経済産業省

Introduction of Long-Term CCS Roadmap

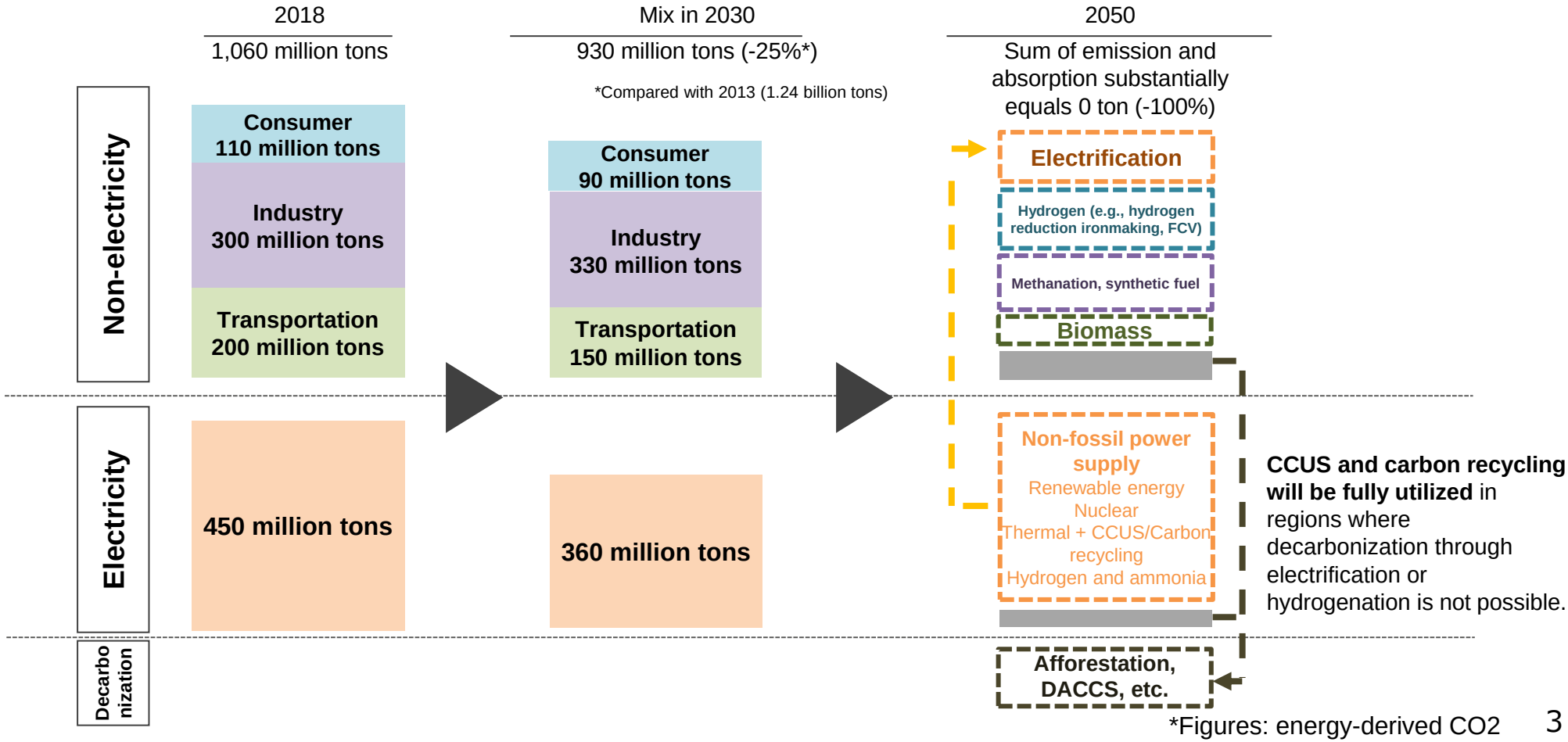
Oil and Gas Division

Agency for Natural Resources and Energy

1. Status of CCS in Japan

Status of CCUS toward 2050 Carbon Neutrality

- To achieve carbon neutrality in the entire society, **the electricity sector should enhance non-fossil power supply while the non-electricity sector including industry, consumer, and transportation sectors (fuel and heat users) should promote electrification by decarbonized electric power, hydrogenation, and decarbonization with methanation or synthetic fuel.**
- **Toward 2050 carbon neutrality, utilization of CCUS is indispensable for decarbonizing thermal power plants.** Also, **CCUS and other processes should be fully utilized in sectors where emission of CO2 is unavoidable** because decarbonization through electrification or hydrogenation is not feasible.

