TAIHEIYO CEMENT

Developments of Taiheiyo Cement Group's innovative technologies for carbon neutrality

Y. ISHIDA,

Carbon Neutral Technology Development Department,

Taiheiyo Cement Corporation

CARBON NEUTRAL
TAIHEIYO CEMENT

Today's Topics

1. Carbon Neutral Strategy 2050
2. Development Status of Innovative Technologies for CCUS
3. Carbon Neutral Model Plant Plan
4. Summary and Future Development

Developments of Taiheiyo Cement Group's Initiatives

2015

Incorporated the CSR Objectives for 2025, which included a target of reducing greenhouse gas emissions, into the Mid-Term Management Plan.
(10% reduction in net CO_2 emissions intensity compared to 2000)

2019

- Endorsed the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD).
- Formulated the outline for the long-term vision of greenhouse gas emissions reduction towards 2050.

2020

Developed specific measures for the long-term vision of greenhouse gas emissions reduction towards 2050.

2021

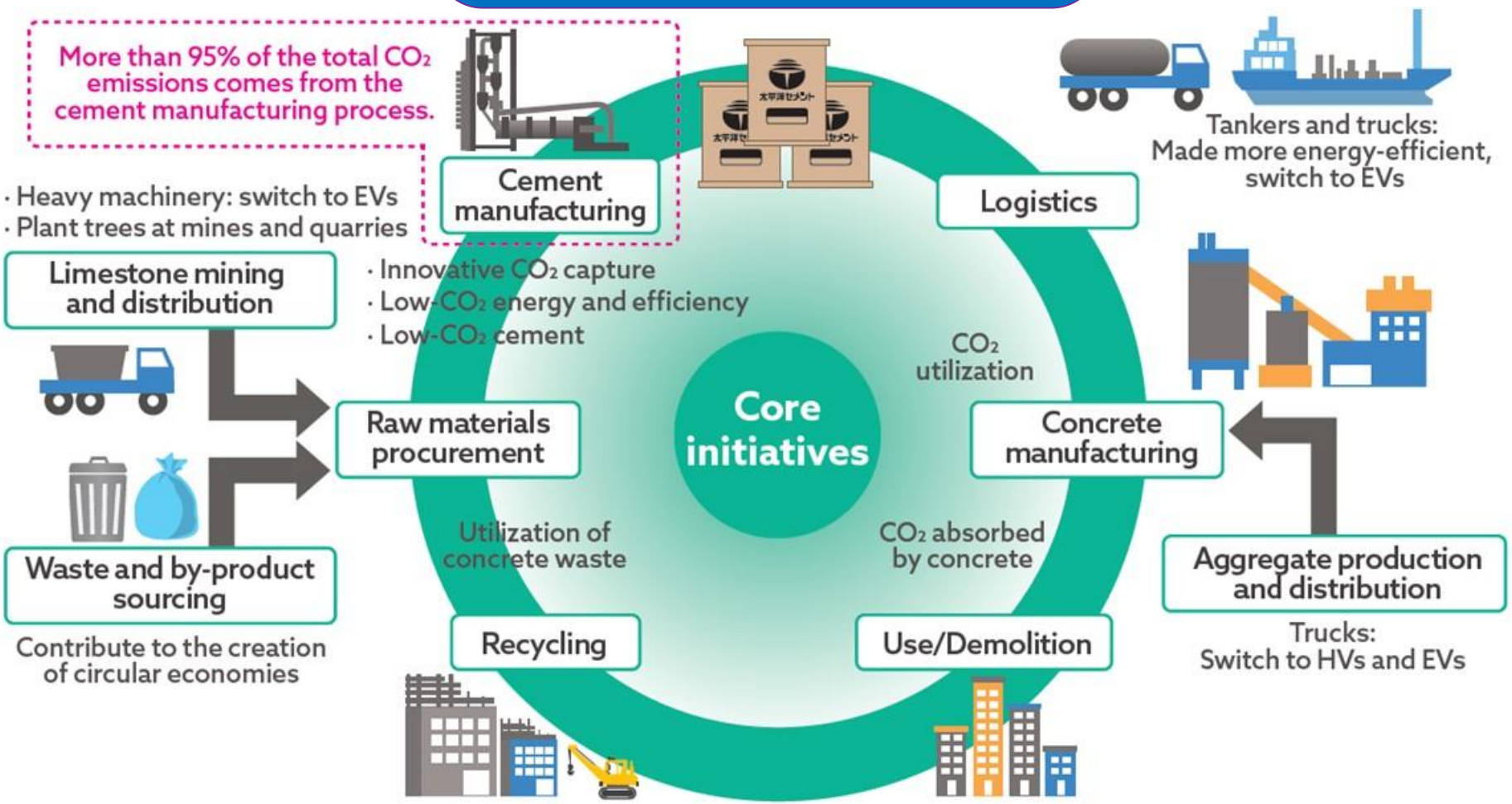
- Established a Carbon Neutral Technology Development Project Team to achieve carbon neutrality.
- Published the 2023 Mid-Term Management Plan in which the **Carbon Neutral Strategy 2050** was announced.

2022

Set up the **Technology Development Roadmap** and the **2030 Interim Target** for the **Carbon Neutral Strategy 2050.**

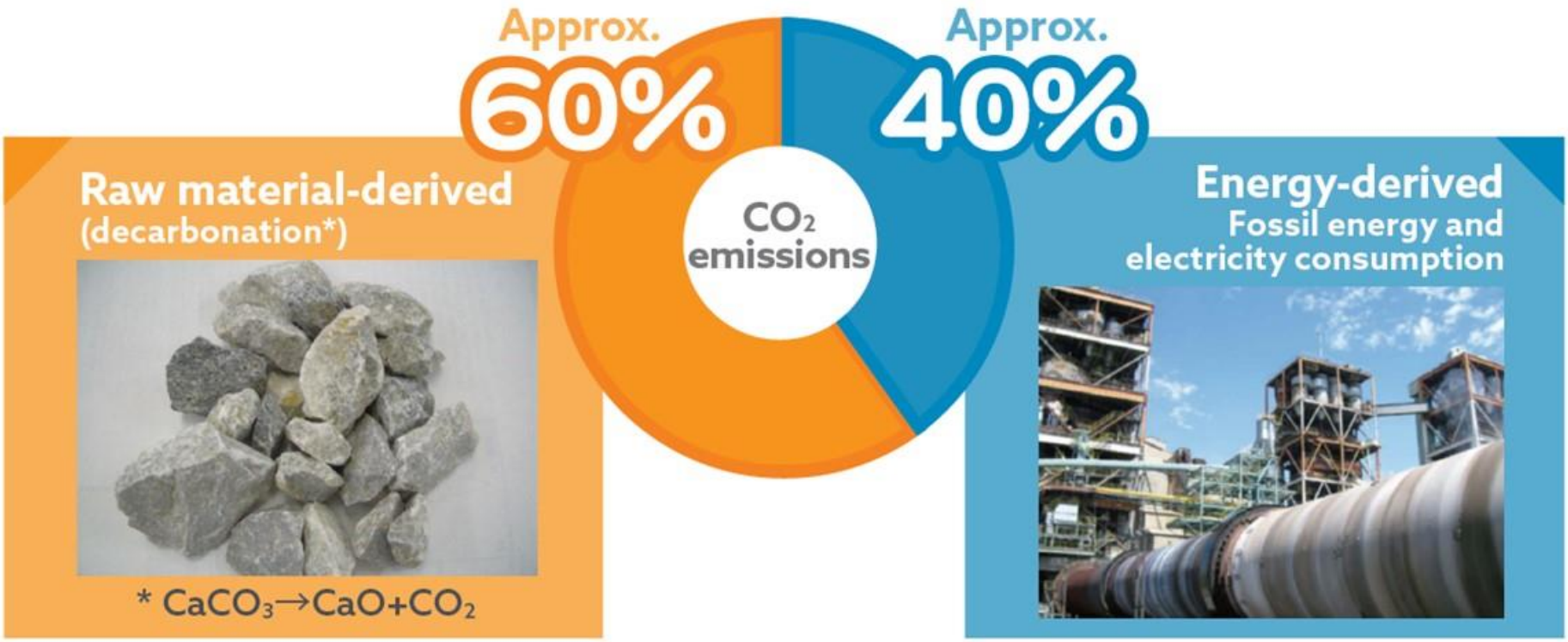
Supply Chain Initiatives for Carbon Neutrality

