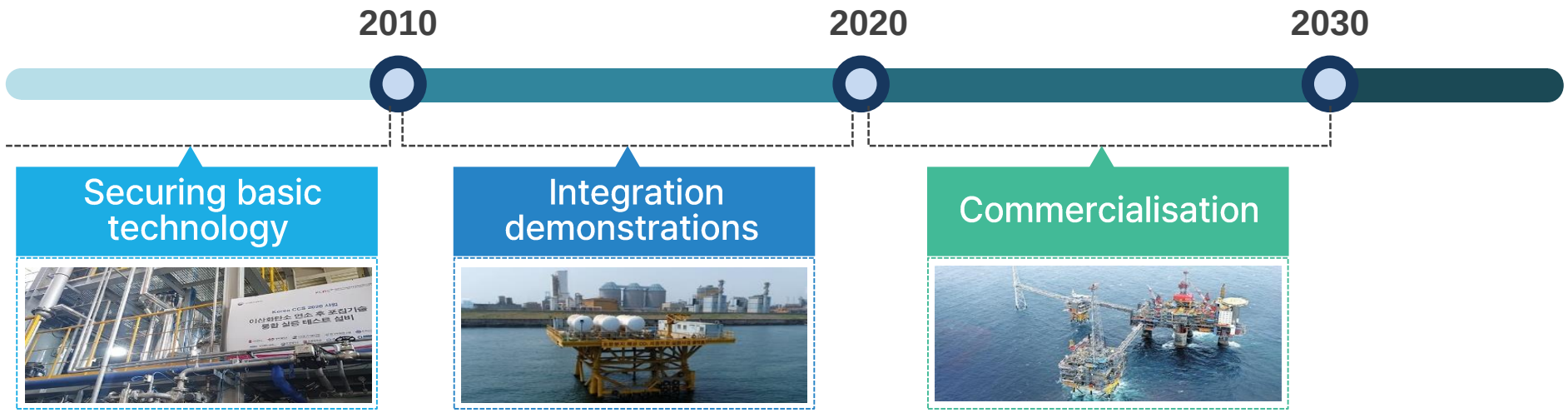
CONTENTS

Current Status

Vision

01. Current status : R&D Activities in Korea

Main R&D topics and technical development stages



R&D Activities

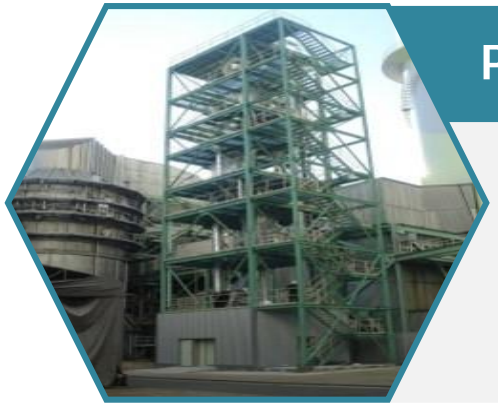
- Basic Technology
- Innovation Technology
- Integration Demonstrations
- Reduced costs
- Large-scale
- Safety
- Law · System

02. Current status : Status of Capture Technology

Conventional capture technology in power generation

Post-combustion absorption capture technology: Boryeong Thermal Power Plant

- Successful construction and long-term operation of the largest 10 MW wet capture plant in Korea
- The absorbent (Kosol) has a CO_2 absorption rate of about 90%, the purity of captured CO_2 is 99.9%
- Cost about USD 29 ~32 (Capture : USD 22, Compression : USD 7 ~ 11)



Post-combustion adsorption capture technology: Hadong Thermal Power Plant

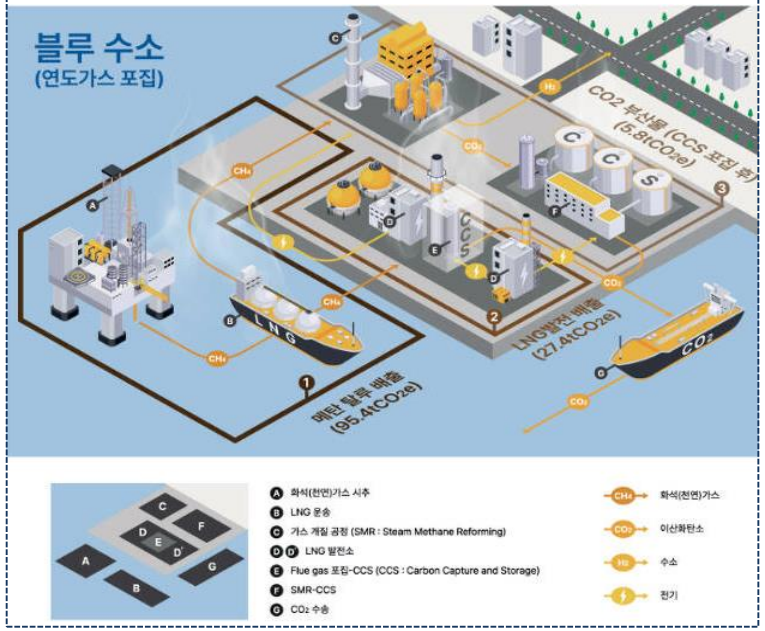
- Successful construction and long-term operation of the largest 10 MW dry capture plant in Korea
- The solid-state adsorbers have a CO_2 adsorption rate about 85% and a captured CO_2 purity of 99%
- Cost about USD 45~49 (Capture : USD 22, Compression : USD 7 ~ 11)