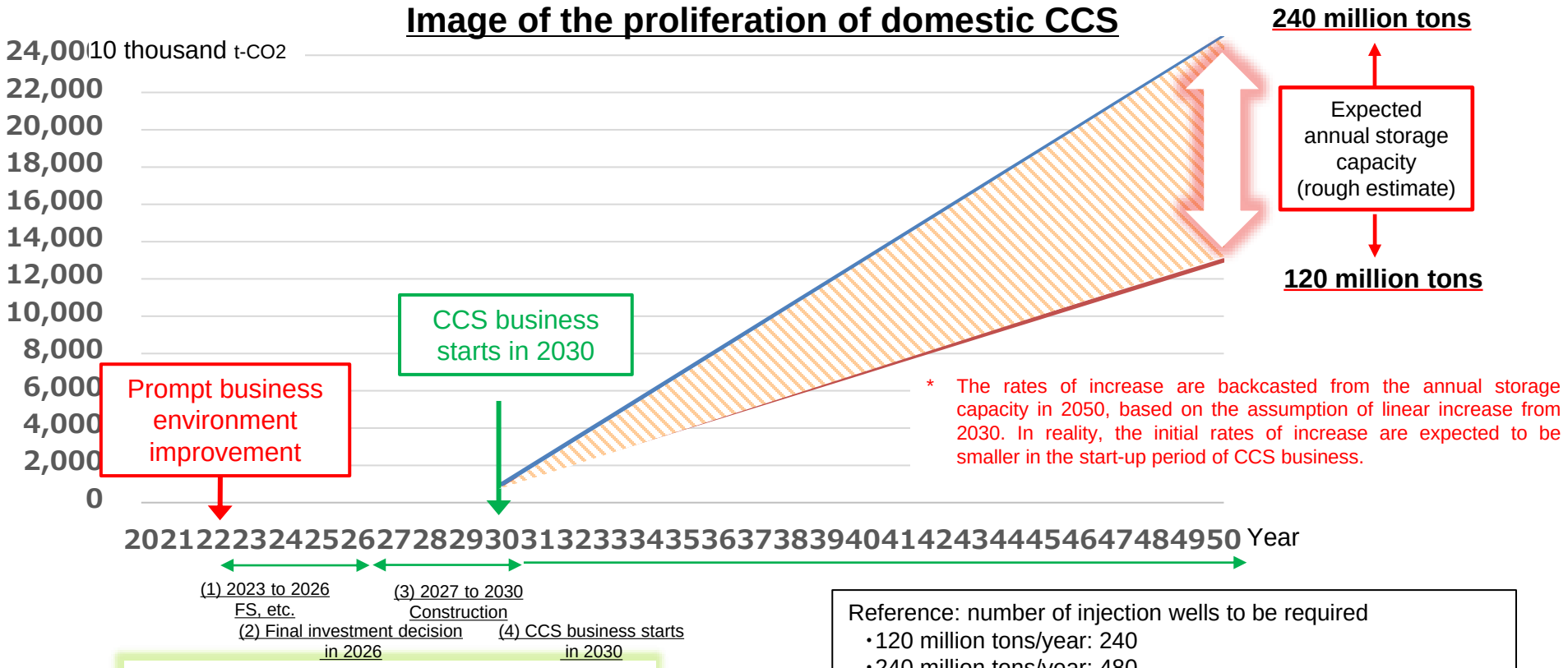


*Figures: energy-derived CO2

Roughly Estimated Annual Storage Capacity of CCS in 2050

- Based on IEA trial calculation, **estimated annual storage capacity of Japan's CCS can be roughly estimated at 120 to 240 million tons in 2050**. Supposing CCS is introduced in 2030, **the number of injection wells needs to increase by 12 to 24 every year during the 20 years until 2050**.
- To start CCS business **by the end of 2030, operators have to start FS, etc. in 2023 and make final investment decisions by 2026.**

Image of the proliferation of domestic CCS



* The rates of increase are backcasted from the annual storage capacity in 2050, based on the assumption of linear increase from 2030. In reality, the initial rates of increase are expected to be smaller in the start-up period of CCS business.

To start CCS business **by the end of 2030**, operators have to
(1) start FS, etc. **in 2023** and
(2) make final investment decisions **by 2026**.

Reference: number of injection wells to be required
- 120 million tons/year: 240
- 240 million tons/year: 480

*Storage capacity per injection well: 0.5 million tons/year
*Prospecting cost: approx. 5 billion yen/well on land, approx. 8 billion yen/well at sea

CCS Long-Term Roadmap Intermediate Summary

Basic principles

To implement CCS systematically and rationally to promote **sound development of CCS business in Japan with minimal social costs**, thereby contributing to **the development of Japan's economy and industry, as well as the securing of stable energy supply**.

Substance

The Government is to make a commitment to improve business environment toward the start of CCS business by 2030 on the assumption that rough estimate of annual CO2 storage capacity in 2050 is in the range from 120 to 240 million tons. The concrete actions in the next clause **are to be implemented as required**.

In addition, **the CCS Business and Domestic Laws Study WG and the CCS Business Costs and Implementation Scheme Study WG are to be newly organized** under the CCS Long-Term Roadmap Study Group **for additional study** focusing on those challenges to complete **the final summary of the CCS long-term roadmap by the end of this year**.

◆WG study items (draft) *The study items and members are to be determined later.

- ✓ CCS Business and Domestic Laws Study WG: Study of various challenges in preparation for the legislation of domestic laws governing CCS business
- ✓ CCS Business Costs and Implementation Scheme Study WG: Study of current costs and future cost targets in the entire CCS value chain as well as ideal support from the Government

CCS Long-Term Roadmap Intermediate Summary

Concrete actions

(1) Study of the legislation of domestic laws required for implementing CCS business *To be discussed in the CCS Business and Domestic Laws Study WG.

⇒ **Agendas toward the legislation of laws governing CCS business should be organized by the end of 2022** (example: foundation of a "CO2 injection and storage right" and limitation of operator responsibility (transfer of responsibility to the Government)). Then, **laws governing CCS business should be legislated promptly** toward the start of CCS business by 2030.

(2) Efforts aimed to reduce CCS costs *To be discussed in the CCS Business Costs and Implementation Scheme Study WG.

⇒ R&D and demonstration should be conducted continuously to **reduce costs in the entire CCS value chain including capture, transportation, and storage**. **The Government and the private sector should discuss and define future cost targets and incorporate them into the efforts**.

(3) Study of ideal support from the Government for CCS business *To be discussed in the CCS Business Costs and Implementation Scheme Study WG.

⇒ **The Government should actively investigate places suitable for CCS in cooperation with operators** and **disclose evaluation data in possession including existing data**.

⇒ **Ideal support from the Japanese government** for **advanced CCS business should be studied, referencing to subsidy systems to provide full support for construction and operation stages in the entire CCS value chain including capture, transportation, and storage in leading CCS countries such as Europe and the US**. Note that **the initiative of this project will be taken by operators**.

⇒ **In the future, ideal additional support from the Government should also be studied flexibly based on commercialization stages, referencing to subsidy systems in the US and other countries.**

*Introduction of a carbon pricing system, which has already introduced in Europe, is not a precondition for the discussion toward the commercialization of CCS due to various factors that have to be considered.

(4) Promotion of public understanding on CCS business

⇒ Based on the way of thinking that all available technologies should be used without ruling out any possibility, with the aim of achieving the ambitious target of carbon neutrality by 2050, **the Government, municipalities, and businesses should be unified to advocate the necessity of CCS in preparation for carbon neutrality by 2050 to the public in order to promote understanding of the public as well as residents in CCS implementation areas through the explanation about, for example, the economic ripple effects of CCUS to the municipalities**.