Actions in the supply chain



To make the entire supply chain carbon neutral by 2050.

CO_2 emissions from the cement production process

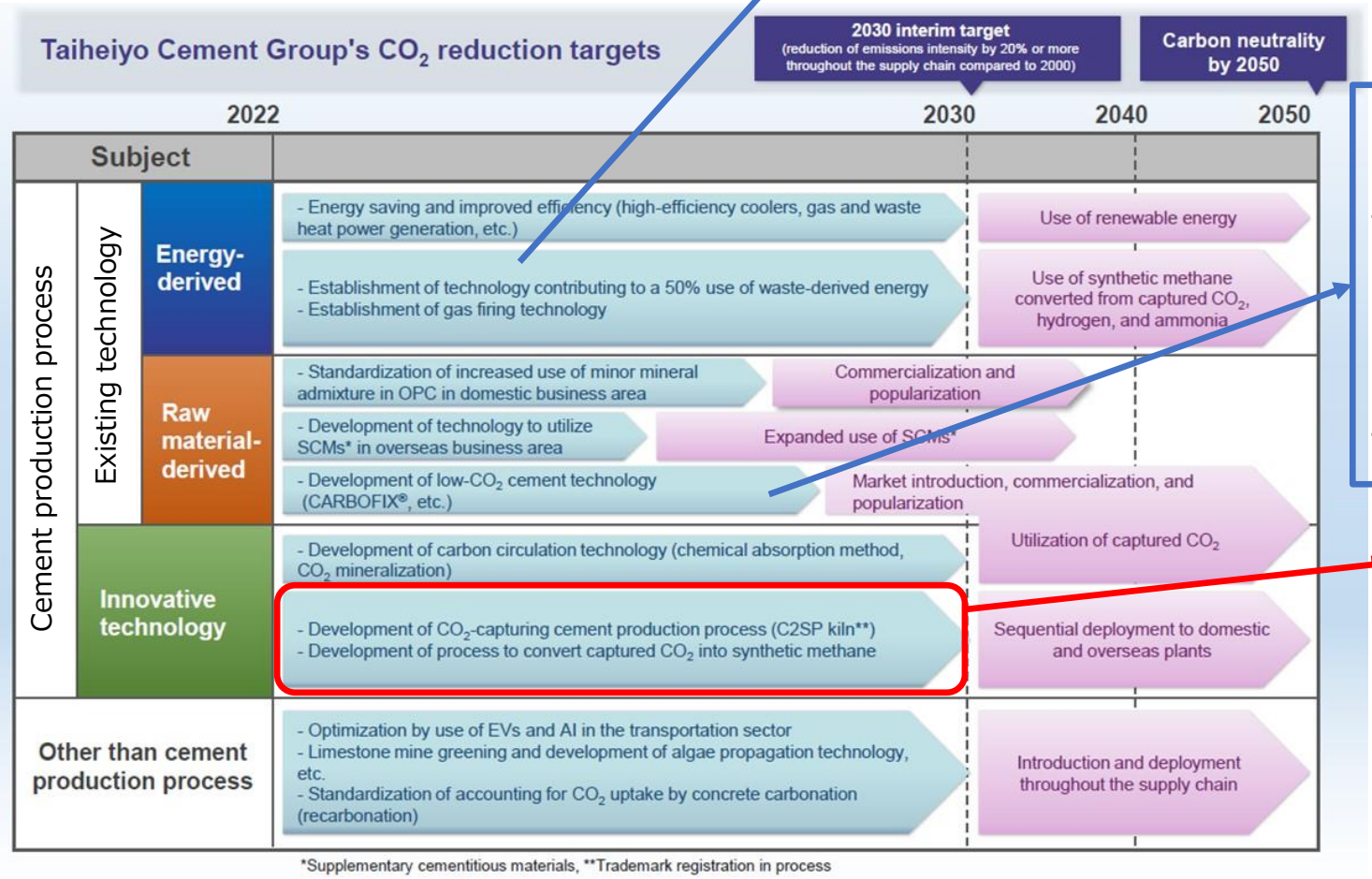


- CO_2 emissions from cement kiln (average): daily 2,500–3,000 tons/kiln
- About 60% comes from raw materials, and about 40% comes from energy use.

→ More than 50% of CO_2 emissions are derived from raw materials.