02. Current status : Status of Capture Technology

◎ Technical development in field of blue hydrogen, LNG power plant and Direct air capture

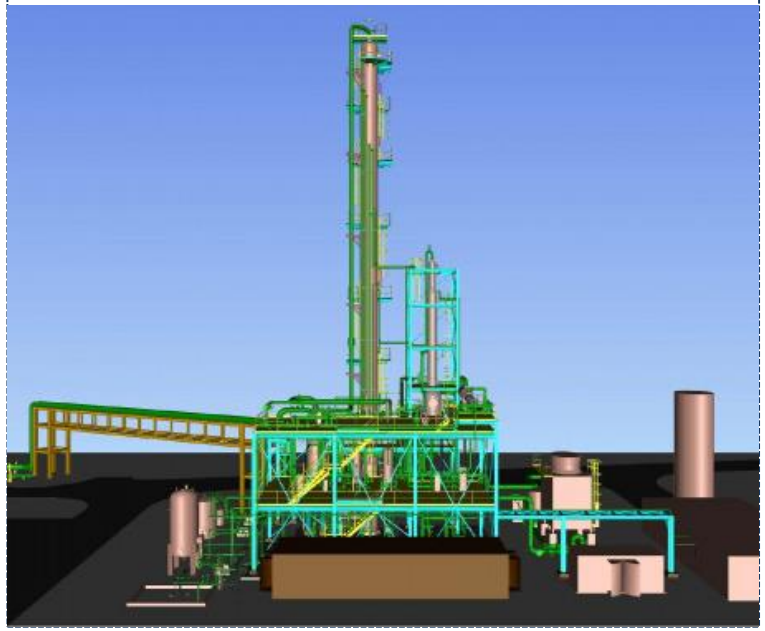
Blue Hydrogen

SK E&S, SK Energy
APPROTIUM



LNG Power Plant

KEPCO, KEWP
HYUNDAI POWER SYSTEMS

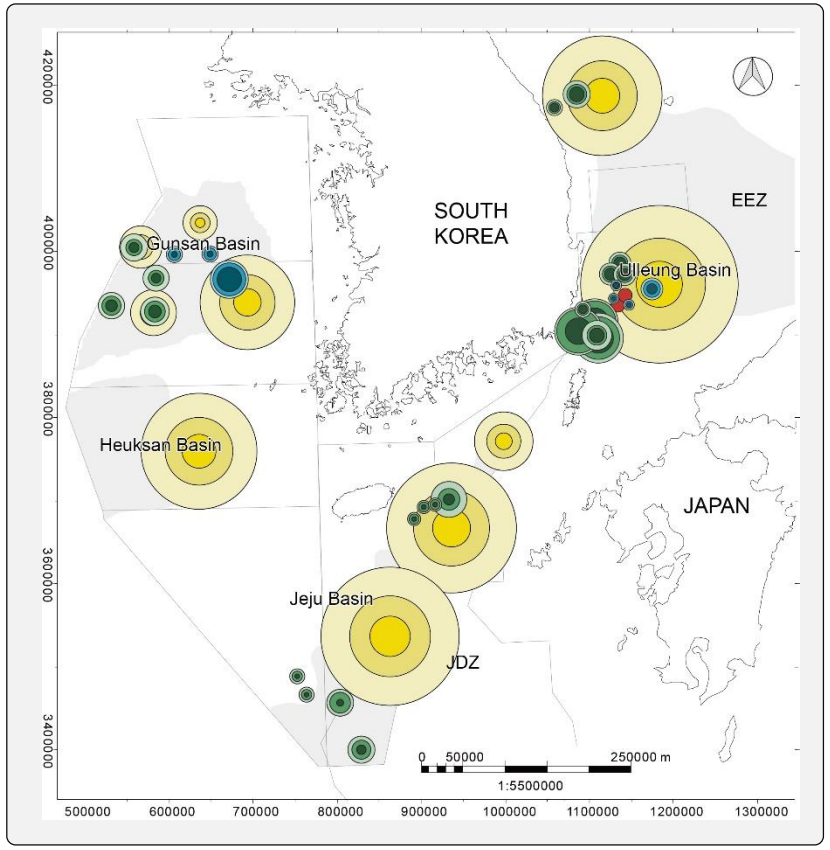


Direct Air Capture

KIER, Low Carbon
Capture6-consortium

03. Current status : Assessment of Carbon Storage Formation in Korea

Result of Site Screening and Evaluation of Storage Capacity in Korea



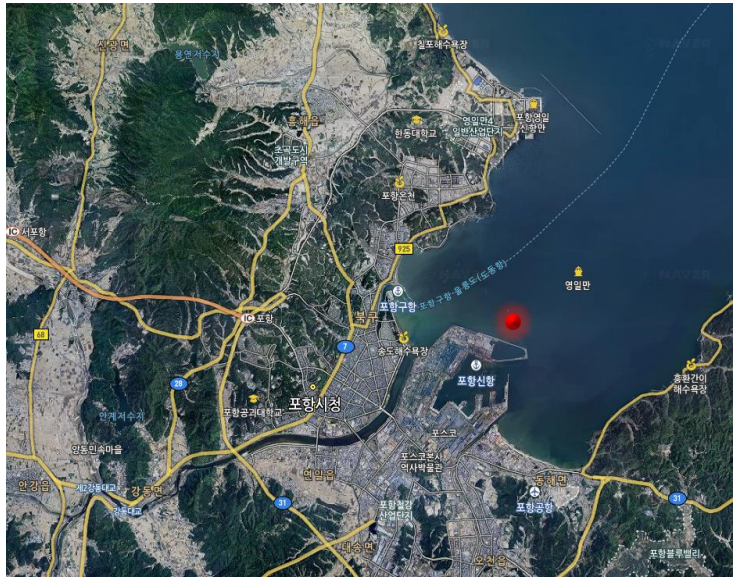
Sea Area	1 step	2 step	3 step	4 step
West sea	94	15.4	5.4	-
South sea	196	13.6	-	-
East sea	314.6	56.8	1.93	0.14
Total	640.6	85.8	7.33	0.14

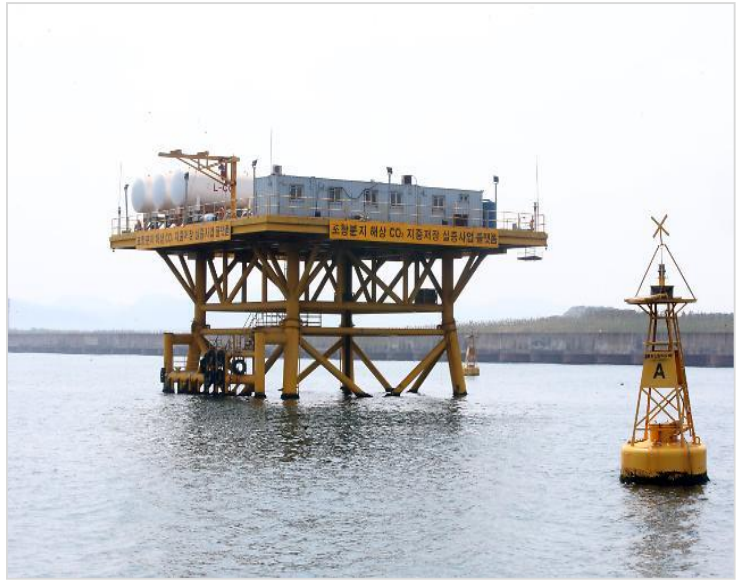
- **Estimation on Korea's domestic CO_2 Storage Capacity: about 1 billion tons**
  - ✓ Storage sites: conventional storage sites (600 million tons), marginal storage sites (200 million tons), through enhanced injection efficiency (200 million tons, 25% increase)
  - ✓ The 2050 Carbon Neutrality Scenario aims to reduce approximately 60 millions tons of CO_2 emissions through CCS, of which **50% involves overseas CCS projects**
- **The scale and geological features of domestic storage sites are not sufficient for large-scale CCS projects (limited national territory)**
  - ✓ **Importance of cross-border projects**

04. Current status : Small-scale Demonstration of Carbon Storage Technology

Carbon dioxides was collected from power plant capture facility
Subsea pipeline transportation
Offshore CO_2 injection platform is located at Youngil Bay