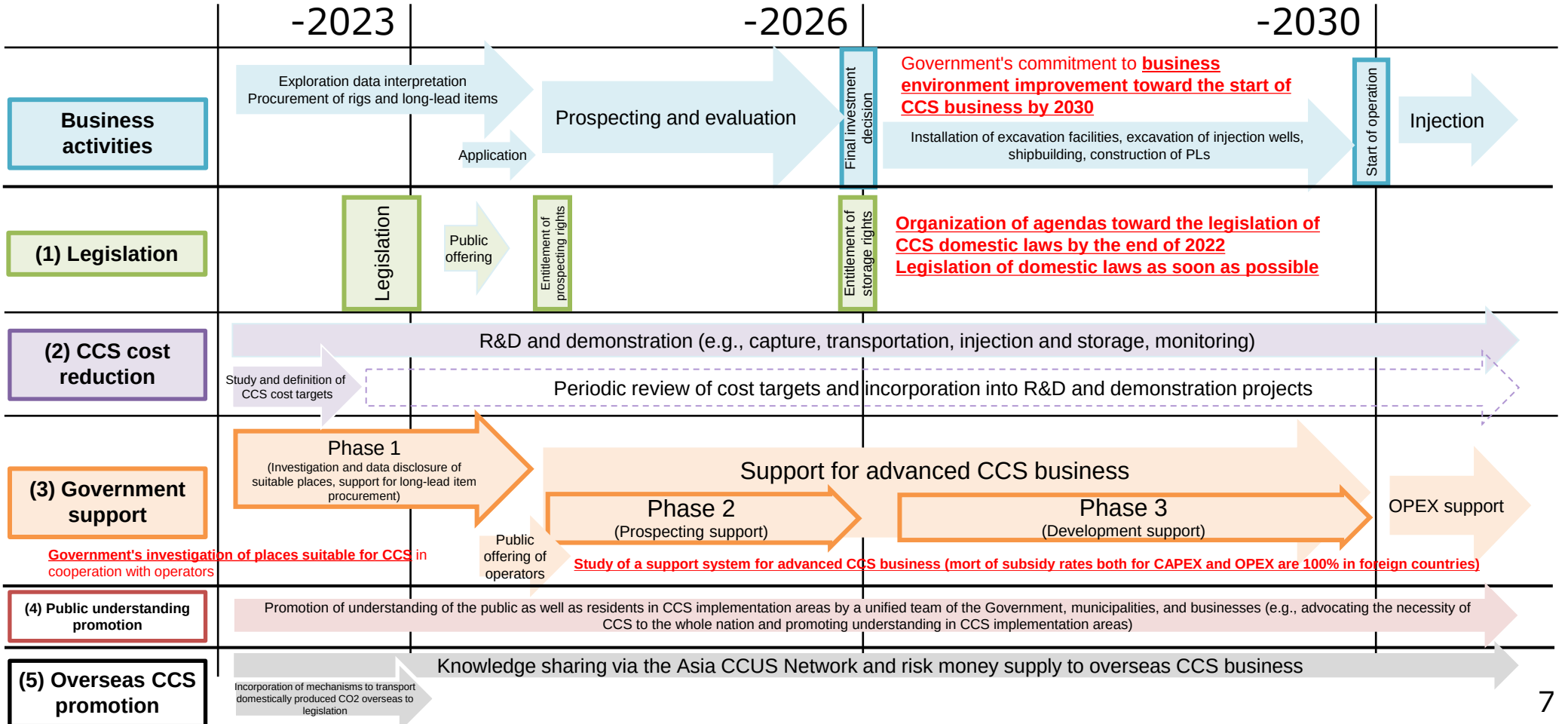
(5) Promotion of overseas CCS business

⇒ In view of carbon neutrality in Asian emerging countries relying on fossil fuels, overseas CNN business should be **supported through knowledge sharing via the Asia CCUS Network, risk money supply to overseas CCS business, and rule making of CCS credits in JCM**.

⇒ **A mechanism to transport domestically produced CO2 overseas for storage should be incorporated in a CCS domestic law to be legislated.**

CCS Long-Term Roadmap Intermediate Summary

- **Business environment improvement toward the start of CCS business by 2030 should be clearly declared as a government target.**
- To achieve the target, the following actions should be taken:
  (1) **Agendas toward the legislation of CCS domestic laws should be organized by the end of 2022 to legislate such laws as soon as possible.**
  (2) **Future cost targets should be defined for each CCS value chain**, and **R&D and demonstration should be conducted to reduce costs**.
  (3) **The Government should actively investigate places suitable for CCS in cooperation with operators** (including disclosure of existing data). **Ideal support from the Government** for **advanced CCS business should be studied**, **referencing to support systems including substantial subsidy systems (most of subsidy rates both for CAPEX and OPEX are 100%) in leading CCS countries such as Europe and the US**. **Ideal additional support from the Government should also be studied flexibly based on commercialization stages, referencing to subsidy systems in the US and other countries.**
  (4) **The Government, municipalities, and businesses should be unified** to **promote understanding of the public as well as residents in CCS implementation areas**.
  (5) **Overseas CCS should be promoted** through knowledge sharing via the Asia CCUS Network and risk money supply to overseas CCS business.