Technology Development Roadmap

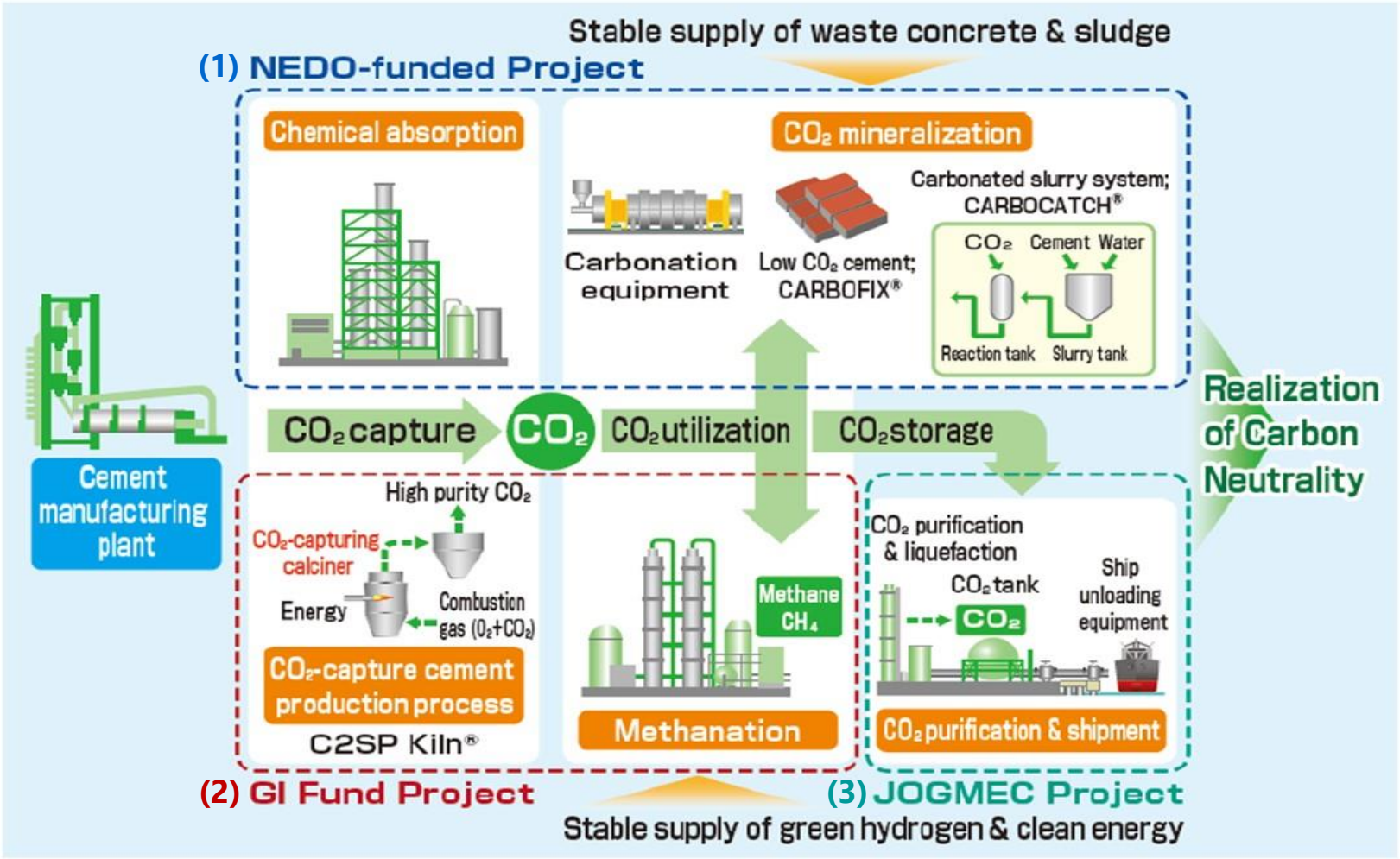
- Establish technologies that contribute to 50% fossil energy replacement.
- Establish gas firing technology and study its introduction in our plants.



Develop and standardize technologies for use of SCMs. Develop low-CO_2 cement technologies.

Develop CO_2 capture and utilization technologies.

CCUS-related Technological Development Projects

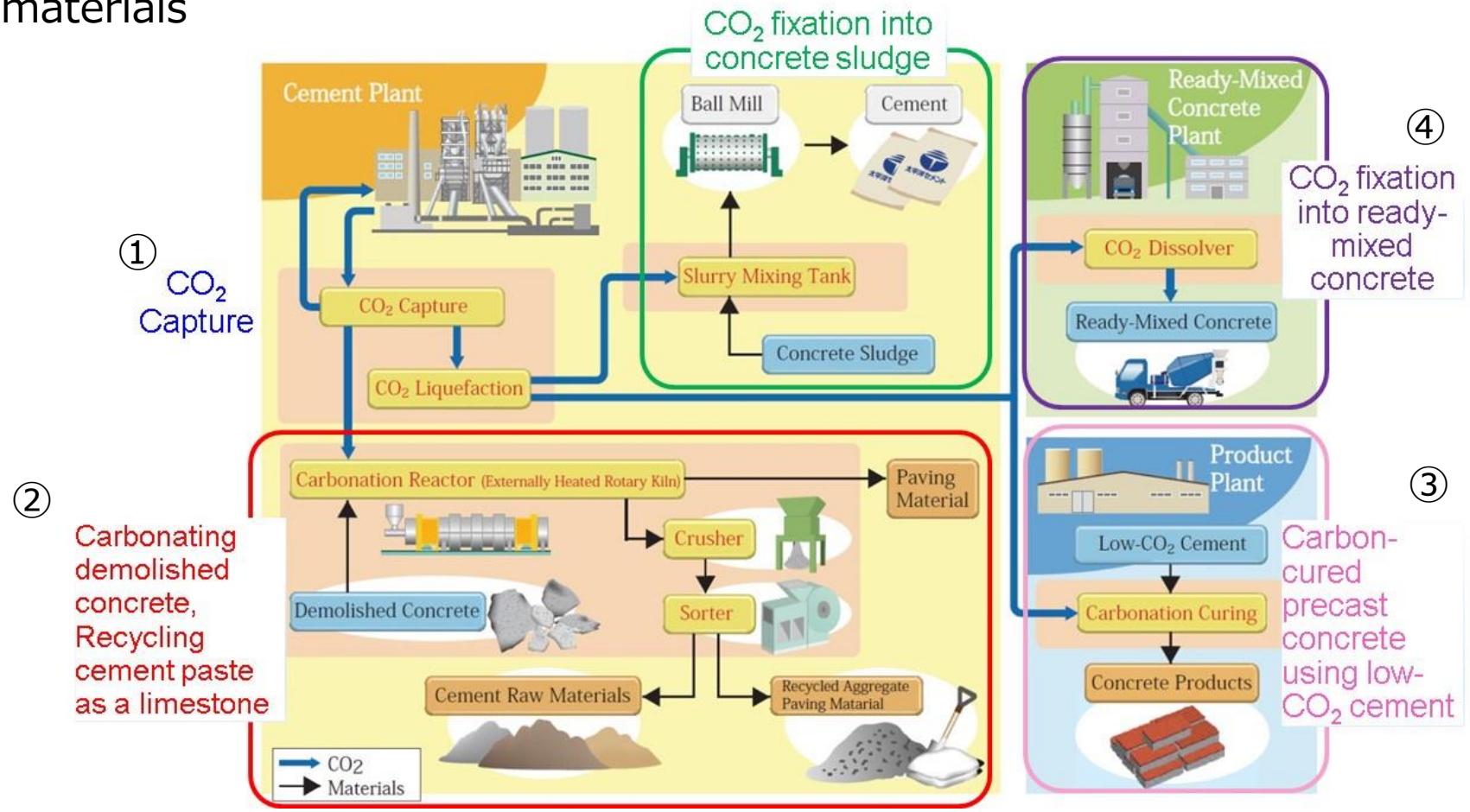


- Our technological development has been supported by various government subsidy programs, including GI Fund and others by NEDO and those by JOGMEC.