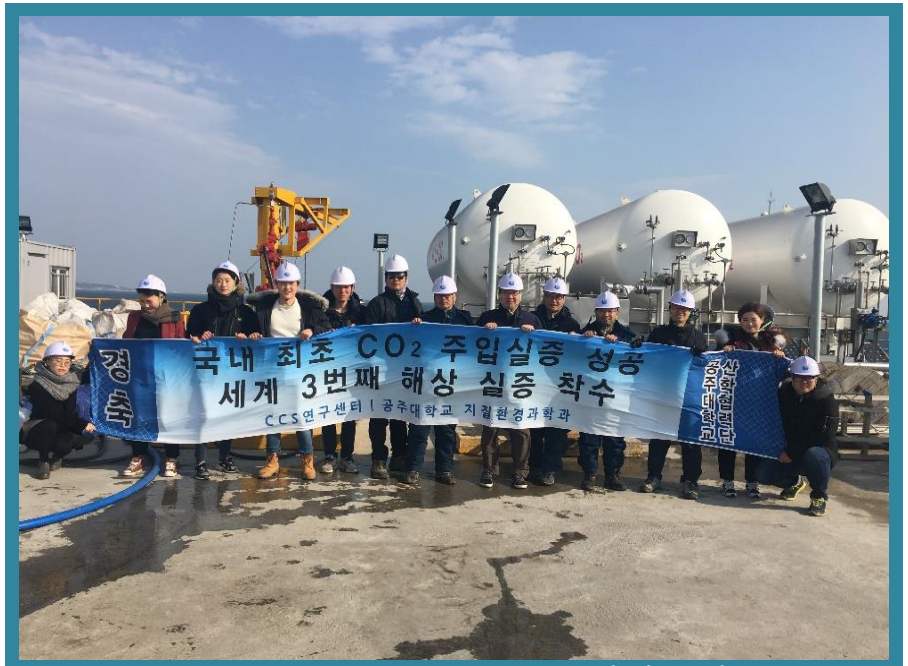
“ Small-scale offshore CO_2 storage demonstration project in Pohang Basin, South Korea ”



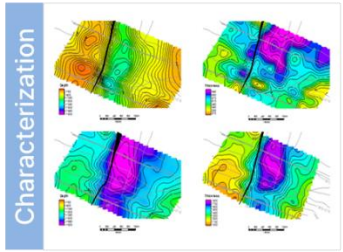


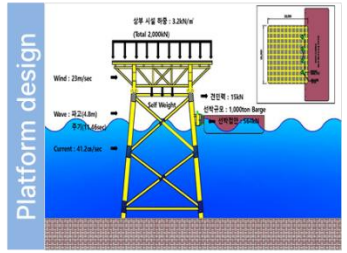
04. Current status : Small-scale Demonstration of Carbon Storage Technology

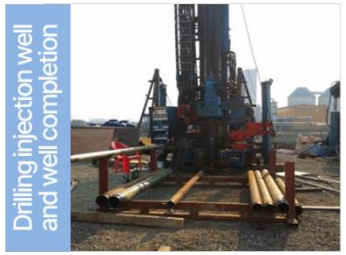
◎ Success of 100 tons of CO_2 injection demonstration ('17.2)



Completed Pohang CO_2 injection demonstration







First successful demonstration of CO_2 injection in Korea

Achievement of more than 80% technological independence

05. Current status : Crisis due to Earthquake and New Beginning

◎ Risk and crisis due to public acceptance issues

- Occurrence of induced earthquakes caused by geothermal EGS project (‘17. 11)
- Opposition from Pohang citizens and worsening public opinion on CCS project
- Rigorous and transparent investigation and communication with civil society
- Resumption and expansion of CCS projects and business

Pohang earthquake

Risk and crisis

Communication

Resumption

05. Current status : Crisis due to Earthquake and New Beginning

Ministry of Science and ICT	Ministry of Trade, Industry and Energy		Ministry of Oceans and Fisheries	Ministry of Environment
Technological Development and Innovation	Capture Demo.	Storage Demo.	Marine Exploration Offshore monitoring	Environmental monitoring on land
Interruption CCS, Focus on CCU	Pause CCS		Project interruption	Project interruption

2017 Pohang earthquake

Small-scale CCS project

Safety investigation of CCS project	Creation of CCS guidelines and manuals	Communication and Public acceptance

Resumption and New beginning of CCS

3rd Nation Strategy and the Five-Year Plan for Green Growth ('19.5) → CCS project resumption

Inter-ministerial cooperation CCS project ('21~'23) → Strengthening inter-ministerial cooperation

Green New Deal

Low-Carbon Green Growth

Net-Zero

2050 Net Zero ('20.10)

06. Vision : Carbon Neutrality Pledge and Act

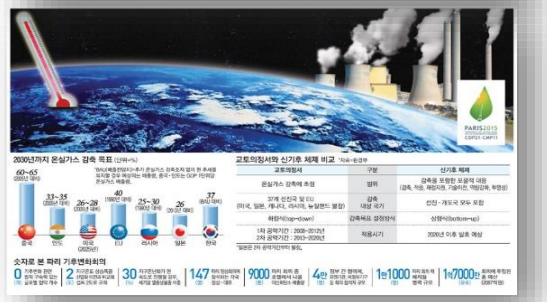
Carbon Neutrality Pledge('20. Oct.)