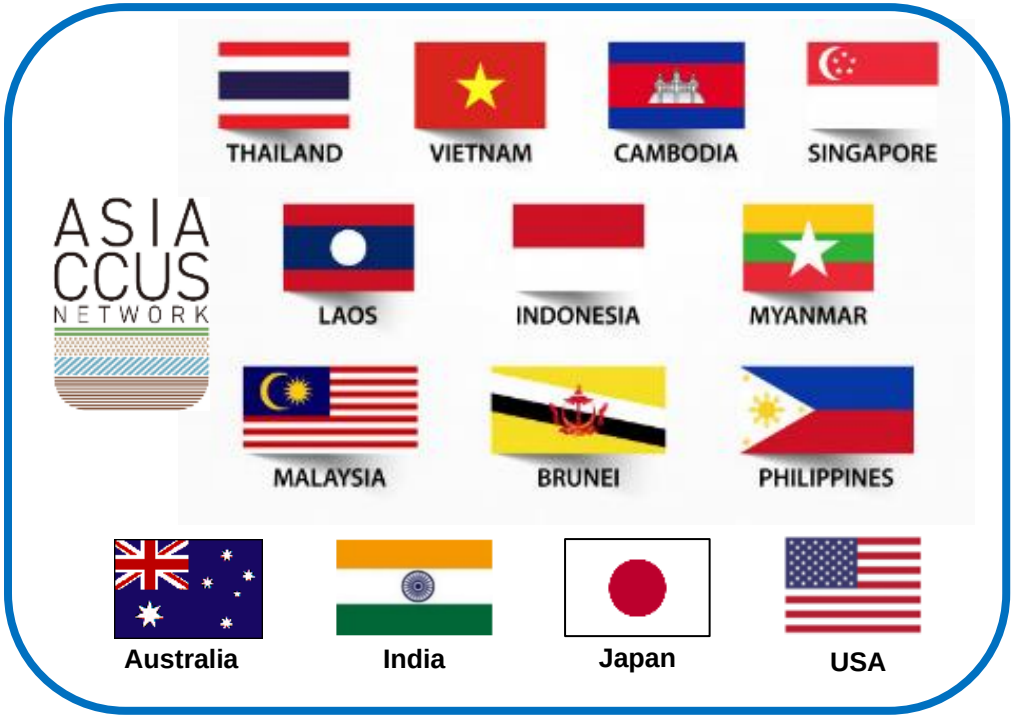


2. Promotion of overseas CCS business

Asia CCUS Network

- Demand for fossil fuel in the Asia region achieving significant economic growth will continue to increase. This region, where CCUS will play a significant role, also has **the potential for large-scale CO2 storage** (190 billion tons or more in the entire ASEAN region).
- In June 2021, the Ministry of Economy, Trade and Industry and the Economic Research Institute for ASEAN and East Asia (ERIA) **announced the launch of the Asia CCUS Network**, which is an international industry–academia–government platform aimed at knowledge sharing and improvement of the business environment for utilization of carbon capture, utilization, and storage (CCUS) throughout the Asia region. **Thirteen East Asia Summit member countries (10 ASEAN member countries, Australia, the US, and Japan) and more than 100 companies, research institutions, and international organizations participate in the network.**

Asia CCUS Network member countries

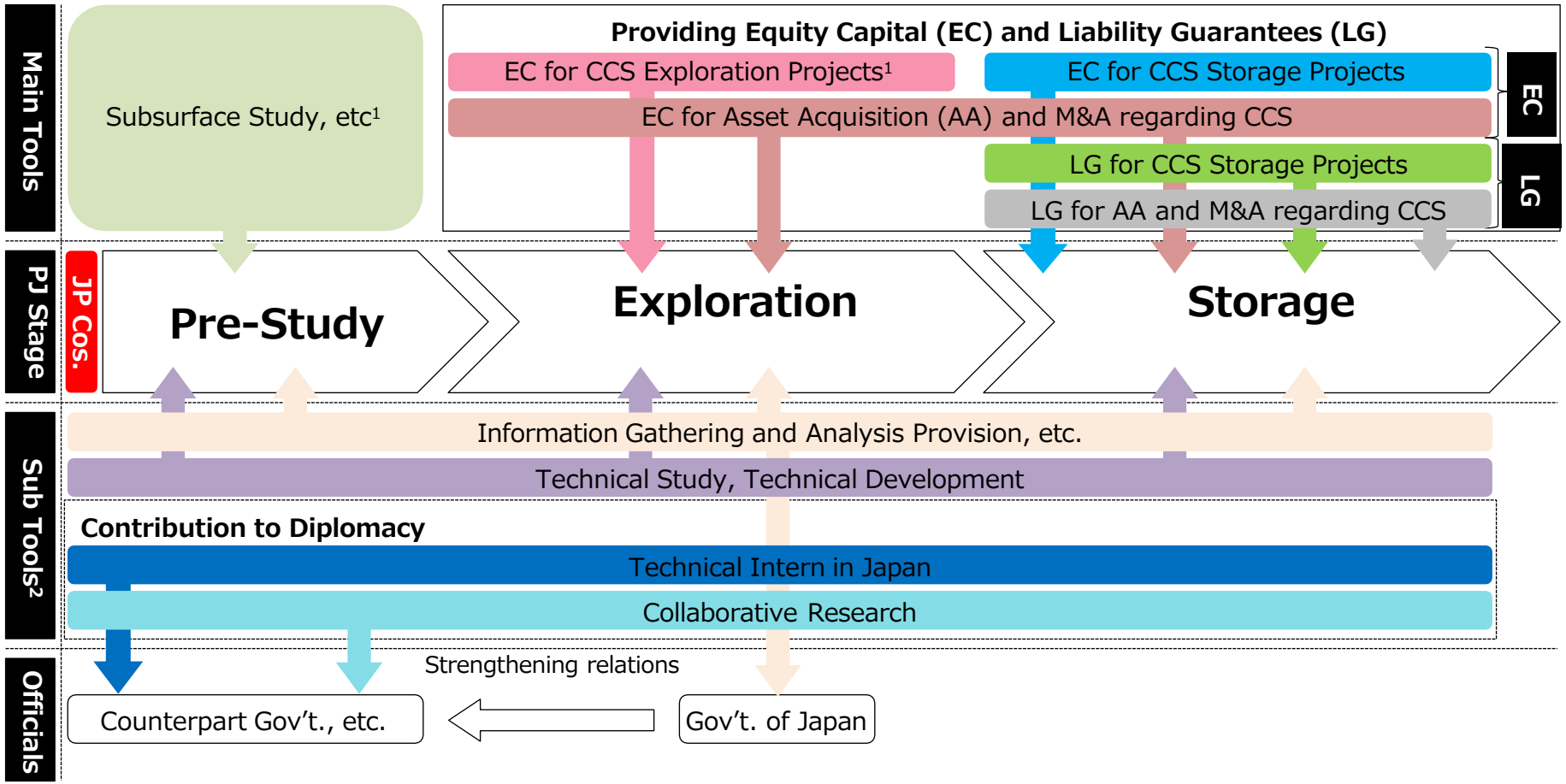


The First Asia CCUS Network Forum

Date and time: June 22-23, 2021, 11:00-14:00 (JST)
Host: The Economic Research Institute for ASEAN and East Asia (ERIA) and the Ministry of Economy, Trade and Industry
Participants: Kajiyama Hiroshi, Minister of Economy, Trade and Industry, EAS key cabinet ministers, international organizations (e.g., ERIA, IEA), private companies, financial institutions, etc.

Business Tools for CCS

JOGMEC promotes projects of Japanese companies both overseas and around the coastal waters of Japan securing suitable places for and implementation of CCS by providing a wide range of assistance as below.