(1) NEDO Project (2020–2021*): Development of Carbon Circulation Technology for the Cement Sector

Themes:

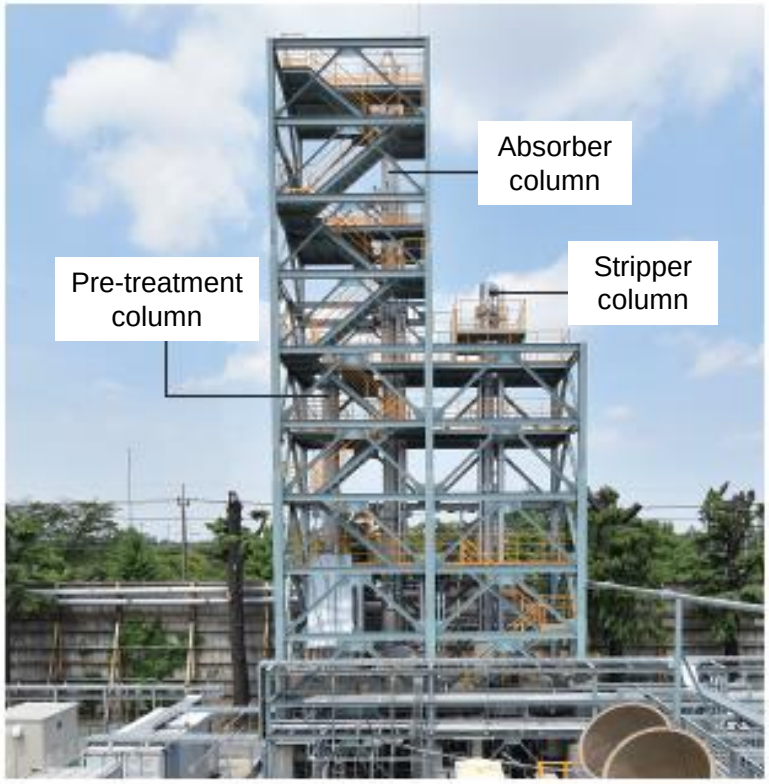
- CO_2 capture technology: chemical absorption method (amine process)
- CO_2 utilization technology: CO_2 mineralization in cement and concrete materials



* Independent testing has been ongoing thereafter

① CO_2 Capture from Kiln Exhaust Gas

Chemical absorption method



CO2 gas tanks (Each 25m³)

Process skid

A complete set of equipment built in a frame for compact installation

«Plant specifications and results»

- Method: amine solution
- Plant height: 25 m
- CO_2 capture capacity: 10 t/day
- Concentration of captured CO_2: 99% or above
- In operation since December 2021.

Demonstration test is ongoing at a scale of 10 t/day, which is the first in Japan for a technology to capture CO_2 from actual kiln exhaust gas.

② CO_2 Sequestration in Waste Concrete

CO_2 sequestration demonstration plant (Kumagaya Plant)

General view

«Plant specifications and results»

- Method: rotary kiln
- Amount of waste concrete treated: 500 kg/h
- Amount of CO_2 fixed: up to 125 kg/t-cement

CO_2 sequestration reactor

③ Low-carbon Concrete Products Cured in CO_2 Atmosphere

CARBOFIX® cement

- CARBOFIX® cement uses less limestone and can be burnt at lower temperatures compared to ordinary portland cement, thereby reducing the raw material-derived and energy-derived CO_2 released during manufacturing.
- High strength is developed by absorbing CO_2 (fixed in the form of $CaCO_3$) during hardening.
- As a result, up to 60% reduction is achieved in CO_2 emissions.

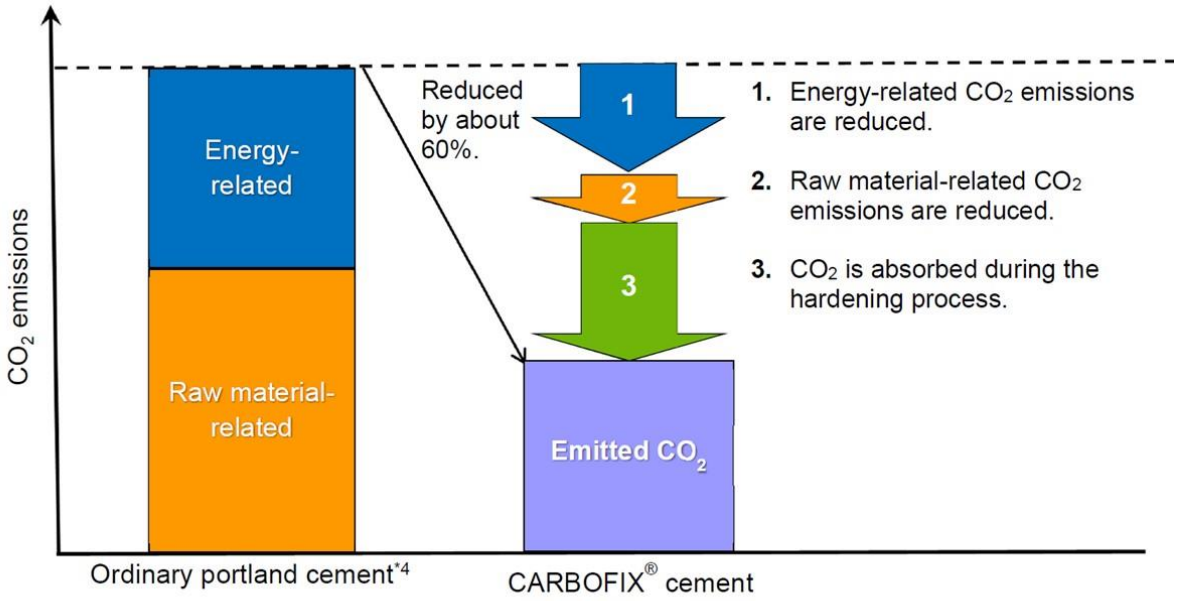


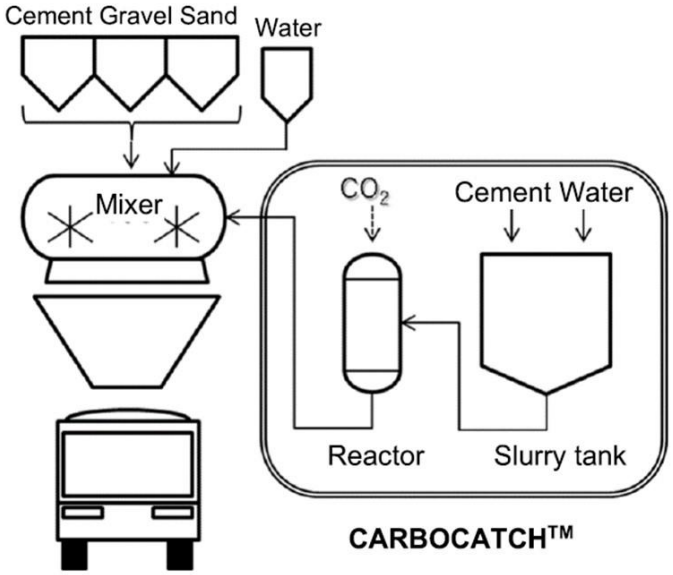
Figure 1. An example of CO_2 emissions of a concrete product using CARBOFIX cement