- Key policy initiatives guide Korea's approach to carbon neutrality and the commercialization of CCUS

✓ CCUS technology represents a critical means to achieve Korea's 30-year NDC and 2050 Carbon Neutrality Goals

Government Action timeline

'20 Oct	2050 carbon neutrality pledge announced
'21 Apr	2030 NDC target announced to the international society
'21 Sept	Korea enacted the "Carbon Neutrality Framework Act"
'21 Oct	2050 Carbon neutrality scenarios released

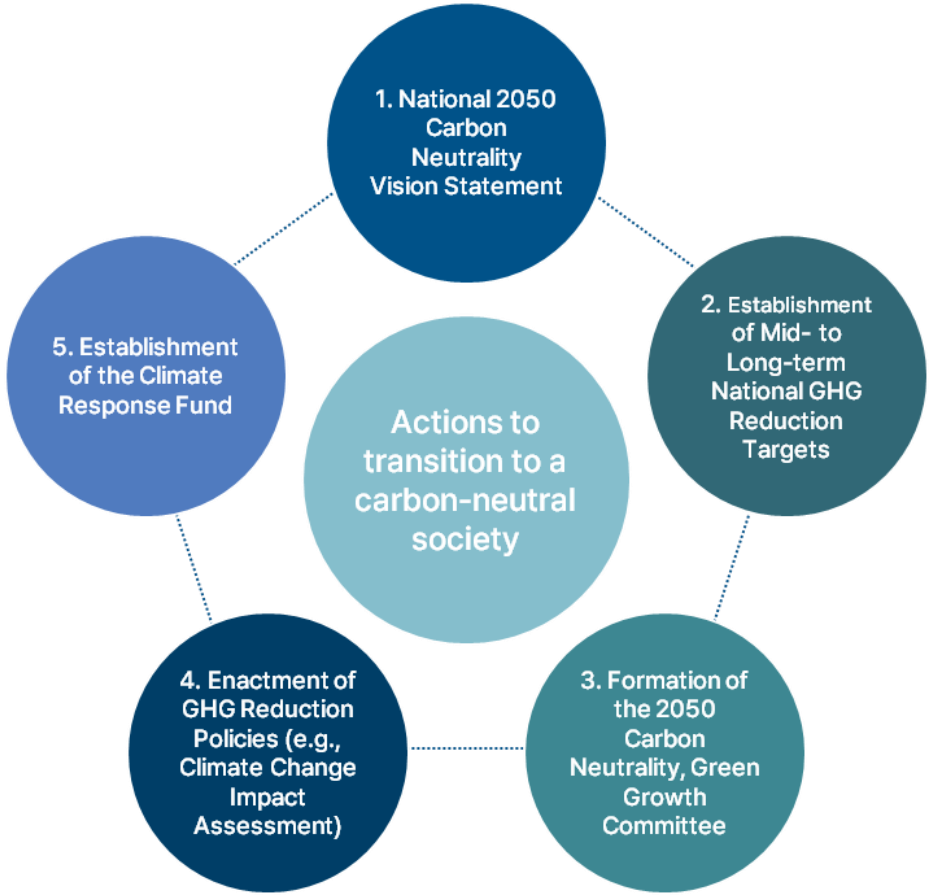


06. Vision : Carbon Neutrality Pledge and Act

◎ Carbon Neutrality Act('21. Sept.)