1 Includes lending a vessel for seismic survey for CCS
2 Ancillary business tools to each tool categorized as Main Tools

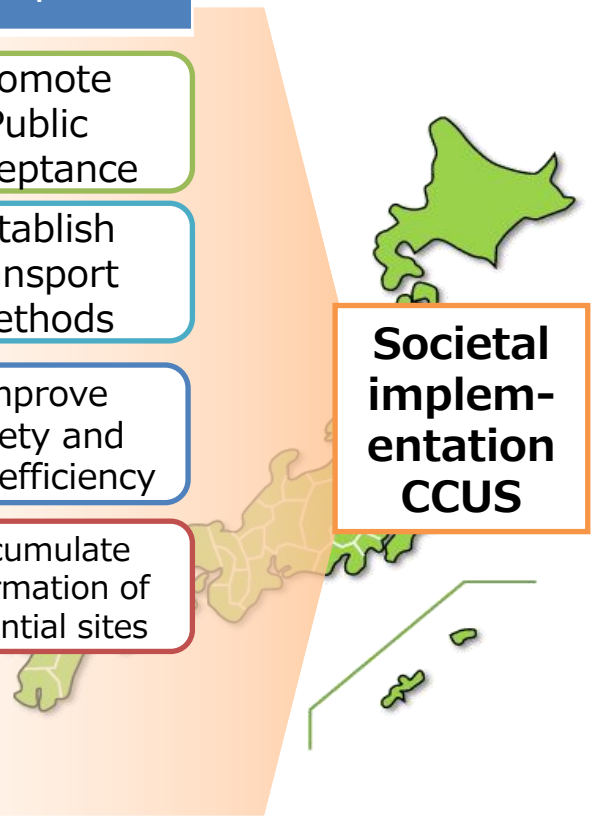
3. References
(Current CCS projects in Japan)

Current CCS Projects

- Toward the start of CCS business by 2030, the followings are being carried out;

  ①Tomakomai demonstration project ②CO2 shipping project ③R&Ds for storage and monitoring technologies ⑤Investigation of Potential CO2 storage sites

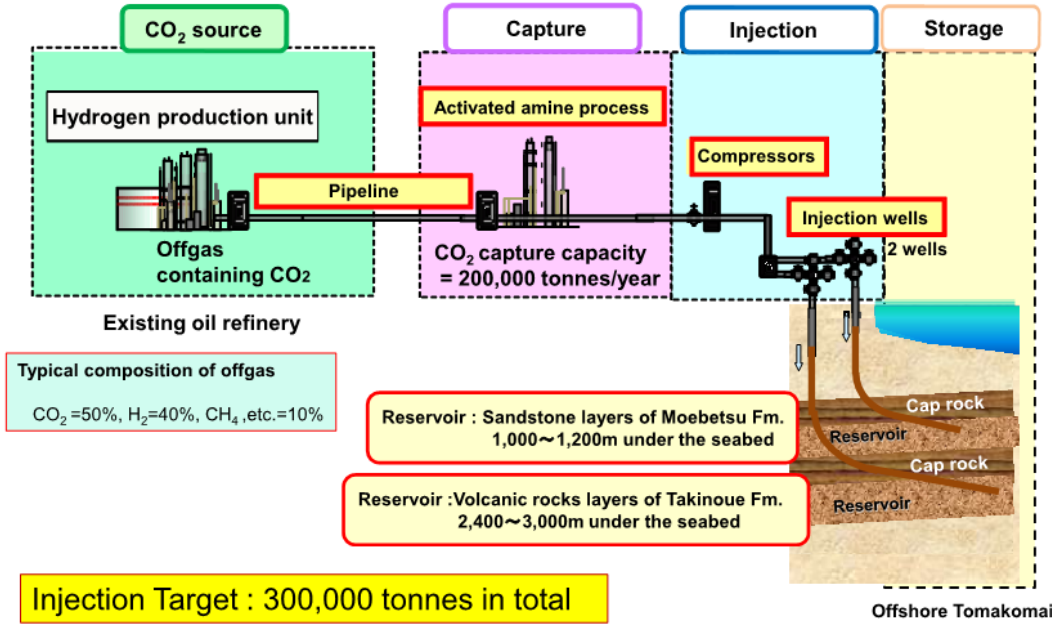
Projects＼FY	2019	2020	2021	2022	2023～	What to expect
Tomakomai demonstration project	300kt injected	Monitoring				Promote Public Acceptance
CO_2 shipping project		Study and preparation			Demo	Establish transport methods
R&Ds	R&Ds for storage and monitoring technologies					Improve safety and cost efficiency
Potential site investigation	Seismic survey, Geological model building, etc.					Accumulate information of potential sites
International collaborations	Asia CCUS Network, CEM CCUS Initiative, IEAGHG, etc. ISO/TC265					



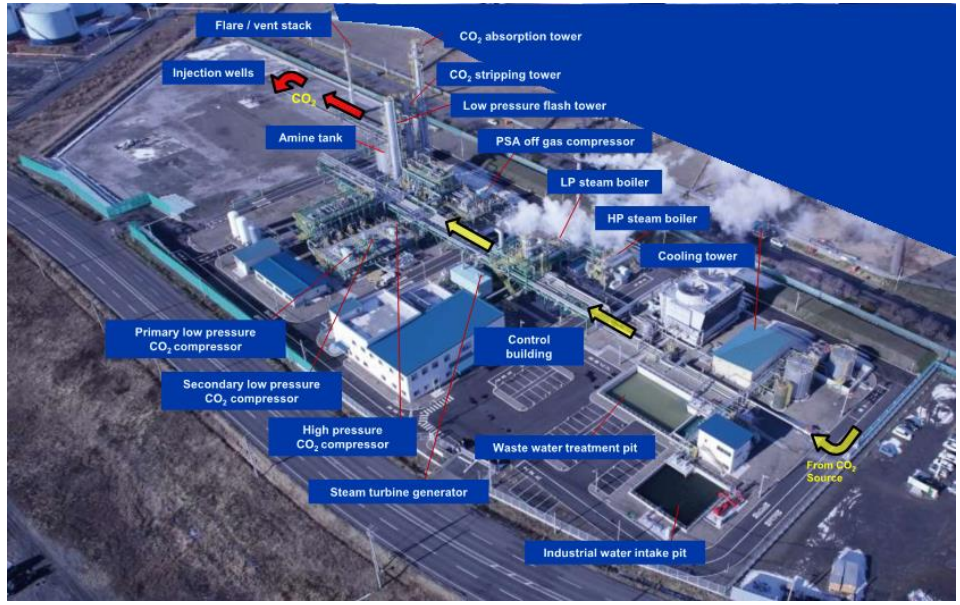
Tomakomai CCS Demonstration Project

- Demonstrate full-chain CCS system from capture to storage
- Target of 300,000 tonnes of CO2 injection achieved in November 2019
- Remove concerns about earthquakes by the data collected;
  - No influence by natural earthquakes on CO2 stored
  - No perceptible earth tremors induced by CO2 injection
- Disclose project information & data and enhance understanding of CCS by local residents