Appearance of CARBOFIX

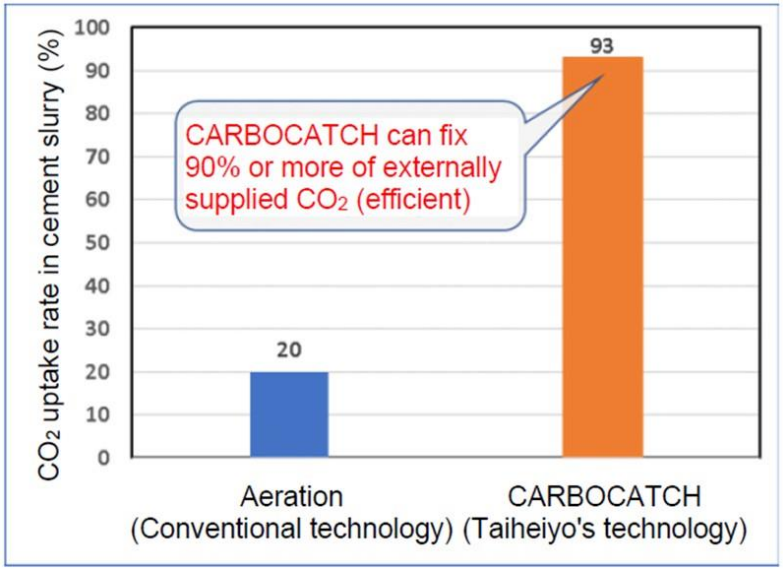
④ CO_2 Sequestration in Fresh Concrete

CARBOCATCH®

- A system that fixes CO_2 in cement slurry at a high efficiency (reaction efficiency: over 90%) while the slurry is circulated through a reaction bath filled with CO_2.
- Applicable to both precast concrete and ready-mixed concrete, and capable of fixing about 8–20 kg of CO_2 per 1 m^3 of concrete (depending on the concrete mix proportions).
- Equivalent to ordinary concrete in strength development and durability.



Conceptual diagram of CARBOCATCH®



CO_2 uptake rate in CARBOCATCH® slurry

④ CO_2 Sequestration in Fresh Concrete

Applications of CARBOCATCH® slurry

Photo 2. Wave-dissipating concrete block manufactured by using CARBOCATCH slurry

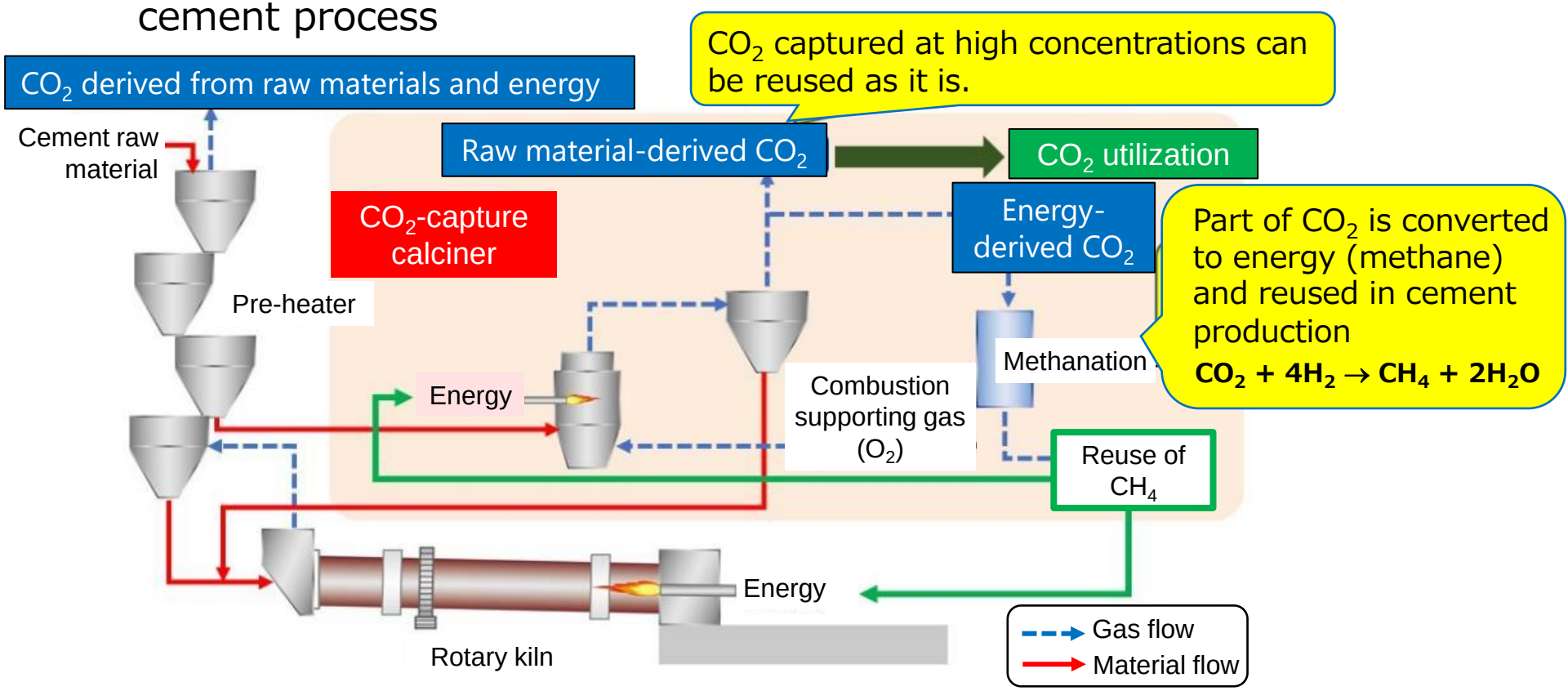
Photo 3. Precast concrete products (continuous foundation blocks for guardrail) manufactured by using CARBOCATCH slurry

Photo 4. Test construction of pavement concrete using CARBOCATCH slurry

(2) GI Fund Project (2021–): Development of CO_2-capturing Cement Production Process

Themes:

- CO_2 capture technology: CO_2-capture calciner (C2SP kiln®*)
- CO_2 utilization technology: methanation technology suitable for the cement process