- Strengthening GHG Reduction and Climate Change Adaptation

National Vision	Transition to a carbon-neutral society by 2050 and promote harmonious development of the environment and economy
National Strategy	① Achieve Carbon Neutrality Responsibly through Specific and Effective GHG Reductions ② Innovative Carbon Neutrality & Green Growth Led By the Private Sector ③ Carbon Neutrality through Cooperation and Understanding with all Members of Society ④ Carbon Neutrality that Leads the International Efforts on Climate Change Adaptation
Mid-to long term Reduction Targets	Aiming to Reduce "GHG Emissions by 40%" by 2030



07. Vision : 2030 NDC & 2050 Carbon Neutrality Scenario

Key policy initiatives guide Korea's approach to carbon neutrality and the commercialization of CCUS

- CCS : reduce approximately 60 million ton of CO_2 emissions through CCS
- CCU : reduce approximately 25.2 million tons of CO_2 emissions through mineral carbonization, chemical-, and biological- conversion and other processes

By 2030, Korea aims to reduce CO_2 emissions by 11.2 Mt* through CCUS (CCS 4.8 MTPA, CCU 6.4 CCU MPTA)

Comprehensive 2050 Carbon Neutral Scenarios *(Proposed)*

Emission Reduction Method	Scenario A	Scenario B
CCUS	-55.1 Mt	-84.6 Mt

In both 2050 scenarios, CCUS is forecast to play a major role in Korea's decarbonization

(Announced October 18, 2021)

07. Vision : 2030 NDC & 2050 Carbon Neutrality Scenario

Paris Agreement Sets Need to Establish NDCs

- Korea's commitment to the Paris Agreement through it's NDC Give Priority to CCUS
- NDC Target - Reduce GHG emissions by 40% by 2030, compared to 2018-levels
  - 72.76 Million Tons to 436.6 million by 2030

- Adjustments to Sectoral Targets Finalized ('23.3), 40% reduction goal by 2030 maintained
  - CCUS Sectoral Goal Revised – from 10.3 to 11.2 million tons (900,000 ton increase)
  - **(CCS – 4.8 million tons)** CO_2 storage site exploration in the East and West Sea Continental shelves. securing large-scale storage (120 million tons, by '23) through drilling, and actively securing overseas storage
  - **(CCU – 6.4 million tons)** Promoting the private sector through commercialization R&D and various institutional supports
    → Full-scale demonstration in '26 to reduce 6.4 million tons per year by '30


Energy Transformation (145.9)


Industries (230.7)


Buildings (35.0)


Transportation (61.0)


Agriculture, Livestock, and fisheries(18.0)


Waste (9.1)

Hydrogen (8.4)


Carbon Sicks (-26.7)

CCUS (-11.2)


Overseas Reduction (-37.5)

07. Vision : 2030 NDC & 2050 Carbon Neutrality Scenario

Announcement of Korea's 2050 Carbon Neutrality Scenarios

- **(Background)** Need to materialize future plans in accordance with Korea's carbon neutrality declaration ('20.10)
  - "2050 Carbon Neutrality Scenario" prepared to specify the future of 2050 carbon neutrality and to specify the policy direction necessary for the structural transformation of the entire society ('20.12~)

- Government Formed a Technical Working Group to Develop the Scenarios
  - (Scenario A) Achieving zero net domestic emissions by 2050 by reducing emissions as much as possible, including a complete shutdown of thermal power generation
  - (Scenario B) Achieving zero net domestic emissions by 2050 by fully utilizing technological alternatives for CO_2 removal, such as CCUS, while retaining partial generation of thermal power using LNG

CO_2 Emissions By Sector, Reduction Targets

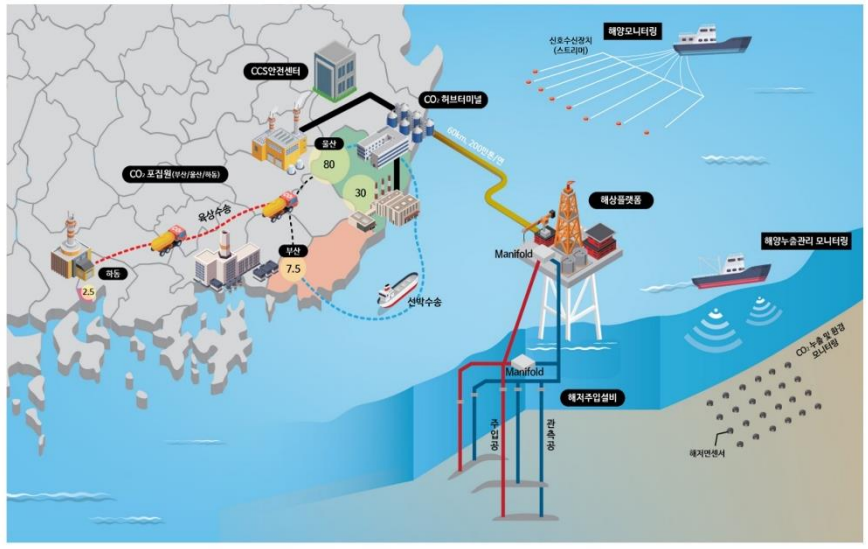
(Unit: million tons CO_2eq)