Flow Scheme of Tomakomai CCS Demonstration Project



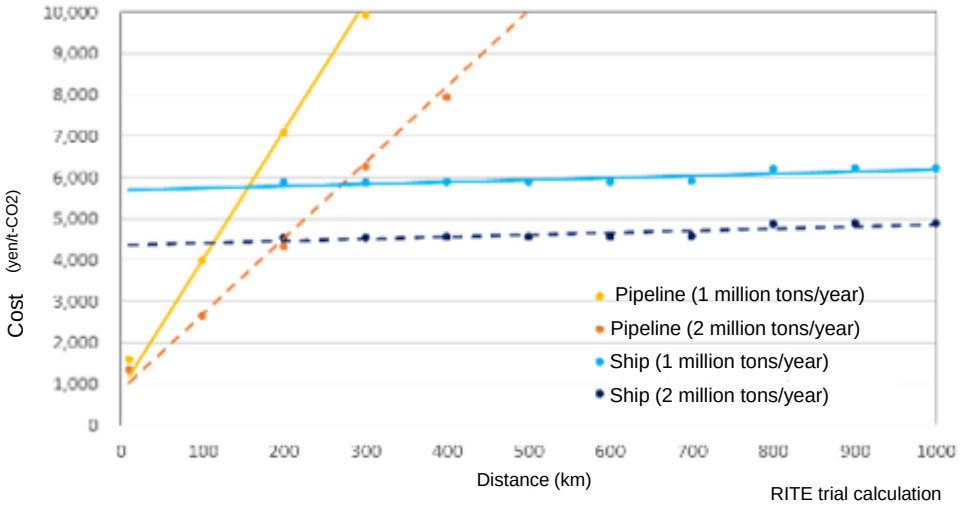
Capture and Injection Facilities of Tomakomai Project



Liquefied CO2 Shipping Demonstration Project

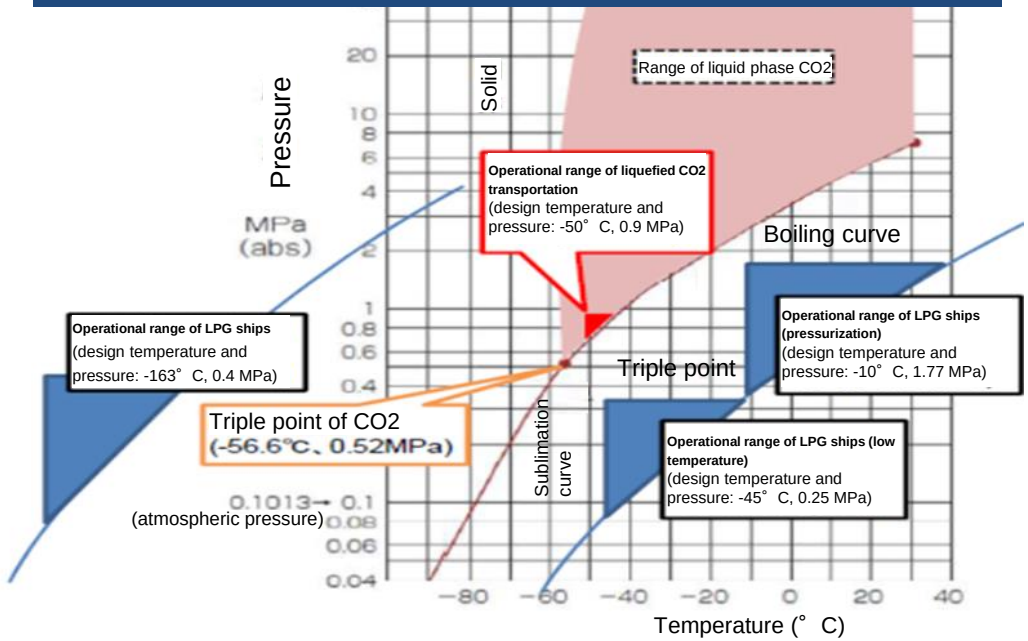
- While areas with high potential for storage are distributed along the Sea of Japan, emission sources are concentrated along the Pacific Ocean. It is expected that **large-capacity long-haul transportation will be required for CCS in Japan**.
- According to a trial calculation, while use of pipelines is lower in cost for short-haul transportation, shipping is lower in cost for long-haul transportation exceeding 200 km. **Current challenges include the lack of established large-capacity shipping techniques for liquefied CO2.**
- Transportation of liquefied CO2 has been available only by small ships in **middle-temperature and middle-pressure conditions at around -20°C, 2 MPa**. To enable large-scale transportation of liquefied CO2, however, establishment of **low temperature and pressure techniques at around -50°C, 0.9 MPa is indispensable**. Japan has been developing such techniques ahead of other countries.

Relation between amount/distance of transportation and cost



[Amount of transportation] Cost is reduced by mass transportation both by pipeline and by ship.
[Distance of transportation] Pipeline is superior for short-haul transportation. Shipping is lower in cost for long-haul transportation exceeding 200 km.
→ Control techniques under low temperature and pressure conditions are indispensable for large-scale CO2 shipping.

Challenge in triple point control during liquefied CO2 shipping



Transportation of CO2 under the low temperature and pressure conditions (the ◤ area shown in the graph above) requires study on measures, including precise pressure control and facility design, against a risk of solidification (conversion to dry ice) due to pressure fluctuations during operation.

Liquefied CO2 Shipping Demonstration Project

- A demonstration project for long-haul transportation from emission sources to places suitable for storage will be carried out to establish liquefied CO2 shipping techniques. **Specifically, demonstration transportation, including a 1,000-km long-haul transportation route of from Maizuru to Tomakomai, will start in 2024**, with the aim of achieving the world's first results.