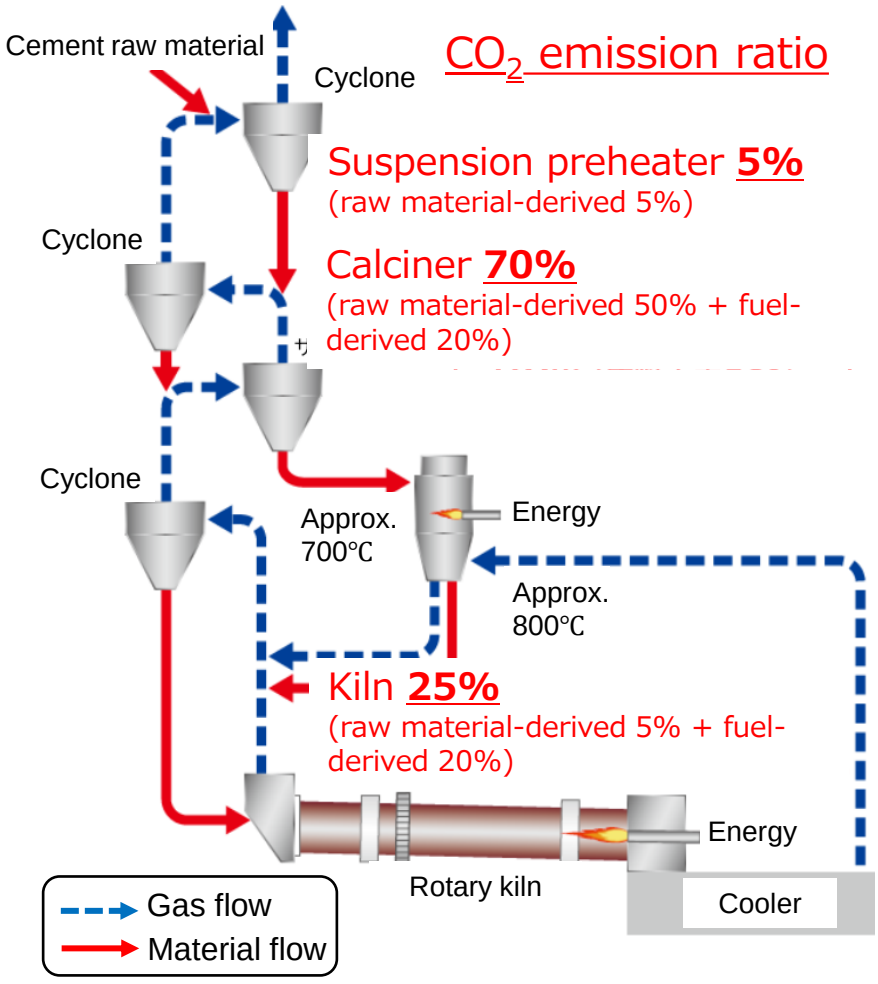


Cement production process incorporating a CO_2 capture system

*C2SP kiln: carbon capture suspension preheater kiln

(2-1) Development of CO_2-capture Calciner

Overview of conventional cement kilns (NSP kilns*)



Suspension Preheater
A heat exchanger that consists of four or five stages of cyclones. Preheats raw materials to about 700℃ by using hot kiln exhaust gas.

Calciner
Calcines raw materials (decarbonates limestone), with energy source supplied.
⇒ Decarbonation rate: 80–90%

Rotary kiln
Burns decarbonated raw materials at about 1450℃ to produce clinker, with energy source supplied.

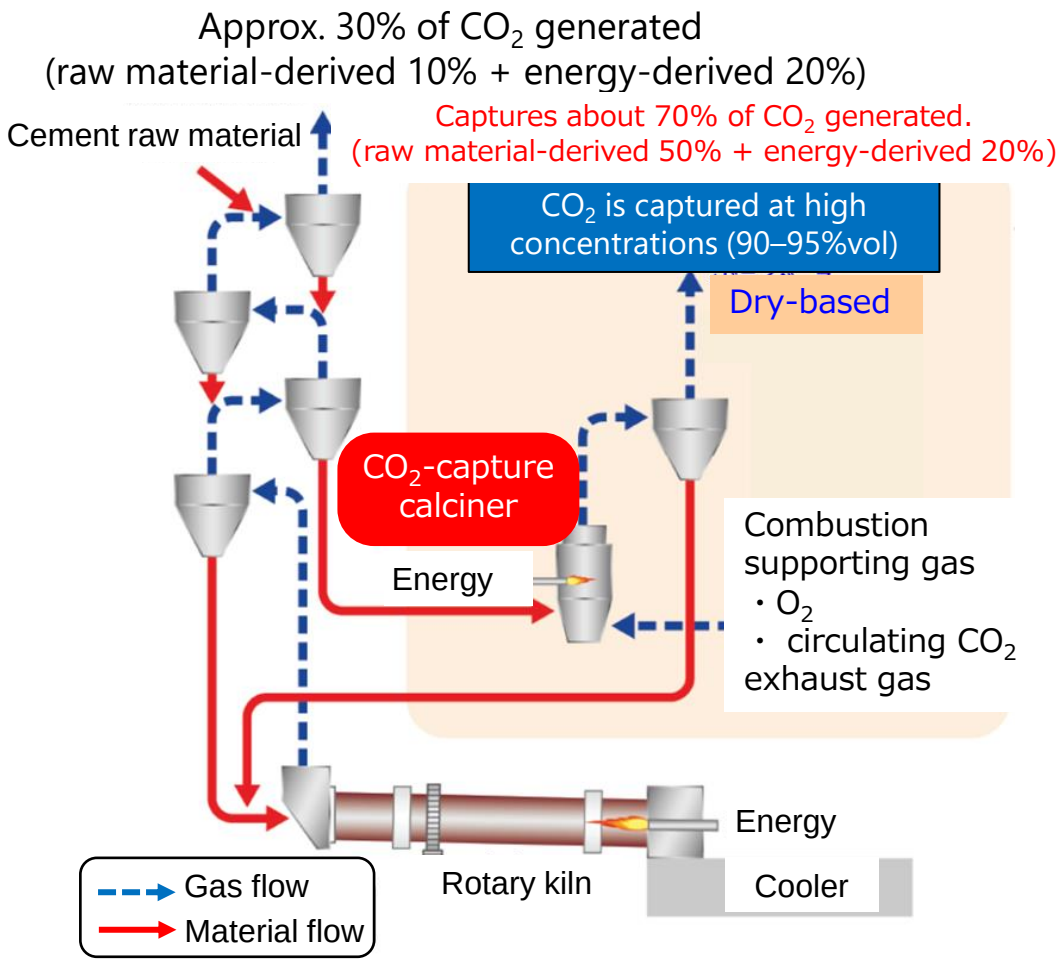
Cooler
Cools hot clinker with air.
Part of the hot (about 800℃) air after heat exchange is used as a

NSP kiln(New Suspension Preheater kiln)
*Suspension preheater kiln equipped with a calciner.