	Gross Emissions	Conversion	Industry	Building	Transportation	Livestock & Fisheries	Waste	Hydrogen	Fugitive Emission	Carbon Sinks	CCUS	DAC
Scenario A	0	0	51.1	6.2	2.8	15.4	4.4	0	0.5	-25.3	**-55.1**	-
Scenario B	0	20.7	51.1	6.2	9.2	15.4	4.4	9.0	1.3	-25.3	**-84.6**	-7.4

08. Vision : Large-scale CCS Demonstration Project

◎ “EAST SEA CCS PROJECT” : Korea’s First Large-Scale Demonstration

- Aim – Reduce 1.2 million tons of CO_2 per year to meet Korea’s NDC targets, safely and economically realize CCS through integrated, large-scale demonstration in the East Sea
- Ministries Involved – Ministry of Trade, Industry, and Energy (Lead), Ministry of Oceans and Fisheries (support)
- Donghae CCS will capture CO_2 from regional industrial and power plants in Korea’s Southeast coast and store it in the Donghae-1 Gas field
- Injection to begin in 2027, upscale to 1.2 million tons/year by 2030



East Sea CCS Project

Depleted gas field in the East Sea

09. Vision : Preparation for CCU Flagship Demonstration Program

CCU Roadmap for Technical Development

- The Korean CCU Roadmap is the long-term strategy for the technological advancement and commercialization of CO_2 utilization

- Korean CCU Roadmap('21.5)
  - **Vision** : Achieve carbon neutrality and spur new industries through CCU technological innovation
  - Policy Objectives
    - Have 14 commercial CCU products by '30
    - Achieve price competitiveness within existing market by '40

2025

2025 Securing Technological Competitiveness

- Relative to comparable advanced countries
- Present - 80%, By 2025 - 90%

2030

2030 Securing Commercialized CCU Products

- Present - No such production
- By 2030 – 14 product types (10 chemical conversion, 4 mineralization)

2035

2040 Securing Cost Competitiveness

- Present – Research stage
- By 2040 – CCU products price competitiveness with existing market

10. Vision : Legislation on CCUS and Transboundary CCS in Korea

Legislation and Building an Institutional and Systematic Foundation

- Progress on legislating the capture, transport, storage, and utilization of CO_2
  - Introducing legislation to the National Assembly by preparing a draft in cooperation with Ministries (MOTIE, etc.) and the Presidential Commission on Carbon Neutrality and Green Growth
  - Enact CCUS law at early 2024, revise and finalize subordinate legislation in the first half of 2024