Demonstration of transportation by ship

○ Important techniques for the CCS hub & cluster plan, in which multiple hubs in Japan are assumed, for transporting CO2 captured at distant emission sources
○ Transportation by a 1,000-ton class liquefied CO2/LPG convertible transport ship

Maizuru Power Station (Coal fired power plant)

Capture
Coal fired power plant
○ Capture with solid absorbents (approx. 10,000 tons/year)
○ Capture to start in 2023

Capture
IGCC
○ Capture based on physical absorption (approx. 100,000 tons/year)

Osaki CoolGen (IGCC)

Carbon recycling R&D base

CO2 transport ship

Tomakomai CCS demonstration

Storage and monitoring
○ CCS demonstration underway
○ Injection started in 2016 and 300 thousand tons completed in Nov. 2019

Tomakomai CCS/CR hub
○ Facilities for Tomakomai CCS demonstration are utilized.
○ CO2 captured in distant emission sources is utilized in Tomakomai, an industrial city, through efforts of carbon recycling.

R&D Project of CO2 Storage Techniques for Safe Implementation of CCS

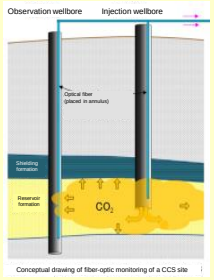
- CCS, in the transition phase from practical implementation to commercialization, has challenges of **risk reduction and economic efficiency improvement toward commercialization**.
- R&D on CO2 storage techniques will be continued with the aim of achieving the establishment of **low-cost and practical-scale safety control techniques with safety ensured**.

⇒ Including fiber-optic measurement techniques, development of a reservoir control system and tool to evaluate social acceptability called social license to operate (SLO), and wellbore plugging feasibility study

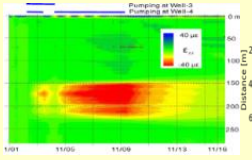
- With the aim of prompt establishment and widespread proliferation of the techniques, **every option available for overseas deployment should be considered, including the use of joint crediting mechanism (JCM)**.

Fiber-optic measurement technique　2020 Functional establishment▼　2023 Technical establishment▼

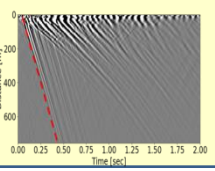
○ Advantage: Functional establishment in domestic indoor field tests
(1) Implementation of the multi-sensor function (see figure below)
→ Reduction of monitoring costs
(2) Semipermanent use → Suppression of facility and maintenance costs
(3) Full-time continuous position observation
→ Improved safety



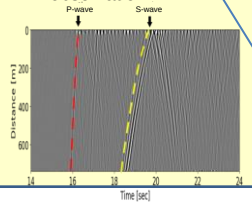
Deformation measurement



DAS/VSP



Natural seismological observation



○ Large-scale demonstrative verification and technical establishment
: Verified in a US site (a few hundred thousand t-CO2 class)
・In-well measurement and surface elastic wave measurement
→ Establishment of geologic stability monitoring techniques
→ Establishment of CO2 behavior monitoring techniques

Demonstration in North Dakota, US

▼2023- Practical application

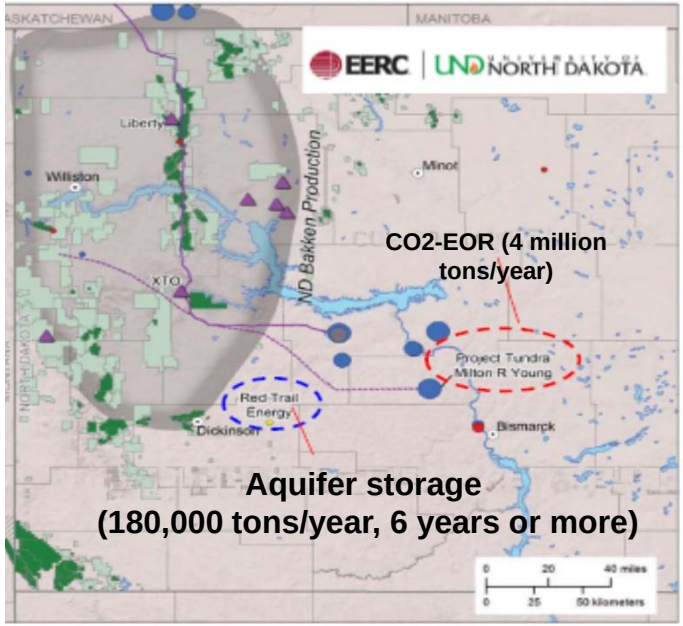
○ Practical application to CCS
・Application to domestic and overseas CCS sites
→ Improvement of safety and economic efficiency
→ Overseas deployment of Japan's techniques

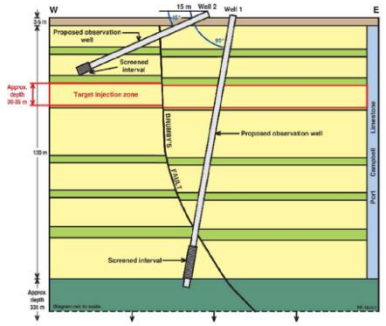
○ Ripple effects
・A wide range of application including building maintenance
→ Acquisition of enormous market

R&D Project of CO2 Storage Techniques for Safe Implementation of CCS

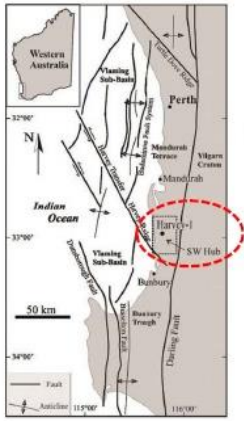
- **Large-Scale Demonstrative Verification in Cooperation with Overseas Institutions**
- **Fiber-optic monitoring and measurement systems are to be demonstrated** in the US (EERC) and Australia (CSIRO and CO2CRC).