Our GI Fund project aims to develop technologies to efficiently capture CO_2 generated in the calciner (70% of the amount generated).

(2-1) Development of CO_2-capture Calciner

Overview of the CO_2-capture calciner



○ Compact CO_2 capture system

- Taiheiyo's technology to efficiently and directly capture CO2 from the calciner at the source.
- The concentration of CO2 is made higher by replacing air with oxygen to support combustion.

○ Advantages of the conventional NSP kiln are inherited.

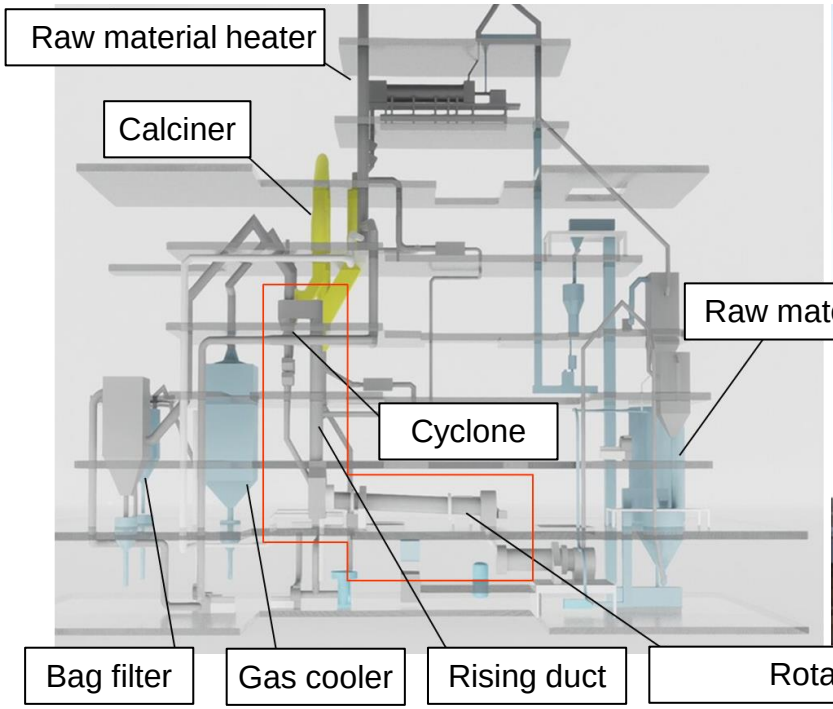
- The high heat exchange performance of the NSP kiln is maintained.
- Waste usage is at the same level as, or higher level than, conventional kilns.

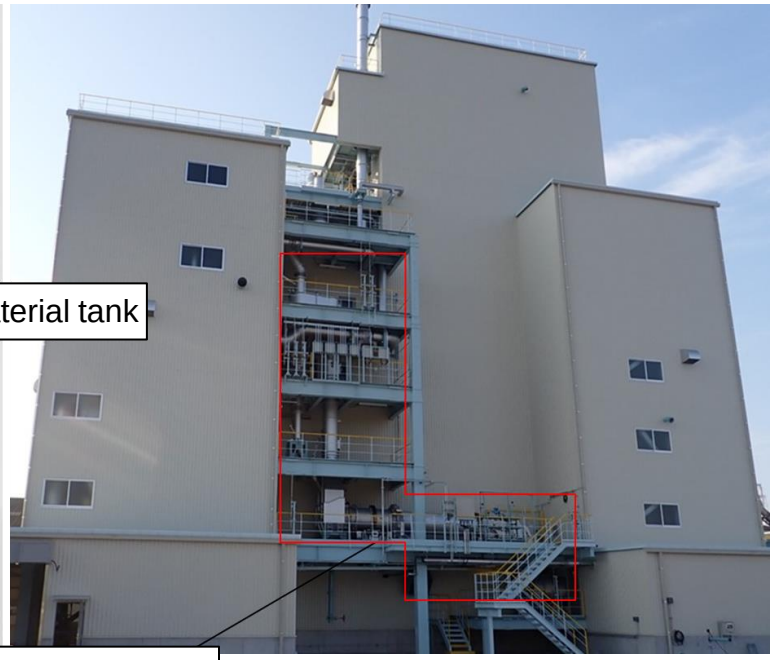
Carbon neutrality will be reached, with the CO_2 reduction (20%) through the use of carbon-free alternative energy and the natural CO_2 uptake (15%) by the concrete in service taken into account.

① Development of CO2-capture Calciner

Small-scale demonstration equipment

Location: Sanyo Onoda City, Yamaguchi, Japan (in the premises of Onoda Plant, Taiheiyo Materials Corporation)



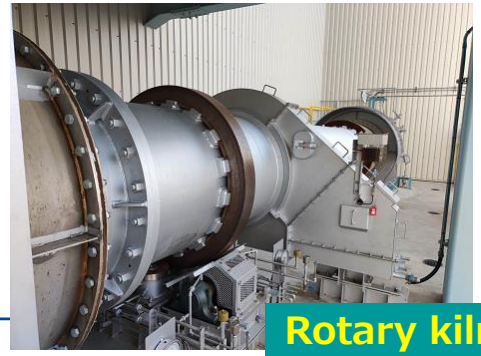


«Specifications of the equipment»