Background and progress

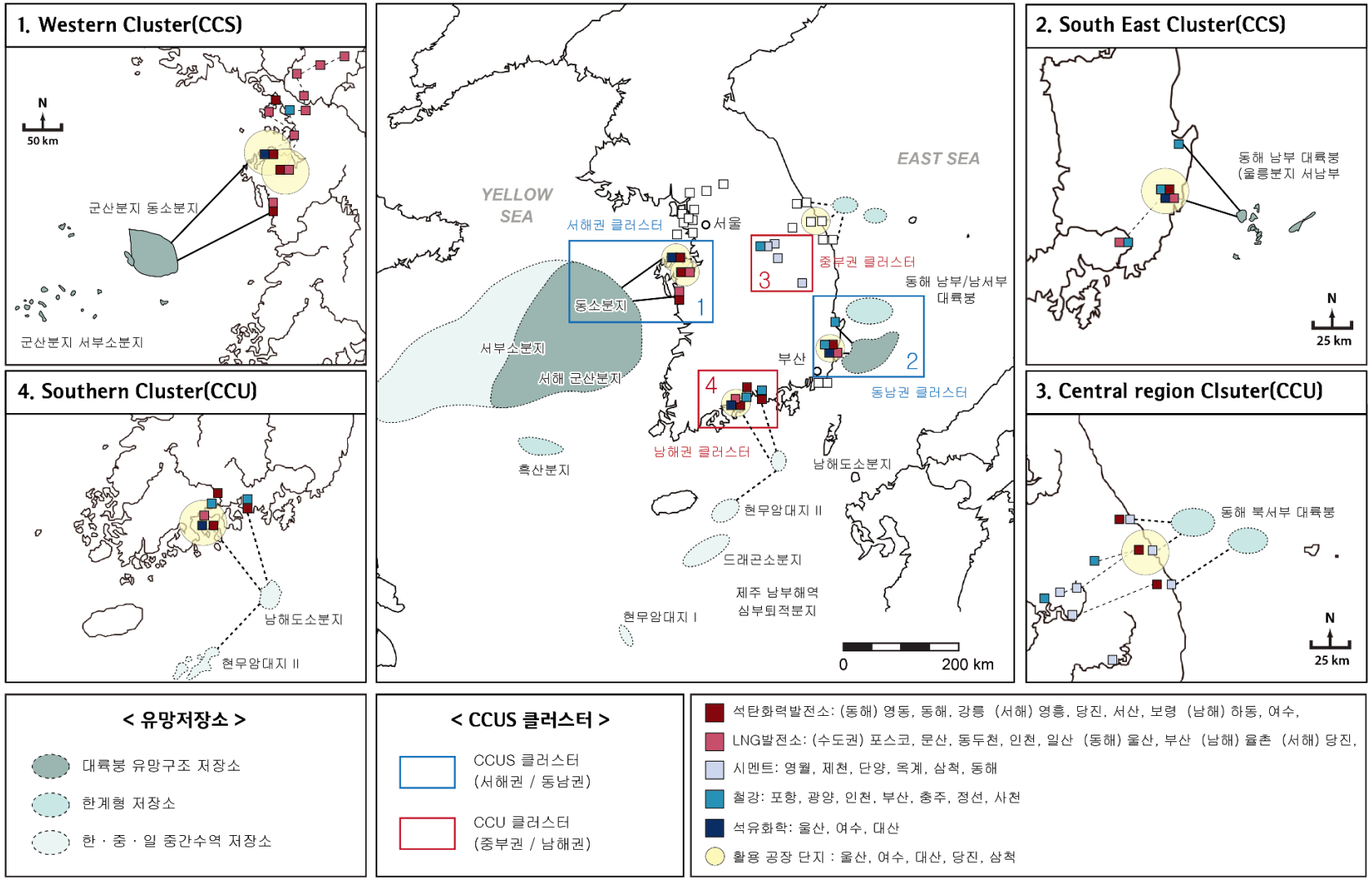
- **(Background)** CCUS is partially regulated by more than 40 laws without a single law, so there is a consensus among ministries to establish a basis law for efficient CCUS commercialization, etc.
- **(Progress)** After agreeing on the need for legislation, research was promoted through a multidisciplinary CCUS project, a cross-ministerial council led by Prime Minister's Secretariat was organized to discuss the issue, and a bill was drafted through a bill drafting taskforce (MOTIE)

Composition of Act on capture, transport, storage, and utilize of carbon dioxide(draft)

- **(Purpose)** Contribute to efficiently responding to the climate crisis and developing new industries by establishing a legal basis for CCUS
- **(Contents)** Consisting of relevant provisions such as ❶ General Provisions ❷ Establishment of Master plan ❸ Installation of capture facilities, etc. ❹ Exploration of storage candidate sites ❺ Permission of storage projects ❻ Designation and operation of integrated complexes ❼ Promotion of industries including capture

10. Vision : Legislation on CCUS and Transboundary CCS in Korea

◎ CCUS Hub & Cluster in Korea



10. Vision : Legislation on CCUS and Transboundary CCS in Korea

Korea's Current Status and Projects of Cross-border CCS

- Cross-border CCS is being promoted based on procedures for international cooperation
  - Korea completed its IMO deposition as of April 2022
  - After deposition, agreement/arrangement is needed for specification, so inter-governmental discussions are necessary
  - Currently in preparation for CCS cooperation MOU and agreement/arrangement with Australia and Malaysia

AUSTRALIA: SK E&S – BU Project

- CCS project to convert the Bayu-Undan gas field (located offshore northwest of Australia/south of Timor-Leste) for CO_2 storage after production ends ('23) is underway, pending completion of institutional framework by relevant countries
- Overview : Conversion of the Bayu Undan natural gas production facility offshore Timor-Leste into a CCS plant
- Scale : 10 Mt per year (260 Mt total)
- Timeline: FEED (March 2023) → BU gas field production ends (late 2023) → CO_2 storage conversion > commercial operation (expected 2026)

MALAYSIA: Samsung Engineering Consortium – SHEPHERD Project

- A hub project between Asian countries that aims to capture CO_2 generated domestically, transport and store it in Malaysia (Sarawak), explore local storage sites, and develop the entire value chain from domestic carbon capture to transportation and storage
- Overview : 10 companies are participating as a consortium, currently finalizing F/S and aiming for injection in 2027-28
- Scale : Hubs in 2 industrial complexes (Yeosu/Ulsan) to capture 1 Mt per year (2028), with plans to expand to up to 3 Mt in 2030, (depending on policy and status of nearby complexes)
- Timeline : Full value chain F/S completed (August 2023) → Preparing to start the next phase (pre-FEED/FEED) for each operator → EPC to start after FID (expected in 2025)

THANK YOU