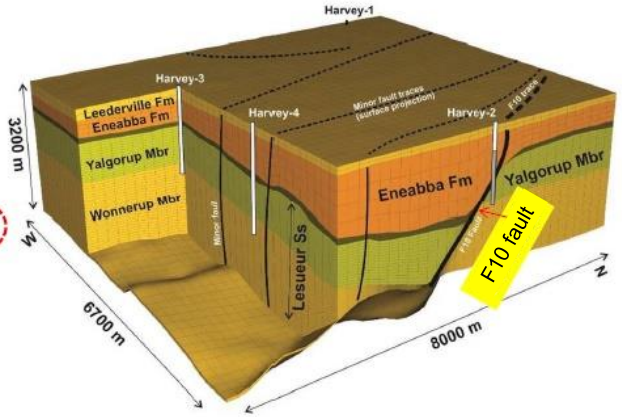
North Dakota, US
Demonstration site
(in progress)
(An MOU has been concluded between RITE and EERC)
- Geologic stability monitoring
- CO_2 behavior monitoring





SW Hub demonstration site in Western Australia, Australia
Otway, Victoria, Australia
(under planning)
(An LOI has been concluded between RITE and CSIRO, and an MOU between RITE and CO2CRC)
- Stability evaluation of faults
- Shallow fault leakage monitoring technique





Field tests for stability evaluation of faults in deep formations

Domestic CO_2 Storage Potential

Jan. 28, 2022
First CCS Long-Term Roadmap Study Group Meeting
(excerpt)

- Although **approx. 240 billion tons of domestic CO_2 storage potential has been assumed** based on basic data from previous investigations by RITE, NEDO, and AIST, places suitable for storage have not been identified yet.
- **Identification of places suitable for storage is inevitable for the commercialization of CCS** and, therefore, various investigations such as 3D seismic prospecting have been carried out since 2014. Based on the investigations already carried out, **approx. 16 billion tons of storage capacity has been assumed in a total of 11 locations by the end of March 2022**.
- This investigation continues at remaining locations in the areas expected to be places suitable for storage (where sedimentary layer thickness is 1,000 m or more; the classes outlined by the red borders in the figure below).

CO_2 reservoirs abundance map

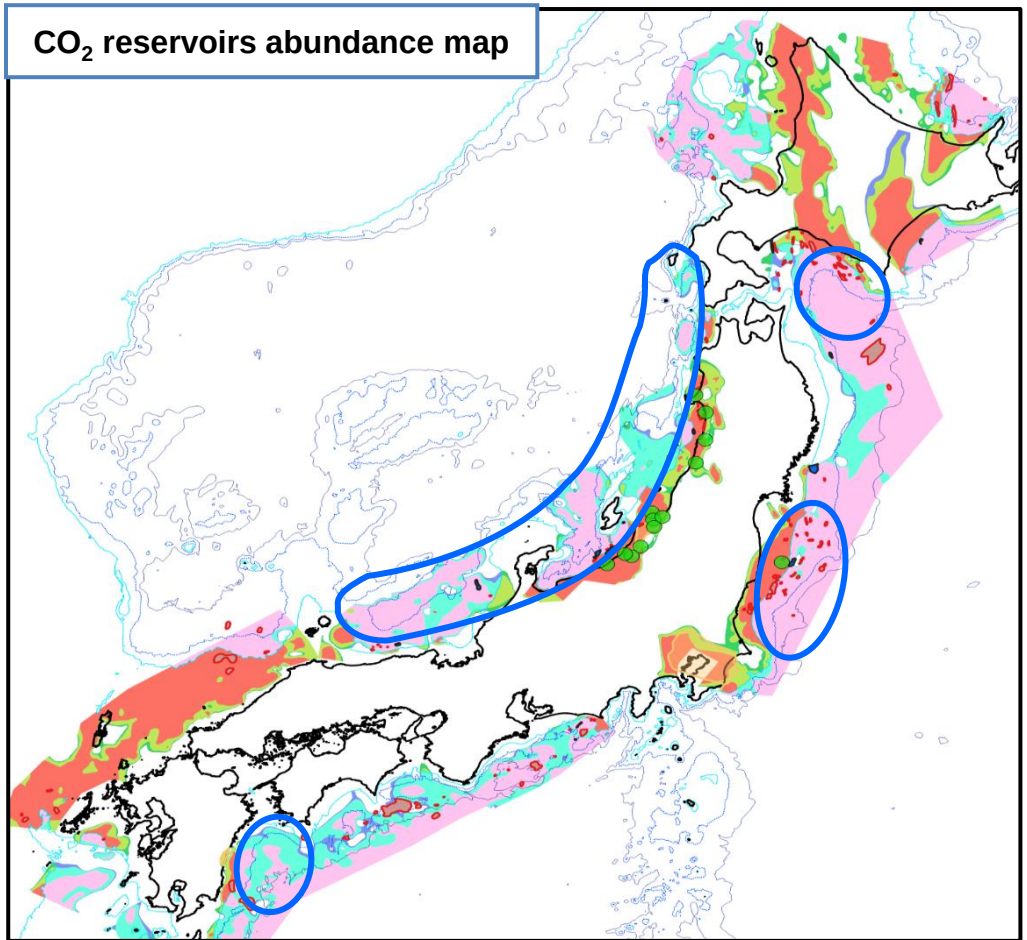


Table. RITE classification of sedimentary layer thickness (2006, 2008)

A1	(oil/gas field)	Fault structure, Anticlinal structure
A2	(excavated structure)	
A3	(unexcavated structure)	
B-1	(water-soluble gas field)	Homoclinal structure
B-2	(sedimentary layer thickness > 2,000 m, depth < 200 m)	
B-2	(sedimentary layer thickness = 1,000 to 2,000 m, depth < 200 m)	
B-2	(sedimentary layer thickness = 800 to 1,000 m, depth < 200 m)	
B-2	(sedimentary layer thickness > 2,000 m, depth > 200 m)	
B-2	(sedimentary layer thickness = 1,000 to 2,000 m, depth > 200 m)	
B-2	(sedimentary layer thickness = 800 to 1,000 m, depth > 200 m)	

Depth: 2,000 m
Depth: 1,000 m
Depth: 200 m

Edited by JCCS (Japan CCS Co., Ltd.) based on RITE (2006, 2008)

Geological analysis area based on 3D/2D scrutiny data (Analyzed at some locations in the ellipses. No meaning with the size of ellipses.)

Lending of Data from Suitable Location Investigation Project and Geophysical Exploration by TANSA

- **With the need for building a mechanism for promptly lending data analyzed by JCCS for suitable location investigation to private sectors** in preparation for the commercialization of CCS, **such data have been transferred to JOGMEC in order. Some of the data have been available since May 10, 2022. Available data are increasing in the order of readiness**.
- Previous suitable location investigations utilizing SHIGEN or TANSA were **intended for the development of oil and natural gas**. When **CCS investigation is added to JOGMEC's functions*, investigations intended for CCS will start from 2023** at the earliest, in addition to the current oil and natural gas investigations.

*A bill for the relevant things has been introduced and is being discussed in the current Diet session.