Clinker output: 5 t/day

CO_2 capture capacity: 2.4 t/day

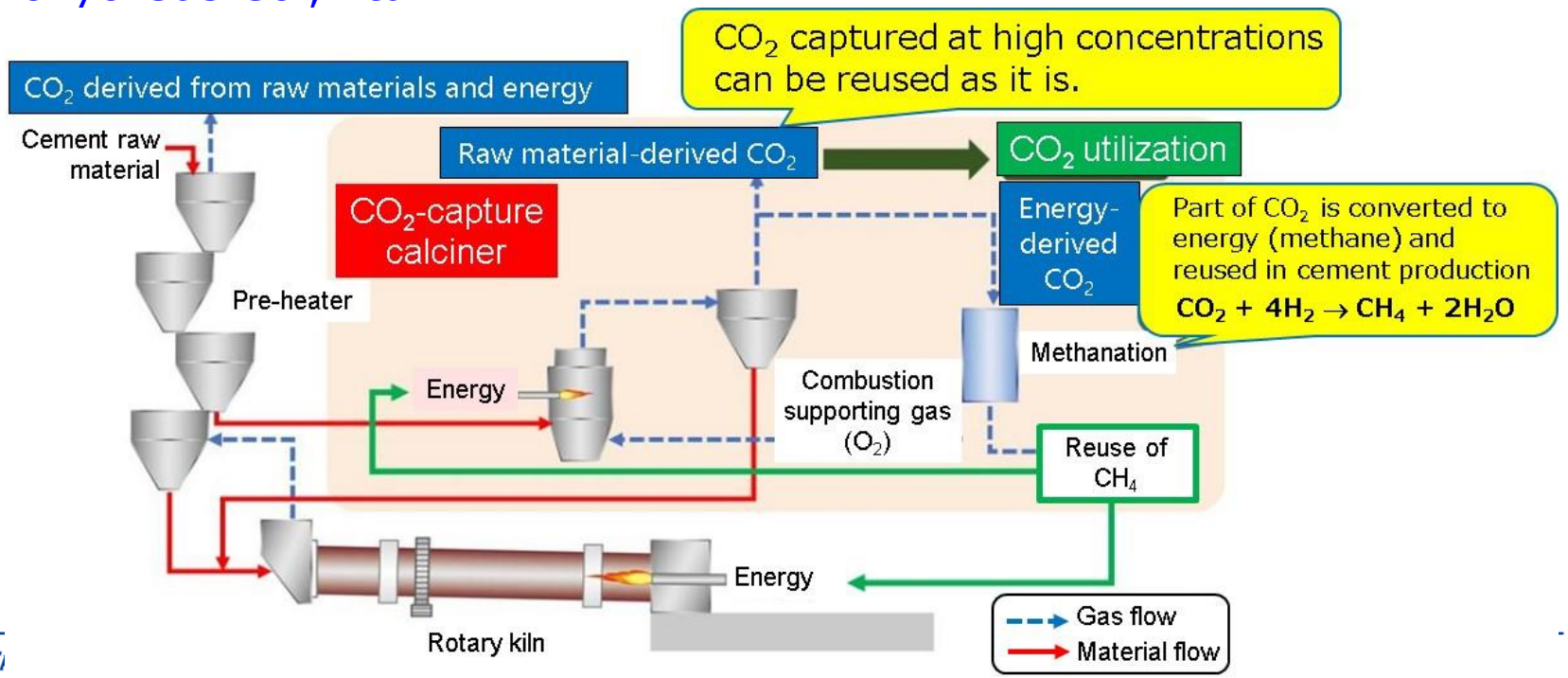
Methanation equipment: 300 Nm^3 of methane/day



Rotary kiln

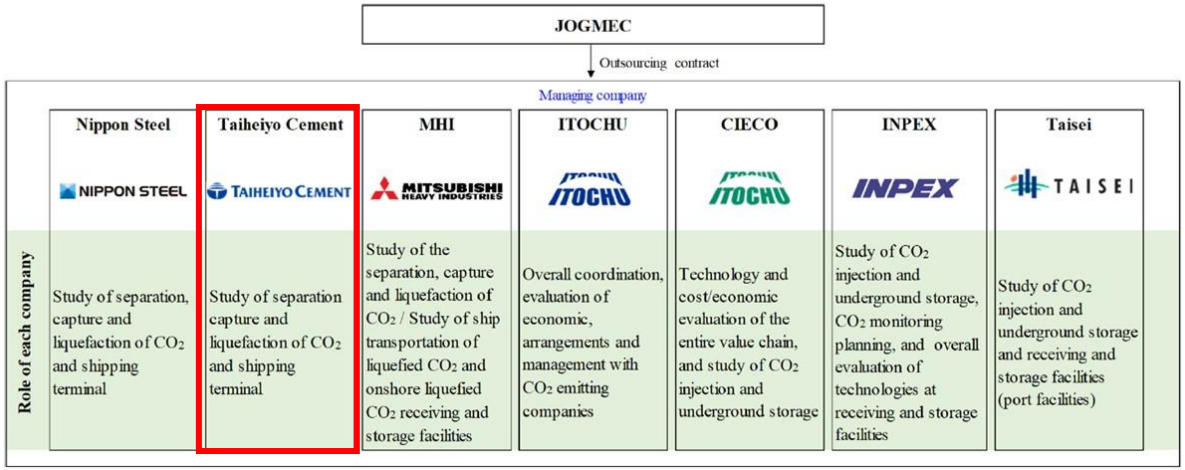
② Methanation Technology Suitable for the Cement Process

- Synthesized e-methane is produced by using the CO_2 captured at the CO_2-capture calciner, and reused as a thermal energy source for the kiln and calciner.
- The captured CO_2 has acid gases, oxygen and other components that inhibit the methanation catalyst, which requires development of pretreatment technology. ⇒ Joint research with IHI Corporation
- Feasibility study (FS) is required for injection of e-methane synthesized from the captured CO_2 to city gas pipelines. ⇒ Joint research with Tokyo Gas Co., Ltd.



(3) JOGMEC Project (2023–): Japanese Advanced CCS Projects by JOGMEC

- ✓ CCS project in the Tohoku region on the Sea of Japan side
  - Capture CO_2 emitted by the hard-to-abate sectors including steel and cement industries.
  - Transport the captured CO_2 by ship.
  - Store the CO_2 offshore the Tohoku region on the Sea of Japan side.
- ✓ Consortium members and their roles



- ✓ Role of Taiheiyo Cement Group
  - Study on purification, liquefaction and shipping bases for CO_2 (captured by the C2SP kiln within the scope of the GI Fund project)
  - Examine Kawasaki Plant of DC Co., Ltd. as a possible model plant

Carbon Neutral Model Plant Plan

- ✓ Innovative CCUS (CO_2 capture, utilization and storage) technologies need to be introduced to make the cement sector carbon neutral.
- ✓ In our GI Fund project, real plant demonstration will start in 2026, and development of innovative technologies will be completed by 2030. ⇒ Our carbon neutral model plant will be realized in 2030.
- ✓ Study on Kawasaki Plant of DC Co., Ltd. for the carbon neutral model plant has been started (released on August 7, 2023).

Conceptual image of a CN Model Plant

Study points for the carbon neutral model plant:

1) GI Fund project: real plant demonstration of the CO_2-capturing cement production system (C2SP kiln®)
2) JOGMEC project: Feasibility Study on the Implementation of Advanced CCS Projects (2023)
3) Study on the carbon neutral model plant plan in which CO_2 capture, CO_2 utilization (CO_2 mineralization, methanation, etc.) and CO_2 storage technologies are implemented at the real plant level.

Summary and Future Development

(1) We have set forth **the Carbon Neutral Strategy 2050**, seeking **to achieve carbon neutrality across the entire supply chain by 2050**. To reach the goal, a technology development roadmap and interim target for 2030 have been formulated.

(2) Innovative CO_2 capture and utilization technologies need to be established for the achievement of carbon neutrality. Such efforts include the GI Fund-aided **development of our original CO_2 capture technology (C2SP kiln®)** which is scheduled to be completed by 2030.

(3) Commercial introduction will start with **plants in urban areas where hydrogen and waste concrete are easily available**, and then be expanded to our Group plants, including those overseas.

(4) During the transition period until C2SP kiln® is widespread, **use of blended cements and other low-carbon cements** will be promoted in parallel.